Southern California Priority Corridor
Showcase Program Evaluation

Regional Automated Vehicle Locator and Transit Management (RAVL) Project Evaluation Report

FINAL

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Abbreviations & Acronyms

ATIS	Advanced Traveler Information System
ATMS	Advanced Transportation Management System
APC	Automatic Passenger Count
AVL	Automatic Vehicle Location
CAD	Computer Aided Dispatch
Caltrans	California Department of Transportation
CCTV	Closed-circuit Television surveillance camera
CDPD	Cellular Digital Packet Data
CM	Configuration Management
CMP	Configuration Management Plan
CMS	Changeable Message Sign
CORBA	Common Object Request Broker Architecture
COTS	Commercial Off-the-Shelf
CPU	Central Processing Unit
CTC	California Transportation Commission
CVO	Commercial Vehicle Operations
CW	Corridor-wide
CWATIS	Corridor-Wide Advanced Traveler Information System Project
CWATMS	Corridor-Wide Advanced Transportation Management System Project
CWCVO	Corridor-Wide Commercial Vehicle Operations Project
CWSIP	Corridor-Wide Systems Integration Project
CWSPP	Corridor-Wide Strategic Planning Project
DOIT	Department of Information Technology
DRI	Caltrans Division of Research & Innovation (formerly NTR)
EAP	Evaluation Activity Plan
EMB	Electronic Message Board
EMC	Emergency Management Center
EMS	Emergency Medical Services
EP	Evaluation Plan
FHWA	Federal Highway Administration
FSP	Freeway Service Patrol
FSR	Feasibility Study Report
FSP/TMT	Freeway Service Patrol/Traffic Management Team
FTA	Federal Transit Administration
FTE	Full-Time Equivalent (one full-time employee)
GIS	Geographic Information System
GPRA	Government Performance and Results Act
GPS	Global Positioning System
GUI	Graphical User Interface
HP	Hewlett-Packard
HQIT	Headquarters - Information Technology (division of Caltrans)
HVAC	Heating, ventilation and air conditioning

Hz	Hertz
IDL	Interface Definition Language
IMTMS	Intemodal Transportation Management System
IP	Internet Protocol
IPR	Intellectual Property Rights
ITS	Intelligent Transportation Systems
ISSC	Information Systems Service Center (division of Caltrans)
ISTEA	Intermodal Surface Transportation Efficiency Act (of 1991)
IVCU	Intelligent Vehicle Control Unit
IWS	Integrated Workstation
LAN	Local Area Network
MHz	Megahertz
MOU	Memorandum of Understanding
MPO	Metropolitan Planning Organization
MTA	Los Angeles County Metropolitan Transportation Authority
MTBF	Mean Time Between Failure
MTDB	Metropolitan Transit Development Board (of San Diego)
NCTD	North County Transit District (northern San Diego County)
NTCIP	National Transportation Communications for ITS Protocol
OCTA	Orange County Transportation Authority
O&M	Operations and Maintenance
OS	Operating system (such as Windows™, Unix, Linux, et. al.)
PA	Public Address
PC	Personal Computer (Windows™-based)
POC	Point-of-Contact
RAMS	Regional Arterial Management System
RAVL	Regional Automatic Vehicle Location & Resource Management System
RCTC	Riverside County Transportation Commission
RFP	Request for Proposals
RIWS	Regional Integrated Workstation
RTDIE	Regional Transit Database Information Exchange
RAVL	Regional Transit Management System
RTP	Regional Transportation Plan
RTPA	Regional Transportation Planning Agency
RWS	Remote Workstation
SANBAG	San Bernardino Association of Governments
SANDAG	San Diego Association of Governments
SCAG	Southern California Association of Governments
SCAQMD	South Coast Air Quality Management District
SCPCSC	Southern California Priority Corridor Steering Committee
SDTC	San Diego Transit Company
SDTI	San Diego Trolley Inc.
SQL	Structured Query Language
TEA-21	Transportation Equity Act for the 21st Century
TMC	Transportation Management Center

TMS	Transit Management System
TMT	Traffic Management Team
TrMS	Transit Management System
TSP	Transit Signal Priority
USDOT	United States Department of Transportation
VDS	Vehicle Detector Station
VOS	Volume/Occupancy/Speed
VCTC	Ventura County Transportation Commission
WAN	Wide Area Network
XML	eXtensible Mark-up Language

Executive Summary

Background

As required by federal law, all Intelligent Transportation System (ITS) projects that receive federal funding must undergo an evaluation to help assess the costs and benefits of ITS. This document is one of 23 reports produced as part of the Southern California ITS Priority Corridor Showcase Program Evaluation to help planners and decision-makers at the federal, state and local levels make better-informed decisions regarding future ITS deployments. This report presents the experiences, costs, and lessons learned from Southern California's RAVL project.

In 1993, the U.S. Department of Transportation designated Southern California as one of four Priority Corridors in which ITS could have particular benefit. Southern California suffers from extreme traffic congestion, limited room for expanding transportation facilities, and above-average air pollution levels. The Southern California Priority Corridor is one of the most populated, traveled, and visited regions in the country, and consists of four adjoining regions:

- Los Angeles/Ventura Counties
- Orange County
- San Diego County
- Inland Empire (San Bernardino and Riverside Counties).

The ITS Showcase Program is one of several programs that have been implemented in Southern California's Priority Corridor to help aid mobility and mitigate traffic congestion and its associated environmental impacts. The Showcase Program consists of 17 ITS projects that collectively form a corridor-wide intermodal transportation management and information network between Los Angeles, Orange County, San Diego, and the Inland Empire.

Each Showcase project deploys a piece of this corridor-wide ITS network, including regional Advanced Traveler Information Systems (ATIS), regional Advanced Transportation Management Systems (ATMS), and regional and interregional communications infrastructure. Eleven of the projects are regional in nature, while the remaining six are corridor-wide. RAVL is one of several federally funded Showcase Projects in Southern California, as identified in the Southern California ITS Priority Corridor Strategic Deployment Plan.

The Regional Automated Vehicle Locator (RAVL) project was partially funded through the Southern California Priority Corridor "Showcase" program under the auspices of the San Diego Regional Transit Management System.

RAVL, which represents the initial "proof of concept" phase of the regional transit management system, was awarded to Siemens Integrated Local Government Group in 2002. The remainder and much larger piece of regional deployment is implemented through the Regional Transit Management System (RTMS) project. Both RAVL and RTMS were designed to interface with the San Diego Intermodal Transportation Management System (IMTMS), which integrates regional modal management systems for freeways, arterials, transit, and traveler information.

The Regional Automated Vehicle Locator (RAVL) project consists of two separate efforts: 1) San Diego Freeway Service Patrol (FSP) & Traffic Management Team (TMT), and 2) San Diego Transit Management System Demonstration. The FSP & TMT project, a cooperative effort undertaken by the San Diego Association of Governments (SANDAG), Caltrans, and the California Highway Patrol (CHP), is designed to enable traffic managers to track the location of in-service Freeway Service Patrol (FSP) and Traffic Management Team (TMT) vehicles to more efficiently dispatch and manage the fleet resources.

Because the FSP and TMT components are not Showcase-funded projects, the focus of this evaluation is on the San Diego Transit Management System Demonstration project, which consists of a CAD/AVL implementation on four transit services:

- Airport Flyer (operated by ATC Vancom)
- Inland Breeze (operated by NCTD)
- Coaster commuter rail (operated by NCTD), and
- Poway transit services (operated by Poway Laidlaw)

This report also focuses on the development of IMTMS bridges and interfaces that enable an interface between RAVL and the regional Showcase Network.

San Diego Transit Management Demonstration Project

The Showcase-funded portion of the project is the San Diego Transit Management Demonstration Project, which equipped Airport Flyer, Inland Breeze and Poway buses with on-board computers to support RAVL functions such as vehicle tracking and data communications. Seven Airport Flyer buses have been equipped with emitters and integration devices. Traffic control components for a signal priority demonstration were installed by the City of San Diego along the Harbor Drive demonstration corridor to demonstrate signal priority and stop enunciation functions. The Coaster Commuter Rail fleet is equipped with on-board computers to support RAVL functions such as vehicle tracking and data communications. This system serves as a partner to the larger MTDB/NCTD Regional Transit Management Systems (RTMS) deployment efforts.

RAVL is an important demonstration project because the interfaces being developed for RAVL are central the integration of transit management, information and functionality in the overall IMTMS Network. The San Diego Transit Management Demonstration project is intended to establish:

RAVL objectives:

- Receive traffic information from traffic management agencies
- Provide transit incident management to traffic management agencies
- More efficiently manage the San Diego regional public transportation system
- Provide enhanced information to the public transportation users
- Enable improved public transportation throughput by use of transit signal priority
- Increase ridership on the San Diego regional public transportation system
- Increase the safety and security of the regional public transportation system
- Provide emergency transport services when activated by regional emergency management authorities

- Methods for integrating transit management systems with other modal management systems in the region;
- Operational methods for dealing with transit management systems;
- Approaches for providing real-time transit information to customers via electronic message boards at stops;
- Techniques for providing signal priority for transit vehicles.

RAVL uses commercial cellular data communications to transmit location, status and messages between vehicles and dispatch. RAVL servers and core equipment are located at the regional Transportation Management Center (TMC), which acts as the communications hub to transit dispatchers.

Evaluation Findings, Conclusions, and Recommendations

RAVL represents an important accomplishment in the San Diego region's ongoing efforts to establish a regional transportation management system. First and foremost, RAVL addresses critical deficiencies in the region's transit communications infrastructure, which will improve the efficiency in transit scheduling and dispatch functions. Second, implementation of real-time electronic signage, which posts next bus arrival information from the CAD/AVL system, will enable service planners to better understand how and where technology can be applied to improve the customer interface.

As a proof-of-concept demonstration, RAVL's principle achievement is the operational integration between different transit services in the region, and with the IMTMS Network. RAVL establishes bridges and network connections from RAVL to interface with the IMTMS Network based on a common definition and standard. Much of the benefit of RAVL will be realized once the interface with the IMTMS Network is fully completed, as transit operators will have access to freeway, highway and arterial traffic information through the RAMS Integrated Workstations.

As of the submittal of this evaluation report, RAVL has not yet been fully implemented. As a result, a comprehensive analysis of system impacts was not performed. There are several areas where RAVL is likely to result in tangible operational impacts:

- Transit dispatchers will be able to view and respond based on actual traffic conditions, emergency situations, special event conditions, and traffic incidents. Quicker response capabilities may result in additional interaction on a continuing basis between transit dispatchers and drivers, but expanded communication will allow for greater efficiency.

- Both RAVL and RTMS will interface to the Regional IMTMS Network, with communications links provided from RAVL to the IMTMS Network. This will enable transit dispatchers to monitor freeway and arterial traffic conditions via Caltrans' ATMS and RAMS. Transit operators report that this information may result in improved transit operations by being able to monitor traffic conditions, and receiving automated real-time traffic advisory information.

- The TSP deployment along Harbor Drive has the potential to improve end-to-end travel times for Bus Route 992 ("Airport Flyer"), without a significant impact of traffic conditions along this important arterial segment. In the future, bus location and schedule adherence data will be able to trigger transit signal priority without dispatcher or human intervention.

- RAVL has demonstrated some benefits of improving voice and data communications in transit management and operations. Operators report that RAVL has enhanced the ability to monitor schedule adherence. Through RAVL, transit managers can obtain real-time information on schedule reliability by bus and by route, for any time period. In the long run, the ability to review accurate data on schedule reliability will provide critical feedback information for route scheduling.

- The CAD/AVL system will enhance emergency response management capabilities in the San Diego region. Major wildfires in Spring 2004 in the San Diego region highlighted the need for a systematic overhaul of the regional emergency response management and radio communications system, both with local fire departments and law enforcement, but also with transit, especially in the event of major evacuations. In emergency response situations, transit agencies will be able to assign and dispatch transit vehicles for emergency transportation or evacuation duty based on pre-established agreements between transit agencies and Emergency Medical Services (EMS)/law enforcement operations.

- With the full deployment of RAVL, SANDAG has created a platform for identifying the impact of improved data communications on transit operations. A major constraint facing the further development of transit management interfaces is funding, which may not be sufficient to capitalize on the development of RAVL or future IMTMS Network communications. Lack of funding could forestall implementation of AVL to the remainder of the San Diego-area transit fleet and the achievement of objectives outlined as part of SANDAG's strategic vision to improve transit management.

- Another concern is availability of funding for ongoing maintenance and operations. With the recent reorganization of SANDAG to include both system implementation and operations, SANDAG is in the midst of developing policies regarding SANDAG's role and responsibilities in supporting regional ITS systems that require financial support from regional and local entities. Given Caltrans' intent to phase out support for RAVL, it is recommended that SANDAG develop an ITS business plan to identify long-term staffing requirements for ongoing support of regional ITS projects being integrated with the IMTMS Network.

1 Introduction

1.1 Purpose and Scope of this Report

As required by federal law[1], all Intelligent Transportation System (ITS) projects that receive federal funding must undergo an evaluation to assess the costs and benefits of ITS. The information provided in this report is intended to help planners and decision-makers at the federal, state and local levels make better-informed decisions regarding future ITS deployments based on the experiences of the RAVL project.

This document is one of 23 reports produced as part of the Southern California ITS Priority Corridor Showcase Program Evaluation, and covers only the events and findings resulting from the RAVL evaluation. The complete set of findings from the Showcase Program Evaluation are found in the following collection of documents:

Document Type/Title	Date	Document Number
17 Individual Project Evaluation Reports		
Corridor-wide ATIS Project Report	7/16/2003	65A0030/0033
Corridor-wide ATMS Project Report	10/28/2004	65A0030/0049
Corridor-wide CVO Project Report	10/29/2004	65A0030/0051
Corridor-wide Rideshare Project Report	11/1/2004	65A0030/0048
Corridor-wide Strategic Planning Project Report	10/29/2002	65A0030/0028
Fontana-Ontario ATMIS Project Report	11/30/2004	65A0030/0047
IMAJINE Project Report	3/17/2003	65A0030/0029
IMTMC Project Report	11/24/2004	65A0030/0054
InterCAD Project Report	4/2/2003	65A0030/0030
Kernel Project Report	5/30/2003	65A0030/0031
LA ATIS Project Report	3/15/2004	65A0030/0038
Mission Valley ATMIS Project Report	11/12/2004	65A0030/0050
Modeshift Project Report	10/28/2004	65A0030/0052
OCMDI Project Report	2/20/2004	65A0030/0040
Traffic Signal Integration Project Report	11/23/2004	65A0030/0055
Transit Mgt System Project Report	**11/30/2004**	**65A0030/0053**
TravelTIP Project Report	2/16/2004	65A0030/0036
5 Cross-Cutting Evaluation Reports		
System Performance Cross-Cutting Report	11/30/2004	65A0030/0056
Costs Cross-Cutting Report	11/30/2004	65A0030/0057
Institutional Issues Cross-Cutting Report	11/30/2004	65A0030/0058
Information Management Cross-Cutting Report	11/30/2004	65A0030/0059
Transportation System Impacts Cross-Cutting Report	11/30/2004	65A0030/0060
Final Summary Evaluation Report		
Showcase Program Evaluation Summary Report	11/30/2004	65A0030/0061

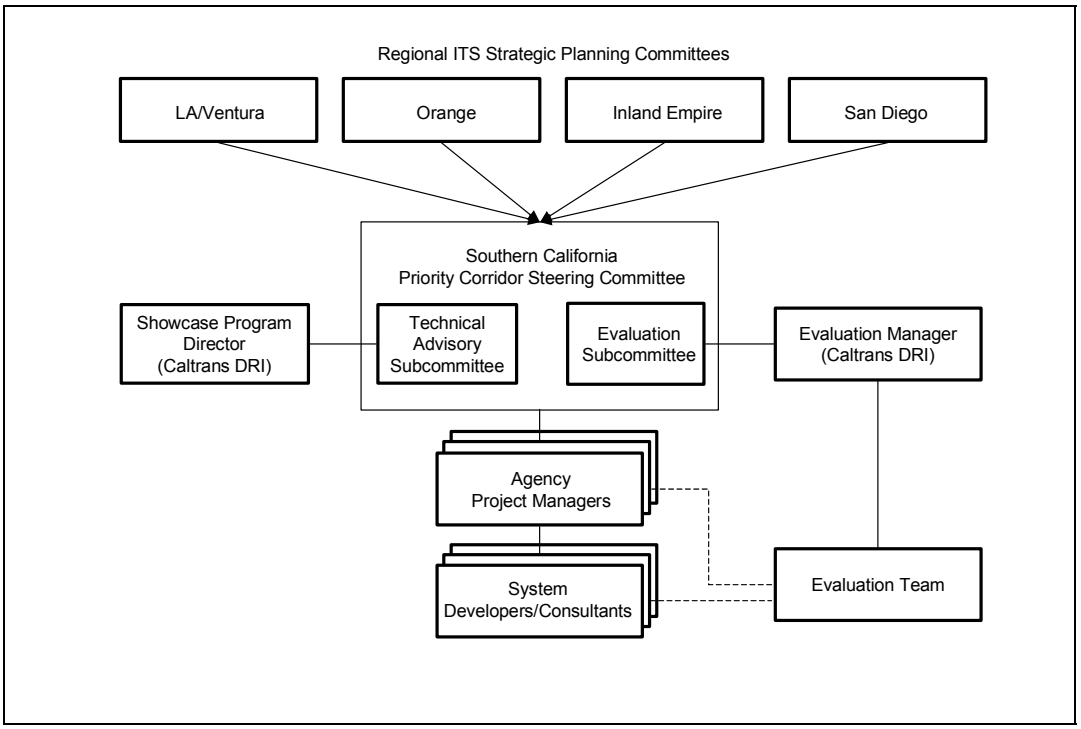
"TBD" indicates a future deliverable that is not yet available.

1.2 Evaluation Design and Approach

The findings outlined in this report are based on over five years of direct observations at project meetings, reviews of released project documents and agency memos, as well as formal and informal interviews and discussions with project partners.

The evaluation is responsive to the needs and suggestions of the Priority Corridor's Evaluation Subcommittee, which reports to the Priority Corridor's Steering Committee. As shown in Exhibit 1, both committees are comprised of stakeholders from federal, state, and local levels.

Exhibit 1 – Management Structure and Organization of the Showcase Program



The Steering Committee's member agencies include:

- California Highway Patrol (CHP)
- Caltrans, Division of Traffic Operations (headquarters)*
- Caltrans, District 7*
- Caltrans, District 8*
- Caltrans, District 11*
- Caltrans, District 12
- City of Irvine*
- City of Los Angeles Department of Transportation (LADOT)
- City of San Diego
- Federal Highway Administration (FHWA)*
- Federal Transit Administration (FTA)
- Los Angeles County Metropolitan Transportation Authority (LACMTA)
- Orange County Transportation Authority (OCTA)

- Riverside County Transportation Commission (RCTC)
- San Bernardino Association of Governments (SANBAG)
- San Diego Association of Governments (SANDAG)
- South Coast Air Quality Management District (SCAQMD)
- Southern California Association of Governments (SCAG).

* Indicates an Evaluation Subcommittee member

The Showcase Program's Evaluation Design is based on a set of evaluation Goals and supporting Objectives and Measures that were developed by the Evaluation Team in partnership with federal, state and local stakeholders, and documented in the "Showcase Program Evaluation Approach" in 1998. Each individual Showcase project is evaluated based on an applicable subset of these Goals, Objectives, and Measures in order to help ensure that summary evaluation results can be aggregated from across the multiple Showcase project evaluations. The Showcase Program's five evaluation Goals include:

- Evaluate System Performance
- Evaluate Costs
- Evaluate Institutional Issues and Impacts
- Evaluate the Use and Management of Transportation/Traveler Information
- Explore Potential Impacts on Travel Behavior

As RAVL evolved, project-specific refinements to the evaluation design were documented in a high-level Evaluation Plan (EP) and a detailed Evaluation Activity Plan (EAP). In general, the EP describes the project and/or system under evaluation, and lays the foundation for further evaluation activities by developing consensus among the Evaluation Subcommittee and project partners as to which of Showcase's evaluation Goals, Objectives, and Measures best apply to the project.

As the project matured, and after the EP had been approved, an EAP was developed to plan, schedule, and describe specific activities (e.g., interviews, surveys) and step-by-step procedures for conducting the evaluation. Data collection began after both plans had been reviewed and approved by the Evaluation Subcommittee and the project's partners.

1.3 Organization of this Report

The RAVL Evaluation Report provides a background description of the Southern California Priority Corridor and the transportation challenges facing San Diego County. This is followed by descriptions of the Showcase Program and the RAVL project, including a detailed technical description. The evaluation itself is subdivided and ordered into the five topic areas described below:

System Performance — provides important benchmark information regarding system availability, reliability, scalability and compatibility. The evaluation quantifies those items and could be used to identify needed improvements and help develop specifications for future systems.

Cost — provides important benchmark information regarding funding sources, software licensing, development costs, costs to re-deploy elsewhere or expand the system, and operations and maintenance (O&M) costs. This report includes an estimate of how much it might cost to re-deploy RAVL elsewhere in the state, and also looks at the incremental costs for integrating additional partner agencies and/or traveler information kiosks into the existing system.

Institutional Impacts — provides important information regarding the administrative, procedural and legal impacts resulting from the deployment of RAVL. Such impacts typically include changes in operator workloads, responsibilities and job turnover rates, as well as changes to and limitations of agency-wide policies, procedures and guidelines.

Transportation & Traveler Information Management — typically provides important benchmark information on system usage and user acceptance (by both agency operators and the general public). This report will provide quantitative and qualitative findings on these items and can be used to identify user demand, needed improvements and potential areas of future growth.

Transportation System Impacts — provides analysis of RAVL's potential impacts on transit usage, traffic congestion, air quality, and traffic safety. Since full deployment of RAVL will not be complete until Fall 2004, this report will not quantify the impacts of the project to the overall transportation system.

The report concludes with a summary, final remarks and recommendations for next steps.

1.4 Privacy Considerations

Some of the information acquired in the interview and discussion process could be considered sensitive and has been characterized in this report without attribution. The Evaluation Team has taken precautions to safeguard responses and maintain confidentiality. Wherever possible, interview responses have been aggregated during analysis such that individual responses have become part of a larger group response. The names of individuals and directly attributable quotes have not been used in this document unless the person expressly consented to its use.

1.5 Constraints & Assumptions

The RAVL evaluation is subject to the following constraints and assumptions:

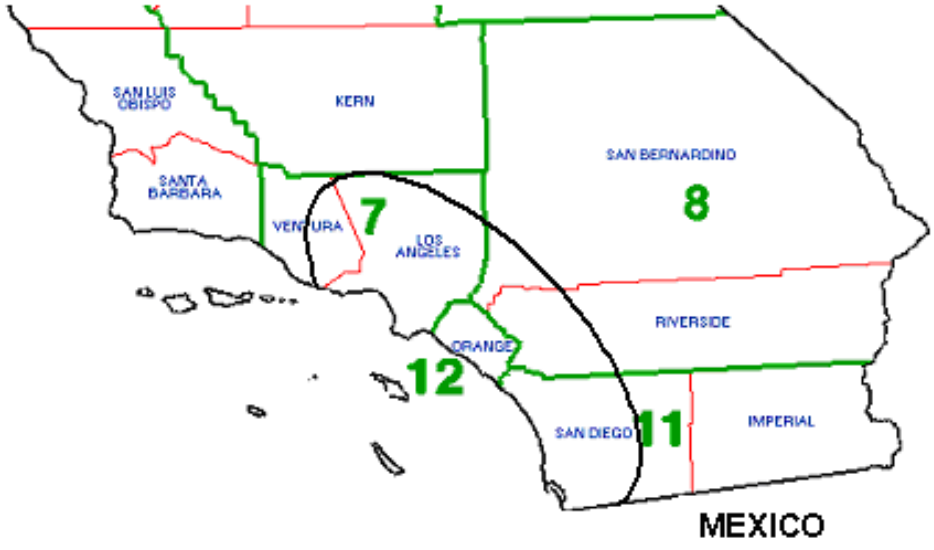
- The project's consultant was not required to disclose actual project expenses, so the project's cost is based on the fixed-price budget stipulated in the RAVL contract and its amendments. The budget reflects the expenses and costs for services paid by the client agency, but not necessarily the actual detailed costs for goods and services borne by the contractor.

1.6 Project Background

1.6.1 The Southern California Priority Corridor

In 1993, the U.S. Department of Transportation designated Southern California as one of four Priority Corridors in which Intelligent Transportation Systems (ITS) could have particular benefit. Southern California suffers from extreme traffic congestion, limited room for expanding transportation facilities, and above-average air pollution levels. The Southern California Priority Corridor, illustrated in Exhibit 2, is one of the most populated, traveled, and visited regions in the country.

Exhibit 2 – The Southern California Priority Corridor and Vicinity



The Southern California Priority Corridor consists of four distinct regions that correspond with the four Southern California Caltrans districts:

- Los Angeles/Ventura Counties (Caltrans District 7)
- Orange County (Caltrans District 12)
- San Diego County (Caltrans District 11)
- Inland Empire (Caltrans District 8).

Roughly two-thirds of the state's population – about 20 million people – resides in or around the Southern California Priority Corridor.

Exhibit 3 – Population and Number of Registered Vehicles by County

County	Population[2] (as of 1/1/2003)	Registered Vehicles[3]* (as of 12/31/2002)	Caltrans District
Los Angeles	10 million	6.7 million	7
Orange	3 million	2.2 million	12
San Diego	3 million	2.3 million	11
San Bernardino	1.8 million	1.3 million	8
Riverside	1.7 million	1.2 million	8
Ventura	0.8 million	0.7 million	7
Imperial	0.15 million	0.1 million	11
Total	**20.5 million**	**14.5 million**	

*Includes autos, trucks, and motorcycles. Trailers not included.

1.6.2 The Southern California Priority Corridor's ITS Showcase Program

The ITS Showcase Program is one of several programs that have been implemented in Southern California's Priority Corridor to help aid mobility and mitigate traffic congestion and its associated environmental impacts.

The Southern California ITS Showcase Program consists of 17 individual ITS projects that collectively form a corridor-wide intermodal transportation management and information network between Los Angeles, Orange County, San Diego, and the Inland Empire. Eleven of the projects are regional in nature, while the remaining six are corridor-wide in scope. Los Angeles County's LA/Ventura project is one of the eleven regional projects.

The 17 Showcase projects are listed by region in Exhibit 4. Eight of the projects, including RAVL, were fast-tracked and designated "Early Start" projects because of their importance as base infrastructure and their potential to act as role models for the rest of the Showcase Program.

Exhibit 4 – The 17 Showcase Projects and their Status as of October 2004

Project	RFP Issued	Contractor Selected	Contract Executed	Project Underway	Project Complete
Corridor-wide					
Scoping & High Level Design (Kernel)*	✓	✓	✓	✓	✓
Strategic Planning/Systems Integration	✓	✓	✓	✓	✓
CVO🗎					
ATIS	✓	✓	✓	✓	✓
ATMS🗎					
RAVL	✓	✓	✓	✓	✓
Los Angeles Region					
IMAJINE*	✓	✓	✓	✓	✓
Mode Shift*	✓	✓	✓	✓	✓
LA ATIS	✓	✓	✓	✓	✓
Inland Empire Region					
Fontana-Ontario ATMIS	✓	✓	✓	✓	✓
Orange County Region					
TravelTIP*	✓	✓	✓	✓	✓
OCMDI	✓	✓	✓	✓	✓
San Diego Region					
InterCAD*	✓	✓	✓	✓	✓
Mission Valley ATMIS*	✓	✓	✓	✓	✓
IMTMS/C (ATMSi)*	✓	✓	✓	✓	
Traffic Signal Integration (RAMS)	✓	✓	✓	✓	
Transit Management System*	✓	✓	✓	✓	

* Indicates an "Early Start" project.
🗎 CWCVO and CWATMS do not yet have approved workplans.

2 Project/System Technical Description

The primary objective of RAVL is to deploy CAD/AVL, Transit Signal Priority (TSP) and other technologies designed to integrate transit management systems, enhance transit operational efficiency, and deliver real-time transit information to customers through electronic message boards. The vehicles to be equipped as part of the system include:

- Coaster Commuter Rail (Coaster) – Coaster is a commuter rail line that operates from Oceanside to San Diego, with eight commuter stations. Each Coaster train is equipped with on-board computers to support vehicle tracking and data communications. RAVL uses cellular communications to transit location, status and messages between the train and dispatch control.

- Airport Flyer – Route 992 ("Airport Flyer") operates along Harbor Drive between two primary terminus locations: San Diego International Airport (Lindberg Field) and downtown San Diego. Next stop electronic message boards that provide real-time information on the arrival of the next train are being installed on the station platforms at the San Diego International Airport in conjunction with the Airport Flyer route. In partnership with the city of San Diego, SANDAG has implemented TSP at eight intersection locations along Harbor Drive, a heavily traveled major arterial road serving the downtown San Diego area.

Traffic signal priority (TSP) is operated at seven intersections along Harbor Drive to shorten end-to-end travel times for Airport Flyer.

- Inland Breeze – Route 980/990 ("Inland Breeze") provides service along I-15 between the Rancho Bernardo area and downtown San Diego. Route 980 is the limited stop service using the Express Lanes and Route 990 is the more locally-oriented service with stops in Mira Mesa, Kearny Mesa, Fashion Valley and Hillcrest areas. Inland Breeze vehicles are equipped with CAD/AVL systems.

- Poway Transit Services – Vehicles in the Poway Transit fleet that operate along Route 844/844A/845 have been equipped with the CAD/AVL system.

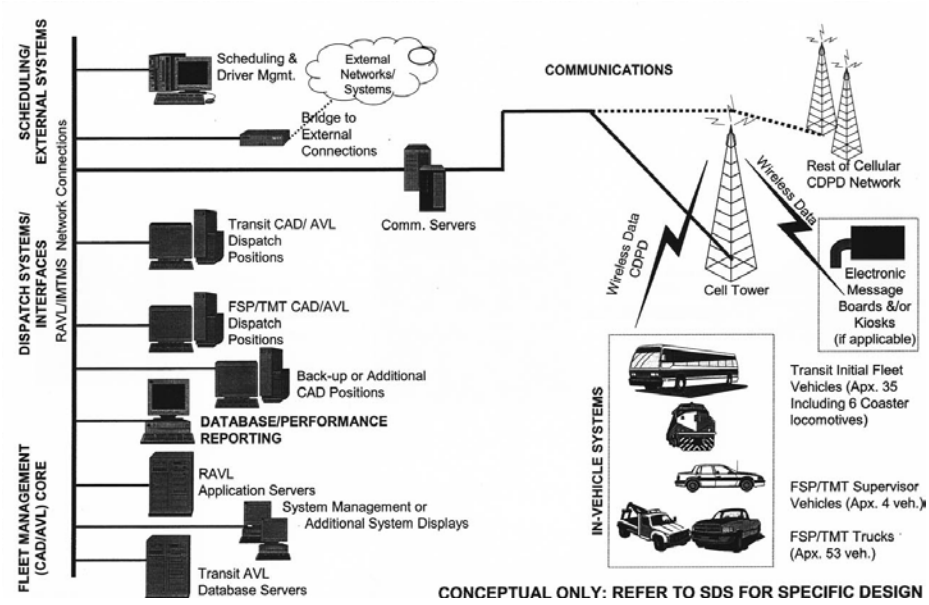
Project Design Concept

The high-level architecture of RAVL is depicted in Exhibit 5. The key components are the TransitMaster application servers, RAVL database servers, local and remote dispatch

workstations, CDPD wireless communications and MCC, in-vehicle systems, an interface with the IMTMS Network, and electronic message boards. Overall, the underlying principles behind the architecture for the interfaces between the transit management systems and the Regional IMTMS Network involves:

- The development of a common definition and standard for transit data information on the IMTMS Network.
- The development of bridges and the necessary network connections from RAVL and RTMS to interface with the IMTMS Network following the common definition
- Deployment of RAMS Tier 2 Integrated Workstations (IWS) at all significant transit dispatch centers to allow transit agencies to receive freeway, highway and arterial traffic information, as well as special events and emergency situation information.
- Future interfaces between the IMTMS Network and RTMS to allow the RTMS CAD workstations to display appropriate incidents in the CAD incident queue. Appropriate is defined as a significant freeway or highway incident or emergency situation.[4]

Exhibit 5 – RAVL High-Level System Design



3 System Performance Evaluation

3.1 The Project/System Development Process and Timeline

RAVL's development followed a systems engineering process, and was completed on-budget, with some delay in the project schedule.

The original Federal Work Plan developed for the San Diego Transit Management System (Phase 1) called for $210,000 to develop system requirements and initiate architecture development efforts, which included three main phases:

- Phase 1 – Requirements Definition and Logical Architecture
- Phase 2 – Initial Transit Management System (TrMS) Deployment
- Phase 3 – Expanded or Regional Deployment of the Transit Management System

Phase 1 was completed in March 1998. Phase 2 of the Federal Work Plan requested authorization for the remaining portion of the Federal grant funds -- $2.23 million, and focused on the deployment of the Transit Management System, of which RAVL is one component.

An initial RFP was released in March 2001, and the sponsor agency, SANDAG, received Board approval in August 2001. A revised workplan was approved in April 2001, and Siemens Integrated Limited Group (ILG) was selected later that month as the system developer. The contract was executed in May 2002. Originally scheduled to be completed in early June 2003, the project scheduled slipped in the Spring of 2004, due to unanticipated delays in the coordination of the training module, vehicle installation, testing issues, the need for additional time to work out problems with a system software upgrade and institutional challenges in obtaining partner agency review and approval of equipment installation and training. It is now envisioned that the RAVL project will be completed in October 2004. The delay in the project schedule has not impacted the budget.

RAVL is primarily a software development and systems integration project, and utilized the traditional systems engineering approach as evidenced by the following project milestones and deliverables:

- Complete configuration of core system components and workstations at Regional TMC
- Commence informal operation of system
- Complete interface control documentation
- Complete Siemens component of "bridge" development
- Complete RAVL core system acceptance
- Complete IMTMS interfaces
- Finalize testing of interfaces

The fixed-price RAVL contract initially specified an 18-month period of performance, but as the dates on the above milestones reveal, the amount of time required to plan, design and reach

consensus on advanced traveler information was significantly greater. The above timeline shows that although software implementation, integration and testing were completed in slightly less than 18 months, the coordination, consensus building and system planning that preceded these activities required over three years of effort. This additional time required the contract to be amended several times to extend its period of performance; however, the fixed-price budget did not increase.

3.2 System reliability, availability, compatibility, and scalability

3.2.1 System Reliability and Availability

Several aspects of the RAVL system are not fully operational.

As of the completion of this report, the RAVL system is not fully operational. The FSP/TMT CAD/AVL system is in place, and a review of system performance logs indicate that there have been no major system failures in the testing period since the RAVL servers have been installed. The TSP system for the Airport Flyer will not be fully deployed until Fall 2004. Also, the CAD/AVL system for Coaster, ATC Vancom and Poway Transit vehicles has not yet been fully tested and deployed.

3.2.2 Compatibility

There are no indications of any system incompatibilities.

Compatibility is the ability of two or more systems or components to perform their required functions while sharing the same hardware or software environment. There have not been any system failures or anomalies experienced during the five months of this study that would indicate an incompatibility with the existing software/hardware environment.

3.2.3 Scalability

As a distributed, object-oriented system, RAVL is scalable to accommodate several additional centers.

Scalability describes the extent to which system usage can grow without sacrificing system performance or requiring architectural or technology changes. In this report, system usage is defined in terms of data (object) throughput and is measured in units of megabytes per second (MB/sec). The factors that influence the system's scalability include:

- Hardware capability
- Software design.

Both the leased CDPD network connection and the Caltrans dedicated T-1 Internet connection have sufficient bandwidth to accommodate future expansion of RAVL through the larger transit fleet.

RAVL uses Caltrans' T-1 server hardware for high-bandwidth Internet access. The current server hardware and communications bandwidth is sufficient to accommodate current and future anticipated networking requirements.

3.3 Impact of Showcase Integration on Project Deployment and System Performance

RAVL is one of 17 projects that make up the Showcase Program and Network. As such, many interdependencies developed between the projects as plans were made for eventual regional and corridor-wide integration. This section describes how these interdependencies impacted RAVL and other Showcase projects.

3.3.1 Impact of RAVL on other Showcase Projects

RAVL is the fourth Showcase Project to integrate transit operations with the regional distributed network.

The regional integration efforts planned between RAVL and other management systems currently under deployment in the San Diego region are predicated on the development of the Regional IMTMS network and the common network services it provides. RAVL originally intended to use network services provided by Kernel Version 1.0, but subsequent updates to the regional system architecture and network management considerations have resulted in the San Diego region's decision to migrate toward a more distributed management structure. Several Modal Intertie servers are providing the same network management functions as the single Kernel server.

RAVL establishes the standards and interfaces to allow transit management and other fleet management systems to share information with other modal systems on the IMTMS regional network. Exhibit 6 shows the link between the ongoing multiple projects in the San Diego region, and how they interface with the regional architecture. The sharing of transit information, as well as the development of standards and interfaces, will allow RAVL on the Regional IMTMS network to exchange information regarding transit schedules and operations with operators in the San Diego region. It will also allow RAVL to provide the data to the Regional Arterial Management System (RAMS) in order to:

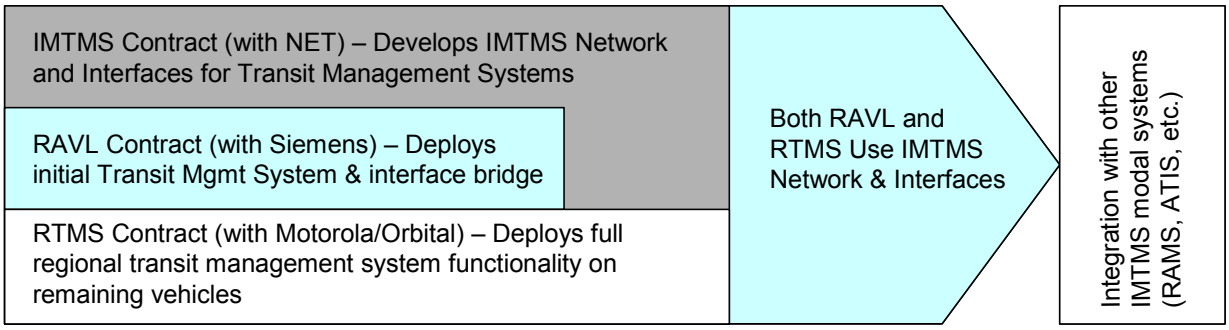
- request and determine the status of signal priority along a corridor
- activate a "transit friendly" regional timing plan for pre/post event conditions
- obtain information on arterial conditions (speeds/congestion)
- obtain information on incidents
- display bus locations on the RAMS Integrated Workstations during emergency situations
- allow transit dispatch to view city CCTV and CMS signs

- allow transit dispatch to more easily coordinate event management activities with cities

The sharing of transit information will also enable the ATIMS server regionally supported by ATIS data providers to obtain real-time transit information, as well as up-to-date schedule information from RAVL, including:

- schedule adherence/next bus arrival time
- general transit service announcements and & EMB messages
- special events services information and regular schedule information

Exhibit 6 – Link Between San Diego Regional ITS Projects



It will also allow the RAVL operators to receive information from the freeway management ATMSi, in order to:

- obtain freeway conditions, congestion and incident information
- identify planned and emergency lane closures
- allow bus drivers/transit dispatchers to notify Caltrans/Cities of incident situations that they may be the first to identify

Finally, it will allow for a regional calculation of transportation system performance measures that cover transit, local street and highway conditions. Sharing of transit information will enable transit/transportation providers to have access to basic system performance data, and service information, and adjust service to meet both recurring and non-recurring traffic conditions.

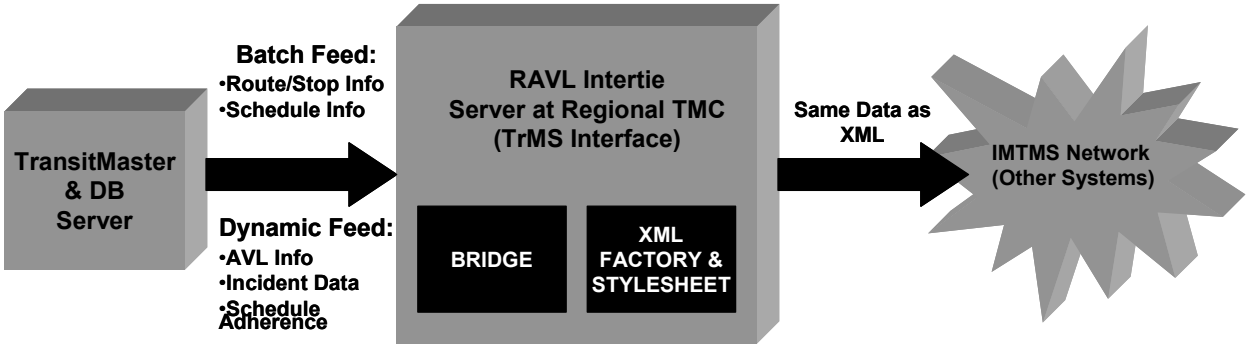
3.3.2 Impact of other Showcase Projects on RAVL

The RAVL Modal Intertie Server will facilitate integration of transit management systems throughout the San Diego region.

The San Diego region has adopted an overall ITS deployment plan that accommodates on-going Showcase based CORBA deployments, as well as setting the groundwork to take full advantage of the emerging XML and web services based tools. San Diego ITS projects will use a CORBA based protocol and Showcase based architecture to serve the planned CORBA clients.

Exhibit 7 illustrates the types of information that flows between RAVL (TransitMaster) software and the IMTMS Network to be made available for other systems such as the RAMS Integrated Workstation (IWS). The RAVL Modal Intertie server supports RAVL Network Services by receiving data from TransitMaster and HighwayHelper for "translation" and distribution on the Regional IMTMS Network. Throughout the Summer of 2003, SANDAG coded and merged schedule and route data for Poway 844A, Airport Flyer, and Coaster vehicles equipped with CAD/AVL equipment into the TransitMaster database. Schedule adherence, vehicle location and incident information are outputs from RAVL, and transit dispatchers will use their IWS to view traffic conditions, emergency situations and freeway/highway incidents.

Exhibit 7 – RAVL Interface to IMTMS Network



4 Cost Evaluation

The cost evaluation draws information from documented costs and personal interviews. Budget information was taken directly from the project's contracts and amendments, while operations and maintenance costs were obtained from discussions with agency personnel. Informal interviews were conducted to verify information and fill in any "holes" that were discovered during analysis.

4.1 Constraints & Assumptions

There are two primary considerations for the Cost Evaluation:

- Since RAVL was funded through a firm fixed price contract, the project's budget information reflects the expenses and costs for services paid by the client agency, but not necessarily the actual detailed costs for goods and services borne by the contractor.

- Operations and maintenance (O&M) costs have been estimated based on available information and certain assumptions indicated later in this section.

The RAVL system involved the acquisition of off-the-shelf server and network equipment, in addition to mobile workstations used for field surveillance purposes. Exhibit 8 shows the type and amount of equipment used to support the RAVL project.

Exhibit 8 – RAVL System Hardware Items

Hardware Items	Quantity
Dell OptiPlex HX260 Work Stations	15
Dell 21" CRT Monitors	17
Dell 19" Flat LCD Monitors	4
HP Color Laser Printer	1
HP B/W Laser Printer	1
Dell PowerEdge Servers	5
Cisco Router Hubs	5
Cisco Firewalls	3
Server Cabinet	1
Panasonic Tough Book Laptops	60
In-Vehicle Docking Stations	60
Transit Vehicle Mobile Data Terminals	35
Vehicle Internal Vehicle Logical Units	85
Electronic Message Board Signs	7

4.2 Project Budget & Estimated Development Costs

This section addresses the project's contracted tasks and budget, as well as its role in supporting the Showcase Program's "design once, deploy many times" philosophy.

4.2.1 Project Budget

The RAVL project adhered to the original project schedule, with a few minor project development issues that resulted in a slight slippage in the schedule.

$2,820,957 was spent on the RAVL project. Of that amount, $332,719 represented software products and hardware equipment, but does not include vehicle costs for equipment, labor, and software modifications. Given the cost by task structure of the Siemens project, it is not possible to break out the financial information for the vehicle costs. Exhibit 9 lists the project's seven major tasks and the budget associated with each one, as agreed in the initial contract and subsequent contract amendments. More detail regarding each task is provided below. Since the project was negotiated as a fixed-price contract, the budgets shown in Exhibit 9 might not accurately reflect actual costs and expenditures.

Exhibit 9 – RAVL Project Cost By Major Task

Task #	Description	Budget	% Contract
1.0	Project Contract & Schedule	$54,900	1.9%
2.0	System Deployment Specifications (SDS)	$140,850	5.0%
2.0A	FSP/TMT Display System Software	$116,190	4.1%
	Subtotal:	$311,940	
3.0	Procure/Install Transit Network Systems	$218,792	7.8%
3.0A	Procure/Install FSP/TMT Network Systems	$101,688	3.6%
	Subtotal:	$320,480	
4.0	Transit Vehicle Surveys/Drawings	$55,800	2.0%
4.0A	FSP/TMT Vehicle Surveys/Drawings	$55,800	2.0%
4.0B	Survey Routes & Develop GIS Codes	$23,400	0.8%
	Subtotal:	$135,000	

Task #	Description	Budget	% Contract
5.0	Install Prototype Transit AVL/GPS Equipment	$94,367	3.3%
5.0A	Install Prototype FSP/TMC AVL/GPS Equipment	$98,809	3.5%
	Subtotal:	$193,176	
6.0	Complete Transit Project Installs	$554,574	19.7%
6.0A	Complete FSP/TMC Project Installs	$858,536	30.4%
	Subtotal:	$1,413,110	
7.0	Future Radio Interface Technical Paper	$31,500	1.1%
8.0	Interface Control Document (ICD) for HANDSHAKE	$9,000	0.3%
9.0	Transit & FSP/TMT Vehicle Fleets Tests	$124,655	4.4%
	Subtotal:	$165,155	
	10% Retainage:	$282,096	10.0%
	TOTAL:	**$2,820,957**	**100.0%**

Exhibit 9 shows the costs associated with each of the major project tasks. The largest project cost was Task 6.0A – Complete FSP/TMC Project Installs, which comprised 30.4% of total project costs. The next largest project cost was Task 6.0 – Complete Transit Project Installs, which comprised 19.7% of total project costs. Tasks 6.0 and 6.0A represent half of the total project costs, largely because of acquisition of hardware and equipment to be installed on the vehicle fleet, the dispatch centers, and Caltrans' district office.

Exhibit 10 summarizes the level and sources of funding for the RAVL project, which includes federal Showcase funds, state contributions and a local match. Showcase funding covers approximately 93.4 percent of the total available funds of $3.175 million.

Exhibit 10 – RAVL Funding Breakdown[5]

	Total Project	Phase 1 Authorization	Phase 2 Authorization	Percent
Federal ITS Priority Corridor Program (Showcase)	$ 2,400,000	$ 168,000	$ 2,232,000	75.6%
State – Caltrans Division of Research and Innovation	$ 175,000	$ 21,000	$ 154,000	5.5%
State – Caltrans Division of Traffic Operations	$ 480,000	$ 16,800	$ 463,200	15.1%
Local – TransNet Sales Tax	$ 120,000	$ 4,200	$ 115,800	3.8%
TOTALS	$ 3,175,000	$ 210,000	$ 2,965,000	100.0%

4.2.2 Design Once, Deploy Many Times

RAVL supports the "design once, deploy many times" philosophy through the use of the Showcase Program's high-level Kernel-Seed architecture, object-oriented technology, and standardized objects and interfaces.

"Design Once, Deploy Many Times" is the Priority Corridor's philosophy for achieving cost efficiency through a modular system design, software re-use, and "economy of scale." In general, RAVL supports the "design once, deploy many times" philosophy through the use of the Showcase Program's high-level Kernel-Seed architecture, object-oriented technology, and standardized objects and interfaces.

4.3 Estimated Operations & Maintenance Costs

4.3.1 Operations

The operations cost for RAVL consists of three components: labor costs, utility costs, and office space costs. Each component applies in varying degrees to each project participant. At this point, no substantive discussions have taken place regarding the ongoing operations and maintenance costs of the RAVL system.

4.3.1.1 Labor

Dispatchers have been trained on the use of the Regional Integrated Workstations (RIWS). Most of the labor costs associated with RAVL are directly related to the maintenance of the RAVL Dell PowerEdge 2650 Server at the Caltrans District 11 Transportation Management Center (TMC). Due to budgetary issues, Caltrans is planning to phase out their staff support for the RAVL project. In the immediate future, SANDAG plans to hire an ITS FTE, with responsibility for providing system administration support to the RAVL project. It is assumed that other agency RAVL support will be absorbed by existing agency staffing.

4.3.1.2 Utilities

The utility costs that are most attributable to RAVL are electricity (for powering the Remote Workstations) and telecommunications (for interagency communications and wireless networking). Some partner agencies may experience a greater cost impact than others, depending on the number of legacy systems already in place. No attempt is made to estimate utility costs by participating agency beyond SANDAG, the project sponsor. Exhibit 11 estimates the annual electricity cost impact that could be produced by RAVL hardware. These estimates are based on the following assumptions:

- An average electricity rate of $0.16 per kW-hour (the actual rate varies seasonally)
- PCs and workstations operate 8 hours per day, 48 weeks per year
- Monitors draw 135W for 8 hours each day, draw 15W in "sleep" mode overnight, and operate 48 weeks per year.

Exhibit 11 – Estimated Marginal Annual Electricity Costs for RAVL

Hardware Item	Model	Power Draw	Power Cost	Est. Annual Cost
1 RAVL Server	Dell PowerEdge	250W ea.	$0.16/kW-hr	$77
1 RAVL Server Workstation	Dell OptiPlex GX260	250W ea	$0.16/kW-hr	$77
1 TransitMaster and Database Server	Dell PowerEdge	250W ea.	$0.16/kW-hr	$77
1 Communications Server	Dell PowerEdge	250W ea.	$0.16/kW-hr	$77
1 FSP Workstation	Dell OptiPlex GX260	250W ea.	$0.16/kW-hr	$77
1 TMT Workstation	Dell OptiPlex GX260	250W ea.	$0.16/kW-hr	$77
12 Integrated Workstations	10/100 Base T Ethernet	250W ea.	$0.16/kW-hr	$924
5 typical 21" color monitors	Various	15W-135W ea.	$0.16/kW-hr	$203
				$1,589

Telecommunications makes up the largest portion of the operating cost. RAVL leases CDPD service from AT&T for network communications. The current monthly cost is $3,400 ($34/modem x 100 modems + $570/month data relay fee). RAVL telecommunications costs consist of the following:

Exhibit 12 – Monthly and Annual Telecommunications Costs (Data only)

Description	One-time Installation Fee	Ongoing Monthly Cost	Ongoing Annual Cost
Leased CDPD Network Connection	-0-	$3,970	**$47,640**
Dedicated T-1 Internet Connection		$300	**$3,600**
			$51,240

4.3.1.3 Office Space

There was no additional financial cost for the space occupied by RAVL equipment, due to the lack of specific accounting down to the project or system level. Monitors were installed in several transit dispatch centers without displacing any existing equipment. The RAVL Intertie Server is located in the Caltrans District 11 TMC server room, and did not require the displacement or removal of any existing equipment or server racks.

4.3.2 Maintenance

Maintenance will be SANDAG's responsibility. The Siemens contract includes a one-year warranty for equipment repair or replacement. The manner in which maintenance is to be carried out beyond the warranty period is yet to be determined, and maintenance costs are not known at this time.

5 Institutional Impacts Evaluation

5.1 Impacts to Operations and Maintenance Procedures and Policies

RAVL will be part of a coordinated support structure through the Joint Transportation Operations Center (JTOC).

At the time of the report submittal, operations and maintenance procedures and policies were being developed by SANDAG, with concurrence from operating transit agencies and other stakeholders. With regional policies relating to operations support not yet in place, full regional integration of RAVL into the IMTMS network is several years away.

Based on the Draft Concept of Operations report, there are several operational policies and constraints that impact the integration of transit management systems throughout San Diego County:

- Transit dispatching/CAD operations occur separately for each operating agency. It is anticipated that CAD operations will be combined in a single facility at some point in the future.

- Due to the fact that various geographic areas are covered by different operators, emergency response for transit incidents is supported by different law enforcement and EMS agencies. The interchange of real-time panic alert information requires a system capable of displaying transit vehicle locations to several different law enforcement and EMS providers.

- RAVL will be interfaced to the Regional IMTMS Network and communications links will be provided from RAVL to the IMTMS Network.

5.2 Impacts to Staffing/Skill Levels and Training

For participating agencies, the deployment of RAVL has resulted in additional system administrator and user training.

The deployment of RAVL requires participating agencies to undergo system administrator and user training. RAVL training was provided for front line supervisors, dispatchers and operations staff. During training, SANDAG noted that an extensive effort was required to get management and key staff at participating agencies on-board to understand RAVL's basic functionality and support its use in ongoing transit operations. Training was likened to a "work-in" period, during which trainees began to engage in detailed operational issues for the first time.

5.3 Impacts to the Competitive Environment

RAVL's system is well documented and consistent with Showcase-defined data conversion processes.

The development of a common definition and standard for transit data from RAVL to interface with the IMTMS Network will enhance the competitive environment for ITS in the San Diego area. Once bridges and network connections from RAVL to the IMTMS Network are created, participating transit agencies will have a host of state-of-the-art data communications and performance tracking capabilities that have the potential to greatly enhance the customer experience and improve transit service delivery.

5.4 Impacts to Local Planning Processes, Policy Development, and the Mainstreaming of ITS

RAVL helped create both a physical and institutional foundation for further ITS development in the Southern California Priority Corridor.

The deployment of RAVL as a "proof-of-concept" has provided an opportunity to test and demonstrate the impact of providing accurate real-time information on operational efficiency. Along with RTMS, these systems will provide important lessons on the penetration of state-of-the-art transit management tools into the remainder of the transit fleet in San Diego County. One of the chief benefits of RAVL will be that transit dispatchers, through the Regional Integrated Workstations (RIWS), can view, react and dispatch assignments based on real time traffic conditions and emergency situations.

6 Traveler and Transportation Information Management Evaluation

6.1 Extent of Regional and Interregional Transportation and Traveler Information Integration Between Agencies

6.1.1 RAVL System Impact on Data Flows

The RAVL proof-of-concept demonstrates that the integration of transit systems into the regional traffic management system can result in benefits to both transit service delivery and traffic management.

As a result of RAVL, transit operations managers and dispatchers have access to real-time information about traffic advisories/events and geographic information about the location of buses currently in revenue service. Although only a portion of each agency's respective fleets has been equipped with RAVL, the impacts associated with improved access to information and better overall situational awareness demonstrate a tangible benefit to expanding RAVL to the wider vehicle fleet.

Several bus stops along the Airport Flyer route were equipped with Electronic Message Boards (EMBs) that post dynamic next stop information provided through the TransitMaster software. ATC Vancom reports that passengers find next stop messaging at station and bus stop locations to significantly enhance the transit experience.

Control of the EMBs is an issue that needs to be addressed, particularly as integration between TrMS and the IMTMS Network advances to the next stage. For the time being, RAVL project developers have determined that control of the Electronic Message Boards (EMBs) should be maintained directly by the dispatchers through RAVL.

6.1.2 Impact on Traffic Operations and Communications

By providing transit dispatchers with more real-time information about the operating environment, RAVL has enabled transit agencies to respond more proactively to rapidly changing conditions in the transportation network.

ATC/Vancom, which operates Airport Flyer, Poway Laidlaw and NCTD have noted that RAVL has enabled their dispatchers to possess a more heightened level of situational awareness of the operating environment within which the RAVL-enabled route provides service.

Interfaces were developed for RAVL that provide a standardized set of transit information focused on transit schedules, transit vehicle status, transit incidents, and related data. Eventually, the transit operators under RAVL will receive information on freeway/arterial traffic conditions, incidents and special events for Regional Arterial Management System (RAMS) and the Regional Integrated Workstation (RIWS). Also, transit operators will receive this information

either through RIWS in their dispatch centers or through direct integration with the Transit Management System (TrMS).

The RAVL link to the IMTMS Network will be provided by two dedicated fiber optic lines currently being deployed between Imperial Division, the Kearny Mesa Division of San Diego Transit, and the Regional Transportation Management Center (TMC).

6.1.3 Utilization of Regional and Interregional Transportation and Traveler Information by Public Agencies

The integration of RAVL to the IMTMS Network will facilitate better communications and improved coordination of the dissemination of transit management information.

There are several potential benefits arising from the RAVL deployment and the planned interface between RAVL and the IMTMS Network:

- Enable emergency response agencies (including 911 Centers) to view the location of vehicles with an on-board emergency.
- Better coordination of transit management and traffic management activities arising from special events, such as a sporting event (the Super Bowl) or a major concert.
- Notification to traffic management centers of real-time incidents and traffic problems encountered by transit.
- Improved coordination and operations of traffic and transit resources during emergency response and disaster response.

These new systems and network connections must be supported and maintained in a regional framework in which member agencies accrue a tangible benefit and agree to a cost sharing arrangement that is fair and equitable.

7 Transportation System Impacts Evaluation

This purpose of this chapter is to describe the likely impacts of the RAVL system on the transportation network in San Diego County. The RAVL project is considered a demonstration project intended to highlight the benefits of automatic vehicle location systems, real-time scheduling information for passengers, and the integration of transit information into the regional intermodal transportation management system. As a result, a detailed observational analysis of the transportation system impact was not conducted. When possible, anecdotal evidence gathered in interviews with stakeholders is presented here to suggest where system impacts may potentially be greatest, with wider deployment of transit management systems throughout the San Diego region.

7.1 Impacts to Transit Usage

Because the RAVL deployment is a "proof of concept" demonstration project that includes 30 vehicles, an assessment of RAVL's impact on transit usage was not performed. To the extent that RAVL enhances the customer interface by providing next-stop information at transit stations and bus stops, and the AVL system results in an important in schedule reliability, it is anticipated that RAVL and wider deployment of CAD/AVL functions to a wider transit fleet may result in improved customer interface and increased transit patronage.

7.2 Impacts to Transit Operations

The primary benefit of RAVL is the implementation of upgrades and communications that represent a major advancement in the level of operational capabilities available to transit operators in the San Diego region. As the operational concepts that are part of the RAVL project expand to wider segments of the transit fleet, the capabilities of transit operators to respond more quickly and efficiently to changes in the operating environment will continue to improve.

A major component of the RAVL system is the deployment of Transit Signal Priority (TSP) on Bus Route 992 along Harbor Drive. TransitMaster software activates 3M 7000 series Opticom emitter placed on Route 992 vehicles. The City of San Diego provided signal controller cards and equipment that were deployed along Harbor Drive. This project is noteworthy because it represents the first opportunity in the San Diego region to assess operational issues relating to the integration of CAD/AVL and TSP systems. There are several potential benefits associated with TSP implementation:

- Schedule reliability
- Reduced travel times
- Reduced wear-and-tear on transit vehicles
- Increased rider comfort
- Reduced emissions
- Increased competitiveness of transit compared to single occupant vehicle travel.

Much of the benefit of CAD/AVL functions is manifested in the dispatcher's ability to respond to operating conditions that impact service delivery. The AVL function may have the potential to render transit operations more transparent, and improved voice and data communications can shorten response time to unanticipated events that impact service delivery. From a customer interface standpoint, it is anticipated that dispatch will be able to readjust next stop information to passengers waiting at stations relatively seamlessly, effectively mitigating to customers the unpleasantness associated with wait time.

7.3 Impacts to Traffic Congestion

RAVL will deploy TSP at seven locations along Route 992 ("Airport Flyer"), which runs along Harbor Drive between San Diego International Airport and downtown San Diego. An assessment of the impact of TSP cannot be performed, since full deployment will not be completed until Fall 2004.

Conclusions and Recommendations

RAVL represents an important component of ongoing efforts to develop a regional transit management system in the San Diego region. RAVL's system architecture was designed well, having developed interfaces that will enable the integration of transit information and functionality into the overall regional IMTMS Network. As a proof-of-concept, RAVL is intended to demonstrate the benefits of automated vehicle location (AVL) systems, real-time schedule information for patrons and the integration of transit information into the regional IMTMS Network.

As of the submittal of this report, several aspects of the RAVL project were not fully implemented. As a result, there are no conclusive findings on the RAVL on transit operations, transit usage and traffic congestion presented in this report. The findings and conclusions presented below focus on institutional issues and lessons learned during the project development phase:

- The data and voice communications system integrated into the transit vehicles addresses several key deficiencies in the radio communications systems. The annual cost of CDPD wireless networking is $47,640, which is based on a per modem fee of $34 and a monthly data relay fee of $540. The service contract provides an option to expand wireless coverage, to accommodate future expansion of the CAD/AVL system throughout the transit fleet.

- Transit dispatchers at several agencies can view real-time traffic conditions, emergency response situations, special events and traffic incidents and dispatch bus assignments accordingly. Participating agencies felt that the ability to view real-time information about the operating environment could enhance the efficiency of the dispatching function, particularly in emergency response situations and major traffic incidents that result in temporary lane closures.

- Both RAVL and RTMS have developed standard definitions that will enable these systems to interface with the Regional IMTMS Network, with communications links provided from RAVL to the IMTMS Network. In the future, bus schedule and schedule adherence by route and/or vehicle should be made available from RAVL to the IMTMS Network, and the Advanced Traveler Information System (ATIMS), which will serve as the network portal to information service providers and the planned 5-1-1 system.

- One of the biggest challenges facing the RAVL deployment was the difficulty in engaging the participating agencies early enough in the project development process to address operational issues well in advance of training. Each participating agency has developed policies unique to their operations, and it was noted that several key detailed operational issues did not get resolved until conflicts with existing policies and procedural standards were identified.

Although management support of the RAVL at each agency was strong, it took some effort to receive strong support from operations personnel, who have developed policies and procedures to address unique data communications challenges. A significant hurdle to overcome was the initial resistance to integration of CAD/AVL among several stakeholders, due to concerns about RAVL's system reliability and functionality. Also, there was some concern about the extent to which a new data communications system would impact existing staffing resources.

- One of the critical attributes of the CAD/AVL system is an enhanced emergency response capability. RAVL enables dispatch to assign and dispatch transit vehicles for emergency transportation or evacuation duty based on pre-established agreements between transit agencies and EMS/ law enforcement operations.

- With the full deployment of RAVL, SANDAG has created a platform for identifying the impact of improved data communications on transit operations. Lack of funding is a major constraint facing the further development of transit management interfaces, as there may not be sufficient funds to capitalize on the development of RAVL or future IMTMS Network communications. Lack of funding could also forestall implementation of AVL to the remainder of the San Diego-area transit fleet and achievement of objectives outlines as part of SANDAG's strategic vision to improve transit management.

- Another concern is the availability of funding for ongoing maintenance and operations. With the recent reorganization of SANDAG to include both system implementation and operations, SANDAG is in the midst of developing policies regarding SANDAG's role and responsibilities in supporting regional ITS systems that require financial support from regional and local entities. Given Caltrans' intention of phasing out support for RAVL, it is recommended that SANDAG develop an ITS business plan to identify long-term staffing requirements for ongoing support of regional ITS projects being integrated with the IMTMS Network.

Endnotes/References

[1] ISTEA requires that "operational tests utilizing federal funds have a written evaluation of the Intelligent Vehicle Highway Systems technologies investigated and the results of the investigation." Although Showcase is not officially an operational test, it deploys and demonstrates ITS services, functions, and technologies under "real world" conditions, similar to an operational test.

[2] California Statistical Abstract, Table B-4. California Department of Finance, Sacramento, CA. December 2003.

[3] California Statistical Abstract, Table J-4. California Department of Finance, Sacramento, CA. December 2003.

[4] Concept of Operations Transit Management Systems, San Diego Regional Intermodal Transportation Management System (IMTMS), Draft. January 2004

[5] FEDERAL WORK PLAN (PHASE 2), San Diego Regional Automatic Vehicle Location & Resource Management System (RAVL), prepared by National Engineering Technology Corp. in association with URS Corporation, September 2003, pg. 23.