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CALIFORNIA PARTNERS FOR ADVANCED TRANSIT AND HIGHWAYS

DOCUMENTATION OF THE IRVINE
INTEGRATED CORRIDOR FREEWAY RAMP METERING
AND ARTERIAL ADAPTIVE CONTROL
FIELD OPERATIONAL TEST

FINAL REPORT

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April 2000

**DOCUMENTATION OF THE IRVINE
INTEGRATED CORRIDOR FREEWAY RAMP METERING
AND ARTERIAL ADAPTIVE CONTROL
FIELD OPERATIONAL TEST**

DISCLAIMER

This work was performed as part of the California PATH Program of the University of California, in cooperation with the State of California Business, Transportation, and Housing Agency, Department of Transportation; and the United States Department of Transportation, Federal Highway Administration.

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official vies or policies of the State of California. This report does not constitute a standard, specification, or regulation.

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ACKNOWLEDGEMENTS

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ABSTRACT

A systematic evaluation of the performance and effectiveness of a Field Operational Test (FOT) of an integrated corridor-level adaptive control system was attempted from fall 1994 through spring 1999 in the City of Irvine, California. The FOT was conducted by a consortium consisting of the California Department of Transportation (Caltrans), the City of Irvine, and two private sector consultants, National Engineering Technologies, Inc. (NET) and Farradyne Systems, Inc. (FSI, now PB/FSI), with the City of Irvine as the lead agency. The FOT was cost-share funded by the Federal Highway Administration as part of the Intelligent Vehicle Highway System Field Operational Test Program. The FOT involves an integrated Advanced Transportation Management System (ATMS) which extends the capabilities of existing traffic management systems in the City of Irvine and in Caltrans District 12 (D12). The evaluation originally entailed both a technical performance assessment and a comprehensive institutional analysis.

This documentation of the Irvine Field Operation Test does not constitute a formal evaluation due to the failure of any of the planned technologies to be successfully implemented in the field. Due to the extended time frame associated with the project and the significant range of technical and institutional issues associated with the development and eventual failure of the FOT, a summary of project development, institutional barriers, and technical failures is provided.

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EXECUTIVE SUMMARY

The work described here was originally a four-part evaluation of the FHWA Field Operational Test (FOT), "City of Irvine Advanced Traffic Control System IVHS Field Operational Test, Integrated Freeway Ramp Meter/Arterial Adaptive Signal Control." The Field Operational Test (FOT) is cost-share funded by the Federal Highways Administration in cooperation with the California Department of Transportation (Caltrans), the City of Irvine, National Engineering Technology Corporation (NET), and Farradyne Systems Incorporated (FSI), a division of Parsons Brinkerhoff.

The observations and conclusions described in this document are based on information provided in numerous FOT partners meetings occurring October 1994 through September 1998, documents provided by FOT partners, inspections of facilities conducted by the evaluation team, telephone and personal interviews with FOT participants, and the Caltrans/Irvine/NET/FSI proposals to the FHWA IVHS Corridors Program "Advanced Traffic Control System IVHS Field Operational Test: Integrated Freeway Ramp Meter/Arterial Adaptive Signal Control" dated July 29, 1993, and April 19, 1994. Funding for this evaluation task is provided via California Department of Transportation Task Order No. 005, and the Master Interagency Agreement No. 65V313.

The final form of the evaluation differs significantly from that originally proposed in the 1995 Final Evaluation Workplan or its predecessor, Revision 3 of the PATH Irvine Field Operational Test Evaluation Proposal (MacCarley, Moore, and McNally 1994).). These differences flow from changes in the Irvine FOT Project. The evaluation was originally designed to include an assessment of the implementation and integration of computational and communications components in the demonstration project. However, the scope of the evaluation changed completely over the course of the project, and reportable conclusions are ultimately limited by the lack of functioning technical deliverables by the FOT partners. As a result, the evaluation focuses primarily on institutional issues associated with the FOT, and lessons learned from this exercise.

The subject FOT involves a cooperative effort between Caltrans District 12 (Orange County) and the city of Irvine. An integrated and jointly managed transportation management system was

to be implemented that extends the capabilities of existing freeway and arterial traffic management systems in the El Toro "Y" corridor defined by Interstate 405 north of the intersection of Interstate 5 in the City of Irvine.

According to documents provided by the FOT partners, the proposed distinguishing feature of the FOT was the integration and real-time control of current and evolving traffic operations technologies, with the objective of improving overall network traffic flow, encompassing both freeways and arterials in the target area. The FOT was intended to integrate locally optimized signal timing control on arterials, adaptive Ramp Meter Control (RMS) on the freeway, and Changeable or Variable Message Signs (CMS/VMS) on both the freeways and arterials. Arterial signal control was to be implemented using the OPAC (Optimized Policies for Adaptive Control) algorithm running on 28 Caltrans specification 2070 Advanced Traffic Controllers (ATCs).

The Management Information System for Traffic (MIST) developed by FSI was to provide network-wide supervisory control of the local OPAC-based arterial signal controls. Its control decisions were to be subordinate to control actions on the corridor freeways, which are monitored and regulated by the Caltrans District 12 (D-12) Traffic Management Center (TMC). The D-12 TMC is in the process of implementing, as a separate but related project, a comprehensive control and decision support software package designated the Advanced Traffic Management System (ATMS), which implements the software-based System-Wide Adaptive Ramp Metering System (SWARMS) for optimized and integrated ramp meter control.

The ATMS system replaces the "Operator Decision Support System" (ODSS) originally proposed for performing various monitoring and management functions, including the control of ramp meters and information dissemination mechanisms including 26 CMS/VMS (Caltrans, NET, FSI, City of Irvine 1994). ATMS and MIST were intended to also provide incident detection and response decision support, via distributed analysis and control actions, as well as general operations support. Physically the ATMS/SWARMS was implemented on HP UNIX workstations in the Caltrans District 12 TMC. MIST was to operate on a network of HP 9000 Workstations in Irvine Traffic Research and Center (ITRAC)

It is the consensus of the evaluators that no integrated control or control functions were implemented, and that no operational systems were implemented. It is therefore impossible to assess the technical capacity the ultimate deliverables of this FOT. Significant lessons were learned, however. The most prominent of these appears to be:

- the importance of incorporating detailed technical specifications in the contract documents, and

- the need for a complete technical review and an appropriate level of understanding by the contracting agency.

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1.   INTRODUCTION

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April 19, 1994. Funding for this evaluation task is provided via California Department of Transportation Task Order No. 005, and the Master Interagency Agreement No. 65V313.

The Irvine FOT involved a cooperative effort between Caltrans District 12 (Orange County) and the City of Irvine. The project envisioned implementation of an integrated and jointly managed transportation management system. The system would extend the capabilities of existing freeway and arterial traffic management systems in the El Toro "Y" corridor defined as north of the intersection of Interstate 405 with Interstate 5 in the City of Irvine. Figure 1 illustrates the geographic area in which the FOT was conducted.

In broadest terms, the strategic goals the FOT partners attempted to implement in Irvine were: to decrease the total vehicle hours traveled for any constant number of vehicle miles traveled; to improve the efficiency of the traffic system (based on several criteria); and to achieve this in an institutionally acceptable and efficient manner. The specific goal was to implement and evaluate integrated freeway and arterial traffic operation for improving total corridor traffic performance.

The distinguishing feature of the FOT as proposed was integration and real-time control of current and evolving traffic operations technologies. Improving overall network traffic flow, encompassing both freeways and arterials in the target area was the objective. The FOT intended to integrate locally-optimized signal timing control on arterials, adaptive Ramp Meter Control (RMS) on the freeway, and Changeable or Variable Message Signs (CMS/VMS) on both freeways and arterials. Arterial signal control would use the Optimized Policies for Adaptive Control (OPAC) algorithm running on 28 Caltrans Specification 2070 Advanced Traffic Controllers (ATCs). OPAC is an example of fully adaptive, second generation intersection control. Network-wide and individual signal timing parameters adjust automatically in response real-time traffic conditions. This integration would enable effective and coordinated operations of freeway ramps, freeway segments, and arterial signals for non-recurring incident congestion using changeable message signs to inform motorists of alternative choices. Accommodation of *recurrent* congestion was not a primary FOT objective.

Based on the final proposal revision, the central control component of the proposed system was to be FSI's Management Information System for Traffic (MIST), which was to provide network-wide supervisory control of the local OPAC-based arterial signal controls. FSI's contribution consisted primarily of OPAC, the real-time adaptive signal control software package, and modifying MIST to provide network-wide supervisory control of the local OPAC-based arterial signal controls.
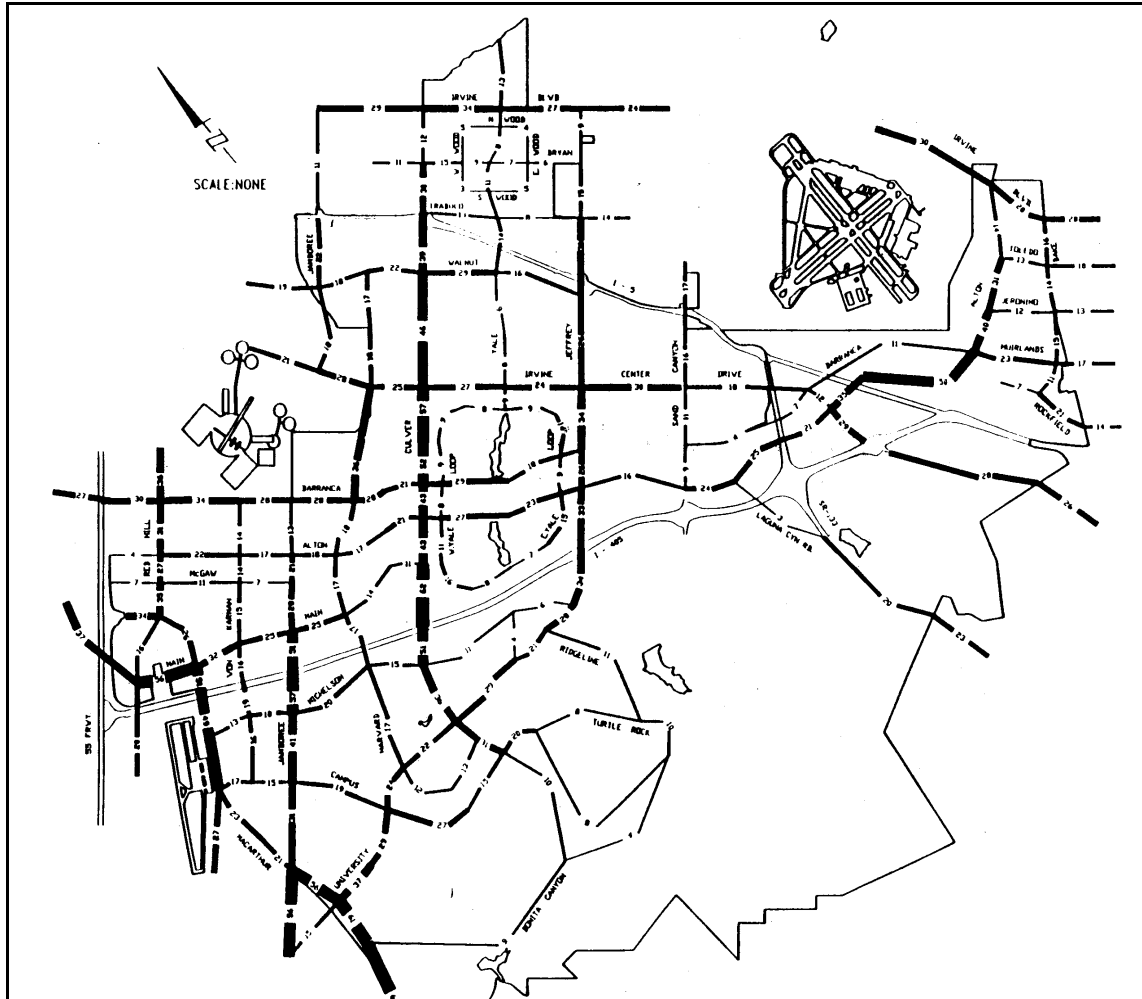
Figure 1.1: Map of FOT Deployment and Study Area

An existing implementation of MIST was modified for the present application and recompiled to run in a UNIX environment. According information provided by FSI (1995a, b) the following subset of MIST's capabilities were to be implemented in the FOT include the:

- operator interface,

- signal control, and

- variable message sign (VMS, AMS) control[1]

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[1] FSI documents refer to Changeable Message Signs (CMS) generically as Variable Message Signs (VMS) consistent with the nomenclature used by some sign manufacturers, and those CMS located on arterial roadways as Arterial Message Signs (AMS) which appears to be unique nomenclature. NET (1995a, b) uses CMS. In this document, we will use the designation CMS universally.

MIST's control decisions were to be subordinate to control actions on the corridor freeways, which are monitored and regulated by the Caltrans District 12 (CD-12) Traffic Management Center (TMC). The CD-12 TMC was to have implemented, as a separate but integrated project, the Advanced Traffic Management System (ATMS). This is a comprehensive control and decision support software package running the software-based System-Wide Adaptive Ramp Metering System (SWARMS) for optimized and integrated ramp meter control. According to information presented at FOT partners meetings in May, June and July, 1995, the ATMS/SWARMS performs the highest decision-making function in the integrated freeway/arterial control hierarchy. Though not originally within the scope of the present evaluation, the FOT partners considered the SWARMS software critical to system integration and basic functionality. The evaluation team was directed to observe and comment upon its operation. Key hardware components are illustrated in Figure 2.

The ATMS/SWARMS and MIST were supposed to provide incident detection and response decision support, as well as general operations support via distributed analysis and control actions. ATMS/SWARMS was implemented on a local network of HP UNIX workstations in the Caltrans District 12 TMC. Some components of ATMS/SWARMS were operating off-line since 1994 in the District 12 TMC, using simulated and archival data (NET 1995a, b). Functional features (only) of ATMS/SWARMS are described by NET (1995b). MIST was intended to operate on a similar network of HP 9000 Workstations in the Irvine Traffic Research and Center (ITRAC). Communications between the two supervisory systems is a critical component of the proposed FOT, and was to be accomplished via one or more data links, not yet fully specified. This link represents the backbone of the integrated system. The hardware implementation of this data link was not completed, and the exact information to be transmitted between the D-12 TMC and the Irvine ITRAC, remained undetermined. Working components of the data link, which have been demonstrated, included several telephone modem connections, the existing and possibly expanded Caltrans Wide Area Network (WAN), and an existing fiber optic high speed data connection. Communication protocols, hardware, interfaces and data types were not specified in the FOT proposal. Original specification for this data link and datacom protocols were provided in the FSI draft "Functional Requirements" Document dated September, 1995, which specifies that an existing fiber optic cable installed between TMC and ITRAC will be used, and that MIST/ATMS will utilize an RPC (Remote Procedure Protocol). The corresponding NET draft document "System-Wide

Adaptive Ramp Metering Functional Operational Requirements Definition" dated August 23, 1995, describes functional objectives but not mechanization.
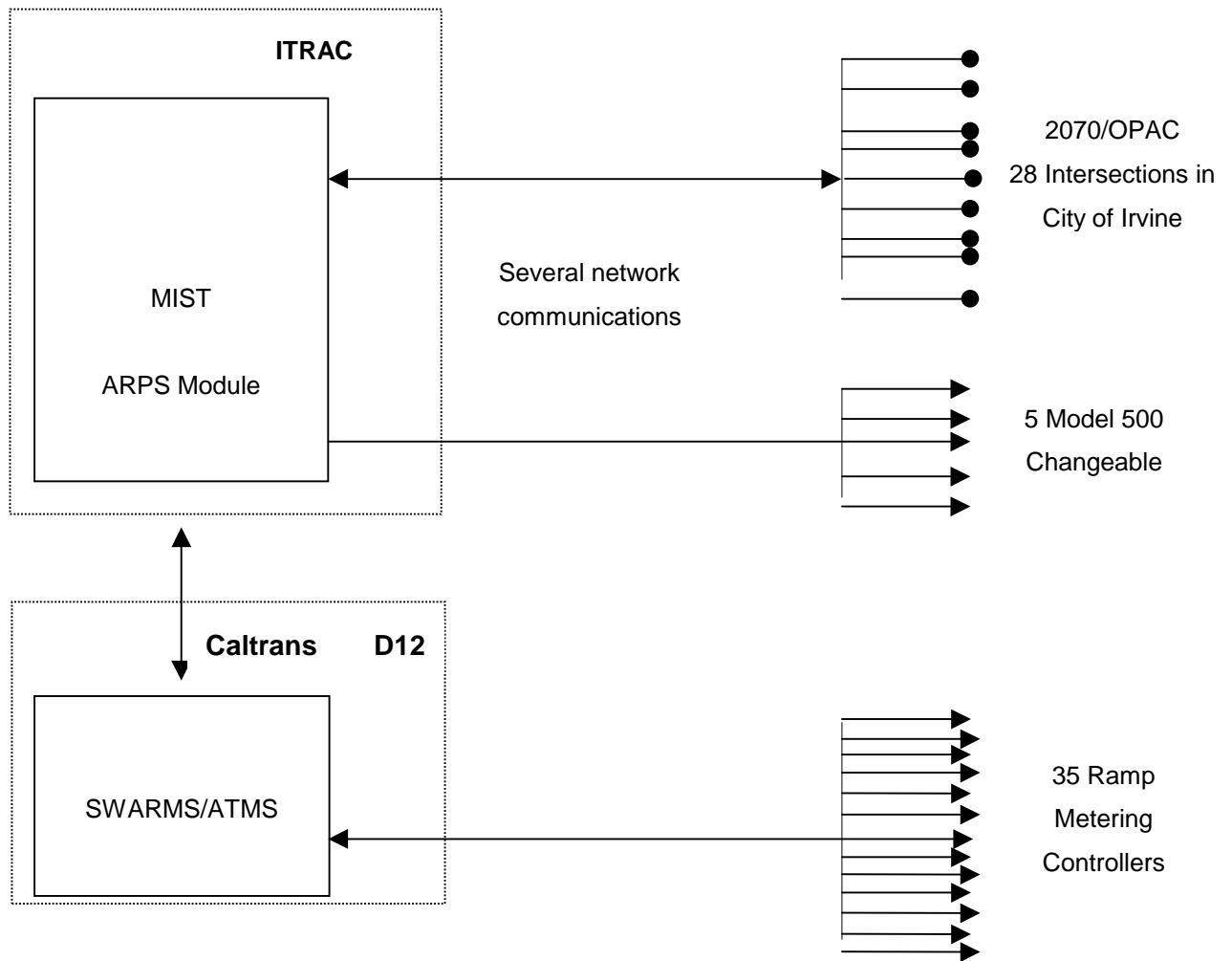
Figure 1.2: Main Components of Irvine Integrated Ramp Meter/
Arterial Adaptive Signal Control System

Known common functions of the two primary (ATMS, MIST) control entities include:

- Acceptance of operator-entered information and direct sensor data feeds to detect and verify incidents,
- Multiple incident and multiple operator capability,
- Option for direct adaptive control of RMS and arterial signals,
- Incident response advisory actions including recommended CMS displays,

- Low level systems support, and
- Archival data collection.

The interaction of these control centers in recommending modifications to ramp metering rates (ATMS) or signal timing (MIST/OPAC) to achieve an overall improvement in traffic throughput is of primary interest. Improvement in this case would consist of network-wide, corridor level improvement, including freeways and arterial diversion routes. Another function of both systems, especially ATMS, was to have been real-time decision support for handling of traffic incidents, by effectively increasing the experience base and decreasing the cognitive load on incident management personnel. ATMS was to include functions to support the management of incidents on freeways. MIST was to include functions to support the management of incidents on arterials. MIST and ATMS were to be interfaced to achieve coordinated management of both arterial street and freeway traffic (Caltrans, NET, FSI, City of Irvine 1994; FSI 1995a; NET 1995a). While FSI was responsible for all aspects of the MIST implementation, NET had primary responsibility for the development of incident response plans for the ATMS and the ATMS/MIST control hierarchy (NET 1995b). A series of Arterial Response Plans (ARPs) was created by the City of Irvine for implementation by MIST but were not implemented during the FOT. Whether these functions were implemented is unknown.

These corridor level strategies are predicated on coordination. Unfortunately, the specifics of the integration originally proposed to put MIST and ATMS into real-time operation in the CD-12 TMC and ITRAC have never been clear. Hours were spent in meetings over the course of the FOT discussing the semantics of the word "integration." Resolution of these details was among the many vague objectives that were to have been clarified as specific FOT deliverables.

SWARMS was tested offline extensively in the D12 TMC, but was never implemented due to operational and functional problems, including, according to CD12 personnel, lack of an operator's manual for the system. Actual ramp meter control under SWARMS/ATMS was not implemented. The City of Irvine installed 2070 controllers at 28 intersections per contract requirements. FSI provided and installed OPAC at one intersection, and operated the intersection off-line. The intersection's potential to communicate with MIST was demonstrated, but since communications with ITRACT were not operational, and MIST was not yet installed, no control function was demonstrated. MIST was ultimately delivered by FSI to the City of Irvine, and a demonstration was conducted in March, 1999. The demonstration consisted of MIST's user

interface only, running on a workstation in the ITRAC. No Caltrans Headquarters, Caltrans District 12, or City of Irvine personnel attended the demonstration. Since data communications were not functional, no features of the system that depended upon communications with either OPAC at an intersection or the CD12 TMC could be demonstrated. The City of Irvine subsequently closed out it's contract with FSI, releasing FSI of obligations for all unmet deliverables.

It is the consensus of the evaluators that no integrated control or control functions were implemented, and that no operational systems were implemented. It is therefore impossible to assess the technical capacity the ultimate deliverables of this FOT. Appendix A consists of an abridged evaluation plan for corridor level performance. The project objectives that would have been most relevant to this moot evaluation effort are:

- Accommodation of traffic transients arising from freeway diversion for nonrecurring congestion,
- Accommodation of recurring corridor congestion through coordinated adaptive arterial signal control and adaptive ramp metering,

Evaluation of system and approach expandability and portability, and

- Assessment of a distributed implementation of a traffic management and operator decision support system serving two coordinated agencies.

None of these objectives were met, and no measurements of outcomes were possible. Appendix A provides further detail with respect to what the Irvine FOT was to have accomplished. Appendix B is an inventory of the FOT technologies to have been deployed, and summary of pre-FOT systems in place in the City of Irvine and Caltrans District 12. Appendix C is a chronology of events associated with the FOT and attempted evaluation.

2.   CONTEXT AND EVOLUTION OF THE IRVINE FOT

2.1   California's Role in the Federal FOT Program

The State of California has taken a pro-active role in the Federal FOT program, and was awarded several of the initial field operational tests. This section provides a brief overview of each of these projects. The Anaheim and Irvine FOTs include somewhat similar technologies. However, preliminary assessment suggests that the institutional issues associated with these projects have much in common. The Irvine FOT institutional evaluation in Section 3 addresses these issues.

2.1.1 Anaheim Adaptive Signal Control (SCOOT)

SCOOT can operate in a network with nonstandard detectorization, and control traffic without causing substantial increases in intersection delays and route travel times.   While Anaheim implemented SCOOT with some degree of success, SCOOT did not show the level of benefits of standard implementations around the world. This is understandable, considering that the SCOOT performance comparisons were made against a baseline system that is considered state-of-the-art in US practice. In addition, technical and institutional problems limited expected performance. Siemens and the City spent minimal time fine-tuning the SCOOT parameters. Training for City TMC staff was incomplete. Communication and controller systems were of lower quality than anticipated. And, there was no acceptance test prior to evaluation of the system. Project deadlines drove responses to these outcomes. Staff changes affecting project management, and delays due to contractual issues. exacerbated these problems.

SCOOT is a system worth pursuing in Anaheim and other US cities (Moore II, Jayakrishnan McNally, and MacCarley 1999). It is able to at least partially model traffic conditions based on nonstandard detector locations. Traffic conditions remained acceptable under SCOOT, and no serious traffic problems arose. Siemens returned to Anaheim following the PATH evaluation to address problems the evaluation identified. SCOOT remains in use in selected areas of the City of Anaheim which plans for system expansion.

2.1.2 Mobile Surveillance

To support testing and evaluation within the California Advanced Testbed, the federal Mobile Video Surveillance/Communications (MVSC) Field Operational Test Project has developed and deployed portable video image processing (VIP) systems and a supporting wireless communications

infrastructure based on Spread Spectrum Radio (SSR) technology. Each VIP sensor node is capable of generating vehicle count, speed, occupancy, density, and queuing data. Additional data on estimated vehicle length and digitized video imaging may also be available from each VIP system. The architecture of this system is designed to permit both applied research and additional operational capability. The MVSC provides capabilities in the following areas:

- Performance improvement in traffic flow resulting from closed-loop, centralized control of on-ramp meters in freeway construction zones without functioning loop detectors.
- Flexibility of a video image processing system as an accurate, reliable, and cost-effective alternative to traditional in-pavement loop detectors.
- Transportable ramp metering system and video image processing system employing spread spectrum radio technology to link the controller to a central computer.

The targeted applications of the MVSC units include:
- Using a machine vision (or VIP) to replace temporarily inoperative in-pavement loop systems for determining traffic parameters, and
- The wireless transmission of closed circuit television surveillance video and traffic data from mobile remote sites to designated TMCs.

The Video Image Processing Surveillance System consists of both fixed and transportable installations. There are two types of transportable systems: Surveillance Trailer systems and Ramp Metering Trailer systems.

The additional surveillance and control functions this mobile system provides offer a unique opportunity to study and evaluate the impacts of ITS projects on traffic management. In addition to allowing individual operating agencies to focus their surveillance functions on particular "hot spots," the system can also greatly facilitate sharing traffic information on a regional basis to better coordinate inter-jurisdictional traffic management. The system currently consists of six Surveillance Trailers and three Ramp Metering Trailers. This system is available for deployment under a wide variety of conditions requiring either more-focused surveillance (e.g., special event traffic), or temporary surveillance and control in locations where such capability is interrupted (e.g., during construction).

2.1.3 San Diego SMART Call Box

Currently, California has about 15,500 call boxes installed in twenty-six of the state's fifty-eight counties, covering 6,300 miles of highway. The call boxes are a stand-alone units: each box uses solar-powered batteries to power a cellular transceiver and a controlling microprocessor. This FOT replaces a box's existing controller card with a "smarter" card. After this swap, the boxes perform ITS services such as counting traffic, detecting incidents, monitoring weather conditions, and hosting slow-scan, closed circuit television cameras.

The evaluation tested whether the modified call boxes could provide ITS functions in a cost-effective manner. Additionally, evaluators examined he institutional issues that might affect a fully deployed system.

The partners for this project included San Diego's Service Authority for Freeway Emergencies (SAFE), Caltrans, the CHP, GTE, and US Commlink. TeleTran Tek Services managed the project, and San Diego State University served as the independent evaluator for PATH. The FOT lasted 27 months and ended on June 30, 1996.

2.1.4 Spread Spectrum Network Radio

This test addressed the goal of reducing costs for hardwiring Los Angeles' expanding ATSAC traffic system. This test used a communication network for advanced urban traffic control systems based on radio rather than hardwired links. The partners involved in this project included the Los Angeles Department of Transportation (LADOT), and JHK and Associates. Hughes Aircraft Company worked as a subcontractor for JHK. The University of Southern California served as the project's independent evaluators for PATH. The project began in September 1994 and was completed in 1997.

2.1.5 TravInfo

This FOT tested the impact of comprehensive, real-time information about current conditions in the Bay Area's nine-county surface transportation system, specifically, the ability to increase use of public transit and ridesharing services. The Metropolitan Transportation Commission (MTC) operated TravInfo as a public/private partnership, and PATH served as the independent evaluators. Metro Networks, a private consultant MTC selected, supervised TravInfo's testing and installation. Testing began in May 1996 and the FOT was expected to be completed in 1998.

2.1.6 TransCal - Interregional Traveler Information System

The TransCal FOT showcased emerging capabilities in computing, communications, and consumer electronics that improved the quality of traveler information. TRW Inc. developed the TransCal system as a interregional traveler information system (IRTIS) that integrated road, traffic, transit, weather, and value-added traveler services data. The University of California at Davis served as the independent evaluators for this FOT.

2.1.7 Other Related FOT Projects

Several early FOT projects were useful in understanding institutional and other project issues in Irvine. The reviewed FOT projects included ADVANCE, Advantage I-75, HELP/Crescent, TRANSCOM/ TRANSMIT, TravTek, and Westchester County Commuter Central (see SAIC, 1994), and FAST-TRAC, Guidestar, Houston Smart Commuter, SaFIRES, SmarTraveler, and TravelAid (see Blythe and DeBlasio, 1995). The Joint Programs Office report to Congress (FHWA, 1996) categorizes all operational tests by broad focus and enabling technologies; few FOTs are similar to the Anaheim project in this regard.

A second SCOOT implementation is underway in Minneapolis (AUSCI project) but involves a downtown grid and extensive detector use via a VTDS (Autoscope). FAST-TRAC and a second FOT (unidentified except for the name ICTM) have implemented SCATS, an adaptive control scheme quite different in design from SCOOT. Finally, as described in a prior section, the Irvine FOT is implementing OPAC, an adaptive control system focused on individual intersection optimization.

2.2 Evolution of the Irvine FOT Proposal

The Federal Government formally announced the *IVHS Field Operational Test Program*, a component of the 1991 ISTEA legislation, in May 1992 (Federal Register, 1992a); a call for participation followed in July 1992 (Federal Register, 1992b). With Irvine's continuing interest in advanced transportation technologies, and Caltrans state-wide policy advocating deployment of Intelligent Transportation Systems (ITS, then IVHS), development of the Irvine FOT proposal proceeded rapidly. Project partners submitted the initial FOT proposal (Caltrans *et al.*, 1992) to the Federal Highway Administration (FHWA) in October 1992. The U.S. Department of Transportation selected the project for funding in the fiscal year 1993 FOT program.

The FOT partners' proposal evolved through several versions. The last two "Proposal Update" versions, dated July 29, 1993 and April 19, 1994 respectively, are of specific relevance. In the 1993 version, the FOT partnership consisted of Caltrans, the University of California Irvine (UCI), NET, FSI and the City of Irvine. UCI's intended contribution to the project was the core intelligence of the proposed system, embodied in two expert system software packages intended to run on unspecified platforms in the Caltrans District 12 Traffic Management Center (TMC). These were Freeway Real-time Expert-System Demonstration (FRED), which would monitor and optimize operations of freeway ramp meters; and an Arterial Real-time Traffic Incident reSponse Tool (ARTIST), which would handle coordination between the freeway and arterial system.

2.2.1 Initial Proposal (October 1992)

The California Department of Transportation (Caltrans), City of Irvine (COI, Irvine, or the City), Farradyne Systems, Inc. (FSI, now PB/Farradyne or PB/FSI), and the University of California, Irvine (UCI) jointly submitted a Field Operational Test (FOT) proposal in October 1992, which the United States Department of Transportation (US DOT) accepted in December 1992 for 1993 fiscal year funding. The FOT proposed integrating an existing centrally-controlled freeway ramp meter system (RMS) with an arterial signal control system in the I-405/Alton Parkway corridor.

Initially, the arterial signal system planned to use existing signal controllers (a Multisonics system), a new prototype Advanced Traffic Controller (ATC), and an adaptive control technique, Optimized Policies for Adaptive Control (OPAC). The City, Caltrans, FSI, and UCI, collectively the initial FOT Partners, planned for two expert systems: the Freeway Real-time Expert-system Demonstration (FRED); and the Arterial Real-time Traffic Incident reSponse Tool (ARTIST). These systems would monitor the centrally-controlled freeway RMS and coordinate interactions between the freeway and arterial systems. The partners hoped to evaluate the operational advantages and disadvantages of effective Advanced Traffic Management System (ATMS) strategies in re-routing traffic from the freeway during incident conditions to the parallel arterial if and when excess capacity was available. They also planned to demonstrate the effectiveness of collaborative efforts between transportation agencies in improving overall corridor traffic flow.

The Irvine FOT proposal included the following system objectives:
- The potential of adaptive traffic signal control techniques to accommodate major traffic transients arising from freeway diversion and/or ATIS recommendations.

- The potential of adaptive traffic signal control techniques to accommodate through traffic diverting from freeway ramp meter locations.

- The potential of a centrally-controlled ramp meter system to accommodate arterial traffic transients arising from diversions to freeways because of incidents.

- The effectiveness of expert systems for controlling and supervising integrated freeway ramp/arterial signal control.

- An evaluation of the adaptive control method under varying traffic conditions, particularly those occurring with ATIS recommendations.

- Documentation and standardization of the implementation processes to assist implementation elsewhere.

Initially, the Partners proposed using Alton Parkway as an alternate route to I-405, and Irvine Center Drive as an alternate to I-5 (revised proposals do not reference providing alternate routes for traffic on I-5). The proposal does not cite a need for traveler information systems to encourage diversion off of the freeway. However, the partners believed that diversion from the arterials to the freeways would require Changeable Message Signs (CMS). Subsequent proposal revisions included Highway Advisory Radio (HAR) and CMSs on both arterials and the freeway. The CMSs would provide information to motorists about alternate route choices. The project included implementation of an adaptive arterial control strategy incorporating eighteen intersections along the Alton corridor (a number eventually increased to 28 intersections). Partners selected the OPAC-RT algorithm to potentially reduce congestion impacts on alternate routes. While the project planned to install ATCs in a portion of the test area, the partners planned to maintain conventional controllers (Multisonics 820A and Caltrans 170) at selected locations. The project identified ARTIST as the system to coordinate operation of existing Multisonics 820A arterial controllers. The project did not, however, define coordination with the 170s (located on arterials at freeway ramps).

Caltrans was responsible for planning the central ramp metering system (RMS) for the FOT, and planned to develop a centrally-controlled, system-wide, traffic-responsive strategy as the RMS. Specifically, the project called for installing this new RMS with a special user interface/platform in both the Caltrans District 12 (D12) Traffic Management Center (TMC) and the City of Irvine's ITRAC. The project stipulated that the control system would have an open architecture to allow integration with other system elements. The proposal included parameters for the following central computer equipment requirements:

- System sizing and software estimates were based on controlling 100 ramp meters.
- The traffic data would be polled from the traffic data master at adjustable time periods from 20 seconds to 5 minutes.
- The ramp control logic automatically performed ramp control with manual operator override available via the user interface.
- The proposed system would support the following modes:
  - ° Time-of-day or Fixed-time Metering

    The operator would compose a time-of-day schedule for each meter or groups of meters for various days of the week.
  - ° Traffic Responsive Metering

    The local detector, and upstream and downstream station data would determine ramp control for a local meter. A table based on the station data would determine pre-assigned metering rates.
  - ° Override

    Operator can override a system-selected metering rate with a manually-entered rate.
- A commercially available screen graphics generation product for a UNIX-based system like Dataviews or SL-Graphics would create the graphical user interface (GUI).
- A DBMS available for a UNIX-based system like Sybase would perform real-time data storage, selection, retrieval and report generation.

Development of the following major functional processes would determine software estimates:
- Ramp meter/vehicle data communications process,
- Ramp control strategy management process,
- Report management process, and
- User interface process.

The partners planned to incorporate real-time ramp metering optimization into the adaptive signal control software because they wanted to provide the District 12 TMC Decision Support System with information pertinent to Caltrans integration of freeway ramp and arterial signal operations. Although the system that controls the operation of the surface street signals could have

provided the ramp metering rates, the proposal allowed Caltrans to retain control of their ramps from their TMC and use the Knowledge-Based Expert System (KBES) for operator decision support.

The FOT involved the application of two KBES prototypes that UCI developed, FRED and ARTIST, to provide assistance to the system operator and to help coordinate both the freeway and arterial system responses. The proposed system should provide decision support to both Caltrans D12 TMC and COI staff for traffic surveillance and control functions involved in joint freeway/arterial operations. The system included five integrated components:

- Incident detection,

- Incident verification,

- Identification and evaluation of alternative responses,

- Implementation of selected responses, and

- Responses monitoring.

Since FRED managed non-recurring urban freeway congestion, the FOT planned to use it to address components one through three. Meanwhile, ARTIST needed to provide incident verification and response with respect to arterial control. ARTIST supplied driver information and managed the traffic control system. After FRED detected and verified an incident, it would select the proper incident response strategies. FRED used three primary response elements, major incident traffic management team, real-time ramp metering, and CMSs to form these strategies. FRED allowed the ramp-metering algorithm to operate independently but interceded when an incident reduced significantly the capacity of a freeway section. ARTIST selected new timing plans and formulated messages for the CMSs directing vehicles to alternate routes.

The FOT planned to provide adaptive control of traffic signals on arterial diversion routes with OPAC, Optimized Policies for Adaptive Control. This control/management system attempted to coordinate operation with Caltrans' traffic signals. Since the COI already operated a centralized traffic control system, the adaptive control subsystem needed to interface with the centralized traffic control system. The FOT proposed using an expert system to provide the interfaces between these two systems. The OPAC strategy required changes for on-line traffic signal optimization; a new version, OPAC-RT, would perform this task.

By the beginning of the FOT, FSI adapted the OPAC optimization algorithm to run on an SBC68 controller, a prototype ATC, for a project in New Jersey. The ATC performed the OPAC-RT timing optimization and provided yield and force-off commands to a NEMA type controller, which

implemented the timing the OPAC-RT algorithm developed. One ATC at each intersection interfaced with each Multisonics controller. In another project in Washington, FSI implemented OPAC-RT using an ATC prototype that interfaced with a Type 170 intersection controller. This FOT used configurations similar to the others, however, the partners decided to use the newly-developed ATC.

Shortly before the partners submitted the proposal, UCI and Carnegie Mellon University delivered to Caltrans a prototype real-time software for the ATC. A library of portable pre-programmed "functional blocks" made up the Advanced Transportation Controller Software (ATCS). These functional blocks performed many specific tasks such as counting vehicles, archiving data, reporting faults, cycling traffic signals, or changing roadway message signs. Constructing complete software systems for intersection control, ramp metering, area-wide supervision, or other tasks required three simple steps:

- Select specific function blocks from a library,

- Configure specific block parameters, and

- Connect the block to the other blocks in the strategy.

Within this software system, a real-time operating system managed block execution for different times and fixed or variable frequencies. The partners supposed that this software system would allow rapid deployment of the ATC for the project.

2.2.2 Memorandum of Understanding (May 1993)

The Memorandum of Understanding (MOU) facilitated and supported the development and implementation of an Intelligent Transportation System (ITS) Program in Orange County by coordinating the activities and efforts of Caltrans District 12, the California Highway Patrol (CHP), the Orange County Transportation Authority (OCTA), and the Cities of Irvine and Anaheim. The MOU stated that the signatory agencies intended to develop jointly an ITS program for Orange County, including participation in the ITS Corridors Program, the FOT Program, and the California Advanced Testbed Program. They also agreed to form a management board responsible for the joint and cooperative implementation of ITS efforts in the County. The Board was charged with the overall management of the effort and the implementation of public-private partnerships involving ITS projects. As part of the MOU, each agency accepted specific responsibilities in the successful development of an ITS program for Orange County, these included:

California Department of Transportation, District 12 (Caltrans D12)

- Responsibility for the construction, maintenance, and operation of freeway projects throughout the State of California.
- Joint responsibility with the CHP to operate Caltrans' Orange County TMC.
- Providing project management of any ITS projects on freeways or state highways.
- Providing the focus for collection and dissemination of traffic condition information during operational testing phases.

California Highway Patrol (CHP)

- Joint responsibility with Caltrans to operate the Orange County TMC where they provided staffing and access to roadway incident information through enforcement communication systems. These include radio communication with patrol vehicles and information from the Emergency 911 and Motorist Call Box Systems.
- Monitoring motorist activities on all highways, county roads, and select expressways in the Orange County area.
- Providing services including roadway surveillance, general assistance to motorists, traffic enforcement, accident investigation, and commercial vehicle safety inspection programs.
- Providing expertise in incident reporting, communications, and roadway conditions assessment.

Federal Highway Administration (FHWA)

- Providing a national focus for the FOT Program and other federally assisted ITS projects.
- Coordinating proposed activities with related activities across the nation.
- Ensuring an independent evaluation of the FOT Program and other federally assisted ITS projects as part of the national ITS plan.
- Providing funding for the FOT Program and other federally assisted ITS projects through the execution of individual Cooperative Agreements with Caltrans.

Federal Transit Administration (FTA)

- Providing a national focus for public transportation-related activities of the FOT Program and other federally assisted ITS projects.
- Coordinating these projects with other related activities across the nation.
- Possibly providing funding for ITS projects.

California Department of Transportation Headquarters (Caltrans HQ)

- Administering and coordinating the ITS Corridors Program and assessing its compatibility and potential for statewide deployment.
- Providing the overall direction of statewide advanced transportation management and information systems research and development.

Orange County Transportation Authority (OCTA)

- Transportation planning, programming, and coordination in Orange County.
- Serving as overall coordinator of ITS efforts within the County.
- Ensuring that ITS projects remained consistent with the Orange County ITS Master Plan and the 2020 Transportation Vision.
- Serving as the lead agency for transit-related projects and other regional transportation projects related to ITS.
- Coordinating ITS funding opportunities and program funding for ITS related projects

City of Anaheim (COA)

- Planning, construction, operation and maintenance of its streets.
- Operation of the Anaheim TMC.
- Providing project management for any ITS activities on its street network.

City of Irvine (COI)

- Operation of the City of Irvine's ITRAC (Irvine Traffic Control Center).
- Providing project management for any ITS activities on its street network.

Partnership for Advanced Transit and Highways (PATH)

- The lead role in the evaluation of FOTs.

2.2.3 Revised Proposal (June 1993)

Following acceptance of the original proposal in December 1992, the Partners attempted to resolve a number of concerns and issues USDOT raised. This proposal revision served to complement the original proposal since it addressed primarily the changes and additions to the October 1992 proposal. The proposed budget increased by 92 percent from about $1.7 to $3.3 million between December 1992 and July 1993, and no longer included UC Irvine as a partner. Responsibility for the traffic management expert systems formerly sitting with UCI now rested with Caltrans and NET.

Defining the following objectives, the FOT would address:

- The potential of adaptive traffic signal control techniques to accommodate major traffic transients arising from freeway diversion and/or ATIS recommendations (same as in the original proposal).
- The potential of adaptive traffic signal control techniques to accommodate through traffic diverting from freeway ramp meter locations (same as in the original proposal).
- The potential of a centrally-controlled ramp meter system to accommodate arterial traffic transients arising from freeway under-utilization (minor change from original proposal).
- The effectiveness of expert-systems in control and supervision of integrated freeway ramp/arterial signal control (same as in the original proposal, but completely removed in the final April 1994 revision).
- An evaluation of the adaptive control method under varying traffic conditions, particularly those arising in conjunction with ATIS recommendations (same as in the original proposal).
- Documentation and standardization of the implementation processes to assist implementation elsewhere (same as in the original proposal).

2.2.4 Final Revised Proposal (April 1994)

UCI was no longer involved in the 1994 proposal revision. The functions of FRED and ARTIST were replaced by the Management Information System for Traffic (MIST). FSI's contribution consisted primarily of OPAC, the real-time adaptive signal control software package, and modifying MIST to provide network-wide supervisory control of the local OPAC-based arterial signal controls. OPAC was to be implemented on "Caltrans Advanced Transportation Controllers" (ATC) to be located at all included intersections, regardless of the existing controller type. This

reference to an ATC apparently predated but anticipated the Caltrans 2070 Advanced Traffic Control (ATC) specification. The City of Irvine uses National Electrical Manufacturers Association (NEMA)-compliant signal controllers and signal control software provided by Multisonics, Inc., installed in NEMA-compliant field cabinets. Under the 1993 proposal revision, FSI anticipated the installation of the ATC in a separate field cabinet. The purchase and installation of all field hardware was the responsibility of the City of Irvine.

The final revision formally addressed project plans to integrate and merge traffic operation technologies. The FOT project would integrate these technologies to accomplish its primary goal of providing Caltrans and the City of Irvine with the capability for real-time dynamic and predictive system control and traffic management for recurring and non-recurring congestion on the freeway or arterials in the corridor. The FOT combined many different system components to attain its primary goals:

- The FOT planned to develop and implement a Ramp Metering System (RMS) concept that addressed the congestion management issue on an "adaptive network basis" rather than on a segment level.
- The FOT arterial traffic control strategy planned to utilize a modified version of the Optimized Policies for Adaptive Control (OPAC) that would run at each of the arterial signal controllers within the project area.
- NET, FSI, and the City of Irvine planned to install a Model 2070 ATC, and they believed that the prototype specification would be published by April, 1994.
- The FOT planned to use the Management Information System for Traffic (MIST) to supervise and monitor signal controllers. MIST needed to be converted from OS/2 to UNIX to maintain compatibility with the Caltrans Operator Decision Support System (ODSS) and the RMS.
- The FOT planned to re-route traffic using a real-time, distributed, advisory/control system with pre-planned traffic management elements within both traffic control centers.
- The District 12 Advanced Traffic Management System (ATMS) included the necessary software-related hooks and graphic user interfaces to support both the integrated ramp metering and operator decision support elements of the FOT.

The project Partners decided to alter this final FOT proposal to reduce the overall budget from $3.3 to $2.7 million. The key change was the decision to eliminate ARTIST from the project.

They also chose to incorporate most of the "rules" of the Freeway Incident Management (FIM, a system-wide version of FRED; see Ritchie *et al.*, 1990) functionality into the real-time expert system capabilities that were already part of the D12 TMC, saving approximately $450,000. Finally, NET's project role as the system-wide technical integrator increased to include the responsibilities for both "end-to-end integration" and the functional design needed for coordinated operation of the two traffic management systems.

Final FOT Objectives were to address:

- The potential of adaptive traffic signal control techniques to accommodate major traffic transients arising from freeway diversion and/or ATIS recommendations (same as in the original proposal).

- The potential of adaptive traffic signal control techniques to accommodate through traffic diverting from freeway ramp meter locations (same as in the original proposal).

- The potential of a centrally-controlled ramp meter system to accommodate arterial traffic arising from freeway under-utilization (same as in the first revision).

- The effectiveness of a distributed implementation of a traffic management and operator decision support system serving two coordinated but autonomous agencies (*a new objective*).

- The potential and effectiveness of ATCs to incorporate adaptive traffic control algorithms in a real-time environment (*a new objective*).

- The potential of integrating future open systems and exchanging real-time traffic information in an open environment (*a new objective*).

- The potential of inter-agency cooperation and joint traffic system management during non-work hours (*a new objective*).

- The evaluation of the adaptive control method under varying traffic conditions, particularly those arising in conjunction with ATIS recommendations (same as in original proposal).

- The documentation and standardization of the implementation processes to assist implementation elsewhere (same as in the original proposal).

Caltrans District 12 and the City of Irvine planned to implement a system that would provide real-time corridor management through the use of changeable message signs (CMSs), adaptive traffic signal control, and a centrally-controlled ramp meter system, to prove the effectiveness of

adaptive signal control (specifically, OPAC) in accommodating heavy demands resulting from traffic diversion strategies. The D12 ATMS would oversee the freeway test section and provide corresponding incident detection, surveillance, ramp metering, and CMS control. The FOT proposed installing twenty-eight 2070 ATCs that MIST would oversee. To facilitate diversion, the FOT planned to install two freeway CMSs, twelve arterial CMSs, and twelve fixed trailblazer signs. NET planned to use ODSS (incorporating elements of UCI's real-time expert systems) to integrate their centrally-controlled freeway RMS with Irvine's MIST system to collect data from the arterial signals in the study area. Since ODSS required a viable communication link to exchange data with MIST, NET identified three possible alternatives:

- An existing wide area network (WAN) link between Caltrans and the City of Irvine,

- A fiber optic connection from a Caltrans/Irvine/UCI inter-tie project, or

- A high speed telephone system such as ISDN.

The ATMIS/SWARMS replaces and supercedes many of the ODSS functions originally proposed to perform various monitoring and management functions, including control of ramp meters, 26 CMS/VMS (Caltrans, NET, FSI, City of Irvine 1994), and related mechanisms. The ODSS replaced the Freeway Real-time Expert System Demonstration (FRED), the expert system developed by the University of California at Irvine (Deeter and Ritchie, 1993, Ritchie and Stack 1993, Zhang and Ritchie 1993). ODSS used freeway and arterial data to determine the need for freeway diversion and advise Caltrans and Irvine staff of appropriate diversion plans and detour messages. During normal working hours, Caltrans and Irvine would decide jointly whether to use the suggested traffic plans or to override with other alternatives. When Irvine's ITRAC was unmanned, Caltrans would have permission to implement traffic diversion plans independently (from City-approved responses). The FOT was to evaluate the benefits of effective ATMS/ATIS strategies in the re-routing of congested traffic to surface arterial.

Institutional Roles of Project Participants

Caltrans D12

Oversee the freeway section, control the RMS, monitor the section using the District 12 ATMS, authorize diversion strategies, and freeway CMS placement.

NET

System-wide integration, central freeway ramp metering design/installation, and freeway CMS placement.

FSI

Adaptive signal control (OPAC) design/installation, conversion of MIST from OS/2 to UNIX, arterial CMS placement, and arterial trailblazer placement.

COI

Oversee the arterial section, monitor OPAC via MIST, authorize diversion strategies, arterial CMS placement, and arterial trailblazer placement, and

2.3   A Proposal for an Independent Evaluation

Negotiations between federal and state DOTs defined the funding stream for the California FOT projects and designated PATH at the University of California, Berkeley as the FOT evaluator. PATH then solicited independent parties to serve as formal evaluators. The initial evaluation team was selected and approved in July, 1993 and involved faculty and researchers from three academic institutions in Southern California. Together this team has extensive experience with adaptive traffic control, institutional issues, and system evaluation, and a track record of participation in local and regional transportation projects. The final evaluation team proposal was approved and work was underway, after substantial contractual delay, by the end of 1994.

2.3.1 Evaluation Plan

The first evaluation team task was to develop and submit a formal Evaluation Plan specifying evaluation hypotheses, methodology, and data. This evaluation plan was responsive to

federal guidelines (USDOT, 1993) developed by Mitre (aka, the Mitre Guidelines), although a good deal of discussion addressed the appropriateness of those general guidelines relative to standard federal contracting guidelines, to the Volpe guidelines developed for the Federal Transit Administration, and the requirements of an independent and unbiased evaluation. As noted in Section 1, Appendix A contains an abridged evaluation plan for the corridor level elements of the Irvine FOT.

2.3.2 Coordination of Field Operational Test Evaluation Projects

In Fall 1995, Booz-Allen & Hamilton Inc. (BAH), FHWA's FOT evaluation support consultant, held Operational Test workshops in McLean, Virginia. The Irvine project manager and two evaluators attended a workshop that presented BAH's guidelines for a successful FOT. The workshop provided guidance and illustrated how individual tests fit into the national FOT program. The workshop included an explanation of the National ITS Program, including the evolution of the ITS Program, the Operational Test Program, and the Evaluation Process. The workshop also focused on the Operational Test Evaluation Development Process, concentrating on the development process and expected products. Finally, the workshop presented brief overviews of all FOT projects.

3.   INTERVIEWS AND OBSERVATIONS

Achieving the FOT objective of adaptive arterial traffic control requires identifying, evaluating, and resolving a wide variety of institutional barriers to successful project completion. While both federal and state policy are firmly supportive of the rapid deployment of new technologies in Advanced Transportation Management Systems, actual deployment involves integrating diverse technologies from a variety of competing vendors. Since local operators have little, if any experience with ATMS technologies, they must learn to deal with technical and, necessarily, institutional implementation issues. This assessment seeks to identify structures enabling operators to deploy advanced transportation management strategies. The limitations institutional issues pose should not reduce or confound system effectiveness. Unfortunately, the scope of potential institutional issues is quite wide.

The assessment of institutional issues is clearly the central evaluation task For the Irvine FOT evaluation task. The range of potential issues, however, makes the *a priori* identification of pertinent issues difficult. Therefore, a comprehensive set of institutional factors, both barriers and incentives, may be potential measures of effectiveness in a qualitative evaluation of the FOT.

3.1   Overview of Institutional Issues

In this FOT, there is no system to evaluate, and little in the way of individual components. The institutional issues associated with this outcome are quite varied, but are grouped in at least two related ways. First is the nature of the issue, such as project administration, and second is the deployment stage, such as system baseline, implementation, operations, maintenance, and transferability. This chapter presents a comprehensive assessment of the five major stages of the operational test by evaluating goals and objectives, as defined prior to evaluation and modified during the evaluation process. The question of interest here is determining a structure and methods for applying ATMS technologies without reducing or confounding their effectiveness through institutional limitations on programming, implementing, and operating such technologies.

3.1.1 Administrative Issues

These issues arise at the general administrative and project management levels, in both operational and strategic management. Critical assessment areas include:

- Initial needs and funding,

- Inter-agency coordination and cooperation in planning and operations,

- Coordination and cooperation with consultants in planning and operations,

- Commitment from higher level agencies (county, state, federal), and

- Public relations.

A number of key general characteristics of cooperative efforts apply to this assessment:

- Communication problems increase with the number of participants,

- It is essential that participants have realistic expectations of improvement goals and appropriate time schedules,

- Strong project management is necessary to ensure adequate planning and funding, and

- Ongoing efforts are required to sustain a cooperative project beyond initial implementation.

3.1.2 Leadership/Personnel Issues

These issues concern individuals rather than the administrative processes described above, although the two are clearly interrelated. Leadership and personnel issues vary across FOT partners and include:

- Agency advocates who assume leadership in project management and decision-making,

- Current and future staffing considerations (quantity and quality),

- The evolution of institutional staffing policies, and

- Impact of indirect effects on associated departments and agencies.

These issues are critical but difficult to evaluate. An active agency spokesperson seeking commitment for traffic improvement projects will generally be more successful and may provide the catalyst for new funding, new cooperative relationships, and new applications. Successful projects require a pro-active project manager and committed and qualified staff at all levels among all partners. However, it is difficult and sometimes impossible to identify, quantify, and assess problems of leadership or personnel performance. It is often necessary to address difficult personnel issues during projects such as the FOT.

3.1.3 Financial Issues

A readily available source of funds is (minimally) required to pay for the physical cost of implementing new technologies. Programs such as the federal field operational test program can meet this requirement, however, they typically do not address long-term financial impacts such as:

- Fiscal constraints and economic leverage for other related projects,

- Funds for planning, development, implementation, and operations,

- Future funding for continued operation, training, and maintenance,

- Unanticipated costs and unforeseen impacts, and

- City, county, state, and federal perspectives.

3.1.4 Legal and Liability Issues

Legal and liability issues often cause the longest delays in applying new technologies. Obtaining agreements between agencies where little, if any precedent exists, requires a rather lengthy approval process at all levels of decision-making. Relevant legal and liability concerns include:

- Risk management,

- Lack of prior experience with contract structure and issues,

- Existing and evolving institutional structures, and

- System liability such as operations and maintenance concerns.

Risk management is a primary issue in any municipal activity, and is particularly important in traffic operations due to the obvious safety concerns. Legal agreements between the FOT jurisdictions appear to be a bottleneck to project progress rather than a real constraint. Both city traffic engineers and their city councils tend to support projects such as the FOT because of the promise for improved flow and safety through advanced traffic management and substantial outside funding.

3.1.5 Technical Issues

The technical evaluation task addresses technical issues directly. Here, we consider their critical impact on other institutional issues and overall project performance. These issues include:

- Project impact on other infrastructure and/or operations within agencies,

- Preferred system specifications,

- System compatibility,

- Operations, analysis, and monitoring, and

- Training and maintenance.

3.2   Evaluation Data

Data required for evaluating institutional issues are substantively qualitative and often somewhat subjective. To minimize bias in interpreting data, it is important to gather information from multiple sources. The first source was direct observation of participants over the duration of the project at formal project meetings and in less formal situations. The Project Manager and members of the evaluation team shared independently-recorded meeting minutes documenting formal meetings. Although approved early, the Irvine FOT evaluation followed that of other FOTs due to various delays. Several reports documenting institutional issues associated with these projects provided a second useful data source (see SAIC, 1994; Blythe and DeBlasio, 1995). The Anaheim FOT evaluation (McNally, Moore II, MacCarley, and Jayakrishnan 1999), which the same evaluation team completed concurrently, was one of these sources.

Finally, the evaluation includes interviews with all key project participants to learn their opinions on the progress of the FOT and on the relative role of various institutional issues. The team structured interviews around a series of questions about anticipated institutional issues (see section 3.1). The level of involvement of the interview subject (high-level administration/oversight, project management and engineering, or operational staff) determined which of three separate but overlapping sets of questions the team would use.

3.3   Interviews with Key FOT Participants

Members of the evaluation team interviewed key project participants as part of the institutional evaluation. The interview process began in January 1997 and ended with final interviews and follow-ups in March 1999. The team decided to interview key individuals from all agencies and firms participating in the project including participants from the City of Irvine (the City), PB-Farradyne, Inc. (PB/FSI), National Engineering Technologies, Inc. (NET), Caltrans Headquarters (HQ), Caltrans District 12 (D12), the City of Los Angeles Department of Transportation (LADOT),

and the Federal Highway Administration. The evaluators also interviewed selected FHWA administrators in Washington, DC to obtain a national view of the project. In some cases, evaluators conducted follow-up interviews for clarification of certain issues.

The interview consisted of four sets of questions, one set for all participants, and another set for each of the three groups of participants. These three groups are:

- High-level administrative participants,
- Project management (key agency and firm participants), and
- Engineers and technicians.

A single member of the evaluation team interviewed each person in these groups separately. These interviews followed an open format to encourage greater depth and breadth of discussion. Initial interviews averaged 1.5 to 2 hours. Copies of the questions are available, however, respondents did not see the questions prior to or during their interview.

The next section provides a brief background and project role summary for each interview participant. The following section summarizes the interviews around the general topics the predetermined questions covered. Several specific issues generated more intense, interrelated discussion; section 3.6 summarizes these cross-cutting issues. The following chapter synthesizes the interview findings with other qualitative data and summarizes the overall findings of the institutional evaluation by project objective.

Mike Freitas (Chief, Fleet and Rural Systems Branch, FHWA) managed the Booz-Allen & Hamilton contract for the FOT program. He initiated this contract in June 1994 to provide evaluation assistance for the FOT evaluators. He participated in some of the technical reviews of FOT proposals.

Alberto Santiago (former Chief, Traffic Systems Branch, FHWA) left for a position with the National Highway Institute during the project. His involvement in the FOT program began in 1991 after passage of ISTEA, and he participated in the evaluation of several FOT proposals. As a recognized ITS expert, he provided technical assistance to the national FOT program. His expertise in traffic control, particularly in adaptive control, drove his interest in the Irvine FOT. He expressed personal interest in this project, its interfaces, and the questions it hoped to answer.

Frank Cechini (ITS/Information Technology Engineer, FHWA) was the FHWA project manager for the Irvine FOT. His role was ensuring completion of the FOT according to stated goals and objectives and, most importantly, ensuring completion of an unbiased evaluation.

Richard Macaluso (Associate Transportation Engineer, Caltrans Office of New Technology) was the contract manager on this project for PATH and the City of Irvine. Macaluso joined the project during the Summer of 1994 when he assumed responsibilities for establishing the initial contracts, handling invoicing issues, and managing budgets. Macaluso also handled all of the technical reviews for Caltrans following resolution of all 2070 issues. Finally, he helped the City of Los Angeles, Caltrans, and the City of Irvine agree on an MOU defining interests in the development of 2070 firmware (Caltrans paid $30,000 for this firmware).

John Thai (Principal Systems Engineer, City of Irvine) replaced Rob Hughes late in 1993 and began work on the second proposal update. Throughout the project, John served as the project manager and reviewed all technical documents, coordinated activities with Caltrans New Technology and FHWA, coordinated consultant activities, managed budgets, worked with purchasing to issue RFPs, and protected the City's interests. He left the City of Irvine in July 1997, but continued as project manager under a consulting agreement from July 1997 to June 1999.

Chau Nguyen (Senior Transportation Engineer, City of Irvine) assisted the consultants with all phases of implementation and provided support throughout the project. In March 1997, he replaced John Thai as the on-site supervisor for technical issues.

Barry Greenstein (Senior Civil Engineer, City of Irvine) assumed the role of (provisional) City Transportation Engineer during a staffing reorganization. In July 1997, Greenstein assumed John Thai's all administrative responsibilities and became the administrative lead for the City. In this role, he authorized payments to the consultants and coordinated all efforts between PB/FSI and ITRAC.

Ed Khosravi (ITS Development Branch Chief, Caltrans District 12) oversaw Caltrans involvement and met D12 needs relating to the FOT and was in charge of all Caltrans FOT interests. He was involved in the original proposal development in 1992.

Tadeo Lau (Associate Transportation Electrical Engineer, Caltrans District 12) served as a project engineer from early 1997 and served as the D12 representative and primary point of contact for all other partners. Lau filled many roles within the District including coordinating efforts between the City and Caltrans to develop an MOU, working with James Arceneaux on technical concerns, working with NET on delivery of SWARM and some portions of the ATMS, and working with NET during SWARM software development.

James Arceneaux (Associate Transportation Engineer, Caltrans District 12) was responsible for trouble-shooting the data and database within the ATMS system and SWARM.

Phil Tarnoff filled an advisory role for PB/FSI during the Irvine FOT. He served as a trouble-shooter on the proposal regarding contracting problems, detector locations, and City management issues. Tarnoff was involved in initial discussion of an integrated corridor from early 1990.

Teri Argabright (Vice President, Western Regional Manager, PB/FSI) was a Senior Supervising Engineer with PB/FSI at the beginning of the project. After the proposal process, she replaced Cheryl McConnell as the project manager for PB/FSI, handling project scope, schedule, budget, and resources.

Arti Gupta (Lead Systems Engineer, PB/FSI) served as the deputy project manager and technical lead for the FOT. With a background in statistics and operations research, Gupta joined the project in June of 1995. She looked after day-to-day operations and personnel resource management. With Chris Tivoli, Gupta wrote the requirements documents that covered system design (MIST/OPAC). As part of the system design effort, she determined the proper modules and functional requirements for the system. Finally, she served as the liaison between the City and PB/FSI software personnel.

Chris Tivoli (Lead Software Engineer, PB/FSI) served as the lead for ARP and MIST/OPAC. Tivoli joined the project in June 1995 replacing Mark Sinkavitch (currently with Trosted Systems in Gathersburg, MD). She defined requirements for PB/FSI, handled resource control and management, and directed six to eight programmers.

Mark McDermott (Senior Software Engineer, PB/FSI) authored the device driver software and served as the systems integrator for the project. He worked on both the hardware and software for the RS232 communications. McDermott, who joined PB/FSI in 1996, was involved in the last half of the project only; apparently there was no one in his role prior to this.

Chris Andrews (Senior Technical Specialist, PB/FSI) updated the OPAC algorithm by designing some minor changes. She verified the infrastructure, assured OPAC implementation quality control, and lab-tested the algorithm's interaction with the traffic signal control program (TSCP). In 1987, Chris joined the company and worked on the OPAC enhancements that extended it beyond two-phase operations. As part of this project, she ran OPAC training, designed the OPAC parts of the acceptance test plan, and created the OPAC portions of the user/operations manual.

Jim Kerr (President, NET) served as NET project manager for the FOT. He declined to participate in the interview process.

Jeneane Prince (Vice President, NET) served as a NET project manager during the later phases of the FOT. She declined to participate in the interview process.

Carla Simone (Senior Transportation Systems Engineer, NET) served as the Deputy Project Manager for the Irvine FOT. During the last half the project, Simone split project management responsibilities with Greg Mosely, who handled technical issues for the duration of the project. She handled internal cost controls including status reports and adherence to schedule. Simone developed the transportation related applications, such as response plans, coordinated the project with PB/FSI, and acted as the partner liaison.

Greg Mosely (Chief Engineer, NET) served as the senior systems engineer for NET's work on the Irvine FOT. Mosely joined the project a few months after its inception and oversaw system development and design. He filled in for Simone while she was on leave from the project.

Sean Skehan (Transportation Engineer, City of Los Angeles Department of Transportation) served as a software developer for the Model 2070 controller, writing the TSCP software. Skehan developed independently software for the 2070 controller hardware that was in development when the FOT commenced. Skehan's work was a potential solution for the FOT when hardware development out-paced associated software development. The City of Los Angeles obtained ownership of Skehan's software and contracted with the City of Irvine to complete development of the 2070 software package.

George Chen (Transportation Engineering Associate, City of Los Angeles Department of Transportation) set up the communications between TSCP and the OPAC algorithm. He made changes to TSCP to facilitate these communications, and made additional changes to TSCP for the City of Irvine.

3.4 Summary of Interviews

The evaluators organized each interview into sections based on broad areas of inquiry including:

- Project goals and objectives,
- Implementation,
- Financial issues,
- Working relationships, and
- Summary comments.

3.4.1 FOT Goals and Objectives

The purpose of these questions was to elicit individual opinions on the evolution of the Irvine FOT in terms of overall project goals and objectives. Questions related to the development of both initial and revised project goals, defined locally, and relative to the national ITS program.

Role of the Irvine FOT

Most respondents believe that the Irvine FOT held an important role in the national FOT program because it considered adaptive arterial control, specifically OPAC, integrated with adaptive ramp metering, specifically SWARM. The evaluators asked high-level administrators to indicate the overall importance of the entire statewide FOT program in California. While the national significance of individual FOTs varied, the California FOT program stood in the spotlight because other states tended to follow California's early response to ITS technology implementation. Many states followed Caltrans' specifications and the state had established a reputation for following through on projects.

Originally, the national FOT program expressed considerable enthusiasm for the Irvine FOT; however, project time delays have dampened these feelings. High-level respondents indicated that the Irvine FOT's innovative concept, the usage of OPAC, and the involvement of UC-Irvine and the City of Irvine contributed to selection of the Irvine FOT. All respondents focused on the integration of arterial and freeway operations when expressing their opinions on selection of this FOT as part of the national FOT program. Reasons mentioned for its selection included using two existing technologies, MIST and OPAC, in conjunction with a new adaptive ramp metering system, SWARM. Another important feature of this FOT centered on its use of 2070 controllers. Further, the project location, the first ATMS in a Southern California Caltrans District, was a natural place for an FOT. These factors, combined with favorable weather conditions in Southern California, indicated that the project could be started and completed quickly.

Virtually all respondents who addressed potential national impacts of the Irvine FOT focused on the nationwide spread of the new 2070 controllers, particularly in applications using advanced algorithms. For example, one respondent indicated that the Irvine TSCP may have a national impact because it is public agency domain software. One respondent hoped that interest in the controllers might encourage other agencies to help adjust 2070 specifications and operations. A few respondents mentioned the spread of the specific adaptive control packages OPAC and SWARM, however, most respondents focused on the 2070 itself. Participants frequently mentioned the FOT goal of integrated operations and coordination between state and local agencies as important in a national context. In contrast, one interviewee focused on the shortcoming of this FOT because he believed that adaptive algorithms, system-wide integration, and SWARM all remained unproven as a result of this FOT. A final respondent believes that every successful FOT helped generate more ITS funding at the national level, while every failure hindered the national funding effort.

Partner Involvement in FOT Development and Evolution

Farradyne became involved in the project in response to the FHWA RFP and Cheryl McConnell organized the project. Chris Andrews participated in early development of the FOT because she and PB/FSI wanted to use OPAC for two purposes: to accommodate freeway dumps onto arterials (which remained part of the final FOT proposal), and to adapt OPAC to model queues on ramps. If PB/FSI modified the algorithm successfully, OPAC would have set ramp metering rates based on ramp queues. Caltrans, however, did not like this approach.

Greg Mosely provided technical overview for NET during the development of the FOT. He helped address hardware, software, and architecture decisions. NET became involved because it built the District 12 ATMS system from 1993-97. Ed Khosravi remembered that FHWA requested PB/FSI involvement, and recalled that NET was involved all along with Homar Naroozi, Rob Hughes, Cheryl McConnell, and Jim Kerr organizing the effort. Khosravi did not recall the initial involvement of Stephen Ritchie and the Institute of Transportation Studies at the University of California, Irvine. John Thai revised the proposal. As part of this process, he did research and development with the State and the consultants on building a framework for the FOT, and the conceptualization of a network between Caltrans and the City of Irvine. The City of Irvine became involved in the FOT when Rob Hughes (City Traffic Engineer), UC Irvine, Caltrans, and PB/FSI submitted their proposal to the FHWA.

Goals of the Irvine FOT

According to many of the partners, freeway to arterial diversion, one of the cornerstones of the project, was not important to either Caltrans or the City of Irvine. District 12 was focusing on the full closure case, which was already used on other parts of the network not integrated with an adjoining arterial. One participant believes the City was more interested in OPAC than in freeway to arterial diversion. Two respondents highlighted the City's desire to handle an orderly diversion as opposed to a haphazard dumping of traffic. Only two participants believe that balancing the traffic between the arterial and freeway remained important to the City and Caltrans D12.

Responses relating to project goals were fairly detailed. According to the participants, the primary goals were corridor-level integration, evaluation of SWARM, evaluation of OPAC, development and deployment of 2070 ATCs, and inter-jurisdictional cooperation. Of these, participants believe the project succeeded only in developing and deploying 2070 ATCs.

Unfortunately, the only FOT proposal goal related to ATCs was assessing ATC effectiveness in real-time traffic control. This FOT ultimately did not examine this ATC compatibility.

All but one participant highlighted corridor-level integration of freeway and arterial as a key FOT goal. Nine of the thirteen interviewed view the project as unsuccessful in meeting this goal; some view it as a complete failure. Two respondents believe the project met this goal, but did not prove integration capabilities. Three others highlighted the fact that NET was no longer a member of the team working to complete this integration. Over half of the participants identified testing the SWARM algorithm as a major FOT project goal; however, only two members believe the algorithm might be successful if Caltrans followed through with implementation. Other participants knew the SWARM algorithms still required more work, and might never function to Caltrans' expectations.

Eight of thirteen participants emphasized the OPAC algorithm as one of the primary FOT goals. Almost half believe the project would at least be somewhat successful in meeting this goal. The other half viewed the project as a complete failure in this respect because they had not seen the OPAC algorithm work. Eight of thirteen respondents mentioned the development and deployment of 2070 controllers as a key objective. All but one believe the FOT was a complete success in meeting this goal, and the one dissenting opinion noted severe delays. Five participants mentioned City and State cooperation as a goal. The partners were divided on this goal; two believe the FOT achieved cooperation and two believe the City of Irvine and Caltrans District 12 failed to work together towards a common goal.

Project members mentioned few other goals infrequently. Two participants expected the FOT to provide the City of Irvine with a new traffic signal system. One of these believe the FOT seemed to meet the goal. The other believes that MIST did not function properly. Two others believe that CMS deployment was a major goal of the FOT. One Caltrans respondent indicated that the arterial portion of the project seemed to have more importance than other goals.

Few of the respondents recalled any changes in FOT goals or priorities after the project started. However, over half of the respondents noticed significant changes to *portions* of the project. According to two respondents, the consultants underestimated the scope of the project. NET tried to reduce its deliverables, while PB/FSI reduced its product to he essential features. Two participants recalled questions about recurring congestion. Two others highlighted the inclusion of 2070s as a significant change to the FOT because the initial proposal never mentioned 2070s (*Note: the final proposal update discussed using signal controllers procured against the pending 2070 ATC prototype specification*). Instead, PB/FSI wanted to use the ATCs and BiTran firmware that they used for their New Jersey project. Furthermore, the initial proposal did not discuss the

conversion of MIST from OS/2 to UNIX. A few participants observed that the partners seemed to be on different pages about the proper approach throughout the project, and the changes in personnel early on created tremendous confusion and conflict about the actual direction of the project. One consultant's workload increased due to a requirement for intermediate deliverables to the City of Irvine. A final partner did not see any changes in the goal of overall corridor coordination, however, she recalled questions about integrating SWARM and the arterial system.

Most respondents believe the FOT was split almost evenly between implementation and operations, and research and development. The City of Irvine and Caltrans expected implementation and operations, and they had no idea of the depth of the research and development required for the project. The implementation and operations component of the FOT was almost nonexistent, and the partners seemed to ignore the magnitude of the research and development required to complete the project. One participant believes the FOT was only forty percent research and development. One respondent feels the scope of work increased in association with the City's requests to improve the final product. Only three partners seemed to grasp fully the magnitude of the research involved when they estimated that almost 90 percent of the FOT effort was for research and development.

3.4.2 Implementation

This section of the interview addressed the FOT implementation process, and considered project scheduling and deliverables, implementation costs, the contracting process, operational and maintenance policies, and technical implementation issues.

Project Scheduling

Table 3.1 describes each agency's assessment of its ability to maintain its project schedule. It also summarizes any problems that respondents for other partners may have identified. Overall, many agencies indicated they failed to maintain their project schedules. However, respondents who identified schedule delays most often attributed these delays to *other* participants. This section provides some brief remarks about most of these conflicts, while section 3.5.1 provides detail about these conflicting reports and perceptions.

Project Management

Interview respondents were sharply divided along jurisdictional lines over project management. The City of Irvine and NET, the two partners responsible for project management and system coordination, feel the project management and schedule were extremely useful. All other parties think the project lacked overall management and reported that the schedule served no purpose because most participants did not use it. Caltrans D12 was frustrated by the consultants' ever-changing deadlines because it had no authority to impose any consequences since Caltrans was not managing the contract. Farradyne feels the team needed an independent project leader such as Caltrans New Technology or FHWA because the City of Irvine, the project manager, never reported on some of its responsibilities. The City of Irvine expressed some concern about NET's departure from the project team when its contract ended before the end of the project. The City offered to extend NET's contract a few times, but NET never replied. NET respondents were concerned that during the project, other partners eventually did not deliver updated schedules to NET.

Implementation Costs

Almost all of the respondents said their firm or agency underestimated project implementation costs. Table 3.2 summarizes the unanticipated costs each agency and firm incurred. The most critical increases came in four separate areas: MIST conversion from OS/2 to UNIX; the 2070 controller and firmware; City of Irvine infrastructure; and the Arterial Response Plan (ARP). The MIST conversion was the only cost increase caused exclusively by technical problems. Better planning might have reduced the other increases. ARP development diverted PB/FSI time from other pursuits, draining PB/FSI resources since it received no additional compensation. At times, Farradyne's technical team was unable to complete its tasks because the City failed to fix its communications, wasting travel resources. Furthermore, Farradyne did not anticipate having to make decisions about supporting technology such as the number of loops for a substandard OPAC implementation.

Table 3.1: Summary of Project Scheduling Problems

AGENCY	COMMENTS
FHWA	The FHWA fully maintained its schedules and deadlines.
Caltrans Headquarters	Caltrans headquarters maintained its schedule. However, respondents said Caltrans HQ could have facilitated earlier development of the MOU with the City of Irvine.
City of Irvine	All City representatives indicated that the City did a fair job of maintaining its deadlines; however, it encountered some infrastructure problems due to new construction. Concerns from the other partners focused on slow decision-making, infrastructure problems related to new construction, and poor management.
Caltrans D12	District 12 did not seem to encounter any delays; however, it did not provide a consistent presence early in the project. District 12 did not provide any technical review or leadership throughout the project.
NET	Although NET experienced technical problems with SWARM implementation, and its schedule slipped a little, NET finished SWARM before the end of the project.
PB/FSI	Farradyne did not realize the scope of work required to convert MIST from OS/2 to UNIX. Slow development of the 2070 specifications and firmware added to the delays, as did slow decision-making by project management.
LADOT	LADOT placed higher priority on this project than on others. City of Irvine respondents feel LADOT response time was quick and LA DOT responded to all City needs. PB/FSI respondents feel LADOT had a tremendous impact on its ability to finish tasks in a timely manner because PB/FSI was effectively beta testing TSCP for LADOT.

Table 3.2: Unanticipated Implementation Costs

AGENCY/ PARTNER	UNANTICIPATED COSTS	REASON/CAUSE
NET	Increased effort for SWARM design	The algorithm was more complex than expected.
PB/FSI	Increased software development costs	The conversion of MIST from OS/2 to UNIX was more complex than expected.
	Arterial Response Plan (ARP) proposal costs	The ARP proposal had to be written to correct an omission in the original proposal.
	ARP development costs	These necessary costs were inadvertently unbudgeted.
	Other software development costs	Untested hardware (e.g., 2070 controller) and software (e.g., Changeable Message Sign firmware) changed many times during the course of the project.
Caltrans D12	Increased loop detector maintenance costs	Working loop detectors are critical to the function of SWARM.
	SWARM training and documentation costs	SWARM training and documentation were eliminated from the final proposal to reduce (apparent) costs.
City of Irvine	Increases in staff time requirements	The OPAC deployment included both field equipment requirements and substantial in-house integration.
	SOH loop detectors that internally calculate speed, occupancy and headway; and communications equipment	The COI had incomplete knowledge of the condition of its infrastructure (e.g., 50% of all cable pull boxes were full).
	Consultant contract with John Thai	John Thai elected to leave the City of Irvine for a position in the City of Anaheim due to organizational restructuring by the COI.

FOT Technologies

Respondents identified potential problems for all planned FOT technologies: SWARM, OPAC, MIST, ARP, and the 2070 ATC.

SWARM

Respondents reported two primary concerns about SWARM. First, Caltrans received neither the training nor documentation needed to understand fully SWARM operations. Second, SWARM did not seem to work when Caltrans ran it. After running it for several days on a road section, Caltrans did not find any evidence that SWARM was actually affecting any ramps. Interviewees also noted that SWARM's inability to save parameters might render it practically unusable.

OPAC

Farradyne participants stressed multiple concerns about implementing the OPAC technology, while other participants questioned its validity as an effective algorithm. Since OPAC still was not running, Farradyne worried that:

- City staff must understand and set-up OPAC parameters.[2]

- OPAC might have difficulty coordinating closely-spaced intersections.

- An oversaturated arterial might overwhelm OPAC.

OPAC/MIST operations would burden City staff. Establishing timing pages seemed quite time-intensive, and even the PB/FSI technical team did not fully understand the process.

Farradyne expressed further concerns about the substandard OPAC implementation. The quality of data from the stopline detectors determines OPAC performance. Since OPAC usually controlled only the arterial, it could increase side street delay. However, this delay would not increase *overall* intersection delay unless the side street traffic volume was significant. Although the substandard OPAC implementation would not optimize green times, it should at least provide time-of-day service. PB/FSI would have to write a device driver and make changes to the timing

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[2] PB/FSI was not contracted to perform this work; therefore, the City of Irvine had to configure the timing pages for TSCP1 and OPAC.

pages because the FOT used a UNIX platform, with a 2070 controller with a change in firmware, in another location.

MIST

The MIST system also elicited differing opinions about the technology. Farradyne respondents stressed that the City of Irvine would need to invest adequate staff time to learn the new system and complete its implementation. The primary technical concern related to using too many devices on one communications channel. The agencies questioned MIST's overall functionality rather than specific correctable details.

ARP

Since the FOT never tested ARP, its functionality was unknown. Administrators and consultants stated simply that ARP might be routinely ignored. Obviously, this technology fails if the agencies decide not to use it.

2070 ATC

Respondents expressed a variety of technical concerns regarding the 2070 Advanced Traffic Controllers. The consultants worried about 2070 stability and functionality, specifically that the CPU might not optimize OPAC completely. One participant from the City of Irvine worried about keeping up with frequent maintenance problems. Two other agency respondents were preoccupied with firmware functionality. They were concerned that it might not work properly, or it might not work with the future 2070 specification, especially the device drivers. Farradyne respondents observed hardware flaws such as electrical shocks and fires, and blown modem cards. The 2070s were poorly manufactured; during an environmental test, one third of the power supplies died.

In summary, two respondents stressed the difficulties of deploying so many new technologies at once and integrating all of their operations. Respondents from one agency expressed significant liability concerns related to malfunctions of new technologies.

Operational Policy

Overall, respondents did not expect to see changes in existing operating policies with respect to OPAC. City respondents stated it was not necessary to change operating policy because the City would not use these new technologies. Farradyne respondents expected the City would

need more staff time to operate OPAC, and hoped to eliminate timing plans from their operating policies. Two respondents expected Caltrans D12 would need to change its SWARM operating policy, while Caltrans D12 employees did not. Since Caltrans D12 did not have an operational policy for ramp metering, the Agency had to decide how and when to use metering. Furthermore, Caltrans D12 needed to identify who in the organization would be responsible for selecting between SWARM's multiple ramp metering algorithms, and to set SWARM's many parameters. Caltrans did not have a policy for ARP either, therefore operators needed to know what conditions required contacting the City of Irvine. They also had to develop an agreement on how to use City of Irvine signs. Furthermore, Caltrans D12 did not expect to change overall policy regarding the City.

Maintenance Policy

Farradyne respondents believe the City of Irvine would need to make loop maintenance critical. However, since the City did not expect to use OPAC, it did not expect to need changes in its maintenance plan. A third of the respondents expected the 2070 controllers would require additional maintenance. NET respondents did not foresee any reason for Caltrans D12 to change its regular field maintenance policy. However, NET respondents believe Caltrans needed to maintain the software for SWARM and the intertie. Caltrans staff required more technical knowledge to accomplish this.

3.4.3 Financial Issues

Most of the interviewees indicated that the budget was insufficient to complete the project as planned, and that all of the parties incurred non-budgeted expenses. The delays associated with this project increased administrative costs for Caltrans and other partners.

Caltrans never anticipated working on SWARM algorithm development. Over a third of the participants noticed that the need to purchase SOH detectors (which process all of the data at the detector station before sending it to the controller) significantly increased City of Irvine infrastructure costs. Additional work on conduits and pull-boxes, and extended equipment warranties further increased City infrastructure costs. Trouble-shooting the new system also cost the City project management consultant and staff-time. An incomplete project proposal and contract contributed to cost increases. Specifically, interview respondents mentioned financial strains related to:

- Purchasing the LADOT firmware, Traffic Signal Control Program,
- Delays in developing TSCP,

- PB/FSI underestimating the costs for porting its system from OS/2 to UNIX,

- The OPAC to 2070 communication environment (no one accounted for the time required nor the environment itself),

- Unanticipated integration trips for PB/FSI, and

- Cost overruns in implementing SWARM software.

Only one respondent anticipated that a similar budget would be adequate for implementing this project in a similar situation. However, he believes the group of partners would need to change for a subsequent project. Two agency participants expected a similar project would require at least $3.25 million, and perhaps as much as $4 million. Since SWARM requires an ATMS, a SWARM system would increase costs significantly in future implementations. The budget for SWARM itself would need to increase slightly to decrease the risk in developing SWARM. PB/FSI believed it might be able to reduce its costs to $300,000 to $400,000 if it were solely a vendor. However, for a customized application with systems development, PB/FSI would need to increase its budget from the current $1 million to $1.5-$2 million.

We asked each interviewee to identify one aspect of the project they would change given a ten percent budget increase. Half of the respondents said they would have spent the increase on training and documentation, specifically for SWARM or TSCP. A third indicated they would simply offset their loses with any budget increase. One participant wanted to pay for the complete system design before starting the FOT, while another would have ensured installation of all of the pieces and allocated more time for system tests.

3.4.4 Working Relationships

Each subject addressed general questions relating to personnel issues and working relationships with each of the other agencies and firms. Responses reveal strains in working relationships on this project, and PB/FSI and the City of Irvine seemed to receive a majority of the complaints about working relationships.

The City of Irvine

Many respondents expressed concerns about City of Irvine staff during the project. One non-Farradyne respondent held the City ultimately responsible for the project outcome. The City hampered the FOT because it was unable to make decisions, did not have contingencies (i.e., the

2070 problems), and exhibited poor judgment. The City and PB/FSI did not work together towards a common goal because the City failed to share critical information throughout the project. The City's slow decision-making and infrastructure preparation problems delayed the FOT significantly. These decision-making issues focussed on the 2070s, LADOT firmware and other technologies. The City seemed to change software requirements from month-to-month, adversely affecting other partners. One participant believes the City's lack of internal oversight may have contributed to these difficulties because only one staff member was assigned to the project. The City of Irvine expected Farradyne to deliver a new traffic control system for everyday use, while Farradyne believed the FOT was still testing concepts.

Other responses showed support for the City of Irvine. One participant staunchly defended the City because it lacked contract authority to penalize consultants. One administrator said he worked well with the City, but was consequently more patient with the project than he should have been. LADOT respondents did not believe administrative issues affected the project once Irvine and LA negotiated their contract. NET coordinated with the City of Irvine on developing the intertie and response plan, and these activities seemed to run smoothly. Although Farradyne struggled to coordinate a common vision with the City, the technical team found City staff completely supportive and helpful to their work.

Caltrans District 12

Most of the respondents noted the District's slow decision-making and lack of interest. Similarly, most participants commented on changing points of contact and decision-makers until late in the project. Caltrans Headquarters has little authority over its district offices so Headquarters personnel could not force D12 to participate. On the other hand, Caltrans D12 helped NET with the design and requirements for SWARM and coordinating response plans. Furthermore, D12 improved the project with its crisp understanding of the ramp metering concept. One interviewee commented on the District's failure to review technical documents while another believed monthly reports were needed. Everyone agreed that Caltrans was responsible for managing overall SWARM and ATMS implementation as well as coordinating integration with the City of Irvine.

PB/FSI

Almost all of the interview participants believe Farradyne undermined the FOT. Farradyne seemed to fail on three accounts: not allocating enough qualified technical personnel to the project;

not providing a technical contact on the west coast; and not confiding in other partners about problems it encountered early in software development. These failures caused major delays and ultimately lowered the quality of deliverables. Respondents reported a range of PB/FSI shortcomings:

- One participant believes Farradyne behaved like a consultant as opposed to a partner.
- Another believes PB/FSI was technically unable to produce software.
- Farradyne seemed to mis-allocate personnel resources (when employees left the company or were reassigned during the project).
- PB/FSI showed poor internal project management.
- One interviewee believes Farradyne was mainly responsible for reducing project capabilities, and lacked quality control.

NET had a good relationship with PB/FSI because they shared project roles as technology providers, and Farradyne's primary problems did not affect NET. This relationship enabled coordination of schedules, development of response plans, and intertie design. Further, NET's technical expertise helped the intertie process with Farradyne run smoothly. The City of Los Angeles and PB/FSI also seemed to have a fairly cordial relationship. However, communication was difficult at times because PB/FSI was not familiar with traffic control. Unfortunately, this relationship began to deteriorate during implementation when Farradyne started blaming its delays on LADOT.

NET

While NET seemed to perform very well early in the project, it was absent at the end of its contract and refused to accept contract extensions to complete system integration. NET's contract expired in June 1997, and the City of Irvine extended it in November 1997, but NET never responded. Nearly three quarters of the respondents believe they worked well with NET and found NET helpful in all facets of the project. NET served as system manager/integrator, finished ATMS, developed SWARM, and designed and implemented a MIST interface inside ATMS

LADOT

Public agency respondents felt LADOT performed admirably and delivered a quality product, while the private firm respondents believe LADOT was uncooperative, and hindered substantially

successful FOT completion. Primary concerns regarding LADOT focused on a lack of accountability and low motivation to work with Farradyne. According to one participant, LADOT seemed unresponsive to Farradyne needs, and shared information only when necessary. Other problems included: inadequate access to LADOT personnel; numerous bugs requiring revisions to the firmware; and LADOT's unsuccessfully attempt to use TCSP 2 requiring substitution of TCSP 1.

The public agency respondents supported LADOT for a variety of reasons, mainly responsiveness throughout 2070 software development. These participants also noted that LADOT:

- Drove ATC hardware development and provided software for 2070,

- Helped provide the only real deliverable from the project, and

- Helped Farradyne trouble-shoot problems with 2070 device drivers.

LADOT respondents did not think relationship issues affected the software they developed. They noted that LADOT assigned two staff members to the project, an adequate number, although they believe the work would have progressed faster with more staff.

FHWA

Seven in ten respondents believe FHWA had an impact on the FOT project overall. In fact, Caltrans would have likely cancelled the project in June 1997 without FHWA involvement. Other respondents were sharply divided on FHWA's contributions. One group believes FHWA helped the project by moving the entire process forward, monitoring project progress, and keeping an eye on its goals. For example, FHWA forced the City of Irvine to make decisions and held both the City and State accountable. According to this group, the project would have been farther behind without FHWA. Another group believes FHWA failed to provide strong direction on project goals. They wanted FHWA to provide definitive oversight in decision-making for the project. A single respondent said that FHWA influenced her overall performance on the FOT because they provided insights to the national picture for this project.

Caltrans Headquarters

None of the respondents believe Caltrans had an impact on their performance or on the FOT overall. Rather, most respondents identified oversight and funding as Caltrans project responsibilities. Caltrans provided extensive administrative support throughout the FOT, according

to another interviewee. One participant said Caltrans helped by advancing the FOT and by being proactive in meetings.

The Evaluation Team

None of the respondents believe the evaluation team had a significant effect on the FOT outcome, although one participant felt the team might have altered group dynamics at meetings. Respondents recognized the evaluation team role as evaluating FOT goals and objectives, assessing project successes and failures, and monitoring the technical and institutional impacts of implementing an integrated corridor. One participant believes the evaluators came into the project too early, while the evaluation team's inability to settle on a course of action frustrated another. Less than half of the respondents recognized PATH's role as the formal evaluator (evaluation team members were official PATH sub-contractors).

3.4.5 Concluding Interview Comments

The last portion of each interview addressed the effect of various issues on overall performance of the FOT project. Questions concerned groups of issues defined in the Evaluation Plan for the Institutional Assessment.

Administrative and Financial Issues

The administrative concerns focused on leadership and decision-making. Respondents felt that since the City was in charge, it did not have to answer to anyone and felt no need to consult with any other partners in making decisions. The City demonstrated very little administrative follow-through and required considerable time to complete decision-making tasks, especially regarding ARP, the 2070 software and hardware, and CMS hardware. According to respondents, the City's poor project administration hindered the entire project. A few other administrative concerns arose, including:

- A lack of contract penalties made it very difficult to control the consultants.

- Status meetings seemed to work better with a smaller group in attendance.

- The City of Irvine did not consult with any other partners when making all of the major decisions related to TSCP and the role of LADOT role in the project.

Participants suggested several significant changes to the FOT process to address administrative issues including:

- Require software developers to put up a bond, as construction contractors do.

- Require an upfront "systems requirements document" designed to fit existing budgets. The document should cover functions and features of the technologies.

- Remove the cost-sharing requirement when an FOT is really a research and development project.

- Clearly define decision-making authority by empowering either the group, an independent party, or FHWA.

Personnel Issues

Almost half of the respondents indicated that Farradyne did not assign enough qualified personnel to the project. However, one LADOT respondent feels PB/FSI staff seemed technically competent, even though they required time to learn traffic control terminology and approaches. Another respondent from the City of Irvine believes PB/FSI had good personnel, but exercised poor quality control on products. Farradyne respondents admitted personnel scheduling problems due to project delays from slow decision-making. Numerous respondents believe a greater presence in Southern California would have helped PB/FSI, and that PB/FSI seemed to need more expertise in transportation programming. A majority of respondents advocated either replacing Farradyne if they could do the project again, or simply improving its technical team by providing more traffic expertise to programmers.

Many interviewees feel the City of Irvine needed more personnel on the project. One participant wanted Irvine to devote at least one person to the project full-time. On the other hand, too many Caltrans D12 people were involved in the FOT. Caltrans D12 did not provide a clear contact until late in the project. One respondent believes D12 did not provide adequate personnel considering its role in the project, while another wanted D12 to designate a project manager. One respondent would have reduced the number of agencies and companies involved from the beginning. Other comments on personnel issues were mixed and included the following:

- FHWA needed to provide oversight throughout the decision-making process.

- The project needed a good, strong project manager.

- Good groups were involved in the project, but they needed to work together to form a partnership.

- LADOT seemed to allocate adequate staff to complete its work in a timely manner.

- NET seemed to need more expertise in transportation programming.

Legal and Liability Issues

The primary liability issue in the FOT was Caltrans D12 unwillingness to divert traffic off of the freeway during partial closures. In fact, Caltrans D12 has a policy of diverting traffic off of the freeways *only* in the event of a full closure. The City of Irvine was concerned about the long-term liability consequences of using so much unproven technology. Several issues arose on the legal side:

- The issue of transferring software led to delays in the LADOT contract, but did not have a major impact on the project.

- City attorneys required Los Angeles and Irvine to develop documents covering in-field implementation.

- A representative of FHWA suggested changing the FOT contracting process to design-build or design-build-operate projects to avoid some of the problems on this and other FOTs.

Technology Issues

Over three quarters of the respondents believe this FOT was overly ambitious in attempting to integrate too many untested new technologies, especially the 2070 ATCs and SWARM. A majority of the interviewees wanted to prove the technologies separately before bringing them together in smaller pieces. Ideally, separate field operational tests would evaluate the 2070, MIST Conversion, and SWARM. Over a quarter of the participants recommended scrapping MIST and OPAC altogether and replacing them with different technologies. MIST's inability to provide real-time management (actual performance is every 30 seconds) and OPAC/MIST's lack of quality control make them unattractive for future implementations. Further, neither system was Y2K compliant. Another quarter of the participants noticed that the project stalled repeatedly while waiting for technical decisions on technology selection. One respondent blames the slow progress of the arterial side of the project on NET's failure to complete integration. Various respondents advocated a few other technology changes, such as:

- Change to object-oriented communications between systems that fit into the overall showcase structure.

- Simplify and refocus the FOT process.

- Use more off-the-shelf technologies that are fully developed and ready for implementation at the beginning of the project.
- Discover a better solution to the 2070 ATC problem.

The respondents did not offer unanimous approval for any of the technologies. A slim majority of respondents indicated they would recommend 2070 ATCs to other agencies in the future. One in four supported ARP even though it was never fully implemented or tested. About a quarter of the respondents recommended SWARM and MIST/OPAC for future implementation; however, these supporters were all consultants that designed those technologies. Finally, one participant refused to recommend any of these technologies to other agencies.

Evaluation Issues

Several respondents recommended that their agency or firm participate in future field operational tests; Table 3.3 summarizes the reasons for this support. Respondents from three agencies, LADOT, PB/FSI, and Caltrans D12, were divided on participating in future field operational tests, while the Caltrans Headquarters representative was against all future FOT participation. He no longer believes FOTs provide a good return for the money and time invested because the chance of success is so small. Another Caltrans District 12 employee believes the large risk of bad publicity associated with a failed project outweighs potential benefits. An LADOT participant would only participate in another FOT if he contracted directly with the FOT (i.e., FHWA) and not through another agency. He believes this is necessary to have more input in the project. Three-quarters of the Farradyne participants expressed reservations about another FOT. Two of them would carefully examine the FOT to ensure the entire team has a strong, universally understood focus before starting. Another Farradyne respondent would never recommend participation in another FOT because the cost-sharing requirement is too tough, especially when a project includes new products, not off-the-shelf technologies.

Operational Issues

Almost unanimously, respondents believe the partners failed to plan adequately for the operations, maintenance, and training needs of the new system. Half of the respondents emphasized that NET and Caltrans D12 each forgot to include SWARM training. This seemed to be the most critical omission during the planning phase. Three in ten respondents noticed that the 2070s required more

maintenance than the existing controllers. Furthermore, the City did not plan adequately for the transition to a new system; it seemed unprepared to care for the system or to add intersections. However, the City blamed these difficulties on the software configuration and poor training. The City admitted that it did not understand MIST or OPAC operations. PB/FSI provided training, but the City staff were unable to attend on a consistent basis. Farradyne recommended follow-up training after an initial burn-in period. Finally, one participant reports not receiving enough training for the 2070s because the consultants were concerned only with deliverables, not functionality or training.

Table 3.3: Agency Reasons for Recommending Participation in Another FOT

AGENCY	REASONS
FHWA	System testing is an important element of implementation.
Caltrans D12	Some success with FOTs; FOTs provide potential benefits.
City of Irvine	Application and development of new technologies benefit the community and provide flexibility for the traffic engineer.
Farradyne	FOTs provide financial and image benefits. FOTs provide interesting work and positive effects on the industry.
NET	FOTs provide NET with experience in software integration and working with the Southern California Caltrans Districts. FOTs remain important for promoting ITS.
LADOT	The FOT provided a good learning experience, and support from the City of Irvine assisted in developing TCSP.

OPAC performance thresholds varied among City staff who suggested reducing delay and stops 10 to 25 percent relative to the Multisonics system. City respondents indicated they anticipate

scrapping the OPAC system and returning to the existing Multisonics system. Opinions were mixed relative to SWARM performance requirements. Despite its problems, Caltrans D12 expected to use SWARM if it met current functional requirements and operated twenty-four hours a day. Other Caltrans respondents expected SWARM to reduce delay on the freeway and be completely automatic and robust. NET believed the entire ramp metering system should switch to SWARM operations because SWARM has a built-in failsafe.

While the team's opinions on ARP performance requirements differed greatly, a significant portion of them simply wanted to see it function. However, one respondent did not believe that the agencies would use ARP under any circumstances. Other requirements for ARP use included:

- Agency confidence in all of the associated liability issues,

- A 90% connection rate with Caltrans D12,

- Operator acceptance, and

- Proper adjustment of response plan design.

A City of Irvine respondent expected any given diversion scenario to move traffic on the arterials more effectively than existing traffic signal plans. Another respondent expected Caltrans D12 and the City would be satisfied with any diversion scenario if the system operated completely.

Anticipated Overall Project Results

A Federal respondent interviewed early in the project believes that the national FOT program would fail to meet its overall goals, but that the Anaheim and Irvine adaptive control projects had a good chance of success. Another Federal respondent said the local projects might influence national implementation.

A majority of the respondents believe this FOT was critical to SWARM development. Both Caltrans and NET benefited greatly because the FOT provided funds to develop their ramp metering system. During the project, Caltrans expanded its adaptive ramp metering algorithm to a system-wide algorithm. NET respondents believe this project was not critical to overall SWARM development, rather it was an important stepping stone. Caltrans wanted a system-wide adaptive ramp metering system long before the initial FOT proposal, but lacked the money to develop it. Other benefits included the following:

- Caltrans coordinated corridor operations with a city.

- District 12 planned to showcase its SWARM and ARP operations for other agencies and Caltrans District.

- The FOT provided a financial boost for the TMC ramp metering and ATMS.

Participants were evenly divided on the FOT role in overall development of the District 12 TMC with about half thinking the FOT role was important, half not.

Farradyne respondents are also divided on the importance of this FOT to their overall OPAC/MIST development. Two members feel this FOT was critical because it was the first UNIX implementation using 2070 controllers. The other two Farradyne members had differing opinions, for example, this FOT helped only in the development of a few useful libraries and modules. In financial terms, PB/FSI lost $500,000 during the project, which it hoped to recover in the future. Two agency participants believe this FOT was critical for OPAC/MIST development and operational flexibility.

Respondents reported that all of the partners except the City of Irvine thought the FOT played an important role in overall ITRAC development. According to these participants, the FOT was an important step in developing a City-wide, state-of-the-art traffic control system, and in expanding city-wide 2070 usage and MIST coverage. The FOT enhanced City capabilities and allowed improved service. In financial terms, the FOT helped the City, which wanted to replace its existing traffic control system, by providing new 2070 controllers, five CMSs, loops, and other hardware. City respondents believe Irvine benefited operationally because it worked with District 12 and obtained a more responsive system with more tools.

Some partners view the project as a limited success while others view it as a complete failure. Three of the participants highlighted the completion of the 2070 ATC and its migration to other agencies as the primary benefit of this FOT. Two participants expected the FOT to supply the City with a state-of-the-art traffic control system in a small area. Two participants said the only long-term benefits were realizing the difficulties of implementing new technologies and learning who to work with in the future. Another partner found the FOT completely lacking in short-term benefits. Another respondent hoped that SWARM would be complete in the near future. Various respondents identified other potential short-term benefits:

- Improving corridor performance,

- Proving the efficacy of the 2070 ATC,

- Evaluating the OPAC algorithm,

- Proving system-wide benefits of SWARM and providing it to Caltrans D12, and

- Realizing professional benefits from working closely with FHWA and Caltrans.

The interviewees shared some opinions regarding potential long-term outcomes. Half of the participants believe this FOT might provide a good platform for eventually completing the technologies. Two in ten respondents believe the entire concept (shared data, adaptive control, and response plans) might be feasible in other locations. Respondents mentioned other long-term benefits, such as:

- The City would replace Multisonics with MIST and integrate CCTVs with MIST.

- The FOT would improve coordination and communications between Irvine and Caltrans District 12.

- The agencies might continue to use MIST/OPAC and SWARM.

- Use of 2070s and SWARM might expand within the City of Irvine and Caltrans, and to other agencies as well.

3.5 Cross-Cutting Issues

Participant interviews reveal three cross-cutting institutional issues.

3.5.1 Finger-pointing

According to interview respondents, the partners tended to place blame for project shortcomings on other parties. While Farradyne in particular blamed others, it was the only partner to accept some responsibility for causing major project delays. Both City of Irvine and NET respondents admitted they might have fallen slightly behind schedule at times, they do not believe they were responsible for the ultimate failure of the FOT.

According to Farradyne respondents, weakness among initial representatives from each company delayed the contracting and proposal processes. They also lacked a clear vision for the project. Farradyne's original proposal borrowed components from multiple operating systems and painted an unrealistic picture of system capabilities. The proposal was short on details had a significant impact on the FOT since all of the participants, particularly the City of Irvine and

Farradyne, interpreted the proposal differently. All of the FOT participants had difficulties meeting their deadlines at times, especially the City of Irvine and Farradyne.

While many participants feel the City of Irvine met all of its deadlines, others, including the entire Farradyne firm, believe the City failed to meet all of its deadlines. Farradyne respondents said some improvement occurred because the City just wanted the project to end. Farradyne respondents believe the City lacked a strong management structure at the beginning of the FOT. They also expressed concerns over a failure by NET and FHWA to provide strong project management. Other parties' inability to participate in project management led to numerous conflicts between the City and Farradyne including:

- The City of Irvine seemed to focus on the ultimate usefulness and benefits of the project rather than on testing systems and it continually asked for more than Farradyne promised.
- Caltrans and the City of Irvine seemed to focus this FOT without the consent of the other partners. For example, Caltrans and Irvine insisted on using 2070 controllers even though they were not fully specified at the beginning of the project. Caltrans added NET to the project and expanded ramp metering to address system-wide concerns. The City insisted on using LADOT firmware.
- The City failed to provide ARP in the contract and Farradyne had to halt work for six months to write a proposal for ARP. However, Farradyne received no money for ARP after receiving the contract. NET noticed that the City of Irvine impacted ARP with slow decision-making.
- The City of Irvine had problems making decisions, especially regarding signs and controllers.
- When the City's management left for new positions during the project, no one stepped in to make decisions or handle concerns.
- Poor management resulted in infrastructure problems, specifically, CMS sign placement and subsequent destruction, communications problems, and the type and location of loops (the City considered both autoscope and loops).

In general, public agency respondents found the work of both consultants lacking, criticizing Farradyne in particular. Everyone found Farradyne's delays completely unacceptable. MIST/OPAC never functioned properly and remained unstable because Farradyne was unable to port MIST effectively. According to a non-City participant, Farradyne did not seem to have the technical expertise to port MIST to a UNIX platform. City participants noted that Farradyne had problems with the 2070 drivers, especially after a project participant left the company. According to City

respondents, Farradyne software development went in the wrong direction and reassigned personnel had to restart it. NET realized it still needed to test the intertie design with PB/Farradyne. However, according to NET, Farradyne needed to finish integration and finalize testing plans with NET before NET could proceed. NET was responsible for ten to twenty percent of the integration between MIST and Caltrans District 12 when they left the project team. Finally, NET decided not to complete the project, and the system they delivered still did not function properly two years after its contract ended.

Farradyne acknowledged many internal delays, but continued to blame three other parties, the City of Irvine, Caltrans, and LADOT, for imposing further delays. Farradyne respondents admitted they did not maintain the schedule or meet deadlines due to a lack of urgency at the beginning of the project. Farradyne did not maintain its schedule as result of internal delays in converting OS/2 to UNIX, and external delays the City caused by changing Farradyne's specifications. The City had long delays in deliverables, actions, and decision-making. The schedule delays forced people to leave the project for other endeavors, exacerbating the existing internal delays. Coordinating OPAC and the firmware caused an unexpected slowdown for OPAC. Farradyne did not realize the scope of the software development required to complete the project. Furthermore, it did not realize the impacts of agreeing to work with the 2070s and LADOT firmware. Higher-level members of PB/FSI supported the switch to 2070s, but never the LADOT firmware. Eventually, Farradyne had to spend its own research and development money to create a useable product.

Caltrans Operations/New Technology delayed Farradyne's work by developing specifications for the 2070 slowly. City of Irvine respondents agreed this hamstrung both Farradyne and LADOT. Technical problems with the 2070 hardware and software caused tremendous FOT delays. However, the parties responsible for the 2070 and its firmware were not part of the project and not accountable for providing these products. Farradyne respondents admitted that the City's controller decision slowed LADOT's work.

Farradyne's relationship with LADOT seemed to start poorly when the City of Irvine forced all information-sharing with LADOT to pass through the City. PB/FSI was not allowed to communicate with LADOT early in the project while the City negotiated the firmware's cost and structure. LADOT respondents believe Farradyne should not blame LADOT for all of its delays. The City of Irvine supported LADOT because it corrected bugs promptly (in one to two weeks). Unfortunately, LADOT did not provide documentation for its firmware, and had no charter to develop

software for this FOT. Apparently, the City of Los Angeles could be more careful dealing with consultants, in fact, it might need to be more confrontational.

Respondents reported that Caltrans District 12 was not sufficiently interested in FOT goals and priorities, for example, D12's slow response interfered with project communications. Caltrans D12 lacked a single focus concerning the FOT, respondents said. Caltrans D12 impeded NET's performance by refusing to help test SWARM, and activity that required D12 assistance.

3.5.2 What Really Happened?

Originally, PB/FSI wanted to use OPAC on arterials to accommodate freeway dumps, although they ultimately recommended OPAC to model queues on ramps. If PB/FSI successfully modified the algorithm, OPAC would have set ramp metering rates based on the ramp queues. Caltrans did not like this approach, however. During the proposal process, Caltrans changed certain objectives and partners. For example, Caltrans tried to eliminate OPAC completely, and use an NTCIP installation and its own ramp metering. Furthermore, one of the partners insisted on a UNIX platform for MIST. Caltrans unilaterally selected NET to replace the University of California - Irvine on the project and for ramp metering because of its existing statewide relationship with Caltrans. Early in the proposal process the partners selected the Irvine site.

At the time of the proposal, the partners realized no 2070 firmware existed, but the City of Irvine volunteered to obtain it. Three entities were working on 2070 firmware at the time, LADOT, Gardner Systems, and Kessman for Las Vegas and Houston. Selecting the firmware provider required a great deal of time. According to City respondents, everyone knew that the LADOT controller software worked and had been used during the 1994 FOT research and development phase. However, there was not a prototype to allow development of device drivers. The City selected LADOT because its price was low, they had worked together in the past, and the City did not have to pay a license fee. PB/FSI remained staunchly opposed to the LADOT firmware throughout the FOT because respondents felt public agency software represented a high risk and was not available to private agencies. The firmware required diverted FOT funds because it was not part of the budget.

2070 usage problems began during Caltrans testing and prevented the City from establishing a final prototype until early 1996, not 1994 as in the proposal. Caltrans HQ handled the 2070 development, but continually changed its specifications. The first "prototype" from Caltrans

HQ came out in the middle of 1995, over a year late. As a result, software coding became extremely difficult. Device Drivers posed a problem for Farradyne as well as LADOT. LADOT involvement began in 1994 when it developed software for the "wrong" prototype on its own.

The City wanted to use 2070s as opposed to ATCs for a variety of reasons. First, it did not want to use two controllers, ATC and multisonics, in one cabinet. Second, Caltrans would provide support for 2070s in the future. During this decision-making stage, the City consulted with Caltrans HQ and LADOT, but excluded the other FOT partners, specifically Farradyne. In hindsight, one Farradyne participant believes they should have demanded using ATCs with the BiTran firmware.

Some OS/9 developers worked on some of the algorithm programs. The only area of OPAC research associated with this project was addition of cumulative delays and stops to the algorithm. PB/FSI spent considerable time implementing the platform change to a UNIX system and 2070 controllers. Developing the server, timing pages and TSCP was associated with these tasks.

Sometimes, the City had difficulty readying all of the infrastructure for PB/FSI. Late in the project all of the interim deliverables increased PB/FSI's delay. The Changeable Message Sign (CMS) firmware also created significant problems. Changes and bugs at different points during the project might have cost PB/FSI an entire month of delays. LADOT slowed OPAC implementation while waiting for an agreement on data exchange between TSCP and OPAC. As a result, LADOT changed its firmware to try accommodating OPAC's needs. Instead the change constrained optimum operations.

Coordinating systems information and dissemination to all parties required a systems engineer. A systems engineer might have been able to address some of PB/FSI's problems with LADOT, which had to supply the device driver for PB/FSI's systems driver. LADOT might have made more than twenty revisions to TSCP, and contributed 300-400 hours of delay and undocumented costs to PB/FSI.

Most PB/FSI staff worked on this FOT full-time; although the number of people assigned to the project varied over time. In the Fall of 1996, four or five people worked on the project; by the spring of 1997, six people were working on the project; and seven to nine worked on it in the summer of 1997; however, this number later shrank to three.

Farradyne did not recall any bad development paths, although numerous bottlenecks existed with multiple lateral shift at each bottleneck. The 2070s complicated PB/FSI technologies, and the uploads and downloads to the 2070s were also a problem. These uploads and downloads required an unacceptable amount of time (i.e., six minutes), so PB/FSI had to solve a TSCP problem. If the

City used 2070s from another company' and LADOT fixed the memory map, then TSCP should run well, respondents said.

SWARM lacked documentation, and its failure management and malfunction scheme needed redesign. SWARM and all pertinent reports were tied onto the end of the ATMS project, which hindered their development. Caltrans tested SWARM over a six week period, nothing related to SWARM ever appeared, and Caltrans never identified what SWARM did internally. Caltrans let SWARM run in the field for two days, but once again SWARM failed to indicate that it was actually working. NET last responded to Caltrans D12 during late summer 1998. Major problems with the algorithm included implementing SWARM one ramp at a time (as opposed to by section), and a lack of permanent memory for the setup parameters at each ramp meter. Caltrans respondents do not believe NET anticipated the extensive testing that District 12 performed on SWARM.

District 11 in San Diego had imported NET's system, and would be installing its system in all Southern California Districts. NET was responsive to many requests, but refused all requests that "required a major redesign." NET never did much follow-up work on SWARM. Therefore, District 12 had to wait for completion of ATMS2, the District 7 system, before it could begin testing ATMS and SWARM again. District 7 would perform most of the testing of ATMS2. District 12 stressed the importance of a future evaluation of SWARM.

From January 1998, NET and Caltrans conducted weekly meetings regarding the ATMS reports, including all of the ramp metering reports. As a result, NET had a lot more contact with Caltrans than during other years. According to NET respondents, these meetings have evolved into mini-training sessions where NET helps Caltrans understand every SWARM component. Currently, the meetings occur only at Caltrans' request, as opposed to weekly.

Other key points about the overall FOT emerged from some interviews:

- Farradyne lacked sufficient experience with UNIX or OS/9.
- The FOT provided funds for an ATMS server and some ATMS development work.
- Farradyne's technical visits extended over Fridays and weekends when the City was closed. Farradyne expected the City to work on the FOT only when the technical team was in town. A City reorganization caused some problems with coordination.
- PB/FSI originally developed an impractical design for the detector locations, increasing implementation costs, but seemed happy with the eventual design.
- Irvine FOT consultants lacked the expertise of Anaheim FOT consultants.

- Farradyne worked on a FOT in Nogales, Arizona that expedited processing at international crossings. This project worked better as a test because one agency did not have a vested interest in the end product.
- SWARM grew into a system-wide ramp metering approach because D12 engaged in a political ploy to improve ramp metering.

3.5.3 LADOT Involvement

LADOT become involved in the Irvine FOT because it was working on a software package for the Model 2070 controllers. The City evaluated a number of options for developing software before selecting LADOT. LADOT worked on defining the interface between TSCP and OPAC based on PB/FSI's interface requirements document. LADOT also changed TSCP by adding the new communications protocols required to complete the interface. The final design for TSCP developed from PB/FSI's recommendations and requirements. The City of Los Angeles made no changes.

The Cities of Los Angeles and Irvine and Caltrans have adapted TSCP, and the three agencies own the code jointly. The City of Los Angeles received payment for additional modifications to TSCP, not for the basic TSCP. The modifications responded to OPAC requirements and City of Irvine add-ons for its own traffic control purposes, such as bicycle traffic. Los Angeles found implementing Irvine's requests easier than the OPAC modifications, but both were significant. One respondent was saddled with a higher volume of work than expected. The City of Los Angeles and City of Irvine worked very well together.

PB/FSI and other FOT partners had an impact on LADOT's work during the integration phase. The City of Los Angeles needed a simulation to identify some of the problems Farradyne identified in its lab. Los Angeles requested Farradyne's simulation repeatedly in order to run the same simulation and identify the reported problem, but Farradyne denied these requests for about a month. Eventually, Los Angeles spent an additional week developing its own simulation. The project may have started off in the wrong direction when Los Angeles had difficulty clarifying OPAC's needs, and when Farradyne seemed to lack a general understanding of TSCP capabilities and some components of traffic control. LADOT seemed pleased with the final product combining TSCP and OPAC. However, OPAC could not keep up with TSCP which makes decisions every second while OPAC requires four.

Farradyne set the project schedule and timetable for its work with LADOT. However, Farradyne did not budget for the costs of working with LADOT to beta test firmware. Although no schedule existed for the LADOT's tasks, this FOT had higher priority than other projects. LADOT usually met with the City of Irvine once a month, and held weekly conference calls with Farradyne in Maryland to resolve any problems arising between meetings. LADOT tried to resolve these problems in a timely manner. However, LADOT progress sometimes depended on Farradyne's work, so LADOT was idle while waiting for Farradyne to complete its part. LADOT hoped all participants realized they had to work diligently to maintain the schedule. LADOT has a lot of other responsibilities, but tried to keep its work on track throughout the project. In order for a project like this FOT to succeed, both agencies need a strong commitment to the project. The City of Irvine provided all City of Los Angeles funding and made a one-time payment of $30,000 to LADOT for its FOT work.

The City of Los Angeles budget was insufficient to complete modifications to TSCP. However, LADOT provided a working software package with all necessary enhancements for OPAC operation, and continued to support that program as necessary. LADOT would not set a fixed-fee on such a large contract again. It recommended an itemized costing of each part, with additional monies for change orders, to better manage the costs. In order to complete this implementation project under similar circumstances, the agency needed to budget 300 to 400 person-hours.

LADOT believed the entire system was quite complex so operators would require a good understanding of each component to make it all work without significant problems. Although MIST and OPAC software was new to the City, Los Angeles was able to interface the software so the project would work. LADOT believes there might be other issues for TSCP in the future, especially with frequent changes within the traffic control industry. Users would have to consider enhancements to the software and controller specifications.

4. CONCLUSIONS AND LESSONS LEARNED

It is the consensus of the evaluators that no integrated control or control functions were implemented, and that no operational systems were implemented. It is therefore impossible to assess the technical capacity of the FOT's ultimate deliverables. Significant lessons were learned, however. The most prominent of these appears to be:

- The importance of incorporating detailed technical specifications in the contract documents, and

- The need for a complete technical review and an appropriate level of understanding by the contracting agency.

Greater attention to these two elements would have greatly increased the likelihood of identifying and preventing the problems that lead to the FOT's major delays, and ultimately to the failures in delivery and implementation encountered in the Irvine FOT. For example, the Caltrans 2070 controller was specified as the platform for OPAC under the 1994 (final) proposal revision. The proposal did not specifically address the issue of whether the 2070 would replace the existing Multisonics controllers, or would be installed in addition to the existing controllers. The proposal also did not specify what entity would be responsible for the signal actuation software that would be required for the ultimate configuration, which would consist of either the Multisonics controller and the 2070, or the combined functions operation of just the 2070. These ambiguities subsequently led to contractual disputes between FSI and the City of Irvine, and were ultimately the source of the most significant project delays. An independent entity (Los Angeles DOT) was brought in to supply custom signal control software that could communicate with OPAC and MIST.

FSI clearly expended a great deal of effort on the FOT. NET met contract deliverables by providing over thirty status reports and specification documents, many duplicative and irrelevant to the successful execution of the project.

The problems that might realistically have been avoided include the following:

- Dependency of the 2070 controller, which had not yet been fully specified or delivered, could have been avoided. Depending on a controller that was still in development complicated the software porting tasks required of FSI, and was cited by FSI as the primary reason for delays.

- The need for signal control (actuation) software required so both the intersection control and OPAC modules could to be implemented in common on the 2070 controller could have been avoided if these functions had remained split between the Multisonics and 2070 controllers. This split configuration had been assumed by FSI.

- The integration deliverables to be performed provided by NET were largely decoupled and independent of FSI's work. Integration must occur concurrent with other implementation activities. If this had been recognized, some provision for NET's continued involvement after their contract expired in 1997 could have been incorporated, anticipating the possibility that FSI's deliverables might be delayed well beyond that time.

- The contractor should establish the nature of the documentation required rather than the vendors. This would have helped to avoid the problems associated with NET's choice to provide large quantities of mostly irrelevant status reports and specifications for systems that would never be implemented, while failing to provide an operator's manual for the SWARMS software.

- A schedule of formal design reviews, tied to contract milestone payments, should be incorporated in partner contracts. This is typical in similar contracts administered by the DOD or DOT.

- Success of large technical projects such as the Irvine FOT is usually facilitated by assigning the program manager full responsibility and authority. The Irvine FOT was characterized by a desire for consensus that translated into nebulous project authority and a circular review structure. This ultimately led to loss of coordination, project direction, and morale.

- It is essential that technical leadership have direct access to the actual software development personnel any project involving the development of large integrated software packages involving multiple developers and responsible entities. In the Irvine FOT, attempts to achieve coordination only through high-level management contacts led to miscommunications, unrealistic lead time requirements for simple changes, and extensive development delays.

- Provision for independent technical evaluation and review should be incorporated into the original program proposal and all participating partners' contracts. The inclusion of evaluators early in the process, and a clearer standing of the evaluation team within the context of the project, would have led to more productive use of evaluation resources. Evaluators might be consulted with regard to the specifications, workplan and deliverables

in the partners contracts prior to their approval. In the Irvine FOT, the evaluators were not permitted to see the partners' contracts until after the project was terminated, over five years after the fact.

- The actual FOT deliverables and timetable were never fixed, evaluation man-hours were wasted meeting *ad hoc* requests from the FOT partners to repeatedly update evaluation workplans for systems that were ultimately never deployed. The evaluation team complied with these requests in an unsuccessful effort to encourage reciprocal responsiveness from the FOT partners. The objective of the evaluation should have been allowed to focus on assuring technical and institutional performance, rather than assessing the consistency of the FOT with nation-wide ITS objectives.

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APPENDIX A: Evaluation Plan Task A: Corridor Performance

Task A: Corridor Performance

A.1   Context of the Evaluation

The Irvine Field Operational Test (FOT) evaluation project is a part of the FHWA program to evaluate ITS (Intelligent Transportation System) concepts and technologies that have the potential for improving mobility, safety, and transportation productivity, as well as reducing congestion and emission across the national highways. In broadest terms, the goal of the strategies being implemented in Irvine is to decrease the total vehicle hours traveled for any constant number of vehicle miles traveled, to improve the efficiency of the traffic system (based on several criteria), and to achieve this in an institutionally acceptable and efficient manner. The specific goal is to implement and evaluate integrated freeway and arterial traffic operation to improve total corridor traffic performance. The goal defines several objectives. The project objectives most relevant to evaluation Task A are

(1)   accommodation of traffic transients arising from freeway diversion for nonrecurring congestion;

(2)   accommodation of recurring corridor congestion through coordinated adaptive arterial signal control and adaptive ramp metering;

(3)   evaluation of system and approach expandability and portability; and

(4)   assessment of a distributed implementation of a traffic management and operator decision support system serving two coordinated agencies.

The FOT integrates centrally controlled freeway ramp metering with an advanced arterial traffic control system utilizing an Optimized Policies for Adaptive Control (OPAC) algorithm. This integration exists at institutional and operational levels, and to a more limited extent at the technical level. A map of the study area Caltrans District 12 equipment locations appears in Figure A1.

This integration is intended to enable effective and coordinated operations of freeway ramps, freeway segments, and arterial signals for non-recurring incident congestion and to use changeable message signs to inform motorists of alternative choices. Accommodation of recurrent congestion is not a primary FOT objective. While coordination of State and local traffic management plans are clearly important to all parties, there is less agreement about the desirability of allocating arterial capacity to freeway flows under recurrent conditions. Thus the degree to which the second objective can be met is constrained by separate treatment of freeway segments and arterials under recurrent conditions.

The project may still contribute improved management of corridor capacity under conditions of recurrent congestion. If the FOT technologies permit arterial capacity to be used more effectively when non-recurrent congestion is present on the freeway, then the agencies involved might ultimately extend the coordination engendered by the project to include arterial responses to

IFOT FIELD DEVICES LOCATION
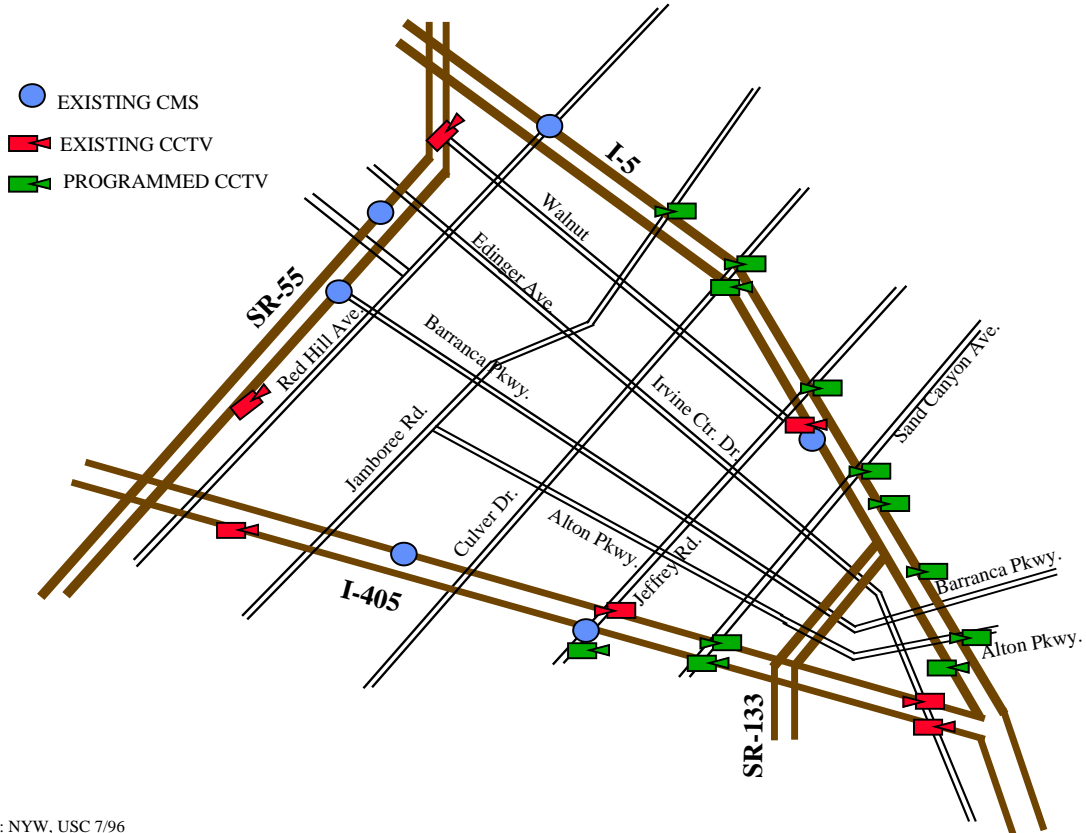
By: NYW, USC 7/96

Figure A1: Irvine FOT Study Area

recurrent freeway conditions. Much depends on the how such measures can be expected to affect level of service on the arterial network.

The evaluation plan summarized here is designated Task A, and deals with the evaluation of corridor impacts. This includes an emphasis on the quality of traffic conditions on the freeway ramps and mainline segments of the freeway network. However, evaluation of freeway conditions and arterial conditions must be concomitant, since measures intended to effect both sorts of facilities are to be implemented simultaneously.

The operational portion of the Irvine Field Operational Test most relevant to corridor performance consists of three elements.

(1)   The Management Information System for Transportation (MIST) is a data manager and supervisor that enables interaction between freeway and surface street operation control technologies to be installed by Farradyne Systems, Inc (FSI). This will allow City of Irvine Traffic Research and Analysis Center (ITRAC) operators to

A - 2

- monitor traffic conditions and status of field devices,

- control their field elements,
- develop and implement scenarios for management of planned events, and

- respond to requests from a decision interface with Caltrans District 12 for implementation of plans for management of non-recurrent congestion within the corridor.

(2)   The System Wide Adaptive Ramp Metering (SWARM) to be deployed in the Caltrans District 12 Transportation Management Center (TMC) by National Engineering Technologies (NET). SWARM and District 12's Operator Decision Support System (ODSS) constitute the adaptive decision elements of the District's Advanced Traffic Management System (ATMS).

(3)   And, the Arterial Response Plan (ARP) module, which is the decision interface that coordinates the functions of ATMS and MIST, and the elements that support these systems. The ARP module is not part of MIST. It is being developed separately.

This list emphasizes the technical elements most relevant to corridor integration and control. It is incomplete with respect to the FOT, which includes several other important technical elements addressed in other tasks, but are partially relevant in the context of Task A. One of the system elements MIST manages is the Optimized Policies for Adaptive Control (OPAC) algorithm. OPAC is a tool for advanced traffic control. Intersection controllers are being upgraded to Model 2070 to support implementation of OPAC. Communications between the various operational elements include fiber optic and other inter-site communications connections, network components and protocols specific to the Caltrans District 12 TMC, and HP 9000 workstation computers used to support MIST, the ARP module, and the ATMS.

Figure A2 summarizes the corridor control system elements. This system is capable of incident detection, surveillance, and pre-planed response, and other informed responses that take into account real-time traffic conditions both on freeways and arterials. If traffic diversion is warranted, the response plans will consists of actions required by Caltrans District 12 and by the City of Irvine.

The determination of whether non-recurrent conditions exist and whether diversion is warranted is made by the ATMS. The ARP module is applied in response to this determination. There is no other mechanism for designating non-recurrent congestion on the freeway. Expanding this approach to include arterial responses to special or routine cases of recurrent congestion includes two elements. These are the creation of new (recurrent) arterial response plans, and definition of a recurrent congestion category the ATMS can report to the ARP module. This extension is not part of the FOT.

A.2   Purpose of the Evaluation

In broadest terms, the goal of evaluating corridor performance is to identify technical constraints and quantify to the maximum extent possible improvements provided by the system . This objective can be met only if the state of the network can be assessed in appropriate terms. The ideal evaluation

would include panel data at the level of individual travelers, including average origin-destination travel times by trip type occurring on the Irvine network. This is not feasible.

Figure A2: Irvine FOT Corridor Control System
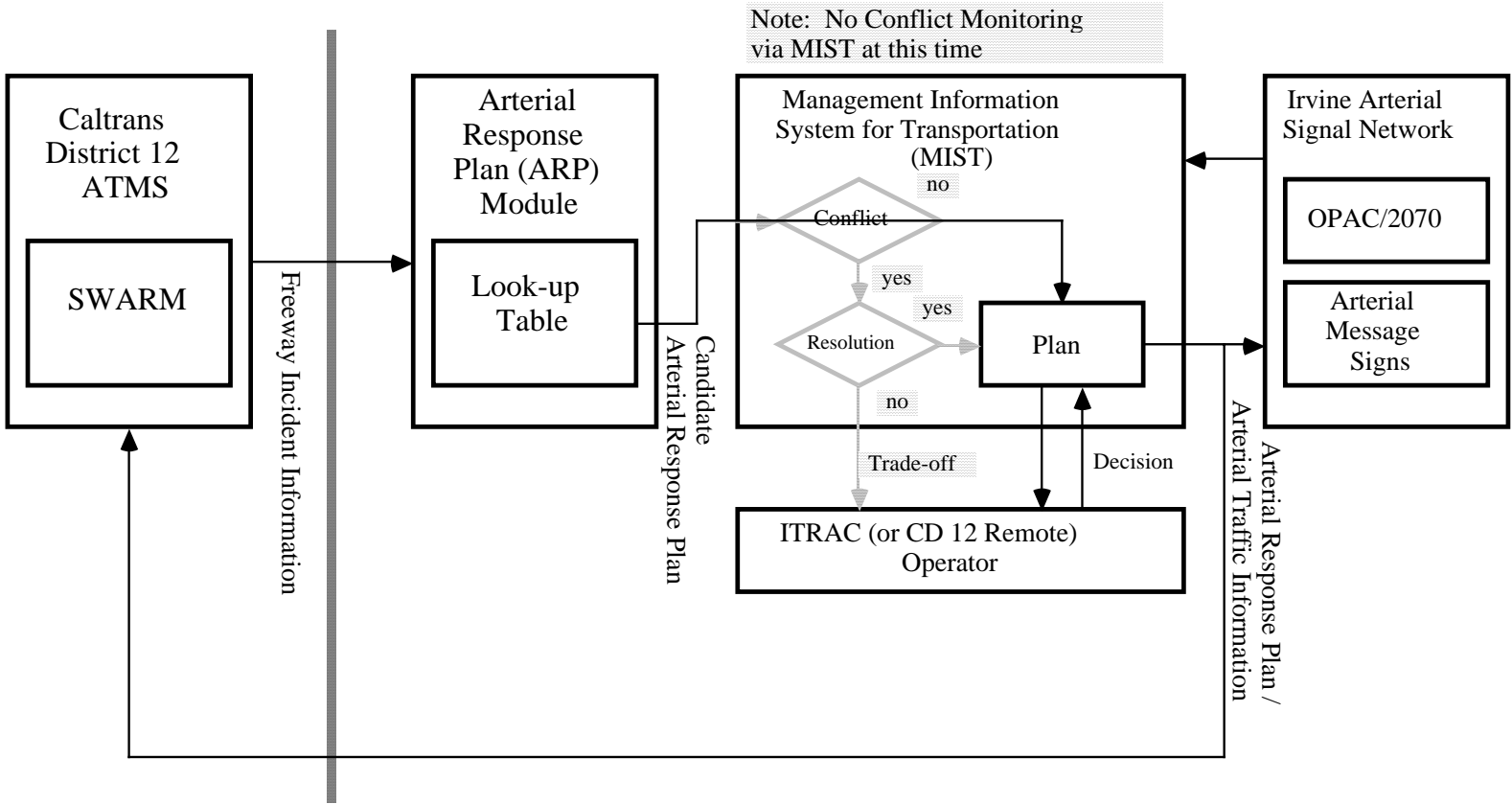
The state of the Irvine network is a vector quantity, and changes in the vectors' components have to be individually and collectively examined during the evaluation. Changes in network performance resulting from the implementation of the corridor control system will have to be measured in terms of the surveillance information provided by the by the ITRAC and the Caltrans District 12 Transportation Management Center (TMC) and limited field observations.

Each of the evaluation's specific goals relates to at least one of the goals found in the National Program Plan from ITS America. The evaluation plan develops the evaluation objectives that are associated with each goal. The objectives help to clarify the evaluation goals.

The first evaluation goal associated with Task A is to demonstrate the viability of flow adaptive ramp metering as an alternative to conventional, static metering schemes. The test proposal anticipates that the use of this technology will result in the ability to increase the efficiency of urban traffic control operations by allowing the control system to adapt to real-time traffic conditions. This relates directly to the national ITS goal of increased efficiency of ground transportation systems by increasing the capacity of existing facilities. The evaluation objectives for this goal are listed below. This evaluation will

(1)   assess the change in level of service (LOS) on freeway segments subject to adaptive ramp metering, and

(2)   assess the change in level of service (LOS) on freeway ramps subject to adaptive ramp metering.

The second evaluation goal associated with Task A is to determine the operator acceptance of adaptive ramp metering technology. The FOT proposal hypothesizes that the Caltrans District 12 will be able to support the implementation of the ATMS. This goal relates directly to the national ITS goal of creating an environment in which the deployment of ITS can flourish. The evaluation objectives for this goal are listed below. This evaluation will

(3)   assess the ATMS user interface with particular attention to SWARM;

(4)   assess the adequacy of current telemetry as data sources for the Caltrans District 12 ATMS; and

(5)   assess operators' estimate of ATMS effectiveness with respect to traffic operations, with particular attention to SWARM.

The third evaluation goal associated with Task A is to measure the benefits of coordination across freeway segments and arterial streets under conditions of non-recurrent congestion. MIST will be able to manage a large variety of real-time scenarios to be coordinated via the ARP module with management of freeway segments. This relates directly to the national ITS goal of improved productivity by utilizing different network links more effectively.

A.3 Evaluation Test Description

This section provides a technical overview of the evaluation methodology, and explains the rationale behind the technical approach to the evaluation. Each of the evaluation tests provides a specific set of data to help complete the evaluation objectives and reach the evaluation goals.

A.3.1 Statistical Perspective

The state of the network is a random vector quantity even under conditions of fixed supply of and demand for travel. Even if the processes generating network states are invariant, an observed state is only one of many possible outcomes these processes might produce. Consequently, there are certain to be differences in the network states associated with the before and after implementation of the FOT elements. The objective of evaluating corridor performance is to explain systematic variations in the most likely network states in terms of the effects associated with the FOT elements. If the improvements associated with these project elements exceed the randomness in traffic flows, then it will be possible to construct interval estimates of these improvements.

The Irvine FOT corridor evaluation is based on a sampling approach that relies on basic statistical properties. The evaluation develops a sample that is representative of the network, conducting an in depth statistical analysis of impacts related to the FOT's corridor elements. These impacts occur on a defined subarea and are measured relative to a the subarea's before state and relative to a representative control subarea.

A.3.2 Scenario Building

The Irvine FOT has evolved substantially since the deployment was originally proposed. On May 8, 1996, the project partners, sponsors, evaluators, and other observers met at the Headquarters of Caltrans District 12 to review the project goal and objectives, and to recommend operational scenarios for evaluation. Numerous scenarios were discussed. Figure A3 summarizes the scenarios collectively identified by the partners and other project personnel as important for comparison. This summary is an incomplete representation of all options discussed, but is consistent with minutes of the May 8 meeting circulated by the City of Irvine May 31, 1996.

Combinatoric requirements are critical for any field evaluation. Resources for the project evaluation do not permit all of the scenarios to be compared. However, the overview informs all aspects of the evaluation effort and is particularly relevant to corridor level efforts.

The evaluation team met subsequently to establish priorities within this context. They modified the partners' scenario classification for in light of priorities expressed by the partners, the evaluators priorities, published guidelines, and resource constraints. The classification in Figure A4 emphasizes corridor objectives.

Given that SWARM is ultimately to be deployed State-wide by the California Department of Transportation, an evaluation of SWARM is clearly desirable. NET maintains that SWARM performs well enough that Caltrans should not incur the liability associated with turning the system off once it has been deployed. This means that any evaluation would have to be begun before SWARM is deployed in the fall of 1996. If this is feasible, the USC team will undertake the evaluation. Under this scheme, any evaluation of SWARM would be essentially independent of

other corridor elements. Thus Figure A4 includes a sub-baseline category defined to permit a potential evaluation of SWARM.

	Recurrent Congestion	Nonrecurrent Congestion	
Baseline (Before) Conditions	• OPAC Off / TOD • SWARM operating • No D12 elements • No ARP generation • No active diversion	• OPAC Off / TOD • SWARM operating • No D12 elements • No ARP generation • No active diversion	• OPAC Off / TOD • SWARM operating • No D12 elements • No ARP generation • passive diversion, CMS = Congestion Ahead
Future (After) Conditions	• OPAC On • SWARM operating • Other D12 elements • No ARP generation • No active diversion	• OPAC On • SWARM operating • Other D12 elements • No ARP generation • Active diversion, CMS = Alton Available	• OPAC Off / TOD • SWARM operating • Other D12 elements • ARP generation • Active diversion, CMS = Alton Available
	• OPAC On • SWARM operating • Other D12 elements • No ARP generation • No active diversion	• OPAC On • SWARM operating • Other D12 elements • No ARP generation • No active diversion	

Figure A3: Operational Scenarios Emphasized at the Special Meeting to Review Project Goals and Objectives, May 8, 1996.

It is unlikely that SWARM can be evaluated at the level its Statewide deployment justifies in the context provided by the FOT. The Evaluation Team remains cognizant of the importance of SWARM, and open to prospect of evaluating its deployment to the extent resources and coordination with other objectives permits. For example, comparing system states under Scenario 1 to system states under Scenario 3 measures the contribution of SWARM under recurrent

conditions. This can be accomplished without data from floating cars or other arterial data, and requires no special coordination with Task B.

	Recurrent Congestion	Nonrecurrent Congestion
Baseline (Before) Conditions	Scenario 1 • OPAC Off / TOD • No SWARM • No ARP generation • No active diversion SUB-BASELINE TECHNOLOGY	Scenario 2 • OPAC Off / TOD • No SWARM • No ARP generation • Passive diversion, FCMS = Congestion Ahead SUB-BASELINE TECHNOLOGY
Adaptive Ramp Metering (SWARM)	Scenario 3 • OPAC Off / TOD • SWARM operating • No ARP generation • No active diversion BASELINE TECHNOLOGY	Scenario 4 • OPAC Off / TOD • SWARM operating • No ARP generation • Passive diversion, FCMS = Congestion Ahead BASELINE TECHNOLOGY
SWARM/City of Irvine FOT Elements	Scenario 5 • OPAC On • SWARM operating • No ARP generation • Passive Arterial CMS • No active diversion	Scenario 6 • OPAC On • SWARM operating • No ARP generation • Passive Arterial CMS • Active diversion, FCMS = Alton Available
Corridor (COI/CD12) FOT Elements	Scenario 7 • OPAC On • SWARM operating • ARP generation • Active Arterial CMS • No active diversion	Scenario 8 • OPAC On • SWARM operating • ARP generation • ACMS • Active Arterial CMS • Active diversion, FCMS = Alton Available

Future (After) Conditions

Treatment = SWARM

Treatment = OPAC

Treatment = Coordination

Treatment = Corridor Coordination and OPAC

Figure A4: Operational Scenarios Emphasized at Post-Review Evaluation Meeting.

Comparing system states under Scenario 2 to system states under Scenario 4 measures the performance of SWARM under non-recurrent conditions. Given the design objectives stated to District 12 by NET, the benefits associated with adaptive ramp metering could be maximum under this scenario. This comparison can be accomplished without arterial data, and thus requires no special coordination with Task B. However, since freeway traffic incidents occur without notice, it is almost impossible to survey traffic diversion unless the diversion is scheduled. The freeway lanes will have to be closed to simulate a non-recurrent incident. Caltrans District 12 personnel suggest lane closures near the end of the afternoon peak period are the most viable. It is important to minimize the number of incidents that must be simulated. Thus it is desirable to coordinate this closure with the requirements of other evaluation tasks, especially Task B. Lane closures might logically be used as maintenance opportunities by Caltrans District 12.

The partners have requested that the Evaluation Team also make maximally productive use of telemetric data currently subject to automatic collection during unscheduled episodes of non-recurrent congestion. The utility of this data depends largely on the capacity of the Evaluation Team to elicit episodes of rapid, routine coordination across the Caltrans District 12 TMC and City of Irvine ITRAC facilities.   The evaluators will make every effort to elicit this state of affairs, because telemetric and video data of real incidents is likely to be of considerable secondary value. However, it is not a replacement for data collected during scheduled lane closures.

A.3.3   Scenario Selection

Comparisons of system states under Scenario 3 to system states under Scenario 5 or Scenario 7 are not particularly relevant from a corridor perspective. The Irvine Field Operational Test was never intended to focus on simultaneous management of freeway and arterial capacity under recurrent conditions. Indeed, diversion under recurrent conditions is deemed institutionally unacceptable by the partners. Upon reflection, the partners report that Scenario 7 is an empty set, because the FOT includes no implementation of arterial response plans under conditions of recurrent congestion. However, the arterial element of the comparison between Scenarios 3 and 5 is relevant because it captures the efficacy of the OPAC deployment under recurrent conditions. This comparison is part of Task B.

The comparison between Scenario 4 and Scenario 6 is simultaneously part of Tasks A and B. The comparison between Scenario 6 and Scenario 8 is of central importance from the corridor perspective. The ARP module provides a degree of coordination between freeway and arterial operations unique to this deployment. Comparing Scenario 4 to Scenario 8 addresses the relative importance of using OPAC in a coordinated environment. This is a desirable but less important determination.

The corridor evaluation priorities for Task A are summarized in Table A1.

Table A1: Evaluation Priorities for Task A: Corridor Effects

Comparison	Treatment	Order of Effect	Measurement Difficulty	Priority
Scenario 4 vs. Scenario 8	Adaptive signal control (OPAC) in a coordinated environment	First and second order	Intermediate to High	High (Prototype deployment of a new system and approach)
Scenario 4 vs. Scenario 6	Adaptive signal control (OPAC) in an uncoordinated environment	First order	Intermediate	Intermediate to High (Relevant to both Task A and Task B)
Scenario 6 vs. Scenario 8	Coordination (ARP) in addition to adaptive control	Second order	High (Higher order effects are more difficult to observe)	Intermediate to High (Higher order effects have less impact on level of service)
Scenario 2 vs. Scenario 4	Adaptive ramp metering (SWARM) under non-recurrent conditions.	First order	High (requires coordination across Tasks)	Low to Inter-mediate (Deployment is inevitable)

A.3.4   Specific Hypotheses to be Tested

Test hypotheses associated with these comparisons are organized into sets that include null and alternative hypotheses. Note that this does not necessarily imply the execution of statistical tests. In many cases this will not be possible because the requisite statistical distributions are unknown. Rather, these hypotheses will be evaluated using a variety of analytical means such as qualitative and quantitative comparisons of performance attributes and how this performance contributes to attainment of objectives, direct network traffic quality analysis using floating car studies and surveys, indirect network traffic quality analysis using telemetry and/or traffic simulation models, and multivariate statistical analysis on variables amenable to such analysis. Some of these analysis techniques will be developed during subsequent refinements to the evaluation plan, and others are summarized in the following sections. The following list of hypotheses to be tested with these

techniques is not expected to change substantially, thought the test results may prompt new hypotheses.

(1.)   Scenario 4 versus Scenario 8

H_0:   The ARP Module is unable to link to the operations of the ATMS and MIST.

H_1:   The ARP Module is able to link to the operations of the ATMS and MIST, but operators are unable to place confidence in system responses.

H_2:   The ARP Module is able to link to the operations of the ATMS and MIST, and operators are able to place confidence in system responses.

H_3:   The ARP Module is able to link to the operations of the ATMS and MIST, but this link is irrelevant to the respective performance of MIST and the ATMS.

H_4:   Unanticipated alternative hypothesis.

This comparison supports the third evaluation goal: measuring the benefits of coordination across freeway segments and arterial streets under conditions of non-recurrent congestion.

(2.)   Scenario 6 versus Scenario 8

H_0:   The ARP Module is unable to link to the operations of the ATMS and OPAC.

H_1:   The ARP Module is able to link to the operations of the ATMS and MIST, and operators are able to place confidence in system responses with the exception of advanced traffic control under OPAC.

H_2:   The ARP Module is able to link to the operations of the ATMS and MIST, and operators are able to place confidence in all system responses.

H_3:   The ARP Module is able to link to the operations of the ATMS and OPAC, but this link is dominated by the link between the ATMS and MIST. OPAC irrelevant to system performance given the ARP link between MIST and the ATMS.

H_4:   Unanticipated alternative hypothesis.

This comparison also supports the third evaluation goal: measuring the benefits of coordination across freeway segments and arterial streets under conditions of non-recurrent congestion.

(3.)   Scenario 4 versus Scenario 6

H_0:   OPAC is unable to accommodate non-recurrent congestion under active diversion.

H$_1$:   OPAC is able to accommodate non-recurrent congestion under active diversion in a manner comparable to Multisonics or other Time of Day control.

H$_2$:   OPAC is able to accommodate non-recurrent congestion under active diversion in a manner superior to Multisonics or other Time of Day control.

H$_3$:   Unanticipated alternative hypothesis.

This comparison also supports the third evaluation goal: measuring the benefits of coordination across freeway segments and arterial streets under conditions of non-recurrent congestion. This comparison also supports Task B.

(4.)   Scenario 2 versus Scenario 4

H$_0$:   SWARM is unable to perform as ramp metering system in a manner comparable to that of the existing metering scheme.

H$_1$:   SWARM is able to perform as ramp metering system in a manner comparable to that of the existing metering scheme.

H$_2$:   SWARM is able to perform in a manner superior to that of the existing metering scheme.

H$_3$:   Unanticipated alternative hypothesis.

This comparison supports the first and to a lesser extent the second evaluation goals: measuring the benefits an operator acceptance of adaptive ramp metering under conditions of recurrent and non-recurrent congestion.

(5.)   Scenario 2 versus Scenarios 4, 6, and 8

H$_0$:   SWARM cannot be integrated with the ATMS environment.

H$_1$:   SWARM can be integrated with the ATMS environment.

H$_2$:   SWARM enhances the ATMS environment.

This comparison also supports the second and to a lesser extent the first second evaluation goals: measuring the benefits an operator acceptance of adaptive ramp metering under conditions of recurrent and non-recurrent congestion.

A.3.5   Diversion

The comparisons listed in Table A1 all include active versus passive diversion. The effects of the diversion message are combined with the effects of the corridor control measures. Diversion information will be announced through freeway Changeable Message Signs (CMS). In some cases, the message to divert will be passive (CONGESTION AHEAD), and in some cases active

(CONGESTION AHEAD: ALTON AVAILABLE). Under crisis conditions, the message will be explicit and urgent.

Response to information on CMS has not been systematically investigated at the scale made possible by the FOT. In all cases, drivers' diversion decisions will vary. Some drivers may change their route immediately, some may do so later, and some drivers will persist on their original route, regardless of the incident or messages prompting the diversion. It is desirable to measure the degree of diversion prompted by an active diversion message separate from diversion's managed effects on the system (freeways and arterials). The following hypotheses relate to diversions.

(1.)   Scenario 2 versus Scenario 4

   H_0:   There is no change in the probability of diverting from the freeway if passively informed to do so when SWARM is operating.

   H_1:   There is a decrease in the probability of diverting from the freeway if passively informed to do so when SWARM is operating.

   H_2:   Unanticipated alternative hypothesis.

(2.)   Scenario 4 versus Scenarios 6 and 8

   H_0:   There is no change in the probability of diverting from the freeway if actively informed to divert rather than if passively informed to divert.

   H_1:   There is an increase in the probability of diverting from the freeway if actively informed to divert rather than if passively informed to divert.

   H_2:   Unanticipated alternative hypothesis.

A.4   Data Requirements

A.4.1   Data Sources

The primary sources of data for corridor evaluation are

(1.)   vendor and sponsor defined sources; including

   •   information routinely made available to operators by the systems deployed, and

   •   nonproprietary test data;

(2.)   ramp and mainline loop detectors, including any post-processed volume detector data normally made available by the Caltrans District 12 TMC;

(3.)   arterial upstream and stop line loop detectors; including any post-processed volume detector data normally made available by ITRAC;

(4.) Caltrans District 12 TMC and ITRAC operator logs (manual and automatic);

(5.) Caltrans District 12 TMC and ITRAC video cameras and videotapes;
(6.) floating cars fielded for Task;

(7.) manual ramp counts and surveys;

(8.) simulation (if appropriate);

(9.) interviews with Caltrans District 12 TMC operators and ITRAC staff; and

(10.) Irvine FOT technical committee and other special meetings.

Primary measures available from ramp and mainline loop detectors include lane volumes in vehicles per hour, travel speeds estimated from volume and occupancy data, approximate queue lengths on ramps. Delay and stops data will be available from floating cars fielded for Task B. Floating car data provides a measure of vehicle hours and miles traveled through subareas of the network, including average length time in intersection queues. Video cameras operated by Caltrans and the City of Irvine are important sources of information about ramp performance and diversion rates from Interstate 5. All information regarding system operations are very important to the evaluation. Loop detector and video resources in the Caltrans District 12 TMC and Irvine ITRAC center are being documented. It is possible that simulation will be used for data on fuel consumption and emissions impact, but this is a secondary objective.

The evaluation of the Irvine FOT is based on a before and after study comparing the baseline system with the system state under an alternative control technology. Logically, two sets of data must be collected

(1.) Conditions under existing (baseline) control systems (Scenario 2 or Scenario 4); and

(2.) Conditions under new corridor control measures (Scenario 6 or Scenario 8).

A.4.2 Establishing the Baseline

The obvious baselines are Scenario 1 for Task B and Scenario 2 for Task A. These scenarios consist of Caltrans District 12's current metering scheme and the time of day traffic control scheme used by the City of Irvine. If SWARM is not evaluated, the base line for corridor evaluation becomes Scenario 4.

In addition, the evaluators will document current ramp metering and signal timing mechanisms, and telemetric data sources including

(1.) detector data (volume, occupancy)/loop locations for freeway segments;

(2.) video data/location/fields of view for freeway segments;

(3.) time of day plans (age of plans) for ramp meters;

(4.)   detector data (volume, occupancy)/location locations for arterials;

(5.)   video data/location/fields of view for arterials;

(6.)   time of day plans (age of plans) for arterials;
(7.)   system logs;

(8.)   reports (hardcopy, tape, other media); and

(9.)   current decision rules with respect to timing changes.

A.4.3   Control Area (Control Net)

Demand patterns will vary across the corridor. The network is subject to different daily and hourly traffic patterns, and thus different levels of recurrent congestion. Evaluation of corridor performance must account (control) for these differences. Observations on network states must be controlled for seasonal, time of week, and time of day, and special event effects.

The before and after design imposes considerable control with respect to treatment effects. Still, the evaluation might be improved by a redundant comparison against a spatially distinct control network subject to the same traffic demands as the test network, yet exempt from test control strategies. This would help control for temporal effects not obvious in the results provided by a before and after study. For example, a control area would provide a benchmark for and identify changes in demand. Such a control area should have both arterial and freeway components. Potential arterial locations for this control area are Alton Drive (West of the study area) or Michelson Avenue (Southwest of the study area), both of which parallel I-405 through the City of Irvine. Throughout the study, conditions along the Alton corridor can be compared with conditions existing in the control area. Much depends on the level of detectorization and video resources available in these areas. The role of the control net is summarized in Figure A5.

A.5   Evaluation Test Procedures

Data collection for evaluation of corridor performance will be as concomitant as possible with data collection for arterial performance under non-recurrent conditions. As noted above, incidents will be simulated by closing one or two freeway lanes in corridor. The geometry and location of the closure is a function of telemetry resources, field of view for Caltrans District 12, and ITRAC cameras, District 12 concurrence on procedures.

A.5.1   Comparing Selected Scenarios

Scenario combinations will be compared as follows. This procedure will be made as standard as possible for all comparisons. There will be one dry run executed prior to data collection. The dry run will be coordinated with an arterial floating car exercise but without a lane closure. Under base line conditions, vehicles will be passive instructed to divert (F CMS = CONGESTION AHEAD). Arterial LOS will be measured based on floating car studies executed by UC Irvine personnel with assistance from USC personnel. This effort will be coordinated with Task B. Resources permitting, probe vehicles may also be used to assess freeway conditions, but it is more important that probe vehicles be available to assess LOS on the arterial network. Consequently, freeway level of service will usually be measured based on volume, occupancy, and estimated speed data from freeway loop

detectors. These data sources will be redundantly reinforced with time stamped videotapes of traffic flows across arterial and freeway loop locations. The upstream location of the shockwave front will be estimated from loop detector data and video data. Volume, occupancy, derived or space mean speeds, and queue length will allow estimation of aggregate delay on the freeway.
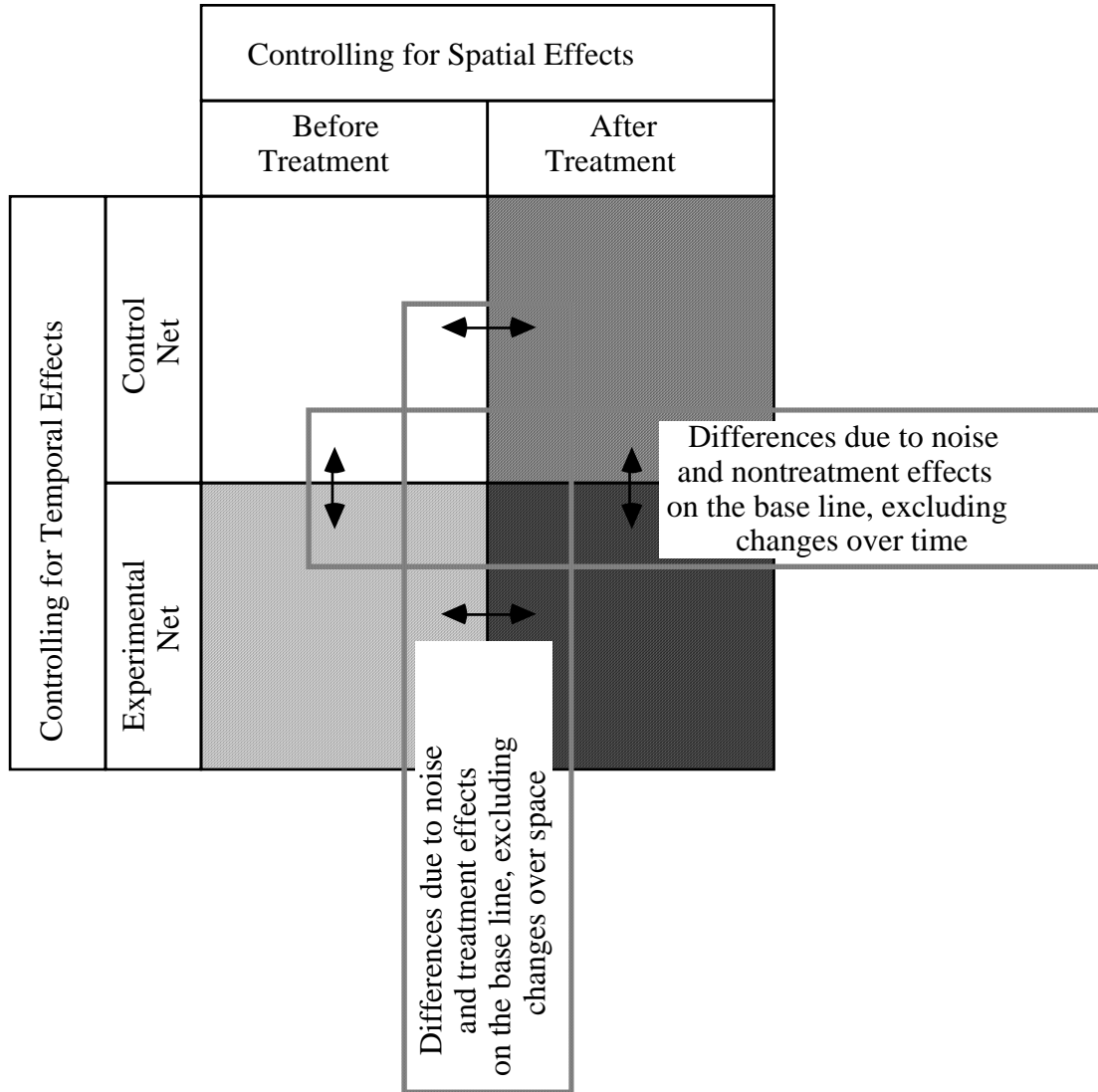
Figure A5: Changes in System States Across Treatment and Control Dimensions.

A.5.2 Measuring Diversion Rates

It will be important to relate changes in arterial LOS to the degree of diversion that takes place from the freeway. Consequently, diversion rates must be measured carefully. The evaluation team is considering the following options.

(1.)   Headlight survey method

In response to a scheduled lane closure, a message is put on the freeway CMS system telling drivers to divert and turn on their headlights. Personnel posted at the off-ramps can

count vehicles and vehicles with their headlights on, and/or the ramps can be videotaped using Caltrans cameras.

2.) Passive vehicle survey method

In response to a scheduled lane closure, a message is put on the freeway CMS system telling drivers to divert. Personnel posted at the off-ramps count vehicles, insert colored tags under windshield wipers, and vehicles with tags returning to the freeway are counted or videotaped at downstream on ramps.

(3.) Active vehicle survey method

A post card survey costs less than a full scale survey effort, but still provides considerable information about diversion decisions. In response to a scheduled lane closure, a message is put on the freeway CMS system telling drivers to divert. The post card method surveys the diversion fraction by distributing pre-printed survey post card to the drivers. Personnel posted at the off-ramps count vehicles pass out mail back post card surveys to vehicles exiting the freeway. The post cards are pre-paid by the receiver, and contain the following

- An explanation on the survey,

- "What are your trip origin and destination?, "

- "Did you see the freeway incident notice on the message sign?," and

- "Did you change your route due to the freeway incident notice on the message sign?"

(4.) Traffic volume changes

Historical approaches provide a redundant mechanism for estimating diversion. This method requires detailed traffic volumes at exit are available. Recurrent volumes for a given time of day are identified. Given the ambient volumes for each freeway segment, the volumes for the incident condition can be compared to estimate the increased exit volume associated with diversion. Once an incident is declared, the volumes at exits and freeway segments are measured. Uninterrupted freeway traffic demand on upstream freeway segments is used to adjust historical volumes on the affected segments. By comparing historic and incident volumes on affected segments for the specific time of day, the estimate the net increase in exit volume can be estimated. Presumably this difference accounts for the effect of diversion.

(5.) The approaches listed above might be applied individually or in combination.

A.5.3 Tactical Procedures: Primary Data Collection

Primary data is data collected during scheduled freeway lane closures. Primary data collection requires coordination across Caltrans District 12 maintenance personnel, Caltrans District 12 TMC operators, City of Irvine ITRAC center operators, the USC evaluation team, and the UCI evaluation team's efforts regarding Task B.

(1.) Telemetry

- Identify the locations and operational status of all City of Irvine and Caltrans District 12 loop detectors.

- Identify the locations of pending loop installations associated with the FOT. The collaborating partners are FSI and the City of Irvine.

- Identify the locations, operational status, and fields of view of all City of Irvine and Caltrans District 12 traffic video cameras.

- Arrange for time stamped, videotape record making in the City of Irvine ITRAC center and the Caltrans District 12 TMC.

- Arrange for electronic record making in the City of Irvine ITRAC center and the Caltrans District 12 TMC. These electronic records will be accumulate loop detector data in electronic media. Mainframe tapes are acceptable if readable at USC, but diskettes or tape cartridges are preferred.

- Document lane geometries of freeway segments and ramps. The collaborating partner is Caltrans District 12.

- Based on lane geometries and video fields of view, select freeway on and off ramps to be subject to video surveillance during lane closures.

- Select additional off ramps for placement of USC and/or UCI survey personnel as needed.

(2.) Field Schedules

- Schedule early Fall, 1996 lane closures to collect baseline or sub-baseline traffic data (Scenarios 4 and 2).

- Schedule late Fall, 1996 or early Winter, 1997 lane closures to collect quasi-experimental traffic data (Scenarios 6 and 8).

(3.) Data Collection Procedure: Scenario 4 (Corridor Baseline).

- ITRAC implements time of day traffic control. The ARP module is not engaged.

- Telemetric recording in the ITRAC and TMC facilities begins.

- District 12 closes maintenance lanes during the afternoon peak period and posts a passive diversion message on the freeway changeable message signs (FCMS = CONGESTION AHEAD).

- UC Irvine floating cars enter the arterial network. If available, additional probe vehicles will also traverse the freeway. Floating cars do not enter the control net.

- Approximately two hours of peak period traffic data are taken, depending on media storage constraints.

(4.)   Data Collection Procedure: Scenario 6 (OPAC Without Corridor Coordination).

- ITRAC uses OPAC to optimize arterial control. The ARP module is not engaged.

- Telemetric recording in the ITRAC and TMC facilities begins.

- District 12 closes maintenance lanes during the afternoon peak period and posts an active diversion message on the freeway changeable message signs (F CMS = CONGESTION AHEAD: ALTON AVAILABLE).

- UC Irvine floating cars enter the arterial network, with particular attention to Alton. If available, additional probe vehicles will also traverse the freeway. Floating cars do not enter the control net.

- Approximately two hours of peak period traffic data are taken, depending on media storage constraints.

(5.)   Data Collection Procedure: Scenario 8 (Full Corridor Coordination).

- ITRAC uses OPAC to optimize arterial control. The ARP module is engaged. An arterial response plan will be used to restrict or otherwise modify OPAC parameters and designate postings for changeable arterial message signs.

- Telemetric recording in the ITRAC and TMC facilities begins.

- District 12 closes maintenance lanes during the afternoon peak period and posts an active diversion message on the freeway changeable message signs (F CMS = CONGESTION AHEAD: ALTON AVAILABLE).

- UC Irvine floating cars enter the arterial network, with particular attention to Alton. If available, additional probe vehicles will also traverse the freeway. Floating cars do not enter the control net.

- Approximately two hours of peak period traffic data are taken, depending on media storage constraints.

(6.)   Data Collection Procedure: Scenario 2 (Corridor Sub-Baseline).

- The TMC does not engage SWARM. The existing ramp metering scheme is imposed.

- ITRAC implements time of day traffic control. The ARP module is not engaged.

- Telemetric recording in the ITRAC and TMC facilities begins.

- District 12 closes maintenance lanes during the afternoon peak period and posts a passive diversion message on the freeway changeable message signs (F CMS = CONGESTION AHEAD).

- UC Irvine floating cars, if available, enter the arterial network. If available, additional probe vehicles will also traverse the freeway. Floating cars do not enter the control net.

- Approximately two hours of peak period traffic data are taken, depending on media storage constraints.

A.5.4 Tactical Procedures: Secondary Data Collection

Secondary data is data collected during unscheduled freeway incidents and accidents affecting capacity. The resources inventoried for collection of primary data also support collection of secondary data. In the case of secondary data, the Evaluation Team serves only a post processing roles. Collection of secondary telemetric and video data will necessarily be accomplished by Caltrans District 12 TMC and City of Irvine ITRAC center personnel. Procedures for collection of secondary data will be defined and documented as resources and schedules for collection of primary data are arranged.

A.5.5 Statistical Analysis / Summary of System Treatments

The USC team will undertake a statistical analysis of the data with the objective of identifying systematic changes in the network state resulting from the implementation of corridor elements, and will support the UCI team's analysis of OPAC and arterial effects.

A full set of measures of effectiveness have not yet been determined. However, standard traffic engineering measures will be applied to the experimental data. Obvious candidates are point-to-point travel times, intersection delay, ramp delay, mainline travel times. This empirical information will be combined with historical traffic data from Caltrans District 12 and Irvine to estimate corridor wide benefits.

This approach offers a number of advantages including,

(1.)   a well understood set of procedures that can subjected to numerous extensions;

(2.)   a minimal number of parametric assumptions. At the extreme, entirely non-parametric procedures are available;

(3.)   the opportunity to incorporate a variety of measures for treatment effects, including data available from telemetry, and data collected by the UCI team on intersection delays, intersection queue lengths, intersection stops, ramp delays, non-recurrent delays, and ramp queue lengths; and

the means to identify systematic changes in the network state resulting from the implementation of corridor elements.

While the primary responsibility for these studies rests with the USC team; the UCI team will be involved in several components of these studies, including the selection and collection of appropriate data. In particular the UCI floating car studies will be coordinated with the USC corridor study.

	Traffic Conditions without Freeway / Arterial Coordination via ARP Module	Traffic Conditions with Freeway / Arterial Coordination via ARP Module
Traffic Conditions without OPAC	Scenario 4: Within group variance due to randomness in traffic flows	Unobserved: Within group variance due to randomness in traffic flows, between groups variance due to ARP module
Traffic Conditions with OPAC	Scenario 6: Within group variance due to randomness in traffic flows, between groups variance due to OPAC	Scenario 8: Within group variance due to randomness in traffic flows, between groups variance due to OPAC, ARP module, and interactions between OPAC & ARP module

Figure A6: Two Lay-Out for Corridor Data Analysis.

Multivariate Analysis of Variance (MANOVA) in corridor traffic data will take place across the two dimensions. Figure A6 summarizes the layout for the data collection design. SWARM is suppressed. If evaluated it will be handled under a separate layout.

The emphasis on telemetric data sources requires considerable post processing of both primary and secondary data. There is a trade-off between the effort the FOT partners make in providing telemetric access and the speed with which the data provided by these measures can be analyzed. The more carefully telemetric resources can be organized prior to data collection, the more secondary data can be taken and the more quickly results can be generated and disseminated.

A.6   Schedule

The tentative schedule for Task A appears in Figure A7.

Figure A7: Tentative Schedule for Irvine FOT Evaluation Task A.

A - 25

DRAFT SCHEDULE OF TASKS - TASK A: EVALUATION OF IRVINE FOT CORRIDOR PERFORMANCE

Project Planning and Preliminary Data Assessment

Literature Review

Evaluation of Design
Data Requirements

Sampling Frame

Baseline Sample

Data Collection

Data Analysis

Generalization of Results

Final Report

Associate Professor Jim Moore

1 Graduate Research Assistant III

Meetings with Project Team,
Evaluation Team, and PATH

September 1994
November 1995
December 1995
January 1996
February 1996
March 1996
April 1996
May 1996
June1996
July 1996
August 1996
September 1996
October 1996
November 1996
December 1996
January 1997
February 1997
March 1997
April 1997
May 1997
June1997
July 1997
August 1997
September 1997
October 1997
November 1997
December 1997

APPENDIX B: Overview of Irvine Field Operational Test Technologies

B.1   Pre-FOT Traffic Control System

B.1.1   Multisonics Signal Control

The FOT would have replaced Irvine's existing Multisonics VMS-330 traffic signal control system in the test area. The VMS-330 system could control 256 intersections simultaneously with a maximum of eight system detectors, eight vehicle detectors, and eight pedestrian detectors per intersection. The system had a master processor and a maximum of sixteen Network Processing Units (NPUs). Each NPU had four telemetry channels, and each could communicate with four Intersection Control Units (ICUs). The system used a battery back-up real-time clock to maintain correct system time in the event of a power failure. For mass data storage, the VMS used two forty megabyte hard drives. The VMS supported five input/output (I/O) devices, including a hard-copy device, a local high-speed CRT, a remote CRT communicating through a dial-in telephone port, a second hard-copy device in the maintenance shop, and a high-speed line printer.

Users could retrieve the surveillance data through displays and reports. The system allowed operators to issue traffic control commands and set parameters automatically as a function of time-of-day/day-of-week (TOD/TOW). The operators used VMS to perform operational tests to determine faulty controller and/or detector operation. The operator could also designate remedial VMS actions after identifying defective controllers and/or detectors. With a portable (remote) operator's terminal, a telephone jack, a 120 volt 60 Hz outlet and the current system security password, operators could dial-in to the VMS system using telephone company lines. The VMS-330 included a wall map displaying commands and feedback for all communicating intersections, and detailed specific operation modes and status. City of Irvine staff believed these features provided a solid traffic control foundation, and hoped to improve congestion in the Alton Parkway corridor by implementing changes during the FOT.

Multisonics developed its VMS-330 traffic signal control system to improve traffic operations within a network using standard NEMA phasing and by coordinating related signals. A Background Cycle System (BCS), with various control inputs such as Offsets, Cycle Length, Phase Sequence, and Splits, provided system coordination functions. The VMS operator could identify various inputs for calculating the background cycle, including:

- Each intersection had a Sync Point offset from other intersections in its pattern. The VMS referenced each local intersection's Sync Point (T_0L_x) to the Group Sync Point (T_0), which controlled the Background Cycle starting point.
- Each intersection had a green Sync Phase or Phases at the Sync Point; allowing a platoon of vehicles to pass through the group without stopping.
- Each intersection used a Split Set to allocate cycle time among intersection approaches. These Splits defined the maximum phase times during any given cycle; however, any phase could use less than its allocated Split (except in fixed-time operation).
- The operator sometimes needed to assign intersection Ped Splits that differed from the standard Splits to allow for pedestrian movement. These Ped Splits identified the phase or phases to shorten for extra Ped Time. The user made a system-wide selection to make the

Ped/Vehicle Split decision at either the earliest Sync Phase Force-Off or the B to A barrier crossing.

- The user could assign a Vehicle Minimum to each phase to determine which phase might service or re-service a cycle while allowing the Sync Phase to turn green by the Sync Point.
- The user might also choose to assign a Ped Minimum Walking Time to control the length of a "WALK" indication at the intersection.
- The operator sometimes assigned each Sync Phase a minimum green time following the Sync Point. VMS-330 permitted the user to select a cycle length from 30 to 250 seconds.

VMS-330 allowed operators to vary the basic Background Cycle Coordination. When an intersection experienced cross-street demand but no lagging phase demand, each leading phase would be extended by an amount equal to the following lagging phase time, minus the leading phase clearance time. VMS-330 could designate what phases to service out-of-sequence given sufficient cycle time. VMS-330 could also return to the Sync Phase by recalling each Sync Phase to minimum or maximum. The operator programmed the number of transition period cycles when changing from one pattern to another. VMS-330 permitted each phase to extend past the end of its Split as long as: no intervening calls prevented the Sync Phase from starting at its assigned time; and there was no Sync Phase demand.

B.1.2 The Irvine Transportation Management Center (ITRAC)

The City of Irvine developed the Irvine Traffic Research and Control (ITRAC) Center to monitor, manage and research traffic within the City. ITRAC would have monitored and responded to real-time traffic data transmitted from signalized locations throughout the city. Irvine chose to use a variety of electronic surveillance and detection systems, however, video cameras were the primary system. The ITRAC Center controlled each camera's view in order to identify and respond quickly to any non-recurring congestion. Video image detection systems provided Irvine traffic engineers with access to real-time traffic counts, occupancy, speed, delay, and signal operations data.

ITRAC was designed to share information with commuters via traveler access to real-time data at interactive kiosks placed at traffic generators and transit facilities throughout Irvine. The Irvine Transportation Center, a Metrolink station, represented Irvine's most extensive installation of traveler information services. The Metrolink station had a fully-staffed Tourist and Traveler Information Center, in addition to the interactive kiosks, providing personalized information. ITRAC planned to use changeable message signs to advise commuters of traffic congestion and road conditions. ITRAC would share data with the University of California, Irvine where researchers would refine traffic models to help Irvine predict and plan for the future.

The City of Irvine hoped that ITRAC would reduce travel delay and fuel consumption, improve air quality and safety, and enhance the capacity of existing roadways. The City of Irvine had the opportunity to pursue several options for funding the ITRAC construction; however, full funding sources for ITRAC were not identified.

B.1.3 The Caltrans D12 Ramp Metering System

Prior to the FOT, the Caltrans District 12 RMS used pre-timed, time-of-day (TOD) metering, local traffic-responsive metering techniques, and an automated central override to control vehicles entering congested freeways. In addition to these ramp-metering approaches, Caltrans operators

could use a manual or a scheduled override to input a different metering rate manually. Further, operators had the option of turning controllers on or off. When Caltrans metered a ramp using TOD metering, the traffic signal operated at a fixed rate. Caltrans calculated these pre-timed metering rates from historical data that related the ramp flows to the demand and capacity of the freeway.

Caltrans used local traffic-responsive metering as another control strategy. The local Type 170 controller adjusted the metering rates continuously based on the real-time traffic conditions on the adjacent mainline freeway lanes. The controller used real-time occupancy data upstream of the entrance ramp to adjust metering rates. Caltrans used the Central Override Ramp Metering (CORM) algorithms to supplement the TOD tables stored in the Type 170 controllers. The controller used TOD rates unless the CORM rate allowed more vehicles to enter; however, operators at the TMC could override these rates with their own values.

Caltrans had eleven available CORM algorithms which each attempted to maximize the number of vehicles entering a freeway while maintaining freeway operations below saturation conditions. The basic CORM algorithm used a predicted demand and actual capacity to generate metering rates for a particular ramp. Caltrans computed predicted demand from information at upstream and intermediate stations. The algorithm used the capacity at the metered location to determine residue capacity. The CORM algorithm selected the metering rate by allocating all of the residue capacity to the ramp. Caltrans derived the other ten algorithms from the first by varying slightly the demand (actual or predicted), the capacity (actual, total or spare), and the allocation of residual capacity among several ramps in a segment (direct, average or apportioned). Caltrans District 12 continued to use each of the three types of ramp metering approaches to try to alleviate recurring congestion.

The Type 170 controller preprocessed data from central computer mainline detectors. At each field location, a microprocessor collected detector data in thirty second segments and transmitted it to the central computer via commercially-leased telephone lines at 1200 BPS. The field controllers and central computer communicated with each other using the communications software task resident in the host computer. Each field detector returned volume and occupancy data in a sixteen bit format. The controllers transmitted a total of eighty-eight bytes to the central computer. Meanwhile, the 170 controller memory stored the most current five minutes of 30-second data. MODCOMP and the RMS communicated via a host-to-device type interface physically connected through leased telephone lines. The RMS and loop detector data used one transmit buffer to transmit information back to MODCOMP.

The current system issued four different commands to the Type 170 controllers. A "30 second poll" command requested the controller to transmit its data to MODCOMP. Once every hour, Caltrans issued a "time change" command to the controller to synchronize its time reference. The "change memory" command downloads memory to the 170 controller; this command could also change controller parameters. The final command, "send memory," read the Type 170 controller residence program parameters and data. Caltrans District 12 used these four commands to communicate with all of the Type 170 controllers.

B.1.4 D12 2 TMC Operations

The institutional assessment included interviews with Caltrans District 12 TMC personnel. Most significantly, it is clear that this staff had little knowledge of the FOT and the planned integration of the TMC with ITRAC.

B.1.5 Interviewed Participants

1. Mahesh Bhatt   Chief of Traffic Management Branch
2. Paul King   Transportation Engineer
3. Raj Gohil   Transportation Engineer Technician
4. Tariq Baha   Student Assistant

B.1.6 TMC Management

The Supervisor (Mahesh Bhatt) heads the TMC and manages Transportation Engineers (as lead people), and Technicians who handle the daily operations of the center. Students assist with daily reports and system operations. On a typical day (Monday to Friday, 5:00am to 9:00pm), one lead person, two technicians, and one student in the operations area staff the D12 TMC along with a Caltrans communications supervisor, two dispatchers, and one CHP officer. A CHP Lieutenant also has an office in the TMC. A communications dispatcher and student assistant work from 9:00pm to 2:00am and one person works the graveyard shift from 9:00pm to 5:00am.

B.1.7 The D12 ATMS

Computer-Aided Dispatch (CAD) conveys CHP dispatch information on incidents directly to the TMC operator. CAD information includes the location and time of incident, lanes affected, and severity. The following priority codes classify severity: 1 is a pursuit or 1144 (fatality) – the most severe case; 2 is an 1179 (injury); 3 is an 1125 (traffic hazard); and 4 is an 1126 (vehicle on side of road) – the least severs incident. CHP updates the CAD information every second and removes an incident from the CAD list as soon as it is cleared.

Closed Circuit Television (CCTV): There are operational CCTV cameras at 80 different locations throughout District 12. Operators can control all cameras from the TMC ATMS computer terminals. CCTV cameras allow operators to visually verify incidents and keep up-to-date on incident status. According to the interviews, D12 uses CCTV primarily for incident verification.

Changeable Message Signs (CMS): There are CMS at various locations throughout D12. Once a verified incident causes major congestion, operators can turn on the CMS from the TMC ATMS computer terminals. Any confirmed minor incident, which might be a traffic hazard, merits turning on a CMS message. Operators choose from a set of standard messages (e.g., right lane closed ahead, congestion ahead, etc.) based on training. There is no computerized library of messages, only guidelines. A lead person must usually approve a message, and operators often consult a co-worker. An experienced staff member must be involved in the message decision, and supervisors help with composition of complex messages.

From the interviews, it is clear that the TMC operator's sole duty is monitoring and responding to incidents. The set process for using the ATMS system involves: continuous monitoring of the CHP CAD incident log; visually verifying suspected incidents via CCTV; activating CMS when necessary, and maintaining communication with CHP.

Traffic Management Team (TMT): The TMC calls upon the TMT when a major incident requires a major freeway closure or lasts longer than an hour. The TMT goes to the location of the incident and determines a plan of action (i.e., set up portable message signs, set up a detour). The TMT

notifies the TMC and gives instructions (e.g., turn on CMS describing detour, notify the media). The TMT is responsible for re-routing traffic via CMS, operators do not have this authority. Operators can use CMS only to warn commuters of congestion with a set of standard messages.

Expert System: This system is in place, although it is still in development. Neither the D12 TMC nor the TMT currently consult the expert system during incident response. The TMT usually checks the graphics to determine the location of queues, otherwise it relies on information from the field.

ATMS Computer Terminals: The D12 ATMS computer system brings together all of the above tools (CCTV, CMS, and Loop Data). From a terminal, operators can view any of the CCTV locations, activate/edit CMS, and view traffic flow characteristics via the Loop Data.

Before installation of the new system, Orange County Loop Data, a line of raw numbers, went through the District 7 system, to the City of Anaheim, then to D12. The Loop Data updated every 30 seconds on a monitor. Today the Loop Data is sent directly to D12. The data also represents the traffic flow on all highways in D12 graphically. Operators can monitor a graphic display of the entire D12 network, which is covered with colored dots that represent loop detector locations. The colors of the dots represent varying traffic patterns (e.g., green=45 mph or higher, red=20 mph or less). In addition, the operator can click on any loop location and obtain raw data.

B.1.8 Loop Maintenance

Standard policy requires maintenance personnel to check loops every 90 days. In every cabinet, there is a 90-Day check off log that records date of inspection, problem, work performed, and inspector. This is the only record of loop inspection; there is no additional log at the district office. Caltrans maintenance is extremely understaffed, and often checks loops less frequently than every 90 days. Furthermore, loop repair is costly and irregular. In order to install a new loop and run the conduit back to the cabinet, Caltrans must close the entire freeway in order to work in a safe manner (Safety First). Therefore, when loops go down, it takes quite some time before they are replaced.

B.1.9 Baseline System

Current Ramp Metering System: Metering rates are pre-programmed, and only authorized staff can adjust them from the office.

Current Traffic Signal Control: The TMC does not have download capability for traffic signal control. Only certain signal timing staff have limited signal control from the office. D12 does implement time-of-day plans; it programs timing into the controllers in the field on a master controller for interconnected intersections.

B.1.10 FOT Technologies

SWARM: SWARM is installed and has been on intermittently. It is currently under evaluation.

ODSS: Interview respondents provided no information on this topic.

ITRAC Intertie: A TMC engineer did not know why the tie with Irvine was not operational. The only explanation was that the TMC would be moving and it would not be sensible to tie the current TMC

to the City of Irvine then. The D12 TMC communicates with ITRAC by phone and also receives video input.

Ramp Metering Group: According to the TMC, the D12 Ramp Metering Group trouble-shoots traffic data to keep the graphics system running. They also provide the TMC with support for workstations and PCs.

B.2   Proposed FOT Technology: OPAC

For this FOT, PB/FSI planned to use the on-line signal timing optimization algorithm called the OPAC distributed signal control strategy. OPAC features a dynamic optimization algorithm that calculates signal timing to minimize a performance function of total intersection delay and stops. PB/FSI planned to implement OPAC-RT by installation at each intersection running on a processor in controller cabinets at each intersection. The algorithm transmitted force-off and yield commands to the intersection controller. The strategy failed to employ a fixed cycle length; instead, its phase duration remained constrained by maximum and minimum green times.

OPAC used modeled and measured demand to select phase durations. OPAC measured demand by detecting traffic on each approach link. MIST downloaded other optimization parameters OPAC used, such as the initial algorithm settings, including the distance of the OPAC-RT sensors from the stop bar, the average link speed, the weighting factor for stops for the optimization algorithm, and the fixed interval durations for each controller. MIST also needed to download the defined minimum and maximum durations for each controller phase to the 2070 ATC. OPAC-RT optimized its delay and stops function in intervals of 2-5 seconds, and determined when to terminate the current phase.

OPAC is a demand-responsive strategy for traffic signal control (Gartner, 1983), initially designed for controlling two-phase intersections. Gartner's continued work on OPAC development (1987) involved a simulation study analyzing three different OPAC installations: an isolated intersection; a single intersection on an arterial; and a single intersection on the edge of a network. In each of these studies, the OPAC-controlled intersection operated two-phase intersections without communicating with the other intersections. Gartner also simplified OPAC's optimization procedure to enable real-time OPAC operation. He divided the control periods into stages with lengths ranging from 50 to 100 seconds. During each stage, OPAC would change signals one to three times. Gartner's optimization process improvements made OPAC viable for real-time implementation, but the process still needed accurate future arrival information for the entire stage.

OPAC supplied the data necessary to implement a rolling horizon approach to complement the optimization process. Gartner divided each stage into equal steps. For the initial steps, (referred to as the "head" of the stage), OPAC could obtain actual arrival information from upstream traffic detectors. However, for the remainder of the stage (referred to as the "tail" of the stage), OPAC had to estimate flow data from either a model or data collected during previous stages. Next, OPAC determined an optimal policy for the entire stage, but implemented it only for the head portion of the stage. The head section length needed to equal the free-flow travel time from the system detectors to the stop line. After each implementation, OPAC shifted its horizon forward by a length of time equal to the head portion, and repeated the entire process. Using this technique, OPAC estimated some necessary data, but only implemented its optimal control policy for the stage portion where it could calculate data directly.

Gartner (1987) wrote, "Passage detectors [system detectors] would be placed as far upstream as possible (typical[ly] 400-600 feet, depending on block spacing). There would be one such detector in each lane." Placement of the system detector required identifying all traffic on approaches. Further, OPAC must be able to use long rolling horizon head periods to minimize the number of calculations. Gartner later emphasized the importance of placing system detectors well upstream (ten to fifteen seconds travel time) to obtain actual arrival information over the head period. The user could choose any roll period, not necessarily equal to the head period. However, a shorter roll period implied more calculations and, generally, closer to optimum results. Therefore, PB/FSI's OPAC-RT version 3.0 needed detectors well upstream of the intersection to supply the actual arrival information that the OPAC algorithm used.

Later, Gartner (1991) described the results of three field tests using a new Version 2.0 of OPAC-RT that performed dual-ring, eight-phase operations. Actually, the new version merely incorporated some enhancements of the original two-phase version of OPAC. OPAC-RT Version 2.0 effectively controlled the signal timing at an isolated intersection; however, OPAC controlled only the major, typically through phases. OPAC relied on the usual "gap out/max out" actuated strategy to control the minor phases, typically the left-turn phases. Throughout the control period, OPAC stored system conditions such as phase returns, HOLD release times, walk requests, time of errors, detector occupancies, and arrival patterns.

PB/FSI and Gartner continued to improve OPAC-RT and produced OPAC-RT Version 3.0, the most recent version. This version now optimized and controlled all phases in a standard NEMA configuration. To minimize the number of considered phase termination point combinations, the timing algorithm calculated timing ranges for the next barrier. OPAC-RT needed to execute the algorithm in less time than the interval length, two to five seconds; however, an exhaustive search routine required thirty seconds for execution. Therefore, PB/FSI modified the search algorithm to incorporate a "valley-descent" optimization technique to reduce execution time.

OPAC-RT Version 3.0 change minimum green intervals dynamically to account for pedestrian phases. When the system detected a pedestrian actuation, OPAC-RT added the pedestrian clearance time to the minimum green time. This solution was a simple but effective method enabling OPAC-RT to handle pedestrian calls.

For optimal performance, the OPAC algorithm required installing OPAC count detectors in the left turn pockets as well as the through lanes, or obtaining accurate counts from existing actuation detectors. PB/FSI developed several alternative methods for OPAC-RT Version 3.0 to calculate left-turn volumes. PB/FSI recommended their first option when queue volumes rarely filled the left-hand turn bay. This option assumed detector installation at the turn bay entrance, and that traffic rarely backed-up over the detector. Option One accumulated counts from the left-turn detectors on a per-interval basis. PB/FSI recommended the second option when the turn bay had short presence loops at or near the stop line. OPAC-RT accumulated counts from the presence loops for each cycle and smoothed the count exponentially at the end of each cycle. PB/FSI recommended Option Three if a site lacked reliable means for obtaining left-turn counts. With this option, an operator specified a fixed percentage of vehicles on a particular approach as left-turn vehicles.

PB/FSI also developed an enhanced queuing and discharging algorithm for OPAC-RT Version 3.0. This algorithm accounted for queuing vehicles that do not reach the stop line before stopping or delays. The algorithm maintained a current estimate of the front and back of the queue, based on

arrival and discharge patterns, speeds, and a user-specified average vehicle length. This new algorithm allowed OPAC-RT to more accurately model traffic as it approached and left a queue.

OPAC-RT Version 3.0 simulated platoon traffic in the projection horizon (or stage) tail. It collected arrival patterns by interval over a nominal time period for each detector. OPAC smoothed successive data periods to produce an expected arrival pattern. The algorithm incorporated a method for determining the start of platoons, and the headway between platoons. The algorithm used a smoothed value for platoon headway as the nominal period for collecting vehicle counts. Consequently, these nominal time periods fluctuated depending on changes in traffic patterns, and enabled the algorithm to respond according to changes in platoon characteristics. With this algorithm, OPAC-RT estimated future arrival patterns more effectively, thereby improving overall system performance.

PB/FSI used system detector data to develop dynamic speed and travel time calculations for OPAC-RT Version 3.0. OPAC used calculated dynamic speed and travel time values under the enhanced queuing and discharging algorithm. OPAC used a default speed when the algorithm lacked current data for calculating dynamic speed values. This feature integrated the entire system using more authentic real-time speeds and travel times.

Coordination and "rest in the green" phase are the newest features PB/FSI incorporated into the OPAC-RT Version 3.0 algorithm. If OPAC did not detect any demand on the opposing phases, the current phase would remain green regardless of maximum green time settings. To achieve signal coordination among multiple OPAC detectors, PB/FSI used similar phase parameters and modeled the platoons system detectors observed. PB/FSI hoped these latest features increased OPAC-RT algorithm effectiveness.

B.3   Proposed FOT Technology: MIST

PB/FSI also developed the Management Information System for Traffic (MIST) that provided a general development platform for customized traffic control systems including Intelligent Transportation Systems. MIST typically reduces the number of tasks transportation personnel normally perform and helps them move products and people more efficiently. MIST uses multi-tasking operating systems, such as OS/2 and UNIX, to provide powerful environments and user-friendly interfaces featuring pull-down menus. MIST systems display both graphic and text data; in fact, the MIST graphics editor can create, enhance, or edit system maps and/or graphics.

The MIST system uses IBM-compatible 386/486/Pentium PC computers in configurations including a stand-alone mode, Local Area Network (LAN), or distributed system. MIST can support remote workstations with graphic operator interfaces connected via dedicated communication lines. MIST-supported communications media include twisted pair, coaxial cable, fiber optics, radio (both UHF and spread spectrum), microwave, and dial-up telephone lines. MIST applications include signal, freeway, or traveler information systems.

B.3.1   MIST System Features

PB/FSI designed MIST with an open architecture to monitor and control field devices including signal controllers, variable message signs, or any other computer-controlled or monitored electronic device integrated into the system. As a result, MIST requires minimal customization for each new installation. Each MIST component serves a specific role, with a generic software kernel connecting

the components. Every MIST installation includes the required modules only; these are plugged together to form a system.

In addition to providing open system architecture, MIST permits many hardware configurations. Frequently, PB/FSI installed MIST in a Local Area Network (LAN) where each computer performed a specific task (e.g., DBMS, Communications, Operator Interface, etc.). However, a single computer can operate in stand-alone mode to control all system tasks. For coordinating among various independent traffic control systems, PB/FSI recommended implementing MIST in a Wide Area Network (WAN) configuration where independent computer systems share information, such as incident characteristics or traffic flow data. With multiple hardware configurations, MIST can adapt to many potential uses.

MIST uses a database management system supporting the SQL command language as a central repository of system information. This database stores system configuration data, user-defined parameters, status data, and data from field devices. Other programs have access to the system database through MIST's database sever, an application program. PB/FSI built system security features into MIST's software and database. MIST's System Administrator (SA) assigns access privileges to each user. A combination of user name and password identifies each user. The SA determines access rights (i.e., No Rights, Read Only Rights, or Unrestricted Rights) to every menu selection for each user.

MIST monitors all communications equipment, detectors, controllers, and other hardware devices at all times to detect and report malfunctions. Upon detecting a failure MIST can: generate an audible/visual alarm, dial a pager, or enter the failure in the system log. MIST differentiates between two types of equipment malfunctions, marginal conditions and failures. When MIST identifies a marginal condition, it updates the system log and displays the condition on a status display table. However, if MIST identifies a failure, it updates the system log, activates the audible alarm, displays the condition on a status display table, *and* alters equipment operating status.

MIST receives, processes, and stores all traffic data from surveillance system detectors and derives measures of effectiveness (MOEs) from this detector count, occupancy, and speed data. Detector MOEs condense the traffic flow data needed to develop traffic control timing plans and select traffic-responsive timing patterns. MIST seems to transfer system detector data into readily usable formats. MIST stores raw data for a user-defined time period.

MIST's reporting formats provide flexibility for varying user demands. MIST generates standard reports including equipment repair histories, database configuration, system status, traffic flows, user-defined, 123, and rotary file reports. PB/FSI designed the standard reports to provide an easily-read, informative summary of frequently needed information. With MIST 123 reports, users can access SQL database data or transfer it to separate spreadsheet applications. The rotary file format permits users to convert data to ASCII format for use in other software packages.

MIST uses time-of-day/day-of-week/day-of-year settings to schedule system commands and reports. MIST can schedule up to 1,000 functions per 24 hour period with one minute resolution. MIST uses two types of schedules. Permanent schedules store lists of events for each day of the week and generic holidays. Although the system automatically assigns a schedule for each day according to its day of the week, a calendar scheduler allows users to define other generic permanent schedules to preempt the automatic scheduling on any given day. Temporary schedules allow users to program special activities and one-time events. Permanent schedule functions do not change after

execution, however the system deletes temporary schedule commands after execution. Using activity scheduling, MIST can operate and report normally unattended for periods of time. Users can store each set of scheduled commands in a separate file for editing individually.

MIST appears capable of tracking maintenance and inventory activities. It generates maintenance reports showing repair activities, including dates and times, the names of the repairing technicians, and the location of equipment repairs. A failure summary provides the period of operation, the number of failures, the Mean Time Between Failures (MTBF) and the Mean Time To Repair (MTTR) for each specified equipment component. A bar graph also displays MTBF values. MIST's inventory features can identify equipment at specific locations and provide information on this equipment including the type, manufacturer, model, purchase date, warranty period, etc. PB/FSI recommended a combination of a bar code reader with MIST's inventory/maintenance functions to enhance performance.

B.3.2 MIST Traffic Signal System Features

MIST supervises local intersection operation through distributed control of individual traffic signal controllers. The system typically communicates directly with local traffic signal controllers, however, it can also communicate with on-street area masters. Users can up and download to and from a local controller database. Local controllers return acknowledgements when they receive the data correctly, and MIST automatically retransmits if the controller does not receive the data. Using MIST, operators can access each traffic signal controller in the system to adjust controller parameters.

PB/FSI attempted to design MIST traffic control functions with the best characteristics of both the Urban Traffic Control System (UTCS) and the closed-loop system. MIST's traffic responsive algorithm uses the UTCS-type pattern matching algorithm for plan selection. MIST performs system commands in traffic-responsive, time-of-day, manual, free and flash modes, on an intersection, section, or system-wide level. During traffic-responsive operation, MIST uses its master/slave section locking feature, to prohibit sections from choosing their own timing plans, and to make multiple sections behave as one system. MIST automatically generates the necessary algorithm inputs from the historical database. The system also maintains a permanent record of all significant system activities, including user access, intersection operation, detector and link MOEs, trouble calls, and equipment repairs. MIST can compare the field database with the central database to identify any discrepancies. MIST can provide operators with tremendous assistance when performing traffic control functions within all traffic control modes.

MIST uses one of these timing plan techniques: time-of-day, manual, and traffic-responsive. In the default time-of-day mode, the traffic signal controller implements commands in accordance with the time-of-day schedule stored in its local database. When an operator chooses a timing plan for an intersection, the system sets the intersection to manual mode. If a user decides to set a section or link in traffic-responsive mode, then the system implements signal timing plans as a result of the UTCS algorithm. Finally, MIST allows users to operate signals in either free or flash modes. MIST tries to accommodate any mode that an operator might choose to use in a given system.

B.3.3 MIST Freeway System Features

PB/FSI designed MIST to implement fully all features of each Variable Message Sign (VMS) in the Irvine system and to support multiple sign types. MIST stores a list of preprogrammed messages

for each sign in the system. Since most signs also store a list of messages in their controllers, the MIST database keeps a list and description of the messages stored locally at every sign in the system for operator reference. MIST displays each sign location on the system map and can use a unique symbol for each sign to aid identification. MIST operators can identify and monitor signs by mode (on-line, off-line, etc.), and can select, change, and monitor VMS messages.

The MIST system can control highway advisory radio (HAR) transmitter voice message broadcasts. MIST stores the phone numbers of all HAR transmitter sites in the system for dial-up telephone communications It also holds access and function codes for operating the transmitter field equipment. When an operator initiates communications with a HAR transmitter site, MIST generates the appropriate "Bell-compatible" Dual Tone Multi-Function (DTMF) touch-tone codes to control the site's field equipment. The system allows users to send voice messages to the transmitter and to verify them before transmission.

MIST controls and monitors ramp metering equipment. PB/FSI designed these features for both strategic and local traffic flow objectives. MIST can up and download all relevant controller parameters, stored in the local ramp meter controllers, so operators can develop and implement specific ramp metering plans. MIST supports integrating ramp metering algorithms that automatically implement the most appropriate metering plan, based on real-time traffic conditions.

The MIST system gathers and displays the MOEs it collects from count stations throughout the roadway system, including tunnels and near bridges. The count station displays and reports closely resemble those the system detectors provide. MIST's system database stores all MOEs the count station equipment, such as loop inductance detectors, radar detectors, video detectors, etc., generates. MIST's count station capabilities seem to parallel its system detector capabilities.

PB/FSI designed MIST to implement fully all features of each Closed Circuit Television (CCTV) camera controller in the system and to support multiple camera types. MIST's software-based camera control system displays both the camera's video and controls at the computer console. A graphical user interface controls CCTV using dialog box commands and the computer mouse. Using the camera control software, users can control cameras via pan, tilt, and zoom. MIST can display map locations of all cameras in the system in a color denoting their status. The MIST system provides operators with an efficient system for monitoring and controlling CCTV cameras.

MIST can gather various types of environmental data from electronic sensors along the roadway, or from a computer system responsible for collecting environmental data. MIST monitors weather-related conditions such as fog, dust, rain, ice, and air quality. Using this environmental data, the system determines optimum actions given current traffic demand and weather conditions. In the near future, PB/FSI hopes to integrate real-time, traffic-adaptive control algorithms into MIST. These algorithms would suggest signal timing plans, VMS messages, diversion routes, etc. based on environmental and traffic conditions. MIST establishes a framework for gathering environmental data, and PB/FSI hopes to use this data for decision-making in the future.

The MIST system seems capable of integrating various incident detection algorithms. One of these algorithms compares current speed data with a user-defined minimum speed to identify an incident. This threshold might be set according to time-of-day, type-of-day, weather conditions, or location. When MIST detects an incident, it displays an alarm and locates the incident on the system map. PB/FSI incorporated a new ETTM-based incident detection algorithm into MIST that also displays

incident probabilities. MIST's incident detection features allow PB/FSI or the system operator to implement various incident detection algorithms.

PB/FSI integrated fusion software into MIST that accumulates, organizes, and disseminates data from several sources, such as arterial and freeway computer systems, electronically-equipped vehicles, system operators, modeling techniques, and historic files. The data fusion process ascribes quality and age values to each data source, since the data have different levels of quality and time-related deterioration rates. The process produces a score by allocating the quality number to the data source and decreasing the score linearly each minute using an age factor. Data fusion allows MIST to deal with diverse sources of data and transmit the most appropriate data.

The MIST system supports remote terminal access for terminal, graphics workstation, and phone users via a terminal program. This technique enables users with any operating system to access the data. However, it supports text information only and does not provide access to graphic data. Remote graphics workstations are identical to those system operators used. These users receive the same data as terminal users and can also view graphic data, such as a system map. Phone users can transmit or retrieve data to or from system operators. MIST's remote capabilities depend on the hardware and software available at the remote site, and the type of communications between the remote site and the central system.

B.4   Proposed FOT Technology: ARP Module

Using the Arterial Response Plan (ARP) Module, City of Irvine operators respond to freeway incidents. The ARP module obtains information on current incidents from the Caltrans District 12 Advanced Traffic Management System (ATMS), and reports the response plan status to the ATMS upon request. Only the ATMS controls incident opening and closure, and only the ARP process controls arterial response plan implementation. The Incident Client retrieves incident updates from the ATMS system, compares each update with the previous update, and allows the operator to react to the differences between the two. Next, the Client stores the new incident update in the Current Incident Table, and updates the Current Response Plan Table. Each incident update includes the incident location (freeway/direction/postmile), traffic strategy (total/partial closure), traffic impact assessment (high/medium/low), ATMS incident ID number, incident type, lane blockage pattern, and the time and day of the last update to the incident. The Incident Client continues processing the incident by sending this information to the Response Plan Mapping Table to determine the appropriate response plan. It forwards the response plan request to MIST for operator approval. Finally, it receives the operator response from MIST and updates the Current Response Plan Table.

The response plan approval process cascades from the most qualified to least qualified operator as outlined in PB/FSI's Irvine FOT requirements document. MIST returns one of three responses (approved, rejected, or timed out) every time it queries an operator. If an operator's decision times-out, MIST asks the next most important operator for a decision. If all operators time-out, MIST accepts or rejects the response plan based on a pre-configured parameter.

Two ARP database tables allowing the City of Irvine to execute a response plan even after the ATMS closes an incident. One of these database tables monitors the current ATMS incidents while the other monitors the City's response plan. When the Incident Client determines that the ATMS has closed an incident, it asks MIST to prompt the operator to terminate the response plan. The response plan must terminate by implementing the termination plan or executing the response plan for one of the other incident entries in the Current Response Plan Table.

The ARP module uses four database tables: the Subzone Mapping Table, the Response Plan Mapping Table, the Current Incident Table, and the Current Response Plan Table. The Subzone Mapping table links freeway incident locations and freeway subzones. The Response Plan Mapping table provides a mapping between freeway subzone, traffic strategy, traffic impact assignment, and City of Irvine response plan. The ARP module uses the Current Incident Table to keep a list of active ATMS incidents in the corridor. The MIST operator has read-only rights to this report. The ARP module used the Current Response Plan Table to track the City's response to all current ATMS incidents. The City can respond to only one incident at a time.

B.5   Proposed FOT Technology: 2070 ATC

The original ATC prototype was a VME-based unit, with 68040 processor boards, and intelligent I/O and communication boards. The hardware specifications called for an open system based on the proven 32-bit VME bus architecture (IEEE 1014/IEC 821) running under the OS9 real-time operating system. Caltrans used this prototype as a starting point for designing the Model 2070 controller, and it plans to use the Model 2070 to supplement the current Model 170controller. Caltrans plans to use the Model 2070s for very accurate and precise ATMS data processing applications for many freeway lanes. The Model 2070s also provide greater flexibility of communications interfaces and protocols than the Model 170.

Caltrans decided to use the existing Model 170 cabinet system for the new controllers. Therefore, the new controller had to provide a standard Model 170-type C1 interface connector, fit within the same space as the Model 170, and use compatible power and communication connections. Caltrans wanted the Model 2070s to be more modular than existing controllers, and designed the Model 2070 with six basic modules: a central processing unit (CPU), a field input/output module, system communications module(s), a power supply module, a front panel module, and a chassis and backplane.[3] Caltrans hoped this combination of features would provide controller flexibility for adapting to all potential ITS technologies requirements.

Caltrans designed the 2070 Controller to improve processing capabilities tenfold over the current Model 170 controller. Caltrans chose a VME bus single board computer as the CPU module to provide main controller processing capabilities. CPU firmware includes Microware OS-9 kernel device drivers and other support software. The 2070 CPU executes application programs and controls communications and other modules. It also accepts software downloads through a systems

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[3]Caltrans (1993) presented a 2070 system architecture schematic in its Model 2070 Advanced Transportation Management System Controller Concept Description that also describes in detail: (1) the CPU interfaces and architecture; (2) the field I/O module I/O characteristics, interfaces, communication protocols, and architecture; (3) the System Communication Module basic design, data requirements, and data communication protocols; (4) the power supply module maintenance, power monitors and AC synchronization; (5) the front panel module display features, communication protocols, interface connector, and status monitoring; (6) the chassis and backplane's power supply connections, module connections, and VME expansion bus; and (7) a schematic of the 2070 inter-module interface.

communications port. Caltrans created a detailed CPU module design to facilitate supply by different vendors.

Caltrans expected the 2070 design would meet ninety percent of controller applications requirements. The field input/output (I/O) module has the connections and hardware required to be compatible with the Model 170 cabinet system. Caltrans also wanted the field I/O module to meet the needs of the traffic signal, and freeway metering and monitoring station controllers. The field I/O module is the interface between external field equipment circuits and all other internal modules. A separate subassembly handles all existing Model 170 I/O functions; this subassembly includes a standard C1 connector and all necessary mounting accessories detailed in the Traffic System Controller Equipment Specifications. The field I/O C1 connector module supports forty-four inputs and fifty-six outputs, and provides an additional connector for expansion to sixty-four inputs and sixty-four outputs with the same electrical characteristics. Caltrans specified fully the field I/O module to facilitate supply by multiple vendors.

Caltrans intends to use the Systems Communications Module for long-distance communications, and the Model 2070 controller includes four external ports in two separate slots for system communications. Caltrans designed the System Communications Module to be functionally and electrically equivalent to a TSCES Model 400 modem in order to substitute for the Model 170 controller. Caltrans planned the Systems Communication Module to house all of the analog and digital network interfaces for advanced traffic operation systems.

The 2070 power supply module meets all 2070 power requirements and filters and line-conditions incoming power to ensure safe and reliable operation. The power supply module also enables controller operation under *abnormal* AC power by converting AC power to DC voltages for the controller modules. The power supply uses an LED to indicate its operational readiness. Caltrans designed the power supply module to maximize its reliability and maintainability, and used a plug-in power supply unit to facilitate maintenance.

The front panel unit uses the same hexadecimal sixteen-key keypad format as the Model 170 controllers. However, the Model 2070 front panel includes advanced cursor keys and extended function keys. The Model 2070 front panel module also features a back-lit, industrial standard, 4x40 full-matrix Liquid Crystal Display (LCD) with numeric and cursor control keypads. Caltrans plans to acquire front panels meeting functional and mechanical specifications from several vendors.

The Model 2070 backplane provides physical and electrical support for internal controller components. Caltrans plans to use a VME A24/D16 bus backplane with four VME card slots as the Model 2070 backplane. Caltrans also anticipates using the backplane for power, ground, and AC synchronization with the CPU and Communication modules. The Model 2070 uses a 19-inch EIA rack-mountable chassis for controller installation directly in a Model 170 cabinet system. The chassis supports four 3U-VME cards and the other modules.

Each 2070 controller module uses separate interfaces. The serial interfaces between the I/O modules and the CPU enable the controller to use simplified hardware, and isolate functions at lower cost. The controller uses an EIA-485 multi-drop to interface with the field I/O; it extends through the modules for optional connections to remote serially-connected I/O devices.

B.6   Proposed FOT Technology: SWARM System

National Engineering Technologies' (NET) System-Wide Adaptive Ramp Metering System (SWARM) is a methodology for optimizing flow along a large freeway section. NET hoped that SWARM would adapt to local conditions, respond to system-wide conditions, predict the onset of recurring congestion, and respond accordingly. NET planned to implement a two-tiered approach for selecting the more restrictive of two metering rate alternatives. The SWARM system uses two different algorithms to calculate these metering rates: SWARM 1, a system-wide algorithm using a forecasting methodology; and SWARM 2, a local traffic-responsive algorithm using an adaptive methodology (1997c). For maximum effectiveness, the SWARM system must receive reliable data and control all vehicles entering the freeway; so far, this goal appears unattainable in practice. NET tried addressing SWARM constraints while working to minimize negative impacts.

The SWARM 1 algorithm performs two primary functions, forecasting and apportioning system-wide ramp metering rates. Forecasting is a proactive method for controlling freeway congestion. NET decided to use density as a measure of congestion and as a control parameter for the ramp metering algorithm because it is the best measure of congestion. SWARM 1 treats the freeway network as sections. A geometric bottleneck, frequently the location of recurring congestion, is the downstream terminus of each section. The SWARM 1 algorithm operates at the bottleneck and controls upstream locations.

Depending on recent conditions, the algorithm attempts to estimate density at a future time. NET planned on tuning the algorithm for future distance depending on the lead time for metering rates to take effect, and any limitations of the algorithm itself. When estimated density exceeds the bottleneck saturation density, SWARM 1 calculates ramp metering rates to try to prevent predicted congestion. SWARM 1 repeats this forecasting process every thirty seconds. SWARM 1 meets two of NET's goals by responding to system-wide conditions and predicting recurring congestion.

NET planned to designate a nominal saturation density for each VDS. Everyday, the algorithm updates saturation densities for each operating VDS based on values near saturation. Another algorithm, SWARM 2, computes local metering rates in conjunction with SWARM 1. It uses headway theory and a density function to compute local metering rates. SWARM 2 attempts to maintain headway by optimizing density to maintain maximum flow.

NET developed procedures for SWARM to follow when failed detectors caused a loss of data (1997c). When the number of operational lanes associated with a VDS exceeds a pre-determined threshold, SWARM computes the station's statistics from the local "good" data. On the other hand, when the percentage of operational lanes drops below the threshold value, SWARM classifies the station as failed and the system simultaneously removes it from the SWARM operations network. SWARM then searches for the first operational VDS upstream from the failed bottleneck VDS. SWARM 1 continues this search until it locates an operational VDS, or exceeds the maximum search distance and stops operating in that freeway section. Under SWARM 2, the ramp associated with a failed VDS reverts back to time-of-day rates, because SWARM 2 can not function without real-time data.

NET designed methods for responding to other obstacles to successful SWARM implementation. For example, un-metered ramps and HOV bypasses contributes volume to each freeway section, and NET identifies these entries as unrestricted. When unrestricted entries or mandatory metering rates occur, SWARM 1 sets the maximum and minimum metering rates to equal values and

propagates any excess demand to the next upstream metered ramp. While NET described the SWARM 1 algorithm method for adapting to unrestricted ramp volumes, NET did not describe how SWARM determines the expected demand at a given ramp.

When a queue override occurs, as a result of too many vehicles in a ramp queue, the local ramp implements a fixed metering rate to clear the queue. Each ramp in the system operates with a minimum allowable metering rate. When the system recommends a metering rate below this value, the local ramp reverts to the minimum rate, and SWARM 1 equalizes the ramp's minimum and maximum metering rates. Finally, operators can manually override ramp metering settings. SWARM 1 appears to address many potential operational difficulties. The evaluation team summarized the SWARM 1's operation in Figure B.1

NET built the SWARM system around Caltrans District 12's existing system and in response to requests for improvements, therefore it incorporated many of the features of the Caltrans District 12 RMS. SWARM continues to collect field data from the mainline detectors in 30-second segments and process the raw data into familiar parameters, such as ramp delays, meter head operating status, equipment malfunction status, queue loop activation lines, on-ramp speeds, HOV lane percentage usages, etc. SWARM reverts to pre-set time-of-day ramp metering when communications with District 12 fails. SWARM should provide access to all information in the current transmit buffer. It should also be able to transmit 120 bytes, rather than the 88 bytes it currently transmits.

NET also planned to use SWARM for non-recurring congestion management as well as handling recurring congestion. Upon receiving confirmation of an incident, SWARM automatically generates and implements a response plan to adjust system metering rates. When operators know about non-recurring congestion before it begins, such as during special events and planned lane closures. SWARM must deploy the appropriate ramp metering plan before the non-recurring congestion begins. SWARM's ramp metering response plan defines metering rates for selected ramps in response to given traffic conditions. NET outlined different management plans for handling recurring congestion, incidents, special events, and planned lane.

B.7   Proposed FOT Technology: Transition from FRED/ARTIST to ODSS

In April 1994, NET, PB/FSI, and the City of Irvine submitted a proposal up-date. In this up-date, they reaffirmed their intentions to produce an integrated and coordinated centrally-controlled freeway Ramp Meter System (RMS) and arterial traffic management system. They still intended to use the University of California at Irvine's (UCI) Freeway Real-time Expert-system Demonstration (FRED) to monitor the system. NET modified FRED for its District 12 installation and renamed it the Operator Decision Support System (ODSS).

FRED is a prototype real-time expert system for managing non-recurring congestion on urban freeways. FRED can detect and verify incidents, and identify and evaluate alternative responses. Research at UCI developed the Arterial Real-time Traffic Incident reSponse Tool (ARTIST) as an expert system to address arterial control, primarily incident verification and response. UCI developed FRED and ARTIST using G2, a real-time expert system development software. Designed specifically for real-time applications, G2 provided a powerful software development environment. Both FRED and ARTIST operate on a UNIX-based, SUN Sparc IPX hardware platform.

FRED and ARTIST use a series of production rules, each with an associated antecedent and a consequence. When the system satisfies the antecedent conditions, the software executes the corresponding consequence.   FRED and ARTIST actions include graphic displays, posting messages to the operator and external systems, and setting system attributes. FRED and ARTIST examine all active rules every second and respond to these changing data. FRED and ARTIST combine these features in real-time expert systems.

FRED selects incident response strategies after completing the incident detection and verification process. FRED uses three elements for incident response: major incident traffic management, real-time ramp metering, and changeable message signs. The ramp-metering algorithm operates

SWARM Data Flow and Procedure

Raw Data

- Volume*
- Raw Occupancy
- (Estimated) Speed
- (Estimated) Density

*: Volume counts need not be normalized

Failure Management

Determine loop status*
- O.K.(Data O.K.)
- Suspect(Data O.K.)
- Inhibited(Data not O.K.)
- Soft Failed(Data not O.K.)
- Hard Failed(Data not O.K.)
- Disabled(Data not O.K.)

*: Determined how?

Data Normalization*

Remove the effect of loop length for each lane and detectors
- Normalize Occupancy
- Normalize Speed
- Normalize Density

*: Not normalization in the statistical sense

Station Statistics*

Current operational status
- Status 0: O.K.
- Status 1: Local Manual
- Status 2: User Disabled
- Status 3: No Response
- Status 4: Corrupted
- Status 5: Up Loading
- Status 6: Down Loading

*: Describes SWARM system status?

Dynamic Saturation Analysis for all VDS

- Curve to parabolic fitting large flow-density data set
- Compute coefficients for parabola and saturation density
- Filter (update) saturation estimation with new data

Dynamic Section Configuration

Define freeway sections bounded by two bottlenecks* (VDS or I/C)

*: Are bottlenecks fixed or dynamic?

SWARM 1

CD(BN) < SD(BN) — No

Yes

Kalman Filter Forecast FD(BN) for Time T(crit)

FD(BN) > SD(BN) — No

Yes

Compute Required Bottleneck Density (RBD)

$$RBD = CD(BN) - \frac{FD(BN) - SD(BN)}{T(crit)}$$

= current bottleneck density - required rate of change

Define RBD=SD(BN)

Compute Volume Reduction (VR) at all ramp VDS in Dynamic Section

$$VR = \underline{(LD - RBD)} \times (\text{No. of Lanes}) \times (\text{Distance to the Next Downstream Ramp})$$

— positive or negative change in volume
— needed change in density

Compute New Metering Rate (NMR): 1st ramp

NMR = (CMR - VR) or Min. Rate or Max. Rate

Propagate Excess or Surplus Values Upstream within the Section and Compute Upstream NMRs Sequentially

Intra-Section Propagation

Excess values propagated
- to a contiguous section or
- to multiple sections (I/C)
Surplus values ignored

<Glossary>

CD(BN):	Current Bottleneck Density	SD(BN):	Saturation Bottleneck Density
FD(BN):	Forecasted Bottleneck Density at T=T(crit)	T(crit):	Present to Future Elapsed Time Unit
RBD:	Required Bottleneck Density	VR:	Volume Reduction for each Ramp
LD:	Local Density	NMR:	New Metering Rate for each Ramp
VDS:	Mainline Detector(Vehicle Detection System?)	I/C:	Freeway to Freeway Inter Change
CMR:	Current Metering Rate by SWARM2 (2a or 2b), TOD, etc.		

Figure B.1: SWARM 1 Data Flow.

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independently, but FRED intervenes when an incident sharply reduces freeway section capacity. FRED might recommend closing upstream ramps to reduce demand at an incident site. In this case, FRED and ARTIST provide route and other traveler information to motorists through changeable message signs. ARTIST formulates the messages for the CMSs and selects new timing plans for the alternate route arterials. This combination of FRED and ARTIST provides a framework for responding to non-recurring congestion in a mixed freeway and arterial corridor.

APPENDIX C: Project and Evaluation Event Chronology: 1992-1999

1992

May
- The _Federal Register_ (57.90) announces IVHS Field Operational Test (FOT) Program.

July
- The _Federal Register_ (57.139) announces Participation in the IVHS Field Operational Test Program Request for Proposals (RFP).

October
- The initial FOT proposal is submitted by the California Department of Transportation (Caltrans), the University of California at Irvine (UCI), National Engineering Technology Corporation (NET), Farradyne Systems Incorporated (FSI), and the City of Irvine to the Federal Highway Administration (FHWA).

December
- The proposal is accepted for Fiscal Year (FY) 1993 Operational Test Program funding.

1993

March
- The FOT partners meet to detail areas of responsibility, and to review and clarify the FOT's operational and technical aspects.

July
- July 29:   The FOT partners' first proposal revision is submitted to FHWA.

1994

January
- The University of California at Irvine (UCI) drops out of the FOT project. This makes it possible for UCI faculty to participate on the Partnership for Advanced Transit and Highways (PATH) evaluation team without a conflict of interest. UCI Profs. Mike McNally and R. Jayakrishan join University of Southern California (USC) Prof. Jim Moore, and California Polytechnic University at San Luis Obispo (Cal Poly) Prof. Art MacCarley on the PATH evaluation team.
- NET agrees to provide the freeway portion of the functionality originally to be provided by UCI.

February	•	The project scope is revised following demonstrations of Freeway Real-time Expert System Demonstration (FRED) and Arterial Real-time Traffic Incident reSponse Tool (ARTIST).
	•	ARTIST is eliminated from the project.
	•	NET is assigned additional responsibilities including "end-to-end integration" and the functional design needed to accomplish the "coordinated operations" of the two traffic management systems to be installed in the Caltrans District 12 Transportation Management Center (TMC) and the City of Irvine Irvine Traffic Research and Center (ITRAC).
	•	NET will Incorporate most of the rules associated with UCI's Freeway Incident Manager (FIM) functionality into the real-time expert system capabilities already part of District 12's TMC. These changes result in a reduction in the FOT budget from about $3.3 to $2.7 million.
March	•	The City of Irvine, NET, and FSI meet to discuss proposal tasks.
	•	The FOT partners meet to revise the FOT project proposal.
April	•	April 19: The FOT partners' second proposal revision is submitted to FHWA.
May	•	A Memorandum of Understanding (MOU) is signed between the State of California (Caltrans District 12 and the California Highway Patrol, Border Division), the Orange County Transportation Authority, and the Cities of Irvine and Anaheim.
June	•	The evaluation team prepares and PATH submits to Caltrans a preliminary evaluation proposal based on the Irvine FOT Project proposal.
July	•	The proposed budget for the Irvine FOT project is increased by 92 %, adding approximately $1.6 million.
	•	The 2070 Advanced Transportation Controller (ATC) specification is released by the Caltrans Traffic Operations Section (TOS) to interested industry manufacturers as a Qualified Product List (QPL) Application Specification.
	•	July 29: The evaluation team submits an updated project evaluation proposal to PATH based on the FOT partners second proposal revision.
August	•	PATH submits an evaluation proposal update to Caltrans. The proposed budget for the Irvine FOT Project evaluation is reduced from $323,520 to $304,029 with no reduction in the scope of work.

September • The COI City Attorney approves the FOT Cooperative Agreement between the City and Caltrans.

• The Mayor, City Attorney, and City Clerk sign the Cooperative Agreement.

• Frank Cechini of FHWA recommends that the Project Management Team (PMT) and Evaluation Oversight Team (EOT) consist of the same members. The PMT consists of FOT partners, sponsors, and (sometimes) consultants.

• The City of Irvine (COI)and Caltrans sign the original cooperative Agreement on September 13, 1994 with a term of October 1, 1994 to June 30, 1996 (Agreement #65-005). The FOT Project funding includes $2,039,437 in Federal IVHS (ITS) funds and $509,859 in State matching funds.

• COI and FSI sign FSI's consulting contract with the City for the FOT project on September 13, 1994. The term of work is September 1, 1994 and March 1, 1996.

• The City and NET sign NET's consulting contract with the City on September 13, 1994. The term of work is October 31, 1994 to April 30, 1996.

• Caltrans signs an evaluation contract with PATH for the Irvine FOT Project on September 13, 1994 (originally Master Agreement #65V313, Task Order #005). The term of the evaluation contract is from October 1, 1994 to March 31, 1997. The total funding for the Evaluation Project is $327,981. The evaluation team includes faculty and students from UCI, USC, and Cal Poly.

• Addendum to FOT evaluation proposal.

October • The Caltrans Traffic Operations Section (TOS) joins the PMT.

• The Caltrans TOS presents the PMT with a progress report on 2070 ATC specifications development.

November • The PMT reviews the 2070 ATC and traffic controller firmware necessary to operate the 2070 ATC with second generation traffic control software, Optimized Policies for Adaptive Control (OPAC).

• FSI commits to report on different options to make the 2070 ATC operational with OPAC.

• November 10: The evaluation team is not yet under contract to PATH.

December • Final Notice to Proceed/funding is provided by Caltrans for the Irvine FOT Project evaluation.

1995

January
- FSI and City discuss traffic control strategies to reduce confusion.
- The FOT partners decides to integrate OPAC and the traffic control firmware into a single controller, a single central processing unit (CPU).
- January 18: University of California at Berkeley's (UCB) Sponsored Programs Office (SPO) informs Robert Tam of PATH that they will send the UCI, USC, and Cal Poly evaluation subcontractors a letter of approval within one week.
- FSI disclaims responsibility for signal control software that is otherwise an integral and necessary part of the OPAC System development (Cal Poly Prof. Art MacCarley, email message, April 11, 1996).

February
- February 15: The Irvine FOT Project evaluation contract arrives at Cal Poly.
- February 26: The Irvine FOT Project evaluation contract arrives at USC. The budgets attached to the July 1994 evaluation proposals include some errors, and the evaluators send budget amendments to PATH.

March
- March 10: Updated work plans requested by the evaluation team from the FOT partners are due.
- March 20: The new work plans promised to the evaluation team by the FOT partners have not been received. This delays the work of evaluation team. The evaluators will use these work plans to draft an evaluation plan update for discussion at FOT meetings. UCI Prof. Mike McNally states that the "Irvine FOT data collection is complex given the undefined project schedule, the undefined integration of arterial-based control/monitoring systems, the undefined integration of arterial/freeway systems, etc." This source of complexity will remain with the Irvine FOT Project for the remainder of its life.
- March 21: FSI receives a Notice to Proceed under Contract Number 65-005 from COI.
- March 23: Cal Poly Prof. Art MacCarlely states that John Thai of COI has instructed NET to improve communication and technical cooperation with FSI.
- Mike McNally states that one of NET's subcontractors indicates that NET's FOT plans have "not evolved beyond their Caltrans District 7 and Caltrans District 12 TMC plans."
- March 24: UCB SPO calls Christina Wilson of USC's Office of Contracts and Grants regarding the evaluation team's requests for no-cost evaluation contract extensions through March 31, 1997. UCB SPO cannot comply at the time because the current contract ends on March 31, 1996.

- March 25   UCI Prof. Mike McNally reports that Caltrans will be changing the overall project schedule for the Irvine FOT to March 1, 1995 through December 31, 1997.

April
- FSI begins work on the Arterial Signal Control System (ASCS).
- FSI begins work on the ASCS communications design.
- FSI begins work on ASCS project management.
- The City reviews status of 2070 finance development. The Los Angeles Department of Transportation (LADOT) and Caltrans are resolving I/O issues associated with the 2070.
- COI asks NET to assume the role of System Manager.

- April 17: The updated work plan requested by the evaluation team from the Irvine FOT partners still has not arrived and is due at the next project meeting. Cal Poly is still not under contract to PATH.
- April 18   Monthly Irvine FOT PMT meeting. Locations of freeway Changeable Message Signs (CMS) are identified. The locations of Arterial Message Signs (AMS) are not yet determined.
- April 19: June 1 is identified as date work will start on the 2070 signal controllers and their interface with OPAC.
- The updated evaluation work plan is not due until after the partners' revised work plan is available.

May
- NET begins work on the ramp metering system (RMS).
- NET begins work on the RMS functional requirements.
- FSI begins work on the ASCS central software development.
- FSI delivers a "Program Management Plan."
- NET delivers an "Integrated Work plan."
- Frank Cechini of FHWA expresses concern about the 2070 ATC software development.
- May 12: Cal Poly Prof. Arthur MacCarley reports NET has submitted their detailed work plan for Irvine, but FSI has not.
- May 16: Monthly Irvine FOT PMT meeting. NET and FSI review the work flow plan. The COI is to provide plans of loop detector locations to FSI. The group reviews NET's outline for operations/traffic plan requirements. Discussions take place about 2070 software development. Frank Cechini of FHWA suggests the group devise a back-up plan in the event that the software development in the 2070 falls through. FSI and NET will perform field checks.
- Concerns arise about operational policies relating to the 2070 ATCs (USC RA Nichole Walker, May 16 meeting notes, May 18, 1995).
- May 20: Cal Poly Prof. Arthur MacCarley notes that NET's plan does not have the adequate technical details for him to prepare an evaluation

plan, especially with respect to computational issues such as the merging of OPAC, the LADOT 2070 traffic control code, and inter-unit communications.

June	•	NET begins work on System-wide Management/Integration (SMI).
	•	NET begins on the SMI operation/traffic response plan, due April 1996.
	•	FSI begins work on ASCS field controller modification design.
	•	FSI begins work on ASCS OPAC algorithm modifications.
	•	The required communication inter-tie between ITRAC and the Caltrans District 12 TMC should be completed soon. This work remained unfinished as of February 1996. Traffic diversion cannot occur without this inter-tie.
	•	FSI's Management Information System for Traffic (MIST) software will be rewritten to run under Unix and adapted to support the objectives of FOT project.
	•	June 20: Monthly Irvine FOT PMT meeting. Discussions occur concerning the Advanced Traffic Management System (ATMS)/MIST interface and operations, and traffic response plans (UCI RA Steven Mattingly, June 20 meeting notes, June 20, 1995). Caltrans suggests that, due to budgetary constraints, trucks be equipped with both matrix and electronic changeable message signs, and that these be used instead of standard CMS installations. Based on cost of CMS and budget constraints, FSI and NET will revise the diagram showing existing and proposed CMS and AMS locations. Caltrans District 12 will provide the exact cost of existing CMS installations, current mainline and ramp volumes, and loop locations. COI will provide current arterial traffic volumes. NET will provide a diagram showing proposed inter-tie between Caltrans District 12 and the existing connection between UCI and the Irvine Traffic Research and Center (ITRAC).
	•	June 26: Cal Poly Prof. Arthur MacCarley reports that the first quarterly report to PATH is due July 14, 1995.
July	•	FSI begins work on the ASCS field construction design, due March, 1996.
	•	NET delivers a System-Wide System Metering System (SWARMS) draft "Functional Synopsis."
	•	FSI reports that, at meeting attended by NET, FSI identified the need to "Assess whether the traffic data sent by MIST to the ATMS allows the ATMS expert system to choose a scenario which re-distributes traffic for recurrent congestion at ramp movements." NET is to respond. (FSI, meeting minutes, undated)
	•	COI agrees to give Caltrans District 12 three levels of capability: with respect to COI traffic control: read-only, scenario approval, and AMS control (FSI, meeting minutes, undated).
	•	NET agrees to incorporate MIST's remote operator interface into the District 12 ATMS without the purchase of any additional hardware.
	•	Caltrans agrees to develop a draft maintenance agreement for the 2070 ATC hardware associated with the Irvine FOT.

	•	NET suggests using existing CMS equipment to save money for use on new AMS equipment.
July	•	FSI reports they may only be installing ten AMS.

- July 5: Irvine FOT 2070 controller meeting. Use of current Caltrans software with the new 2070 controllers and OPAC is proposed as an alternative to the "mythical" LADOT software (UCI RA Steve Mattingly, Irvine FOT 2070 controller July 5 meeting notes).

- July 11: The evaluation team discusses how to reorganize the tasks in the evaluation work plan in light of continuing project changes.

August

- NET delivers a draft SWARMS "Functional Operational Requirements Definition."

- FSI delivers draft "AMS (Arterial Message Sign) Locations."

- The City reports that, for aesthetic reasons, they prefer trailblazers to stationary signs. However, the FOT Project does not have funds allocated for the necessary hardware and firmware or the software development to control trailblazers through MIST.

- August 7: UCI Prof. Mike McNally submits a summary draft of the "Irvine FOT Evaluation Plan" to the evaluation team.

- August 9: The evaluation team discusses reorganizing the summary draft of the evaluation plan. Discussion draft Task elements of "Irvine FOT Evaluation Plan " are completed.

- August 15: Irvine FOT monthly meeting. FSI is working on a "Systems Requirement Document." A sign policy agreement has been established with COI. A map of potential CMS locations is distributed. FSI is to provide a summary of system architecture by the next monthly meeting. NET is one month behind schedule for document delivery. The FOT partners decide to resolve institutional issues by establishing another MOU. 2070 controller development issues are discussed. FSI reviews potential CMS, AMS, and fixed sign locations on both arterial and freeway segments, and requests comments from the FOT partners and the evaluation team. Drafts of Evaluation Plan Tasks B and D are distributed to the FOT partners.

September

- NET begins work on RMS high level design.

- FSI begins work on ASCS equipment procurement.

- FSI is scheduled to complete their review of COI's existing controller and cable installations.

- FSI delivers draft "Functional Requirements."

- The FHWA holds an Operational Test workshop at Booz-Allen and Hamilton in McLean, Virginia.

- Sean Skehan of LADOT agrees to sell his 2070 traffic control software to the City of Los Angeles.

| | • | Caltrans states that their current freeway diversion policies will remain in effect for the project area. That is, Caltrans will actively divert traffic from the freeway only in the event of a full freeway closure. The evaluation team argues this sharply constrains opportunities for project evaluation. |

September
- The evaluation team submits an updated evaluation plan for the FOT partners' review and comment.
- September 5:   Cal Poly Prof. Art MacCarley arranges for experts in network design/performance analysis and software analysis to assist the evaluation effort.
- September 11   A meeting is scheduled for September 18 at Caltrans District 12 in Santa Ana to review of the functional requirements for the Ramp Metering System.
- September 14: The evaluation team holds working a meeting at UCI in anticipation of the meeting at Caltrans District 12.
- September 18: NET's RMS Functional Review takes place at Caltrans District 12. Two major activities are defined for evaluation Task A: Evaluation of ramp metering and evaluation of incident response.
- September 22: Cal Poly Prof. Art MacCarley completes the work plan for evaluation Task C.
- September 27: Robert Tam of PATH reports that the contract for the Irvine FOT project evaluation will expire on June 30, 1996 and cannot be extended beyond that date due to requirements imposed by Caltrans' cash management system. A new contract will have to be made
- September 28   Robert Tam of PATH indicates to the evaluation team that $259,953 should be spent by June 30, 1996, thus leaving $68,028 available to be spend during FY 1996-97.

October
- NET begins work on the SMI development of a coordinated response system.
- Caltrans recommends Northbound Interstate-5, South of Crown Valley, as a CMS location.
- The City confirms that the Pasadena style signs are selected as the AMS for the FOT project.
- NET distributes maps showing existing and proposed CMS locations.
- October 10   The evaluation team continues design of before-after field studies and the review of RMS, diversion, and other related ATMS strategies Caltrans District 12's cooperation remains unclear.
- October 31,   FSI comments on Evaluation Plan Tasks B and C.
- October 31,   "It was agreed that, when in doubt, the needs of the ASCS are paramount over OPAC's needs." (FSI, conference call minutes, October 31).
- LADOT and COI continue working on an agreement for use of 2070 controller software.

November
- NET begins work on the RMS database requirements.
- NET and Caltrans decide to apply a two-tiered approach to the SWARMS system.
- FSI delivers final "Functional Requirements."
- November 3   Cal Poly Professor Art MacCarley receives NET's comments on Evaluation Plan Task C.
- November 6   Cal Poly Professor Art MacCarley receives FSI's comments on Evaluation Plan Tasks B and C.
- November 11   An updated Draft Evaluation Plan is submitted for Evaluation Plan Tasks B, C, and D. USC Prof. Jim Moore's Task A remains incomplete due to open questions concerning the Irvine FOT Project.

December
- NET delivers their final SWARMS "Functional Operational Requirements Definition."
- NET delivers Draft 1 of a "Traffic Response Plans/Operations" technical memorandum.
- NET completes work on the RMS functional requirements.
- FSI delivers a draft "OPAC Software Test Plan."
- NET and FSI disagree about where the system's arterial response logic is supposed to be installed. FSI's MIST does not have any such logic built into it, and NET insists that installing this function in the District 12 TMC would be outside NET's scope of work.
- USC Prof. Jim Moore circulates a preliminary draft of Evaluation Plan Task A.
- December 12   Monthly Irvine FOT PMT meeting. Discussions focus on definitions of Arterial Response Plan (ARP), under what conditions response plans are to be implemented; and whether the scenarios for arterial response plans will be in the District 12 expert system provided by NET or incorporated into the Unix version of the MIST provided by FSI.
- The evaluation team concludes that FSI has redefined MIST. MIST is no longer a decision-making arterial-response-support engine. It is a Graphical User Interface.

1996

January
- FSI completes work on the ASCS field controller modification design.

- NET and COI decide to place the ARP implementation logic it in a separate ARP Module (NET, meeting minutes, January, 15, January 16, 1996).

- Freeway CMS displays will not be changed based on input from MIST. Caltrans will not divert traffic except for a full freeway closure. Caltrans considers identify possible alternatives.

- NET and Caltrans agree to use the local SWARMS algorithm (SWARMS2) deal with freeway incidents.

- Caltrans plans to slowly phase out the queue override characteristic out of their ramp metering system.

- FSI begins to investigate alternative detectors for COI intersections to be controlled by OPAC.

- FSI orders 2070 ATCs from Matrix.

- Neither NET nor FSI believe that the definition of critical response plans, i.e., integration of the freeway and arterial plans, are within their respective scopes of work.

- FSI states that ARP options would be active when the freeway is closed.

- NET delivers Draft 1 of a SWARMS "High Level Design" for a Freeway Control System.

- January 14:   Cal Poly Prof. Arthur MacCarley reports that the quarterly report to PATH went out on January 9. The report includes USC's inventory of existing video and telemetric data resources available in the Caltrans District 12 TMC.

- USC Prof. Jim Moore is attempting to create and maintain a map of the evolving system architecture, attending meetings with NET and District 12 to track the changing definitions of SWARMSS/RMS/ODSS and related questions.

- Preliminary comments are received from some of the partners on Evaluation Plan Tasks B and C.

- January 16:   Monthly Irvine FOT PMT meeting. The 2070s have been ordered. General Services is holding up the order for reasons unknown. (USC Prof. James Moore, January 16 meeting notes, January 30, 1996).

- January 29:   The evaluation team collectively concludes that there is insufficient integration in the FOT to permit evaluation of an integrated, corridor level system.

- Discussions continue among the evaluation team members concerning what to evaluate.

- January 30: Caltrans development of interim 2070 controller software mandated by Assembly Bill 3418 (AB3418) is proceeding.
- FSI announces that upstream loop detectors are needed for OPAC.

February
- NET begins work on RMS detailed design and coding.
- NET begins work on ATMS interface requirements.
- NET delivers Draft 2 of the SWARMS "High Level Design."
- FSI delivers the final "OPAC Software Test Plan."
- FSI reports that most of COI's cable conduits are full and that the conduits that were not full did not extend the distance required for optimal OPAC loop detector installation. FSI offers the following possible solutions: Leave the intersection approaches without detectors, rely on existing loops as opposed to ideal OPAC loops, use autoscope or an equivalent product instead of loop detectors, or decrease the number of intersections in the demonstration. No matter which solution is selected, FSI will not be installing the system originally proposed.
- NET proposes a means for communication between the Caltrans District 12 ATMS and MIST in ITRAC. However, they are awaiting further responses from COI about funding questions. The evaluation team considers this to be a stalling tactic.
- The ITRAC center is still not connected to Caltrans District 12 TMC because another 400 feet of cable is needed. This subject is reported to have been discussed extensively during the previous year, but the problem has not been resolved.
- The 2070 controllers will not be available to Caltrans until September.
- The partners encourage the evaluation team to simulate diversion scenarios as an alternative to actual diversions. John Thai of COI reports that COI is averse to receiving traffic diverted from freeways and that including diversion would cause the project to die "a quick, painful death."
- The City agrees to pay for a separate ARP Module to perform the arterial response logic needed to select an ARP.
- The evaluation team discusses and notes the reduction in deliverables achieved by the NET and FSI.
- The evaluation team concludes that NET has redefined integration to mean unidirectional communication only, in this case from the Caltrans District 12 TMC to ITRAC.
- Caltrans District 12 clarifies that ATMS freeway ramp controls share no communications or control linkages with arterial control systems at any level.

March	•	NET begins work on the ATMS signing plan design, coding, and documentation.
	•	NET delivers Draft 2 of a "Traffic Response Plans/Operations" technical memorandum.
	•	FSI and COI agreed to reduce the project area to 23 intersections.
	•	COI selects five sites for AMS.
	•	NET delivers a final SWARMS "High Level Design."
	•	FSI delivers Draft 1 of an ASCS "High Level Design Report."
	•	March 15: The evaluation team forwards a memorandum to FHWA detailing conversations and agreements concerning the evaluation plan. FHWA will review the memorandum for consistency with the original FOT objectives and deliverables.
April	•	FSI reports that March 1, 1997 is now the OPAC field implementation date.
	•	NET reports that the lack of ARP information is slowing progress.
	•	NET is concerned about the likely need for contract extensions.
	•	The evaluation team concludes that Caltrans District 12 wants to redefine the District's participation in and contractual obligations to the Irvine FOT Project.
	•	April 25: The first extension for the Irvine FOT Project (Amendment #1) is granted extending the end of the project from June 30, 1996 to June 30, 1997. There will be no further amendments. However, an escrow account was established to distribute funds to FSI as their products were completed and delivered.
May	•	FSI completes a draft "MIST Software Test Plan."
	•	May 8: Special Irvine FOT meeting at Caltrans District 12 to review FOT objectives. Jim Kerr of NET defines three different levels of integration: institutional, operational, and technical. The evaluation team views this as an attempt to classify the absence of substantive technical integration as a form of integration. Kerr also takes the position Caltrans District 12 must not turn off SWARMS for the sake of system evaluation. This would create too much liability. The FOT project partners identify seven basic scenarios that should be evaluated (FOT special meeting minutes, March 31, 1996).
	•	The evaluation team meets to incorporate the FOT partners preferred scenarios into the IFOT Prov
	•	COI is considering integrating AMS and the 2070 ATCS.

June	•	FSI delivers a draft "MIST Software Test Plan."
	•	FSI meets with the City to discuss OPAC loop infrastructure.
	•	FSI develops a final implementation approach for the ARP Module, which COI accepts.
	•	Sarasota Loop Detectors (Model Saratec LMTS38Z) are selected.
	•	GCS Changeable Message Signs are selected.
	•	COI will provide FSI with a GCS CMS, a Sarasota Loop Detector, and model 2070 Controller.
	•	The GMS CMS will be interfaced with central control through a 2070 controller.
	•	COI and Caltrans District 12 agree to schedule a meeting to develop an MOU and operational agreements.
July	•	The meeting between Caltrans District 12 and COI has yet to occur.
	•	Caltrans District 12 and NET hold a user interface design meeting focusing on user design requirements and icon display.
	•	FSI delivers the final "MIST Software Test Plan."
	•	COI, FSI, and GCS meet to discuss arterial CMS design issues.
	•	The evaluation team and the FOT partners began to discuss using freeway maintenance activities as a pseudo incident.
	•	FSI meets with COI concerning the ARP Module, Sarasota loop system detectors, and GCS CMS.
	•	The evaluation team fails to deliver an update of the Evaluation Plan Task B. There are too many project unknowns/
	•	FSI delivers a draft "2070 Specification."
	•	The evaluation team discusses whether and how to evaluate SWARMS.
August	•	City and FSI held a meeting to discuss Planning, Specifications, and Engineering (PS&E) design issues. The evaluation team considers this unusual. PS&E packages are normally completed before an engineering firm bids on a contract, not after the contract is awarded.
	•	LADOT and FSI meet to discuss the Traffic Control Software Program (TCSP) and Field Computer Control Software (FCCS) interface.
	•	NET is developing a ramp metering algorithm for Caltrans District 7.
	•	NET is coordinating the user interface between D12 and D7 so they can use one version for both Districts.
	•	Sean Skehan of LADOT still does not have a legal agreement with COI. COI is working with Caltrans Headquarters and LADOT to work out a software agreement to solve this problem.
	•	COI completes the requisition for the 2070 ATC equipment.

	• COI wants to use narrower cable to connect to field equipment, because many of the COI pull boxes are full.
August	• FSI notes that its software is not designed to accommodate any difference between the vanilla flavored 2070 they are designing for and 2070 NEMA controller to be deployed.
	• NET reports that the SWARMS algorithm will not be fully installed before November. Ed Khosravi of Caltrans District 12 is concerned about NET's slow progress with respect to SWARMS.
	• NET and FSI meet to discuss the MIST and ATMS interface.
	• FSI delivers Draft 2 of a "High Level Design Report."
	• The evaluation Team delivers an updated Evaluation Plan, Tasks A through D, inclusive.
September	• FSI needs the 2070 controller, the AMS, and Sarasota loop detector promised by COI to complete further work.
	• The as-built status of Irvine intersections is further slowing up completion of the PS&E packages.
	• FSI delivers a final "High Level Design Report."
	• NET delivers Draft 3 of a "Traffic Response Plan/Operations Plan" technical memorandum.
	• The City is working on a formal 2070 software agreement with Caltrans and the City of Los Angeles.
	• NET delivers Draft 1 of an "ATMS/MIST Inter-tie Interface Specification."
	• NET delivers Draft 1 of a "Ramp Metering Detailed Design Document."
	• September 17: Monthly Irvine FOT PMT meeting.
	• The Caltrans ATMS user interface storyboard is under development by NET.
	• John Thai of COI reports that the formal 2070 software agreement passed "engineering" and will undergo the "legal" phase. And that, "after that Farradyne can run it."
October	• NET delivers a draft "Ramp Metering Test Plan."
	• NET delivers a final "Traffic Response Plan Requirements" technical memorandum.
	• FSI continues work on the PS&E package.
	• FSI finding it difficult to communicate with LADOT concerning the firmware for the 2070 controllers and related matters because LADOT is devoting most of their time to the SMART Corridor.
	• LADOT anticipated their software development work would require four months after LADOT received the 2070 hardware. It now appears that the LADOT software might not be operational for some time.

- MATRIX has been unable to meet Caltrans QPL specifications. Eagle will receive the contract if MATRIX fails to deliver.
- COI now expects to have possession of a 2070 controller within four weeks.

October
- NET is waiting on controllers from Caltrans, but NET's work has not otherwise been subject to the delays experienced by the other FOT partners.
- The PMT, particularly FHWA, suggests that the evaluation team focus on SWARMS. SWARMS is to be installed statewide, and will likely be available for evaluation even if the arterial elements of the Irvine FOT project are not.
- The 2070 software agreement is still under review by COI, Caltrans Headquarters, and LADOT.
- NET proceeds with ramp metering coding and the inter-tie detailed design.
- The COI and Caltrans meet to discuss maintenance agreements for field and TMC equipment.

November
- FSI signal software development is impeded because neither the LADOT's 2070 signal control software nor the 2070 hardware has been delivered.
- COI suggests that FSI should focus on delivering the MIST system with the ARP and CMS modules by April 1997.
- COI suggests delaying deployment of OPAC until after June 1997 to complete the remainder of the Irvine FOT Project on time. OPAC would not be available for the evaluation before June 1997 (John Thai, COI letter to FSI. November 8, 1996).
- FSI would have to execute a second controller integration when the 2070 signal control software became available, which COI indicates would be funded from sources external to FSI's current contract. FSI would still have to write the signal control software.
- FSI reports that the firm is unable to make the June 1997 deadline for signal control.
- COI and FSI consider installing two 170 controllers at each intersection in lieu of the 2070 controller, but this is not a feasible option because there is insufficient space in controller cabinets.
- The evaluation team takes the position that, if adaptive signal control is removed entirely from the scope of the project, the project goal of integrated corridor control will be impossible to meet.
- COI and Caltrans District 12 are to meet to discuss operational agreements.
- The evaluation plan needs to be reviewed by the PMT and the evaluation team in light of recent project changes.
- NET proceeds with ramp metering coding/testing and the Caltrans District 12/Irvine inter-tie detailed design.
- FSI continues work on the Unix version of MIST, base map options, defining timing plan page layout, and data module library for TSCP-FCCS communication. PS&E work continues.

November	•	COI expects delivery of 2070 and CMS equipment in December, 1996 if MATRIX is compliant.
	•	COI is working with 2070 manufacturers to resolve remaining specification issues.
	•	COI requests that Caltrans TOS test the 2070 controllers based on revised Caltrans requirements.
	•	COI meets with LADOT and Caltrans TOS to finalize the preliminary traffic control software to be used in the Irvine FOT Project. LADOT is to submit RAM pages for access by OPAC, and for MIST downloading and uploading.
	•	COI delivers the remaining as-built plan-set to FSI.
	•	November 10: The evaluation team will provide a new evaluation test matrix updating evaluation scenarios.
	•	November 15: The evaluation Team concludes that there effectively is no Irvine FOT Project without arterial control.
December	•	NET delivers a final "Ramp Metering Detailed Design."
	•	NET delivers a final "Ramp Metering Test Plan."
	•	COI requests Caltrans TOS test the 2070 controller.
	•	COI meets again with LADOT and Caltrans TOS to finalize the preliminary traffic control software to be used in the Irvine FOT Project.
	•	The evaluation Team requests each of the FOT partners (District 12, NET, FSI, City of Irvine) provide a brief statement summarizing expected activity over the remaining six months of the project by the January 1997 FOT PMT meeting. This summary will include (1) current project goals and objectives; (2) project deliverables; (3) a specific statement identifying areas requiring COI and/or Caltrans District 12 cooperation; and (4) a financial summary.
	•	December 12: Monthly Irvine FOT PMT meeting. FSI reports that the first 2070 controllers will not be available until after the first of the year (1997).
	•	FHWA expresses concern that the conversion of the MIST OS/2 platform to Unix has taken such a long period of time. FSI explains that the delay is due to the conversion requirements for the graphical user interface (GUI).

1997

January • January 2: USC Prof. Jim Moore e-mails an evaluation team request for budget information to the FOT partners participating in the Anaheim FOT and Irvine FOT Projects.

• The evaluation team projects the field evaluation to begin in January, 1998.

• Caltrans District 12 states that the agency is willing to turn off SWARMS for the purpose of evaluation.

• FSI reports that it will not be able to complete the project without a new contract.

• NET reports that it will be unable to integrate with FSI without a new contract.

• NET plans to integrate SWARMS into the Caltrans District 12 TMC during March.

• NET delivers a final "ATMS/MIST Inter-tie Interface Specification."

• FSI receives the 2070 and 2070 N controllers. However, the equipment arrives without 2070-6 Modem Boards. FSI will receive these in February.

• FSI submits a white paper on anticipated OPAC performance in the Irvine FOT Project environment.

• John Thai of COI visits FSI Headquarters in Rockville, MD.

• FSI announces their concern over the expiration of equipment warranties and third party software technical support.

• A brief description of deliverables and a high level financial summary for NET's work is provided in response to the request from the evaluation team (NET, attachment to a letter to John Thai of COI, January 21, 1997).

• January 17: Ramp metering demonstration at NET.

• Caltrans extends the termination of the evaluation contract for Irvine FOT Project activities to June 1998.

• January 21: Loop detectors remain on order. The 2070 final product will be available to FSI by mid-February. FSI indicates that debugging and calibration activities may not be complete until December 31, 1997.

• NET states that their internal evaluation of the Caltrans District 12 SWARMS installation will be finished by June.

• January 23: USC Prof. Jim Moore again e-mails the budget request FOT partners, which has been modified to reflect conclusion of expenditures for the IFOT through May 31, 1998.

February

- FSI submits a letter to John Thai of COI committing to deliver and integrate by June 30 the MIST Kernel - UNIX Version, the MIST Operator Interface, the ATMS/ARP Module, the CMS Module, the Field Computer Module, and the Isolated OPAC Module.

- FSI submits the 65% level of the PS&E package for COI approval before proceeding to 100%.

- Caltrans District 12 and NET plan to discuss the SWARMS implementation plan between other scheduled meetings.

- COI plans to deliver the ARP elements by May 1.

- COI distributes a Field Deployment Plan.

- NET and FSI reiterate their need for contract extensions.

- NET completes coding and testing the SWARMS algorithms and Executive Module.

- NET meets with Caltrans District 12 to provide background information as input to Caltrans' efforts to define freeway incident test scenario procedures.

- FSI submits a while paper on "Anticipated Effects of Different Detector Configurations on Coordination in the Irvine FOT Network."

- February 2:   Discussions continue between FSI, NET and COI concerning clarification of FOT contract variables. No system components have been installed at this time. Network and hardware requirements are not yet fully defined.

- FSI is due to complete work on components October 1997, with debugging continuing until December 1997.

- February 11:   The evaluation teams meets via teleconference to discuss fiscal matters related to the completion of the two FOT evaluations. Delays in the progress of both the Anaheim and Irvine FOT Projects will require a considerable extension to the period of performance for the evaluation team. The evaluation team concludes that, given existing funds and with the current project schedule, it will not be possible to complete the proposed evaluation work for both FOT's. Cost extensions to the evaluation contracts are needed.

- February 6:   Robert Tam suggests redistributing evaluation team funds across participating Universities to keep the entire team funded until cost extensions can be provided. The evaluation team agrees.

- February 18:   Monthly Irvine FOT PMT meeting. Loop detectors remain on order. The 2070 final product was to have been available to FSI by mid-February. Carla Simone of NET expects full underline deployment in early October. UCI Prof. Mike McNally, reports that the field evaluation starts on January, 1998 and continues until June, 1998.

- NET reports that the SWARMS installation will be finished by June 30, 1997.

- FSI reports that MIST integration will require one month after June 30, 1997, and an additional month for testing. Debugging and calibration activities may not be completed until December 31, 1997.

February
- Teri Argabright of NET and John Thai of COI report that the ARP will be optimized about October 15.
- USC funding will not be increased for the Irvine FOT Project evaluation. Cal Poly funds will be transferred to USC instead.
- Teri Argabright of FSI reports that partial integration of the 2070 controllers with OPAC and MIST will be complete by June, and that full integration will be complete by August.

March
- NET provides a punch list of Inter-tie and System testing tasks scheduled for the period beyond NET's contract.
- FSI and NET still require contract extensions.
- FSI is holding weekly meetings with LADOT to discuss interface issues.
- FSI is holding meetings with COI regarding the PS&E package.
- FSI's invoices are not being paid by COI.
- The PS&E package causes the money problem related to detector locations to resurface.
- FSI expects LADOT executable firmware to be available by March 30. If LADOT fails to deliver by this date, FSI's schedule may slip further.
- FSI is unsure that they are working with the correct CMS firmware. AESCO may have changed versions.
- COI promises to supply signal timing plans to FSI by April.
- COI receives over half of the 2070 controllers that they have ordered.
- John Thai of COI plans to meet with the City Auditor this month regarding both FSI's outstanding invoices and contract extensions for NET and FSI.
- Caltrans considers withholding $250,000 in project funds until completion of the entire project, but ultimately relents.
- NET prepares a draft "Ramp Metering Implementation," including "Base Ramp Metering Functions and System-Wide Adaptive Ramp Metering Functions."
- NET will modify the Remote Procedure Protocol (RPC) structures and send these to FSI.
- NET will change the FOT_Status to display enumerated values.
- The structure of Field_Message should include an additional enumerated type field containing the device status. NET will define the values.
- FSI will define a convention for arterial postmiles.
- FSI will define the device ID for CMS and links.
- March 26:   Caltrans first extension of PATH's Irvine FOT Project evaluation (Amendment #1) is granted extending the end of the project evaluation from March 31, 1997 to March 31, 1998.
- March 18:   Monthly Irvine FOT PMT meeting.

- Three metered freeway ramps can be placed under SWARMS control.

March
- NET responds to the evaluation team's December request for a status summary. COI, Caltrans District 12, and FSI have yet to respond.
- Frank Cechini of FHWA expresses concern about how little evaluation can now be done for remaining resources and the prospective cost of doing more.
- OPAC is back is back from the dead.

April
- FSI holds more meetings with COI regarding the PS&E package.
- FSI expects to complete the PS&E package next month.
- FSI is completing revisions of the 65% level PS&E package based on COI comments received this month.
- FSI holds weekly meetings with LADOT to discuss interface issues.
- FSI still needs delivery of LADOT signal control firmware.
- Equipment warranty expiration and the need for third party software technical support remains unaddressed.
- Existing CMS documentation does not match demo sign provided to FSI. FSI staff lose two weeks as a result of this mismatch. The final CMS protocol might not match demo protocol.
- John Thai of COI wants to test isolated OPAC at an intersection near City Hall while FSI recommends using an intersection from the FOT area, preferably an intersection with as many OPAC-type detectors as possible.
- COI receives the rest of their 2070 controllers (32 total).
- FSI owes LADOT a module.
- COI has not received all of the AMS equipment.
- COI expects to complete field construction by mid-July.
- COI completes the 2070 timing base.
- The ARP will rely on timing plans designed by John Thai of COI in an *ad hoc* fashion. FSI and John Thai seem to disagree about whether OPAC is part of these response plans. John Thai says "Not unless it works better than I think it will."
- NET delivers a draft "System-Wide Test Plan."
- FSI and NET still need contract extensions.
- Caltrans, NET, and the evaluation team hold a SWARMS meeting at Caltrans District 12.
- NET does not believe contract extension will impact delivery of SWARMS to Caltrans District 12.
- The FOT partners discover there is no plan for SWARMS training. No one budgeted to support SWARMS training. Training is not in NET's scope of

work. NET is waiting for John Thai of COI to approve training funds for Caltrans District 12 personnel.

| April | • | Caltrans District 12 does not have a formal SWARMS implementation plan. Caltrans District 12 plans to start SWARMS implementation with only one ramp, and slowly adding a few ramps to SWARMS control until the entire segment is under SWARMS control. |

       • Caltrans District 12 wants the evaluation team to determine if the SWARMS algorithm can keep the entire county-wide network synchronized. The evaluation team declines, citing the bounds of the Irvine FOT Project area, and rapidly dwindling evaluation resources.

       • The evaluation team has asked NET determine if a SWARMS report can be generated identifying what timing rule/mode is being applied at any given ramp.

       • Ed Khosravi of Caltrans District 12 wants SWARMS installed by mid-May.

       • April 13: Cal Poly Prof. Art MacCarley states that he wants to turn over the lead task in Irvine FOT Project evaluation to UCI Prof. Mike McNally. Prof. MacCarley's attention is needed on new research projects that are about to begin. Prof. McNally agrees.

May
       • FSI receives final AESCO CMS firmware and documentation.

       • FSI delivers the program for testing OPAC sensitivity to COI.

       • FSI and NET still need contract extensions.

       • FSI believes the full project functionality will be integrated between October and December 1997.

       • FSI distributes "Irvine FOT Intersection Design Results," providing the evaluators with their first look at the OPAC loop detector deployment expected for the Irvine FOT Project. No left hand turn bays will be detectorized. Very few intersections will have demand measurement or optimum OPAC detector placement for the side streets.

       • FSI plans to provide June deliverables by June 23.

       • FSI will shift the cost sharing portion of their contract to dates after June 30, spending all of the FHWA contribution prior to July 1. This provides FSI's with the equivalent of a no cost contract extension.

       • Ramp Metering/Integration is still not complete. NET's in-house work is to be completed by the end of the month. On-site work at Caltrans District 12 is to be completed early next month.

       • COI has yet to approve and fund Caltrans District 12 SWARMS training.

       • Carla Simone of NET takes a maternity leave of absence.

       • Even though the City has signed a contract with LADOT, FSI still has not received the LADOT firmware.

       • NET will allow Caltrans District 12 only receive two weeks to review and accept SWARMS after NET's delivery. Caltrans District 12 does not consider this reasonable.

	• Caltrans hopes to define a new contract through the UCI/PATH testbed to fund the work that NET needs to do during the next fiscal year.
May	• COI is working on an internal field construction review. To COI's consternation, the City must get a construction permit from itself.
	• The evaluators still need a report identifying what timing rule/mode is being applied at any given ramp.
	• COI has not provided FSI with signal timing plans.
	• NET completes user interface coding.
	• The inter-tie coding effort is on hold pending resolution of schedule issues.
	• NET will not be able to complete the ITRAC and Caltrans District 12 TMC inter-tie integration and system-wide testing by the end of their contract. NET's ability to proceed is constrained because FSI has not completed Phase 1 integration of MIST.
June	• June 1: LADOT delivered their original firmware to FSI. It runs regular signal operations; however, it cannot communicate with OPAC.
	• FSI and LADOT have not yet finalized the LADOT firmware. FSI continues to meet with LADOT weekly to resolve firmware problems.
	• FSI delivers the PS&E package to COI.
	• COI extends FSI's contract until December 31. However, NET's contract expires June 30.
	• The Caltrans District 12 firewall may pose problems for the FSI/NET inter-tie and integration.
	• COI field construction is proceeding nicely. AMS are installed, but have not yet been powered by Southern California Edison. Loop detector construction is about 50 % complete.
	• COI needs to finish installing the remaining loops, but the FOT account is out of money. The City must go out for re-bid to complete the installation.
	• COI is working on intersection timing charts for FSI.
	• COI has not yet populated the ARP tables for FSI.
	• The evaluation team asks COI to add a shakedown of the ARP elements to COI schedule.
	• John Thai leaves COI to accept employment with City of Anaheim. COI Transportation Manager Arya Rohani states that the City will insure that the Irvine FOT Project is completed.
	• Arya Rohani hires John Thai as a consultant.
	• FSI delivers the Phase 1 version of MIST to COI, including the MIST Kernel - Unix Version, MIST Operator Interface, ATMS/ARP Module, and CMS Module.
	• June 30: NET delivers and installs SWARMS at Caltrans District 12.

July   •   FSI seems to have a version of the LADOT firmware that works.

September   •   September 23:   The evaluation team submits a letter to Caltrans District 12 requesting updated information needed to proceed the evaluation.

•   FSI starts testing and integrating the Phase 1 version MIST at COI's offices.

•   The evaluation team begins refining the SWARMS evaluation plan.

October   •   FSI delivers an initial version of OPAC, limited MIST communications, and an initial Field Computer (FCCS) module.

•   MIST can now communicate with AMS through a modem on the sign, but not through the controller.

•   Whether new signals installed as part of construction in the study area will be under OPAC control remains unknown.

•   No coordination between COI and Caltrans CMS is anticipated.

•   Mike McNally requests monthly status reports from COI and Caltrans District 12.

•   Barry Greenstein takes charge of the Irvine FOT Project on behalf of the COI, replacing John Thai, who will continue to assist the FOT partners as a consultant.

•   FSI submits a letter to Barry Greenstein of COI indicating limitations associated with the MIST software delivery.

•   October 15:   Cal Poly Prof. Art MacCarley speaks with Ed Khosravi of Caltrans District 12 at the annual PATH conference at Richmond Field Station. Ed Khosravi's perception seems to be that SWARMS will be the only Irvine FOT system evaluated. Cal Poly Prof. Art MacCarely reports that Caltrans District 12 is interested in whether the SWARMS algorithms are doing what NET says they are supposed to do. Caltrans also asks for a careful inspection of the SWARMS source code to verify the implementation of the algorithm(s).

•   October 30: $23,727 in PATH evaluation funds is shifted from Cal Poly to USC. The start date for expenditure of the funds is January 1.

November   •   FSI plans to deliver the MIST software in late December 1997, with final systems integration in late January 1998.

•   FSI expects to complete the dynamic database portion of the MIST system in late December 1997.

•   FSI accomplishes testing and integration of the Phase 1 version of the MIST software at the COI offices.

•   FSI cannot yet test the ARP functions between MIST and the Caltrans District 12 ATMS due to communication problems. The hub had a bug that made it shut down when there was too much traffic. Also, the communications software is still having a problem with the Caltrans District 12 fire wall.

November
- Chau Nguyen of COI asks if MIST is capable of broadcasting time to the 2070 controllers from the World Wide Web (WWW). FSI will investigate.
- John Thai of COI asks FSI to finalize items that it needs from the FOT partners, COI, Caltrans, and NET to ensure successful delivery in January 1998.
- The planned 2070 deployment with MIST integration has four phases.
- Ahmad Rastegarpour of Caltrans District 12 asks about Year 2000 compliance, and requests FSI provide compliance certification. FSI requests Caltrans District 12 to provide a standard Year 2000 compliance form.
- COI has not yet completed a draft MOU for ITRAC/TMC Center-to-Center operations. Richard Macaluso of Caltrans New Technologies will help draft the MOU.
- Richard Nelson of COI announces that the new signal at Alton & Jenner should be considered an addition to project area.
- John Thai of COI plans to provide TSCP software training to COI staff on December 8, 1997.
- November 12: Monthly Irvine FOT PMT meeting. Discussion focuses on definitions of arterial response plans; under what conditions response plans to be implemented; and whether the scenarios for arterial response will be represented Caltrans District 12's expert system by NET or incorporated into MIST by FSI.
- The evaluation team reports a strawman field evaluation plan has been prepared that describes the evaluation team's intentions in light of cumulative changes in the Irvine FOT Project. This will be presented to the FOT partners.

December
- John Thai of COI emphasizes that MIST must have the capability to broadcast time to the 2070 controllers in the field. Teri Argabright of FSI will confirm this capability and respond.
- Chau Nguyen of COI asks again about feasibility of using WWW time source for MIST. Teri Argabright of NET responds that this requirement was not in the original specifications, and that the broadcast time is based solely on the MIST workstation clock.
- John Thai of COI reports that the TSCP software testing has gone very well and on schedule. John would like to install a 2070 controller running TSCP in a 332 cabinet.
- John Thai of COI will meet with the Caltrans District 12 staff to install 2070 controller in a Caltrans cabinet.
- The ITRAC/District 12 TMC MOU has not been initiated. Richard Macaluso of Caltrans New Technologies will take the lead and arrange a meeting between Caltrans District 12 and COI.

| | | Tadeo Lau of Caltrans District 12 reports that the SWARMS system is not currently online because the Caltrans District 12 staff is not yet comfortable with the system. |

December
- The evaluation Team delivers proposed strawman field evaluation plan to the FOT partners.
- The evaluation team expresses concern that Caltrans District 12 personnel were unresponsive to information requests from the evaluation team. Ahmad Rastegarpour of Caltrans District 12 volunteers to contact Ed Khosravi of Caltrans District 12 to request additional assistance.
- FSI indicates the need for involvement by NET when the FSI integration team is on-site towards the end of January 1998 to perform systems integration. FSI will review NET participation requirements for COI.
- FSI delivers Phase 4A software consisting of the MIST kernel, MIST Operator Interface, signal Control, and field computer module.
- The evaluation Team assumes that MIST/OPAC/ARP/2070 components will be delivered in January 1998.

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January
- January 9: The evaluation team requests that the FOT partners provide comments on the strawman field evaluation plan the by monthly Irvine FOT PMT meeting on February 4 in Irvine.
- January 20: Richard Macaluso requests a proposal from the evaluation team to amend the contract the evaluation contracts and provide a cost extension for continued work.

February
- COI promises that at least one intersection will be available for initial implementation/testing of MIST, OPAC, CMS, 2070, and related traffic control software by February 23.
- Construction in the FOT area remains a concern for the FOT partners and the evaluation team.
- There is still some hardware problem preventing the Caltrans District 12 ATMS/ITRAC communication link.
- The operating MOU between COI and Caltrans District 12 remains an open issue.
- February 4. Monthly Irvine FOT PMT meeting. There is discussion about postponing the evaluation field data collection until Fall. The decision will be made at a meeting on February 24.
- Richard Macaluso of Caltrans New Technologies reports that, contrary to assurances provided to the evaluation team in past months, Caltrans New Technologies does not feel justified in spending more on the evaluation of

the Irvine FOT Project. There will not be any cost extensions to the existing evaluation contracts.

- James Arcenaux of Caltrans District 12 reports that necessary hardware (loops, communication, etc.) will be in place and operating soon.

February	•	There are problems on the ATMS side of the ATMS/ITRAC communication link. Caltrans District 12 agrees to provide material relating to the hardware (data, communications, equipment, etc.) for discussion at all subsequent FOT meetings as a standard agenda item.
	•	February 6: Caltrans District 12 reports that SWARMS will be implemented in 3 months.
	•	February 18: The evaluation team discusses the feasibility of an OPAC-only evaluation.
	•	February 24: Special technical meeting. Caltrans District 12 will not activate the SWARMS system before it is tested. Integration with COI elements is not possible until Spring 1999. Richard Macaluso of Caltrans New Technologies wants the Irvine FOT Project evaluation finished as soon as possible, certainly before the Fall of 1998. The discussion focuses on OPAC and ARP. COI summarizes installation of detectors and controllers.
March	•	March 26: Caltrans second and final extension for PATH's Irvine FOT Project evaluation (Amendment #2) is granted extending the end of the project evaluation from March 31, 1998 to March 31, 1999.
April	•	April 2: The evaluation team continues to discuss what, if anything remains in the scope of the evaluation. Without a cost-extension, the evaluation team is out of money and time.
	•	The evaluation team discusses how to allocate remaining funds to remaining tasks. Some data might yet be collected if the mobile surveillance units constructed for Caltrans District 12 can be made available at no cost.
	•	April 30: The evaluation Team requests six months (through September 30) to complete an institutional evaluation if the Irvine FOT Project and full documentation of the project to date.
June	•	June 10: NET states that SWARMS reports generated for Caltrans District 12 are incomplete. There is some loss of data. Ed Khosravi and others will revisit the field sites to make sure the loop detectors are working. Tadeo Lau of Caltrans District 12 reports that the mobile surveillance units only work well on AC power. There is no prospect of autoscope data.
	•	June 17: Caltrans District 12 reports that ATMS/SWARMS work is expected to be completed by June 30.
	•	It is unclear whether the mobile surveillance trailers will be usable because it is unclear how to power them in the field. UCI Prof. Mike McNally notes that these units work when plugged into a separate generator. It is not clear to him what hardware will be running in the Caltrans District 12 TMC.
June	•	The evaluation team and Caltrans District 12 continue discussing means of collecting freeway incident data. District 12 is willing to reschedule regular maintenance activities to support evaluation objectives.

- June 18: NET indicates to Cal Poly Prof. Art MacCarley that SWARMS is being installed in Caltrans District 7 and District 11.
- June 30: Monthly Irvine FOT PMT meeting. Teri Argabright of FSI reports that 127 MIST program bugs have been cleared, but a few remained outstanding. She reports extensive integration and module testing, including testing with OPAC. Some bugs affected the efficiency of OPAC. The time-of-day broadcast problem remains unsolved.
- TSCP is not passing the environmental pointer. This is being fixed by LADOT. FSI resists distributing software to other vendors at this time.
- June 20: John Thai of COI reports that FSI staff arrive in Irvine to begin final integration. Their schedule includes training COI personnel.
- June 23: The evaluation team continues to discuss the scope of the evaluation, particularly with respect to MIST. UCI Prof. Mike McNally notes that FHWA, Caltrans, and COI must decide whether MIST/OPAC is to be evaluated as part of a "system verification" evaluation.

July
- July 27 - 29: FSI MIST training takes place.
- July 30 OPAC training takes place.

August
- August 24: COI reports numerous critical bugs in the MIST software. COI has sent FSI several SCRs that detail the bugs for follow-up (Barry Greenstein of COI, letter to Teri Argabright of FSI, August 24, 1998).

September
- FSI reports that its contract prohibits evaluation team access to source code for the software they will deliver to the city.
- September 9: UCI Prof. Mike McNally announces that UCI must terminate participation in the Irvine FOT Project evaluation on December 31, 1998 due to budget problems.
- The evaluation team concludes that only the institutional element of evaluation can be executed. An evaluation of technical aspects is no longer possible.
- September 22: The evaluation team submits a letter to Richard Macaluso of Caltrans New Technologies listing deliverable evaluation products.

October
- October 8: COI requests FSI's immediate attention to the critical bugs found in MIST software (Barry Greenstein of COI, letter to Teri Argabright of FSI, October 8, 1998).
- FSI distributes a Problem Report Summary for Irvine FOT Project.
- October 19: Monthly Irvine FOT PMT meeting.
- October 20: Cal Poly Prof. Art MacCarley notes that the evaluation team can document some impact of the Irvine FOT Project in California. He has traveled 24,000 miles attending monthly meetings over the course of the past four years, almost the distance around the earth at its equator.

December
- December 15: Monthly Irvine FOT PMT meeting. The Irvine FOT Project is concluded. Caltrans New Technologies requests a final evaluation report by March 31, 1999.
- NET reports it has opened the new Caltrans District 7 TMC, and can now return to work on the ATMS bugs in the Caltrans District 12. NET describes SWARM as the kernal TOPS, over traffic operations plan for Southern California associated with the priority corridor.
- Caltrans District 12 reports SWARM was tested in the field for 2.5 weeks. The NET ATMS does not allow communications with non-meter BV surveillance controllers in the field, which constitute about 20% of the total plant. It does allow communications with the ramp controllers, operators find it inefficient. It allows no selection of parameters, timing, or other options. Caltrans District 12 TMC operators do not use this capability at this point. There is no indication that the ATMS does anything at all.
- CI Prof. Mike McNally reports that the TMC interviews with Caltrans District 12 personnel reveal that TMC operators have virtually no knowledge of any of the FOT plans and technologies. They are not aware any of their staff attended training at Irvine. (Ed Khosravi of Caltrans 12 reports that someone named Mimi was there, whom Tadeo Lau of Caltrans District 12 identifies as Mimi Chou, who is a full-time operator).
- UCI Prof. Mike McNally reports that the TMC staff are aware of the Operator Decision Support System (ODSS). ODSS appears in the original FOT proposal, but all Caltrans District 12 parties queried through the Summer of 1998 reported ODSS did not exist. James Arcenaux of Caltrans District 12 reports that the TMC operators have no faith in ODSS. Ed Khosravi of Caltrans District 12 reports that the incident detection algorithm that drives ODSS is unreliable. Both are quite aware of the system. Paul King, the TMC Manager at Caltrans District 12, has only one official response about ODSS, "No comment." James Arcenaux changes his response to, "No comment."
- Caltrans District 12 and COI both plan on completing payments to both NET and FSI to obtain closure and to avoid litigation.

December • UCI Prof. Mike McNally notes that, "In terms of functionality of deliverables, this FOT was an absolute and complete failure. In terms of institutional issues, red flags were raised at nearly every step, and all were virtually ignored." He strongly suggests, "that only the planned institutional (evaluation) report be completed, and this should include a brief section that clearly identifies each of the planned components, and the fact that none of these components functioned upon delivery, period." The FOT partners agree that the report should be factual and should include a full summary of what transpired.

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January • January 14: Teri Argabright of FSI and Chau Nguyen of COI request the presence of evaluation team members at the final MIST acceptance test January 25-27. Robert Tam of PATH endorses the request.

• January 20: The evaluation team, on a mixed vote, decides to send a representative to the acceptance test to serve as an observer.

• January 21: The MIST acceptance test is postponed until February 1-3.

February • February 1: The evaluation team finalizes deliverables. The MIST acceptance test is postponed until March 23.

March • March 23: The MIST acceptance test occurs. CMS works. None of the six intersections ITRAC was communicating with permit manual override. Some do not permit a switch to OPAC. FSI delivers a "COI FOT Acceptance Test Report." COI does not sign off on anything. FSI asks UCI graduate student Steve Mattingly to sign, though on whose behalf is unclear. He declines.

March 31: The Irvine FOT Project evaluation contracts expire.

April • April 5: FSI delivers makes a final delivery of hardware to COI. The hardware is delivered in crates, and is not installed. Teri Argabright of FSI considers this the conclusion of FSI's participation in the Irvine FOT Project.

IRVINE FIELD OPERATION TEST PROJECT EVALUATION DOCUMENTS

Preliminary Evaluation Proposal submitted to PATH, June, 1994.

Revised Evaluation Proposal submitted to PATH, July 29, 1994.

Summary Evaluation Plan submitted to FOT partners, September, 1995.

Evaluation Task A • **Assessment of Corridor Performance** (Moore, USC)
Draft 0.9 - December 12, 1995.
Draft 1.0 - June 30, 1996, revised August 1996.

Evaluation Task B • **Evaluation of Adaptive signal Control System** (JayaKrishan and McNally, UCI)
Draft 0.9 - August 15, 1995.
Draft 1.0 - October 27, 1995, revised November 11, 1995.
Draft 2.0 - December 12, 1995, revised August 1996.

Evaluation Task C • **Technical Evaluation: Data Communications** (MacCarley, Cal Poly)
Draft 1.0 - September 22, 1995, revised November 11, 1995.
Draft 2.0 - December 12, 1995.
Draft 4.0 - August 1996.

Evaluation Task D • **Institutional Issues in system Deployment** (McNally and Mattingly, UCI)
Draft 0.9 - August 15, 1995.
Draft 1.0 - October 27, 1995, revised November 11, 1995.
Draft 2.0 - December 12, 1995, revised July 16, 1996, revised August 1996.

Strawman Field Evaluation Plan Submitted to FOT Partners, December, 1997

Draft Irvine Field Operational Test Project Evaluation Report Submitted to PATH and Caltrans New Technologies, August, 1999**.**

IRVINE FIELD OPERATIONAL TEST PROJECT
AND EVALUATION CONTRACT DATES

Caltrans v COI
- Cooperative Agreement
  Reference: Agreement #65-005
  Signed September 13, 1994
  Term: October 1, 1994 to June 30, 1996.

- Extension as Amendment #1
  Signed on April 25, 1996
  Extended from June 30, 1996 to June 30, 1997.

COI v Consultants
- Agreement for Consultant Services with NET
  Signed September 13, 1994
  Term: October 31, 1994 to April 30, 1996.

- Agreement for Consultant Services with FSI
  Signed September 13, 1994
  Term: September 1, 1994 to March 1, 1996.

Caltrans v PATH
- Evaluation Contract
  Reference: Master Agreement #65V313, Task Order #005
  Signed September 13, 1994
  Term: October 1, 1994 to March 31, 1997.

- First extension as Amendment #1
  Signed on March 26, 1997
  Extended the end of the contract period from March 31, 1997 to March 31, 1998.

- Second extension as Amendment #2
  Signed on March 26, 1998
  Extended end of the contract period from March 31, 1998 to March 31 1999.