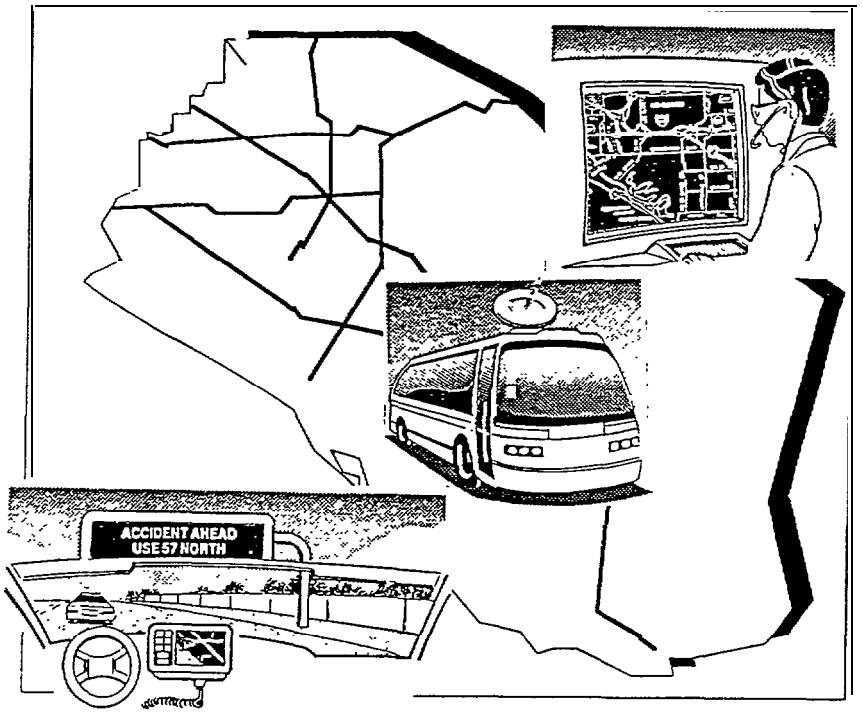
ORANGE COUNTY INTELLIGENT VEHICLE / HIGHWAY SYSTEMS STUDY

Executive Summary

JUNE, 1993



Prepared fur

OCTA

Prepared by

jhk & associates

HUGHES

SGNA
Jacqueline Golob Associates

ORANGE COUNTY

INTELLIGENT VEHICLE / HIGHWAY

SYSTEMS STUDY

EXECUTIVE SUMMARY

Prepared by:

JHK & ASSOCIATES
80 South Lake Avenue
Suite 680
Pasadena, CA 91101

June, 1993

TABLE OF CONTENTS

1. INTRODUCTION

The Orange County Intelligent Vehicle/Highway Systems (IVHS) Study has developed a framework under which advanced technologies will be deployed to improve the operation of the County's highway and public transportation system. Commissioned by the Orange County Transportation Authority (OCTA), and conducted by a team of consultants led by JHK & Associates, the Study is a culmination of tasks which has included:

1) the identification of regional and local transportation goals,
2) an analysis of IVHS strategies and technologies which support these goals,
3) the development of an IVHS transportation network,
4) the investigation of institutional issues associated with the implementation of IVHS,
5) the development of programs and implementation strategy, including estimated costs and funding availability.

This Study is intended to provide a 20-year Master Plan for implementation of IVHS throughout Orange County. It is also intended to serve as a model for the development of IVHS strategic plans for other regions throughout the country. However, as new technologies are continually developing, and applications of existing technologies are expanding, it is cautioned that this plan should be viewed as a living plan which will require updating in response to these developments.

The products of the Study include, in addition to the Final Report, the "IVHS Master Plan," which constitutes the identified IVHS network and recommended programs, and an Action Plan. The Master Plan material is incorporated in the Study Final Report (chapters 3 and 9) and exists as a stand-alone technical memorandum. The Action Plan, which details the Master Plan implementation strategy, has been prepared as a separate document to support and accompany the Final Report.

Important to the successful implementation and operation of IVHS in Orange County, as anywhere, is the realization that IVHS requires dedicated sources of funding and staff commitment for continued operations and maintenance. This need must be realized and met by public agencies responsible for the management and funding of transportation, politicians whose support is necessary to carry out programs, and the public. Currently, there is considerable

support for the study and implementation of IVHS. However, as of yet, there is little or no dedicated funding for the operations and maintenance of the systems being implemented. Without continued support of the implemented systems, the initial investment will be lost in terms of benefits.

2. IDENTIFY STRATEGIES AND TECHNIQUES

Goals and objectives for the County's regional and local transportation systems were identified through interviews with State, County, and local agencies; neighboring agencies; and private. institutions such as major activity centers, Transportation Management Agencies, and the media. Additionally, national IVHS goals were assessed in relation to the County's needs. Eight primary goals emerged, the first five addressing transportation goals, the remaining three addressing goals of the system architecture:

1) Increase Efficiency
2) Decrease Emissions/Energy Use
3) Enhance Safety
4) Support Transportation Operations and Planning
5) Improve Quality of Life
6) Minimize Cost
7) Allow Evolvability
8) Increase Robustness

The consultant team identified strategies which support the County's goals and objectives (Exhibit ES-l). Finally, the strategies, which are independent of technology and type of improvement, were combined into sets of strategies similar in nature in order to assist in identifying user services, and their associated IVHS technologies and elements, which could be used to solve the various transportation problems in the County. Fifteen global strategies emerged which, as can be seen, closely fit the IVHS user services of traveler information, traffic management, freight and fleet management, public transport and emergency vehicle management, and additional services. These global strategies are:

1) Provide Real-Time Strategies for Recurrent Congestion
2) Provide Real-Time Strategies for Non-recurrent Congestion
3) Reduce Traffic Turbulence
4) Develop Decision Support and Response Strategies
5) Enhance Incident Detection and Verification
6) Enhance Incident Response
7) Reduce Incident Duration Through Rapid Removal
8) Support Transportation Demand Management Strategies
9) Provide Pre-Trip Traveler Information

EXHIBIT ES-1

ORANGE COUNTY
IVHS ARCHITECTURE
GOALS, OBJECTIVES & STRATEGIES

Goal Objective Strategy

1 INCREASE EFFICIENCY

1.1 Manage Demand

1.1.1 Transportation Demand Management
1.1.2 Spread the demand (Encourage non-peak travel)
1.1.3 Reduce Demand

1.2 Manage Flow

1.2.1 Decrease Turbulence
1.2.2 Manage Routing in recurring congestion
1.2.3 Manage Routing in Construction/Maintenance/Special Events
1.2.4 Provide Pre-Trip Information to Traveler
1.2.5 Provide Information to Motorist in Vehicle

1.3 Regain Capacity Following Incident

1.3.1 Preplan for Incidents
1.3.2 Detect Incidents
1.3.3 Identify/Verify Incidents
1.3.4 Respond to Incident
1.3.5 Clear Incident
1.3.6 Clear Incident-Caused Congestion

7.4 Increase Capacity

1.4.1 Add Facilities
1.4.2 Eliminate Bottlenecks

2 DECREASE EMISSIONS/ENERGY USE

2.1 Manage Demand

2.1.1 Restrictions on Travel when Air Pollution is High
2.1.2 Transportation Demand Management
2.1.3 Spread the demand (Encourage non-peak travel)
2.1.4 Reduce Demand

2.2 Encourage Fuel-Efficient/Clean-Running Vehicles

2.2.1 Economic Incentives/Disincentives
2.2.2 Mandates
2.2.3 Funded R & D into clean energy vehicles/subsystems
2.2.4 Fines for emissions
2.2.5 Highway Speed Emissions Monitor

2.3 Maintain Steady Speeds

2.3.1 Decrease Turbulence
2.3.2 Manage Routing in recurring congestion
2.3.3 Manage Routing in Construction/Maintenance/Special Events

3 ENHANCE SAFETY

3.1 Reduce the Number of Accidents

3.1.1 Eliminate Infrastructure Hazards
3.1.2 Decrease Turbulence
3.1.3 Prevent Unsafe Driving

3.2 Reduce Severity of Accidents

3.2.1 Eliminate Infrastructure Hazards
3.2.2 In-Vehicle Safety Measures

3.3 Avoid Secondary Accidents

3.3.1 Warn Driver
3.3.2 Respond to Incident
3.3.3 Clear Inciclant

3.4 Speed Emergency Response

3.4.1 Respond to Incident
3.4.2 Clear Incident

3.5 Enhance General Safety

EXHIBIT ES-I

ORANGE COUNTY
IVHS ARCHITECTURE
GOALS, OBJECTIVES & STRATEGIES

Goal	Objective	Strategy
		3.5.1 Improve Emergency Vehicle Access
		3.5.2 Support Civil Defense Plans
	3.6 Minimize Impacts of Construction/Maintenance/Events/Incidents	
		3.6.1 Manage Routing in Construction/Maintenance/Special Events
		3.6.2 Provide Pre-Trip Information to Traveler
		3.6.3 Provide Information to Motorist in Vehicle
		3.6.4 Preplan for incidents
		3.6.5 Detect Incidents
		3.6.6 Identiify/\/erify Incidents
		3.6.7 Respond to Incident
		3.6.8 Clear Incident
		3.6.9 Clear Incident-Caused Congestion
		3.6.10 Support Rerouting
4 SUPPORT TRANSPORTATION OPERATIONS AND PLANNING		
	4.1 *Collect data on system performance and usage*	
		4.1.1 Real-time Data Base
		4.1.2 O-D Data based on AVI/AVL/VIPS
		4.1.3 Credible data analysis procedures for historical analysis
	4.2 Facilitate Interagency Coordination	
		4.2.1 Data Base Accessible to All Agencies
		4.2.2 Enhanced Interagency Communications
		4.2.3 Single Facility for Interagency Activities
		4.2.4 Open Architecture
		4.2.5 Direct Computer-to-Computer Communications
	4.3 Increase Productivity of City/Agency Staffs	
		4.3.1 Real -Time Information
		4.3.2 Interactive/Intuitive Information Display
		4.3.3 Decision Aids
5 IMPROVE QUALITY OF LIFE		
	5.1 Traveler *Comfort*	
		5.1 .1 Assist Stranded Traveler
		5.1.2 Manage Routing in recurring congestion
		5.1.3 Manage Routing in Construction/Maintenance/Special Events
		5.1.4 Provide Pre-Trip Information to Traveler
		5.1.5 Provide Information to Motorist in Vehicle
		5.1.6 Provide Consistent Travel Times
		5.1.7 Provide Information for Tourists
	5.2 Traveler Convenience	
		5.2.1 Transportation Alternatives
		5.2.2 Mass Transit Schedules and Modes Readily Available
		5.2.3 Decrease Turbulence
		5.2.4 Manage Routing in recurring congestion
		5.25 Manage Routing in Construction/Maintenance/Special Events
		5.2.6 Provide Pre-Trip Information to Traveler
		5.2.7 Provide Information to Motorist in Vehicle
	5.3 Equity regardless of socio-economic status, disabilities, etc.	
		5.3.1 Intelligence in Infrastructure rather than in vehicle
		5.3.2 Multi-lingual, both audible and visual information
		5.3.3 Wheelchair accessibility of mass transit
	5.4 Equitable distribution of casts and benefits	
	5.5 Enhance Economic Vitality	
	5.6 *Decrease Noise*	
		5.6.1 Sound Barriers

EXHIBIT ES-I

ORANGE **COUNTY**
IVHS ARCHITECTURE
GOALS, OBJECTIVES & STRATEGIES

Goal	Objective	Strategy
		5.6.2 Reduce Demand
		5.6.3 **Inspections**
		5.6.4 Noise Sensors Combined with AVI
	5.7 Enhance Reliability of System	
		5.7.1 Computer-Based Training
		5.7.2 **Expert systems for Diagnostics/Maintenance**
		5.7.3 Technology Insertion & Upgrade Program
		5.7.4 Computer Simulation
6 MINIMIZE COST		
	6.1 ***Analyze Life Cycle Cost for Range of Alternatives***	
	6.2 Minimize Non-Recurring Costs	
		6.2.1 Minimize Infrastructure Costs
		6.2.2 Minimize Detector Costs
		6.2.3 Minimize Communication Costs
		6.2.4 Reduce Data Processing Costs
		6.2.5 **Reduce Costs of Signage and Displays**
	6.3 Minimize Recurring Costs	
		6.3.1 Reduce Maintenance Costs
		6.3.2 **Reduce Surveillance and Monitoring Costs**
		6.3.3 Reduce Info Mgmt and Dissemination Costs
		6.3.4 **Reduce Response Costs**
		6.3.5 Reduce Costs of Toll Collection
		6.3.6 Reduce Costs of Regulation
7 ALLOW EVOLVABILITY		
	7.7 Allow Expansion to Meat Future Demand	
		7.1 .1 Open Architecture
		7.1.2 Communications Capacity
	7.2 Allow Expansion to Add Capabilities as Technologies, Funding Available	
		7.2.1 Open Architecture
	7.3 Allow Modifications to Meet Future Political and Social Environments	
8 INCREASE ROBUSTNESS		
	8.1 Improve Operational Flexibility	
		8.1.1 Fault Tolerance
		8.1.2 Open Architecture
		8.1.3 Redundancy
	8.2 Provide Maintainable System	
		8.2.1 Automatic Problem Identification
		8.2.2 **Redundancy**
		8.2.3 **Modularity**
	8.3 Adapt to Changing Traffic Pattems	
		8.3.1 Modularity
		8.3.2 Expandability
		8.3.3 **Relatively Load-Insensitive Design**

10) Provide En-Route Traveler Information
11) Support Traveler Safety Measures
12) Provide Full Accessibility to All Travelers
13) Provide Accessibility to All Agencies
14) System should be maintainable and cost effective
15) Support Public Policies to reduce emissions, energy use, and noise

Specific services or techniques which were identified for incorporation in a system which supports these strategies included such items as field deployment of detection and surveillance devices, upgrading traffic management and control, and providing high-speed interagency communication links for incident management, and equipping transit buses and rail cars with vehicle location devices for improved operations and traveler information. These are further detailed in the Proposed IVHS Programs (Section 5).

3. THE TRANSPORTATION NETWORK

In order to prioritize field improvements for the benefit of passenger vehicles, public transportation (e.g, buses, paratransit, rideshare), and commercial vehicles, an IVHS roadway network was identified. Those improvements which are more global in nature or are vehicle-based, such as traveler information and Smart Bus operations, are detailed within the Proposed IVHS Programs (Section 5) Orange County is fortunate in that a number of studies of the physical roadway network have been previously conducted The findings from these studies were incorporated in the analysis of the IVHS network and the following classifications resulted (this list does not necessarily represent order of prioritization):

- Smart Corridors - freeway segments with identified recurrent and non-recurrent congestion and their arterial alternates.
- Smart Streets - arterials located at regular intervals which have the ability to serve as freeway corridor replacements or freeway linkages.
- Locally identified priorities.
- Planned Toll Roads.
- Supplemental freeway segments - those freeway segments not identified as Smart Corridors.

While the specific functions and nature of each of these categories of roadways determines the appropriate elements for deployment, the following is a list of those elements identified for implementation:

1) Accident Investigation Sites (freeways/toll roads)
2) Changeable Message Signs
3) Closed Circuit Television
4) Freeway Service Patrol (freeways/toll roads)
5) Highway Advisory Radio
6) Ramp Metering
7) Roadway Detection
8) Video Image Processing
9) Signal Synchronization (arterials)

10) Reversible Lanes (arterials)
11) Integrated Traffic Signals/Ramp Meters

In addition to these facilities, fixed-guideways such as commuter rail lines are identified for deployment of vehicle location devices.

4. INSTITUTIONAL ISSUES AND INTER-AGENCY RELATIONSHIPS

4.1 INSTITUTIONAL ISSUES

As cited previously, interviews were held with public agencies and private institutions regarding transportation with the County. These interviews were focused on a number of issues:

1) Signal Pre-emption for Emergency and Transit Vehicles
2) Incident Management and Freeway Construction Projects
3) Special Event Traffic Management
4) I&r-Agency Traffic Management
5) Transit and IVHS
6) Air Quality and IVHS

A summary of some of the more relevant consensus items in terms of development of IVHS programs include:

1) the agencies do, and want to, work together
2) a greater degree of coordination between local agencies and Caltrans (California Department of Transportation) is desired
3) the County is diverse in terms of needs
4) the agencies wish to maintain their autonomy

Additionally, some specific items/programs were desired by the agencies:

1) availability of technical assistance
2) real-time notification regarding incidents which may impact a jurisdiction
3) improved signal control and coordination for enhanced flow
4) system monitoring
5) interjurisdictional cooperation
6) local information (e.g., portable CMS for beach parking)

Constraints and concerns regarding the implementation of these items/programs include:

1) limited staff availability for operations, maintenance, and participation in meetings
2) measurable benefits of the programs relative to the expense

3) areas exist where the capacity of both primary and alternate routes is insufficient, thus frustrating attempts to reroute traffic

4.2 INTER-AGENCY RELATIONSHIPS

Of primary importance to the development of an organizational structure for the implementation of IVHS in the County is 1) that jurisdictional responsibilities and autonomy are preserved, and 2) that the organizational structure allows for efficient planning, implementation, and operations. The proposed structure recommends that jurisdictional responsibilities are kept intact with the addition of an IVHS Steering Committee, IVHS Administrative Staff, and expanded Growth Management Area (GMA) roles.

It is recommended that an IVHS Steering Committee of thirteen members be established. Membership would include representatives of Caltrans (2); the North West, Central, and South East cities (6 total), OCTA (2 total representing streets and roads, and transit), the County (l), California Highway Patrol (l), and the Auto Club (1). The responsibilities of the Steering Committee would include directing the development of IVHS in the County. These duties **include:**

1) Identify Future Programs and Modifications to Master Plan
2) Secure Funding
3) Implement Programs
4) Provide Technical Support
5) Traffic Response/Incident Management Plan Development
6) Technical Standards Setting

The Committee would be supported by an Administrative Staff.

The IVHS Administrative Staff would be staff employed by OCTA, the one agency within the County with responsibility for the entire transportation system including streets and roads, and transit. The Administrative Staff would carry out any/all of the administrative functions of the Steering Committee's responsibilities under the direction of the IVHS Steering Committee. Additionally, the Administrative Staff would:

1) Coordinate with GMAs
2) Provide meeting secretarial services to the GMAs and regional agencies as needed
3) Maintain draft agreements
4) Coordinate regional identification and formulation of projects
5) Identify and pursue funding sources
6) Coordinate projects

The GMAs (Growth Management Areas), represent the cities as grouped in geographical subdivisions of the County. These Areas were developed in order to implement transportation improvements in conjunction with Measure M, the County's l/2 cent sales tax dedicated for transportation It is recommended that the activities of the GMAs be expanded to incorporate subregional development, planning, implementation, and administration of MIS programs. Local agencies, if they choose to coordinate through the GMAs, can work cooperatively as a subregion to further IVHS within their area. Some agencies may decide not to participate in this cooperative effort, however, it is recommended due to the considerable efficiencies which may be gained.

5. PROPOSED IVHS PROGRAMS

5.1 ARCHITECTURE

Based upon an analysis of technologies and institutional implications of the architecture, a hybrid architecture of a centralized (a single traffic operations center controls Countywide) and decentralized (multiple traffic operations center act independently) system was recommended. The hybrid architecture specifies local Traffic Management Centers (TMCs) for local monitoring and control, a freeway Traffic Operations Center (TOC), a county-wide multi-agency Traveler Information Center (TIC) for fusion of status data, for distribution to traffic management and travelers.

The system centers around the collection, evaluation, and dissemination of data. The local TMCs and TOC receive data from whatever detection devices or other resources they use, (e.g., loop detectors, CCTV, police reports). This is used to monitor the traffic in the jurisdiction. It is also passed automatically to the TIC, where it is merged with data from throughout the County to form the County-wide status. This status can then be called up by any TMC or by the Caltrans TOC. Furthermore, the TIC will alert any TMC or the TOC of incidents or events to which it should respond. Decision support systems (e.g., Knowledge-Based Expert Systems) will advise action. For example, a major accident on a freeway will cause one or more TMCs to be notified and asked to approve previously agreed upon multi-jurisdictional diversion plans.

5.2 PROGRAM DEFINITIONS

The recommended IVHS programs for Orange County represent five categories of development which are similar to the user services identified previously. These include:

1) Traveler Information
2) Monitoring and Data Collection
3) Traffic Management
4) Public Transit/High Occupancy Vehicles
5) Automated Vehicle Control

The programs, their descriptions, and estimated costs and implementation time frames are detailed in Exhibit ES-2.

Exhibit ES-2

PROPOSED IVHS **PROGRAMS**

Traveler Information: Provide transportation network information to the public, the media, and transportation agencies.

Time Frame: 10 year

cost: $272 M
$202 M In-vehicle related

Programs:

Freeway MIS Elements

Provide en-route information using CMS and HAR on freeways.

$13.0 M over 5 years (builds on Caltrans TOS Master Plan)

Arterial MIS Elements

Provide en-route information using CMS and HAR on surface streets.

$37.5 M over 10 years

In-Vehicle Navigation Support (INVISION)

Provide information and communications infrastructure to support real-time in-vehicle navigation and information systems.

$202 M over 10 years, plus extensive private investment

Universal Traveler Information Program (UTIP)

Development of central Traveler Information Center, database and information servers.

$7.0 M over 10 years

Interagency Transportation Exchange (INTERTIE)

Development of Distributed Interagency Information Processing and Communications Capabilities.

$13.0 M over 5 years

Public Information Campaign

Inform public on use of traveler information and reduction of delays.

$40 K (annually)

Exhibit ES -2

PROPOSED IVHS PROGRAMS

Monitoring and Data Collection: Provide real–time data for transportation and trip management. Provide data for transportation management and analysis.

Time Frame: 20 year Cost: $117 M

Programs:

AVL

Equip vehicles with probes to obtain real-time location and operations data for use in travel monitoring and operations management

$2 M over 10 years (public fleets)
plus extensive private investment

Roadway Information

Provide detection, monitoring, and surveillance equipment to provide quantitative and qualitative traffic data for measurement of congestion and detection of incidents.

Freeways: $40.5 M over 5 years (builds on Caltrans TOS Master Plan)
Arterials: $75.0 M over 5 years

Detector Maintenance

Provide contracted maintenance supporting local agencies' maintenance programs.

$200 K annually

Exhibit ES-2

PROPOSED IVHS PROGRAMS

Traffic Management: Enhance agency traffic operations capabilities and support of both local and regional operations.

Time Frame: 10 year cost: $112 M

Programs:

TOC/TMCs

Build and equip Traffic Management Centers for management and operations of state and local roadways.

$25 M

Agency Traffic Operations Support

Assist local agencies in operation of traffic management systems (TMS) and in new technologies.

Provide maintenance support to local agencies for TMS field elements.

$370 K annually

Decision Support Systems

Develop interagency real-time traffic management capabilities in the Smart Corridor areas through the use of Knowledge-Based Expert Systems.

$16 M over 10 years

Emergency Priority System (EPS)

Develop testbed for interjurisdictional coordination of signal pre-emption through integration with traffic management systems for reduction of delays.

$265 K over 5 years (expand based on success of testbed)

Rapid Incident Clearance (RIC)

Expand Freeway Service Patrols and integrate reporting capabilities with UTIP program to assist in real-time information and management.

Provide accident investigation sites to move accidents out of travel lanes.

$37 M over 10 years, of which 99% is AIS

Adaptive Signal Control and Signal Synchronization

Enhance control of traffic signals in response to real-time traffic conditions.

$22.5 M over 5 years

Corridor Ramp Metering

Enhance real-time freeway traffic flow through corridor-wide ramp metering strategies in response to real-time bottlenecks and incidents. Includes additional ramp metering.

$10.6 M over 5 years

Exhibit ES-2

PROPOSED IVHS PROGRAMS

Programs (cont.):

Integrated Signal/Ramp Meter Control

Improve local signal-ramp meter coordination to minimize negative impacts of restrictive ramp metering on surface street operations.

$700 K over 5 years

Public Transit/High Occupancy Vehicles (HOV): Support Transportation Demand Management strategies through enhanced data collection, information, and dissemination dissemination of transit and rideshare information.

Time Frame: 10 year cost: $12 M

Programs:

Public Transit/Smart Bus

Provide enhanced transit information to public and for use in management of transit services.

$11 M over 10 years

INTER- RIDE

Provide interactive rideshare matching based on real-time traveler requests to a rideshare database. Integrate system with UTIP interactive terminals and bulletin board services.

$630 K over 5 years

Real-Time Intermodal Advisory (RITA)

Integrate transit information with traffic information to perform comparisons of travel times between user-selected origins and destinations.

Provide through interactive terminals and bulletin board services.

$160 K over 5 years

Exhibit ES-2

PROPOSED IVHS PROGRAMS

Automated Vehicle Control (AVCS): Support future needs associated with automated control and central–to–vehicle communications strategies.

Time Frame: 20+ year cost: $207 M (plus private investment)

Programs:

AVCS Operational Support

Support AVCS with communication servers, in-vehicle control systems, and operations systems.

Minimum $7 M over 20 years, plus extensive private investment for in -vehicle elements

Platooning Lanes

Provide electronics infrastructure and modifications to existing freeway lanes or addition of new lanes along freeway corridors.

Minimum $200 M over 20 years, depending on technology and exact infrastructure

[redacted]

6. ACTION PLAN

The IVHS Action Plan, which has been submitted under separate cover from this Final Report, prioritizes the programs and suggests appropriate funding sources, and their associated funding levels, for the programs. The prioritization of the programs is designated as follows:

Ongoing Programs/Operational Tests

- Rapid Incident Clearance
- Signal Synchronization
- Adaptive Signal Control
- Integrated Signal/Ramp Meter Control
- Mobile Surveillance Systems
- Emergency Priority System
- Integrated Transit/Traffic Management Systems

First Level Priorities

- Universal Traveler Information Program
- Freeway Instrumentation (Smart Corridors)
- Arterial Instrumentation (Smart Corridors)
- Interagency Transportation Information Exchange
- Freeway Traffic Operations Center
- Public Transit/Smart Bus

Second Level Priorities

- Freeway Motorist Information System
- Arterial Motorist Information System
- Freeway Instrumentation
- Arterial Instrumentation
- Corridor Ramp Metering
- Traffic Management Centers (local)

Third Level Priorities

- Automatic Vehicle Location (other than fixed-route buses)
- Interactive Rideshare
- In-vehicle Information/Navigation
- Decision Support Systems

- Real-time Intermodal Travel Advisory

Fourth Level Priorities

- Support of Automated Vehicle Control Systems

Enabling Projects

- Agency Traffic Operations Support
- Public Information Campaign
- Detector Maintenance

As with the programs themselves, the priorities of the projects must be viewed as a living recommendation which may be revised as funding becomes available and technologies and new technological applications develop.