# Advanced Transportation Systems Program Plan


California Department of Transportation

New Technology and Research Program



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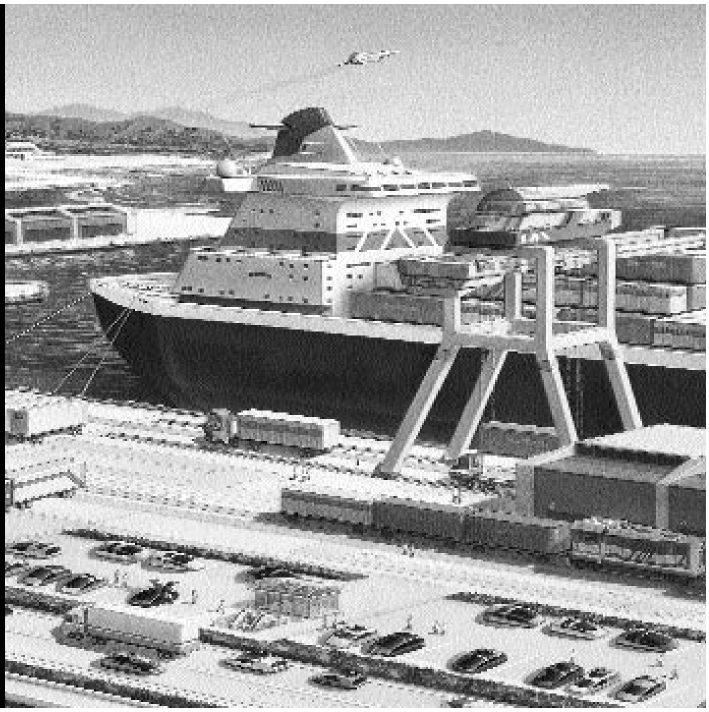
# PURPOSE



alifornia faces significant mobility, environmental and economic challenges as the 21st century approaches. California cannot financially or environmentally support purely traditional approaches to transportation —building additional roadway capacity to solve congestion problems. What is needed is a smarter transportation system, one that functions as an integrated intermodal system offering increased performance and expanded options for people and goods movement. The California Department of Transportation (Caltrans), as the steward of the state's transportation system, has a responsibility to provide leadership to meet these challenges now and into the next century. In this role, Caltrans is committed to developing a dynamic Advanced Transportation Systems (ATS) Program. California has long recognized the potential of applying electronic, telecommunication and other technologies to the movement of people, goods, services and information. Advanced transportation technologies can provide effective and robust tools for realizing the vision of a balanced, multimodal and environmentally sound transportation system. At the same time, application of these technologies to transportation presents major new market opportunities for California industry on an international scale. Since 1986, the California Legislature and two administrations have supported a growing transportation technology effort within Caltrans, culminating with the formal establishment of a multimodal ATS Program (Statutes of 1992) signed into law by Governor Pete Wilson in July 1992.

Comprehensive planning and cooperation between the public and private sectors is critical in order to reach technology's full potential since both play different but equally important roles in the research, development, testing, and deployment of these technologies. The ATS Program Plan provides a framework to facilitate discussion among these sectors and to direct the Department's work in the development and deployment of advanced transportation technologies. This document defines the mission and goals of the program and identifies a 15-year ATS deployment vision which relies on both governmental action and market forces, and which will require extensive cooperation on the part of the state, its political subdivisions, and private industry.

The plan also lays out specific state initiatives, including proposed legislation, and a Caltrans five-year program which contains an array of research, development, testing and deployment activities. These activities are intended to improve California's transportation systems across all modes and to support the private sector's role in providing the leading-edge mobility services outlined in the 15-Year Deployment Overview.

The ATS planning process, begun in 1992, has taken into consideration opportunities and programs introduced by the enactment of the federal Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, and the work done by both the U.S. Department of Transportation (USDOT) and the Intelligent Transportation Society of America (ITS America), a USDOT advisory group, to lay a foundation for federal technology program planning.

The California Transportation Plan (CTP), required by both state and federal legislation, provides direction for planning, developing, operating, and maintaining California's transportation systems. The CTP provides a broad, long-range framework within which the ATS Program Plan was developed. The CTP emphasizes the importance of advanced technologies to the mobility, safety and health of Californians and to the state's economic well-being. Many of the actions called for in the CTP would be implemented under the ATS Program Plan.

# INTRODUCTION

## Features of the Program

The ATS Program is guided by the goals established by Caltrans in pursuing its mission and in realizing the vision of effective, safe and environmentally sound mobility for the people of California. The mission and goals are defined in the plan, as is a vision of technology's promise for transportation that is shared by the program's public and private partners. That vision addresses all forms of transportation—people, goods and information movement—and is user service oriented. The ATS Program Plan presents a 15-year picture of the evolution of the transportation system toward its 21st century vision. The state initiatives and the department's five-year program outlined in the plan are geared specifically toward delivering a broad range of user services over this evolutionary path. Early deployment opportunities are identified and take the form of public services, products available in the marketplace, and cooperative public/private systems. When developed and deployed, the technologies proposed in the plan will lead to a substantially more productive and integrated transportation system for California.

Technology applications addressed by the ATS Program include intermodal facilities, traveler information services, telecommunications, advanced transportation and fleet management, vehicle control, transportation systems automation, alternative vehicles, and maintenance and construction. These would: provide transportation users with comprehensive system information and services; coordinate and optimize freeway and signalized street operations; facilitate telecommuting, real-time ridesharing and electronic payment; reduce accidents through collision avoidance systems; and automate highway maintenance and operations. Fleet operators, including transit providers, could greatly improve their productivity and offer expanded services better tailored to their clients' needs. Options for modal linking would also be expanded. In the longer term, a new unified transportation system could emerge that optimally matches mobility need with mode, and integrates clean and efficient propulsion technologies.

The ATS Program encompasses technology research, development, testing, standards setting and initial deployment. It also addresses user needs, and institutional, legal, market and other issues that impact successful achievement of the ATS vision. The five-year program reflects the breadth and complexity of activities. The size of the existing program is a reflection of the currently authorized budget. The proposed program is based on required activities, increases in state support for the program, the availability of federal ISTEA funding and a reasonable degree of public/private cost-sharing by the department's ATS partners.

## Features of the Program

Critical to the success of the ATS Program is the ability to use available resources in the most cost-effective manner possible. Because funding is limited, it will be crucial to accurately identify which activities are in progress, which are in the planning stage and which have been targeted for near-term development and deployment. This process cannot be done without investigating and categorizing the activities of all 50 states and then working with local and regional partners to establish realistic priorities for California's part in the national picture. This information will be included in subsequent updates of the program plan. The information and input gathered during the statewide and national review of this document by the department's partners will be vital to the success of this process.

Where feasible, the ATS Program takes a "building block" approach to technology. Using computer, telecommunications, sensor, and other "smart" technologies, upgradable, stand-alone systems can be deployed to provide near-term benefit. Integrating these building blocks will generate more comprehensive and effective systems further down the evolutionary path. It will also permit much more robust "packaging" of applications, greatly expanding the options for addressing multiple modes, intermodalism and specific policy objectives. This approach, however, will require adherence to interface standards and protocols organized under an overall systems architecture. The plan outlines these requirements.

Caltrans is committed to integrating new technology development into the transportation planning process to facilitate deployment of advanced transportation systems and to using a continuing programming process in implementing the ATS Program. Management of the program and execution of the work plan include:

- Serving the needs of the user/customer as the principal focus;
- Developing ATS partnership teams in all Caltrans districts to gain an early commitment from those involved in the transportation planning and programming processes at the state, regional and local levels to consider the many options made available by new technology development and to incorporate those options and technologies into their transportation plans;
- Using those partnership teams to gain regional acceptance and coordination;
- Establishing the California Alliance for Advanced Transportation Systems (CAATS) to bring public and private sector partners together to pursue and coordinate ATS activities in the state;
- Consolidating and/or broadening the agendas of existing partnerships to include the consideration of Intelligent Transportation Systems (ITS) technologies whenever and wherever possible;
- Participating in national ATS activities including membership in ITS America; the systems architecture team; and in the National Automated Highway System Consortium (NAHSC);
- Cooperating with the national standards and protocols development efforts;
- Preparing annual ATS Program reports on program accomplishments and recommending activities for the following year; and,
- Conducting periodic updates to the ATS Program Plan.

## Organization of the Plan

The ATS Program Plan is organized into four main sections. The **“Background”** section includes an overview of the problems and challenges that California faces, summarizes the department’s mission in light of these, and discusses how the ATS Program fits within that mission along with program overview, goals, vision, and roles. Next, the **“Fifteen-Year ATS Deployment Overview”** details the elements of advanced transportation systems and defines an evolutionary path toward the ATS vision to which all partners must contribute. Benefits and costs are estimated.

The **“Realizing the Vision”** section starts to focus on state actions required: discussing institutional issues, proposing state policy and legislative initiatives to address these issues, and outlining ATS Program delivery strategies and organization. Finally, the **“Five-Year Program”** details current year activities within the Caltrans program and lays out an activity plan with anticipated milestones for the following four fiscal years. Program resource needs are also discussed.

# BACKGROUND

## California's Transportation Issues

Since the early 1960s, California's population has grown by 89 percent. Although this trend has declined in recent years, past growth has put a real strain on the state's transportation system. The transportation system today is comprised of relatively unconnected segments and modes which are all too often out of balance with mobility needs. In many urban areas, systems are also severely over-saturated. This lack of capacity, balance and "connectivity," together with an almost exclusive reliance on petroleum as a fuel source, has contributed to a number of problems that adversely affect the mobility and economic well-being of Californians.

### Traffic Congestion

Congestion is causing Californians hundreds of thousands of hours of delay resulting in billions of dollars of wasted fuel and lost productivity each year. Without effective new initiatives and programs, traffic congestion in California could increase by 200 percent in the next fifteen years. The level of mobility we came to depend on in years past can no longer be achieved with such an explosive congestion problem.

In addition to surface transportation, aviation in California has played an important role in the interregional movement of people and goods. Both the Federal Aviation Administration (FAA) and the California Aviation System Plan (CASP) project a significant increase in air passenger travel. This will add to the congestion in and around airports, which will continue to cause considerable delays for the traveling public.

### Safety

Increased safety is one of the Department's most important goals. During 1994, more than 4,200 people died on California's streets and highways and another 316,000 were injured.

Despite a drop in the number of fatalities on U.S. highways, motor-vehicle accidents cost the nation more than $137 billion, according to the National Highway Traffic Safety Administration (NHTSA). Health-care costs related to these accidents make up about 10 percent of that amount or $14 billion. Taxpayers pick up $3.7 billion of the health-care bill. Preventing many of the deaths and injuries on U.S. roads can reduce health-care costs by $1 billion each year. Improvements in highway safety will contain healthcare costs.

Significant gains in reducing costs have already been made by reducing the damage when collisions occur. The large future gains will come from collision avoidance. Vehicle innovations, such as Intelligent Transportation Systems (ITS) or "smart vehicle" technology, hold the key to future decreases in accident costs. Most collisions result from problems with a driver's behavior. The new technology can help adjust behavior more easily than an all-out promotional campaign designed to change basic behavioral problems. ITS will augment a driver's ability and correct for deficiencies.

**There are 17,500 crashes each day in the United States. We save $35,000 for each serious motor-vehicle-crash injury prevented. For every dollar invested in highway safety, there is a $3 return.**

**NHTSA estimates that ITS can save 11,000 lives per year nationwide.**

## California's Transportation Issues

A significant increase in safety is a primary goal in the research and development of advanced technologies. New technologies as developed and described in this Advanced Transportation Systems Program document will contribute to a significant reduction in the number and severity of accidents and an increase in safety in rural and urban areas for Caltrans workers and the traveling public.

### Energy

Transportation consumes 45 percent of the total energy used in California. It relies on petroleum fuels alone to satisfy more than 95 percent of its energy needs—a staggering 75 percent of the state's petroleum usage, according to the California Energy Commission (CEC). Because of these characteristics, transportation has been the hardest hit sector in past energy crises in terms of both price and supply. Energy policies in transportation have focused on improving vehicle and system efficiencies and increasing fuel and modal flexibility in order to protect the sector from future petroleum market disruptions.

Congestion contributes significantly to fuel efficiency losses. When average freeway speeds drop below 35 mph, fuel consumption increases because of the increased number of stops/starts. Congestion causes Californians to waste about 750 million gallons of fuel each year. This could increase to nearly 2 billion gallons within 15 years.

Providing for and accommodating safe and convenient non-motorized and mass transit modes will also contribute to energy use reductions.

### Air Quality

California has experienced improved air quality during recent years, primarily due to cleaner burning engines and an increase in vehicle fuel economy. However, major efforts are still required to meet clean air standards. Since over 70 percent of air pollution in California still comes from the internal combustion engine, future major reductions in air pollution must come from: clean fuels and propulsion systems; implementation of transportation demand management strategies such as High Occupancy Vehicle (HOV) lanes, ridesharing, and congestion pricing; and, overall transportation system balance and efficiency. Strategies to improve air quality and to provide congestion relief are not incompatible, and can be implemented using many elements of ATS.

### Economic Impacts

The annual cost of congestion to the state, in terms of lost productivity, lives, pollution and energy waste, is too high. Yet, these costs reflect only part of the danger to the state's economy from deteriorating levels of transportation service. The existing system is an impediment to California's economic vitality. Access to an effective and environmentally compatible mobility system is essential to a healthy economy. Transportation alone contributes nearly 60 percent of the gain in private sector output attributable to public sector infrastructure. California is the seventh largest economy in the world. Around the turn of the century, the annual value of goods and services will increase to some $800 billion. However, these estimates assume an adequate mobility system and the state effectively addressing its critical defense conversion challenge.

## California's Challenges and Opportunities

The California Transportation Plan (CTP) implies that the major challenge facing California over the next 20 years is developing an accessible transportation system which complements and encourages a positive economy and a quality environment. The state cannot financially or environmentally support solely traditional approaches to transportation—building additional road capacity to solve congestion problems. This is particularly true because 60 percent of anticipated future demand for mobility services will be in the mature urban areas of the Los Angeles Basin and the San Francisco Bay Area. What is needed is a smarter transportation system, one that functions as an integrated intermodal system offering increased performance and expanded options for people and goods movement (including the option of substituting telecommunication for travel) and one that can incorporate clean fuel and propulsion systems.

California's opportunities to improve the transportation system have never been better. Recent state and federal laws have mandated new approaches to transportation funding and decision-making, emphasizing flexibility in pursuing the best transportation solutions, intermodalism, and broader participation by regional governments, local communities and the private sector. Stricter regulations demand environmentally-compatible transportation measures. In addition to this new foundation for governmental action, California enjoys a large and diverse industrial base in the technology fields. With declining national defense expenditures, industries involved in such work are actively pursuing civilian markets including transportation-related markets. Caltrans is committed to maximizing the benefits gained from the availability of human resources with advanced technical expertise during this time of conversion of California's technology from military to civilian emphasis. The "blue ribbon" panel of Project California, a joint effort of business, government and academia chartered by Governor Pete Wilson and the California Legislature, has identified advanced transportation technologies as a primary opportunity for industrial defense conversion.

More than $130 billion is spent annually statewide by transportation system users and providers. The development of new, advanced transportation systems will not only increase the effectiveness of this investment (vis-a-vis mobility), but will provide California companies with opportunities to develop and sell products and services worldwide. It will also create jobs and improve the quality of life for the citizens of California. Caltrans, through its ATS Program, is committed to contribute to such mobility enhancement and economic development. The strategy for realizing the advanced transportation technology vision is outlined in the ATS Program Overview section beginning on page 22.

**As a key element in achieving Caltrans' Advanced Transportation Systems Vision, California will spend more than $280 billion in the next 20 years for improving and expanding the transportation infrastructure.**

## Departmental Mission and Program Goals

**Program Goals**

- Enhance Transportation Services
- Improve Safety
- Reduce Energy and Environmental Impacts
- Support Economic Well-Being

The program's charge is to research, develop, demonstrate, and deploy advanced technologies that can improve the mobility of people, goods, services, and information in the state. The economic importance of having a transportation system that offers the best possible movement of goods, services, information and people, particularly for a state with the international connections and stature of California, makes this an important goal of the program.

The program looks beyond conventional methods to explore ways to enhance and connect all modes of travel and respond to societal needs for improved environmental quality, increased safety and equitable service for all citizens. This will require forming new partnerships with others who possess the needed methods and/or resources, including all levels of government, academia and the private sector (see page 20). This charge recognizes Caltrans' responsibilities to shape and build a consensus for public policy that guides the future of transportation in California. This Program is, therefore, a key vehicle by which Caltrans carries out its state leadership role.

The program gives Caltrans an extremely promising avenue to pursue four major goals related to its mission:

### Enhance Transportation Services

- Improve system productivity and reduce congestion and its associated costs;
- Increase the people-carrying capacity of existing systems through higher vehicle occupancies;
- Improve goods movement capacity and efficiency;
- Promote intermodalism through better connectivity between all transport systems and modes;
- Enhance system accessibility, convenience, comfort, reliability and equity for users at all income levels, in all geographical areas, and for those with special needs;
- Improve productivity and reduce costs related to system construction, operation and maintenance;
- Enhance the quality and availability of data required for the planning, development, operation and maintenance of transportation facilities and services;
- Enhance accessibility to products and services through improvements to transportation and travel substitution systems; and,
- Make transportation more affordable.

### Improve Safety

- Reduce the number of fatalities and injuries that occur in transportation and transportation-related accidents;
- Improve the safety of private vehicles, public transportation and commercial vehicles, and of hazardous waste movements; and,
- Improve personal safety in the use, operation and maintenance of transportation facilities and services.

### Reduce Energy and Environmental Impacts

- Reduce harmful vehicle emissions;
- Facilitate deployment of clean fuels and propulsion systems;
- Reduce energy use intensities for all transport modes and systems;
- Expand transportation demand management options and effectiveness; and,
- Promote overall environmental compatibility of transport systems.

### Support Economic Well-Being

- Improve the economic efficiency of the transportation system for all its users, including operating agencies, fleet managers and individuals through the design, development and implementation of ITS;
- Make better use of existing facilities, reducing the need for construction of capital-intensive new systems. Maximize the use of national and other outside resources in the execution of the ATS Program;
- Optimize the use of scarce transportation resources;
- Support and demonstrate new institutional structures for technology development, transfer and deployment in California;
- Promote and facilitate a viable and profitable advanced transportation technology industry in California;
- Promote greater financial benefits for business through better system efficiency leading to a reduction in costs; and,
- Improve the competitiveness of California industries within the United States and world economies.

## The ATS Vision

The vision of a more mobile, economically healthy society that preserves the qualities that make California a desirable place to live was articulated in "California Transportation Directions: Mobility for 2010." This document was developed at the beginning of the 1990s by Caltrans in consultation with the state's transportation stakeholders. It recognized that the economy; energy and land use policies; community values, and protection of the environment are all interwoven with transportation. It also acknowledged that the very concept of mobility was changing with technological advances, which allow mobility options to encompass the movement of information, as well as people and goods. Three basic conditions were defined to enable the state to realize the Mobility 2010 vision:

- Communities will wisely plan, develop and use their land;
- Transportation providers will wisely manage their systems; and,
- Transportation consumers will wisely use the system.

Advanced technologies can provide the tools by which these conditions are realized. From "smart vehicles" to advanced transportation management and information systems, technology can support wise decision-making by all mobility partners. In the near term, the program's products will provide transportation users with comprehensive information and modal services; coordinate and optimize freeway, street and transit operations; and allow for real-time ridesharing and other high-tech demand management strategies. The safety of travel will be significantly increased through advanced vehicle control products which enhance operator perception on a continuous basis, give warning of impending danger, and intervene with emergency control to prevent accidents. Fleet operators, including transit providers, can improve productivity and safety and offer expanded services better tailored to their customers' needs. In the longer term, alternative transport systems would be deployed—from small neighborhood vehicles to automated and/or high-speed ground systems. As these technological building blocks are integrated, options for modal linking will expand. A new unified transportation system could emerge which optimally matches mobility needs with service provision and incorporates clean and efficient propulsion technologies. In the future, revolutionary telecommunication services will change the way Californians approach transportation, altering traditional views on the movement of people, goods and information. A significant part of the population will work at home. Offices and homes will be linked by interactive, multi-media networks to create virtual organizations. By the year 2005, there will be 300,000 video conference systems installed in California. Distance learning and remote health care via telecommunications will be commonplace, as will remote shopping and banking.

One scenario for the vision, therefore, will have a significant number of the California population teleworking, teleshopping and telebanking. When travel is necessary, a push of a button will determine when and how it can most efficiently be done given transportation system options, conditions and costs. Modal options would include a wide array of customized public transportation services that rival the personal automobile in convenience and connectivity. Another button executes the travel plan, alerting any public transportation modes involved. Roadway and public transportation pricing could be linked to each other in real-time (given system conditions, time of day, environmental objectives, etc.) and users automatically charged in one monthly bill. The commute itself might involve a number of modes, some automated, all seamlessly linked to make transfers painless and efficient.

A similar scenario would take place in goods movement, with truck, rail, air and maritime operations completely coordinated and integrated. For example, advanced fleet management and information technologies will allow fleet managers (trucking companies, paratransit services, transit providers, etc.) to optimally route and schedule vehicles given actual system conditions and provide for automated compliance with regulatory and other administrative requirements. Also, use of advanced technologies such as digital maps, global positioning systems, computers and wireless communications will enhance the ability of navigators of sea-going vessels to avoid colliding with other vessels in low visibility areas.

**Achieving this vision will ultimately enable Californians to:**

- **Travel with convenience and pleasure;**
- **Travel with multiple mode options;**
- **Travel at low cost;**
- **Travel with minimal impact on the environment;**
- **Travel safely;**
- **Develop successful transportation related businesses;**
- **Improve and replace travel using telecommunications technologies;**
- **Create new industries and jobs and provide a new model for developing and deploying technologies; and,**
- **Compete effectively in worldwide ATS markets.**

## Roles and Responsibilities

Development and deployment of advanced transportation technologies and systems will require unprecedented levels of cooperation and coordination among all levels of government, the private sector and academia. Systems that provide seamless services across jurisdictions and modes are possible only with the full cooperation of all such jurisdictions and modal operators. So-called "intelligent" systems must rely on widespread use of commercial and consumer products that are compatible with smart public infrastructure. In fact, about 80 percent of intelligent transportation system deployment costs are projected to occur in the marketplace, with only 20 percent attributable to public expenditures (this is further discussed in the Fifteen-Year Deployment Overview section). The very nature of nontraditional ATS approaches demand substantial research and analysis, the kind academia is well suited to deliver. Realization of the vision, therefore, entails the following roles and responsibilities:

The **federal government** will provide national leadership, development funding (particularly during the high-risk phases of research and testing), regulatory support, and national compatibility standards. In addition, it will make federal-aid funding available for ATS deployment.

California **state government** will work in partnership with the federal government, providing leadership by keeping an emphasis and focus on mobility, safety, and environmental and other societal goals. Caltrans will support ATS joint efforts through administrative, legislative, regulatory and public policy initiatives. Caltrans will take the lead responsibility of ATS development and deployment efforts in California, and ensure that adequate state resources are made available for matching federal funding opportunities and for ATS activities of special importance to California (see discussion of state/national program relationships in the Realizing the Vision section). This public investment of resources should act as a trigger for private development.

As a major transportation system owner and operator, Caltrans, in addition to being a primary player within the general state role, will also be responsible for the testing, evaluation and deployment of ATS technologies on state transportation facilities and services.

To achieve a balanced and mutually beneficial system, Caltrans will coordinate its efforts with regional and local agencies and the transportation planning program process. Cooperative partnerships are the key element in the planning and programming of transportation. Cooperative planning is conducted in a coordinated and continuous manner to implement projects within the state. This cooperative effort involves development of the State Transportation Improvement Program (STIP) in coordination with the local transportation agencies' Regional Transportation Improvement Programs (RTIPs) being developed at the local level concurrently.

**Regional and local governments** will play critical roles in identifying ATS-related needs and opportunities specific to their areas, and testing and evaluating ATS technologies on their own systems.

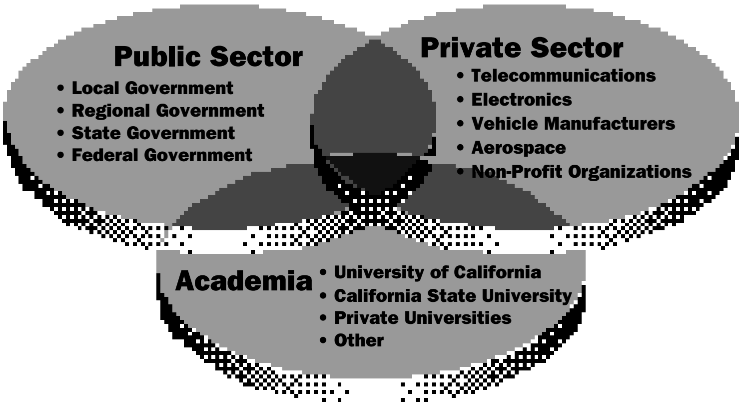
**Roles and Responsibilities**

Metropolitan Planning Organizations (MPOs), an integral part in this process, are responsible, through public participation and coordination with other agencies, for defining the transportation "problems" in their jurisdictions. In cooperative action with other groups and agencies, a "mix" of projects (e.g., transit, HOV, intelligent transportation technologies) are programmed to facilitate the safe and efficient movement of all transportation modes. Strategic plans for the early deployment of intelligent transportation systems are now being prepared by some MPOs as part of their regional transportation planning ensuring that ATS deployment is incorporated into the mainstream transportation planning and programming process.

The **private sector** will bring technology, manufacturing and marketing capabilities to the partnership. The private sector will provide a broad array of products and services to government, including: consulting; research and development facilities; computer software; specialized equipment; communications; system integration and deployment, and operational management support. In addition, the private sector will service the entire market side of ATS deployment in California, the nation and around the world.

**Universities, national laboratories and professional societies** will have a major involvement in research, development, testing, standards setting, training and technology transfer. The California Partners for Advanced Transit and Highways (PATH) Program was established in 1986, by Caltrans and the Institute of Transportation Studies at the University of California, Berkeley (UCB) to develop the foundations for the widespread adoption of advanced technologies that will help improve the operation of California's surface transportation systems. In order to develop these foundations, the PATH Program seeks to identify the impediments to progress, both technical and institutional, and develop strategies for overcoming those impediments. The PATH charter includes conducting leading-edge research, evaluating operational tests, developing public/private/academic partnerships, and educating both students and practitioners about ITS. However, it does not extend as far as deployment or operation of systems, which remain the responsibilities of Caltrans and the relevant local agencies.

Several other prominent California universities have joined in this statewide effort including University of California Davis (UCD), University of California Irvine (UCI), California Polytechnic State University, San Luis Obispo (Cal Poly), and the University of Southern California (USC).



## ATS Program Overview

### Program Scope

The Caltrans ATS Program provides the foundation for ATS efforts in California. As the state's transportation steward, Caltrans envisions the future of surface transportation as one of improved use of infrastructure and enhanced user choices through the application of advanced transportation technologies and services on the public infrastructure and in the marketplace. The ATS Program, therefore, incorporates technology applications in personal, public and commercial transportation, relevant to highway, rail, air or marine modes. It addresses state, local and private transport systems, within both urban and rural environments. The program pursues both supply- and demand-side measures. Most importantly, the program looks for opportunities to link individual system elements, and package measures to promote maximum system productivity.

The program recognizes that energy and environmental goals must be met in responding to mobility and safety needs. Caltrans envisions that the power and robustness of computer, electronic and telecommunication technologies will facilitate the development of transportation tools and packages that can form common solutions to multiple problems.

### Program Principles

**User Orientation -** Program activities will focus on developing and delivering the user services described on pages 31-37.

**Partnerships -** Caltrans will seek to develop partnerships with other governmental agencies, academia and private industry in researching, developing, testing and deploying ATS technologies.

**Education and Outreach -** Caltrans will develop a dynamic outreach program to educate local and regional agencies about the value and appropriateness of incorporating new technologies into their planning efforts to assure timely and appropriate deployment throughout the state.

**Respect For The Environment -** Caltrans will work with others in the public and private sectors to research, develop, and evaluate technologies and systems with a view toward improving air quality, minimizing use of energy and otherwise benefiting the environment. The application of these new technologies must be done with respect for the environment, to eliminate any possibility that they might despoil or create negative secondary impacts.

**Cost Efficiencies -** A major objective of the ATS Program is to introduce new technologies that will facilitate new ways of doing business at reduced cost in transportation, planning, design, construction, operation and maintenance programs.

**Leverage Of Program Investment -** Pooling of resources from multiple sources can reduce costs to individual entities. Cost-sharing using available resources from federal, state, and local governments, academia, and the private sector is a guiding principle of the ATS Program.

**All Modes Of Travel -** The ATS Program takes a holistic approach to transportation technology opportunities, addressing all modes of transportation (surface, air, marine, motorized and non-motorized); and both supply enhancement and demand management approaches to mobility.

**Building Block Development With Early Products -** Technology deployment on the California transportation system will be achieved using a building block approach. Viable stand-alone technologies will be deployed when they can be shown to be cost-effective, and designed to integrate with other technologies into more powerful systems according to a "systems architecture." The systems architecture will be adopted on a national basis, allowing these systems to be deployed across state and national boundaries, to support a national ATS.

**Support For Private Sector Commercialization -** Caltrans' ATS Program will help lay the foundation for new product and service development in private markets. The ATS Program will work closely with private business to ensure the viability of these products and services, and their compatibility with technology deployments on the public infrastructure.

**Deployment Planning -** Caltrans ATS Program prepares and supports early deployment/strategic deployment planning to provide a bridge for new technology into the transportation decision-making process. This planning takes place in the urban and rural areas, addressing near, medium and long-term needs, goals and policies (see Early Deployment Plans and Southern California ITS Priority Corridor, pages 77-78).

## ATS Program Overview

### Program History

Since 1986, the ATS Program has built the foundation of a working partnership with a broad range of public and private interests. A primary partner of Caltrans has been the University of California's Institute of Transportation Studies, which helped in establishing the PATH Program to conduct research for Caltrans. Agencies of the federal government, such as the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), the National Highway Traffic Safety Administration (NHTSA) and the Federal Aviation Administration (FAA) are contributing to several projects under the Caltrans program. Numerous local and regional governmental agencies throughout California are participating with Caltrans in technology research. Non-profit organizations, including ride-sharing agencies, transportation management associations, auto clubs and the California Trucking Association are also participants. General Motors, Ford, Hughes Aircraft Company, TRW, Rockwell International, Southern California Edison and others, including some small businesses, are now private sector partners in the Caltrans technology program.

In addition, Caltrans is working closely with the California Energy Commission (CEC) and the State Air Resources Board on technology development. This cooperation recognizes the importance of addressing energy security and air quality goals in solving transportation problems, and the potential of advanced technologies to do so.

The California Highway Patrol (CHP) has also been a contributor in setting the technology research agenda, particularly as it relates to safety and traffic management. The California Public Utilities Commission (CPUC) is an active partner with Caltrans in testing "smart systems" for commercial trucking operations.

Working with other interested states and USDOT, Caltrans helped rekindle a national interest in technological solutions to growing congestion, safety and environmental problems. That interest resulted in the creation of the Intelligent Transportation Society of America (ITS America; formerly IVHS AMERICA) and the inclusion of a federal Intelligent Transportation Systems (ITS) program under ISTEA. Caltrans and many of its ATS partners in California are charter members of ITS America. As a strong supporter and leading player in the ITS national effort, Caltrans will focus on improving California's transportation system, while cooperating with a national program including the formation of a strong partnership in the Automated Highway System (AHS) demonstration and ATS systems architecture efforts.

### The National Plan

USDOT and ITS America, working in cooperation with representatives of both the public and private sectors, have developed a National ITS Program Plan. User needs that can be addressed through ITS technologies and the services that are being developed or can be developed to meet those needs are identified in the plan. The plan will be used as a "road map" to determine how the interacting goals of industry, government, and users will be addressed in the development and deployment of ITS services in a nationally compatible, intermodal system. The plan represents a consensus view that the states, local governments and private industry can rely on for a vision of the ITS program across the country.

The Caltrans ATS Program Plan takes this process one step further to include the actual deployment of systems and technologies over a 15-year period.

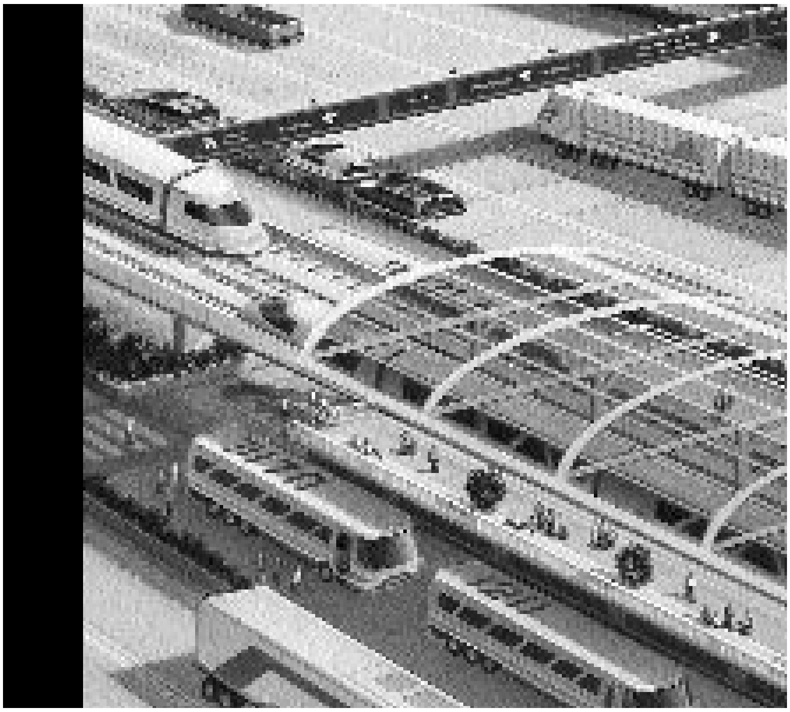
### Caltrans ATS Program

The Caltrans ATS Program has a number of distinguishing features:

- Strong emphasis on addressing safety, energy and environmental issues and goals;
- Strong emphasis on multimodalism in pursuing program goals;
- Advanced transportation system baseline for applying cutting-edge technologies;
- Rural applications of technology;
- World-class research program on vehicle control and robotics technologies for safety and automated operations, including facility maintenance and construction;
- An aggressive, safety-oriented Advanced Highway Maintenance and Construction Technology (AHMCT) Program designed to enable workers to safely and efficiently complete tasks with minimal impact on the traveling public;
- Participation in the National Automated Highway System Consortium (NAHSC), a nine-member cooperative effort funded by the Federal Highway Administration to design, construct and demonstrate a prototype of a working automated highway system in the United States by 2001; and,
- Program scope broader than ITS, incorporating new system concepts, high-speed ground systems and alternative vehicle technologies.

These distinguishing features and Caltrans' direct involvement in ITS America result in an ATS Program that will continue to keep California in a leadership position, taking advantage of program resources and products available nationally without duplicating efforts elsewhere.

# FIFTEEN-YEAR DEPLOYMENT OVERVIEW



## Introduction

This section defines the elements of advanced transportation systems in terms of new or enhanced services that will be delivered to transportation system users over the next 15 years. Benefits and costs are estimated, as are cost allocations for public infrastructure investments and private markets.

The ATS deployment overview provided here assumes that all ATS partners play their roles in pursuing the ATS vision as described in the previous section. While a fully supported ATS Program at Caltrans is a necessary element of this, it is not by itself sufficient. There are many others in addition to Caltrans, in both the public and private sectors nationwide who, in many cases, play a larger or more significant role in the development of ATS across the nation. The deployment milestones and evolutionary paths presented on the following pages, therefore, are scenarios depicting what can happen if an effective ATS partnership is realized. As needs and technologies change, each deployment scenario will be re-evaluated for its importance and benefit, taking into consideration any new or more immediate needs. This will be a critical process so that the program plan can be adjusted as necessary. This on-going evaluation will ensure that the ATS Program will continue to grow and change to satisfy user needs in the future.

This deployment overview details the application of aerospace, defense, computer, communications, and other technologies to the vehicles, facilities, and services that make up California's transportation system. These technologies apply across all modes and throughout all levels of the system. The transportation system includes public transportation; paratransit; rail, maritime and air transportation; highways, including freeways, urban arterials and city streets; and, ridesharing and other high-occupancy-vehicle systems. Movement of goods, services and information, as well as people, is addressed. Alternatives to travel such as telecommuting, teleconferencing, telebanking, and teleshopping are incorporated, as are alternative vehicle systems, including new families of light-weight and alternative fueled vehicles. New technologies will apply to urban, suburban, and rural environments and will involve all of Caltrans' transportation functions including planning, design, construction, operations, and maintenance.

With ATS deployment, California's competitiveness would be enhanced and defense industry conversion greatly facilitated. Future marketability of products and business opportunities worldwide that result from development and application of ATS technology should provide strong incentives for private sector participation.

## Elements of ATS

Following is a brief summary of the elements of advanced transportation system deployments. These are discussed in terms of new or enhanced services that will be provided to transportation system users, whether individuals, vehicle fleet operators or transportation infrastructure managers. Where appropriate, user services are defined consistent with those identified in the National ITS Program Plan. The milestones outlined on pages 41-49 illustrate feasible deployment dates of user services at increasing levels of functionality. In many cases, multiple services can be supported by a single ATS technology "package." In fact, it is the integration of multiple services that defines the ATS vision and holds the greatest promise for benefiting the 21st century transportation user. The reader is referred to "Deployment Evolution" on page 50, for a discussion of this critical aspect of ATS deployment. It must be noted also that each deployment milestone will require research, development and testing activities on the part of ATS partners. While these are not detailed in this section, they are taken into account in determining feasible deployment dates. Such activities required on the part of Caltrans and its immediate partners in the ATS Program are detailed in the "Five-Year Program Plan" section of this document.

## Elements of ATS: Transportation Information Services

### Smart Traveler/Modal Services

One of the most immediate and cost-effective ways to improve mobility is to provide the transportation system user with timely travel information. Users require this information to make informed decisions to most effectively meet their transportation needs. Accessing **pre-trip travel information** from either home or at work will give travelers the ability to select their preferred form of transportation (private vehicle, transit, rail, etc.) and get route and schedule information which incorporates actual conditions on the system (delays, spills, accidents, etc). Recording traveler choices will give the system the information needed to update the data bases for subsequent queries.

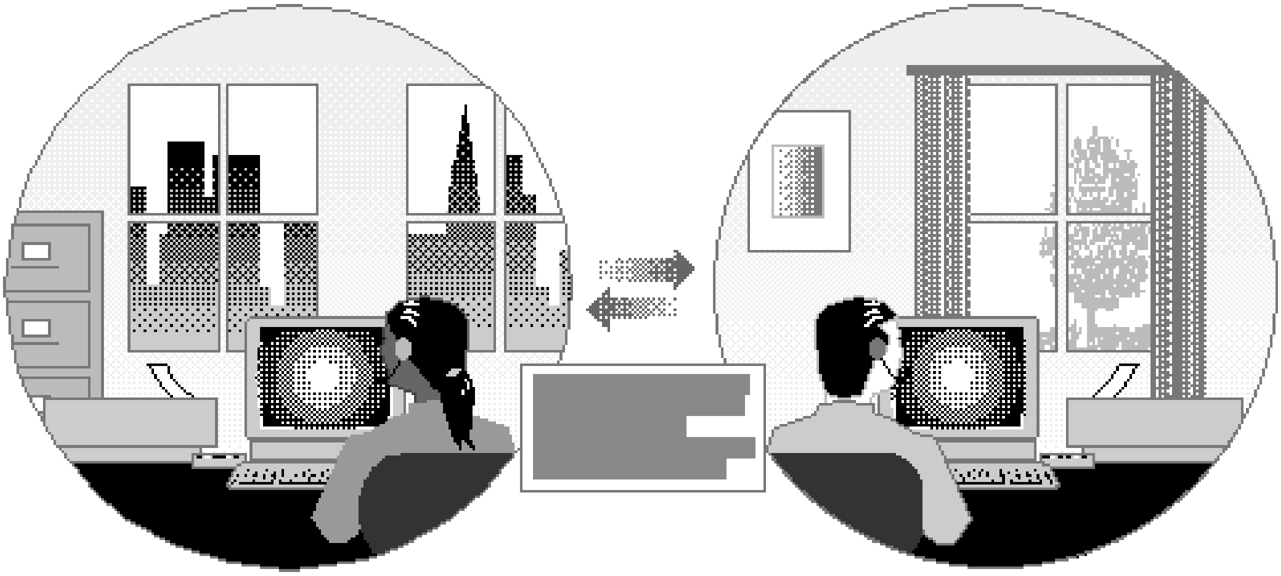
Once the travel choice is made, there are a variety of user services that will help both drivers and passengers to reach their destination quickly, easily and in a safe fashion. After the trip has begun, an **en-route driver advisory** will provide the driver (whether it be of a commercial, transit or private vehicle) with an accurate, up-to-the-minute picture of conditions along the chosen route; while **route guidance** will give turn directions and other instructions (based upon vehicle and/or load characteristics) to enable the driver to reach the desired destination. Hotel, restaurant, service station and other travel information vital to the success of any trip will be available through **traveler services information**—an "electronic yellow pages" service. After the trip has begun, transit riders will be able to reach their destinations more quickly and efficiently, changing routes and modes during their trip if necessary, using information provided through **en-route transit advisory** services. All systems can be designed to provide information in a variety of languages, and for the vision and hearing impaired. This is a must in a diverse society.

Through new developments in real-time **ride matching and reservations,** commuters traveling between similar origins and destinations will soon be able to get information that will allow them to find a match to meet their needs, whether it is for a single trip, recurring trips, or en-route pickups. An advanced transportation interactive information system becomes even more important as transportation management systems mature, integrating traffic conditions data, modal choices, and real-time information with system management strategies.

## Elements of ATS: Transportation Information Services

### Travel Substitution

ATS technologies can improve and enhance transportation demand management through travel substitution. Work, education, health care, banking, shopping and other activities that have required travel will soon be done, in whole or in part, using advanced telecommunications—moving information and services rather than people. Since the 1980s, telecommuting, teleconferencing, telebanking, and teleshopping have grown more popular. America's investment in roads, bridges and transit facilities has evolved into high-tech information systems. Nationwide, a record $489 million will be spent in this area between 1993 and 1998. With resolution imminent on key regulatory issues, the technological revolution expected in the 1990s, termed the "Information Superhighway," will deliver voice, video and computer data simultaneously from coast to coast and into every home that is equipped with a telephone and television or computer screen by the year 2015. Interactive, multimedia systems such as smart phones, interactive TV, advanced personal computers and other products will deliver vastly expanded information and transactional services to Californians. These will be driven in large part by market forces and will extend well beyond transportation, involving entertainment, educational, and "electronic yellow page" services, as well as the Smart Traveler services described previously. The result should greatly increase opportunities for substituting telecommunications for other modes of travel, resulting in a beneficial effect on the rest of the transportation system.



## Elements of ATS: Advanced Vehicles

### Smart Vehicles

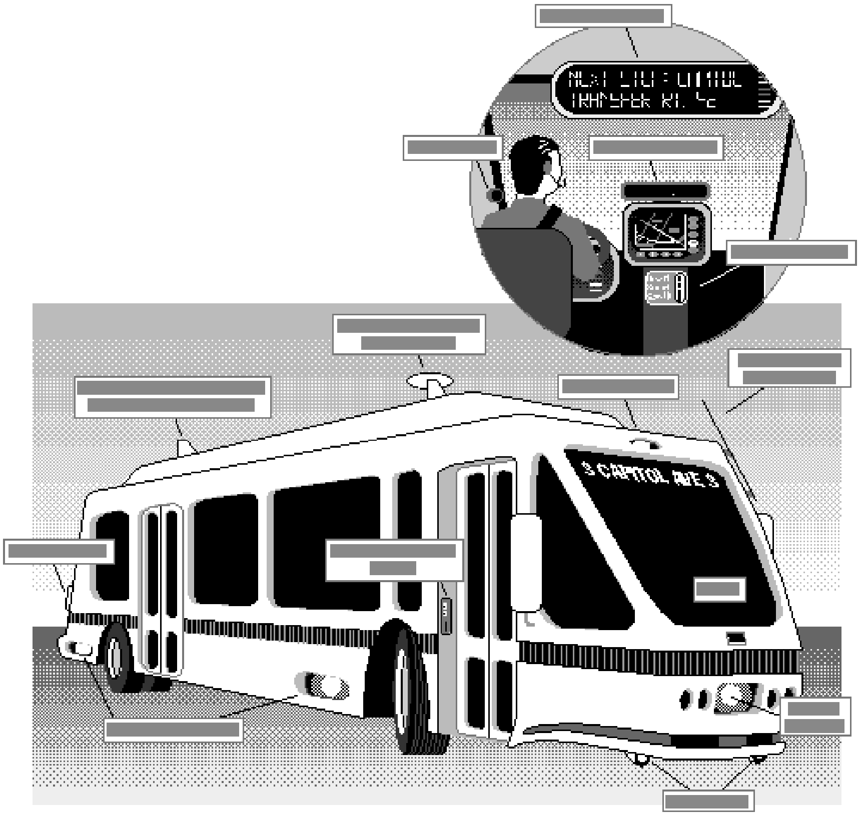
Smart vehicles can be trucks, buses, cars, trains, ships or airplanes. They are "smart" because they have communications, navigation, computer, and/or sensors/actuator systems that can provide information or assistance to operators, as well as passengers. In addition, they can contain operator advisory capabilities, smart fare card readers, locator devices and in-vehicle signs and displays. A significant increase in driver and passenger safety, as well as a reduction in the number and severity of accidents are the primary targets in the development of smart vehicle technologies.

The implementation of both **longitudinal and lateral collision avoidance technologies** will result in reducing both the number and severity of collisions that occur from fast-approaching and overtaking traffic, lane encroachment, obstacles within the back-up path, and facilities with close lateral clearance, etc. Accidents caused by vehicles within the driver's blind spot, and collisions occurring at intersections, blind curves, railroad grade crossings, or anywhere in which impaired or reduced visibility is a causal factor, will be significantly reduced using technologies designed for **intersection collision avoidance** and **vision enhancement for crash avoidance.** Injuries caused by vehicle collisions will be reduced through **pre-crash restraint deployment,** a means to anticipate an imminent collision and to activate passenger safety systems prior to the actual impact.

Better levels of service than are available today in terms of safety, efficiency of operation, and comfort will be made available through **fully automated vehicle operation**. Safety will be significantly enhanced through **on-board safety monitoring** technologies which can detect tire air loss, speeds unsafe for negotiating impending curves, and the safety status of a vehicle, cargo, and driver at mainline speed.

Transit users will benefit by the availability of **personalized public transit** which integrates various flexible-route and demand-responsive vehicles (buses, shuttles, taxis, carpools, jitneys) into a cost-effective transit feeder and door-to-door "personalized" public transportation system.

**California has 22 million vehicles operating on 180,000 miles of roads and rails. This program will develop system/vehicle controls to make existing infrastructure perform at a much higher level of efficiency.**



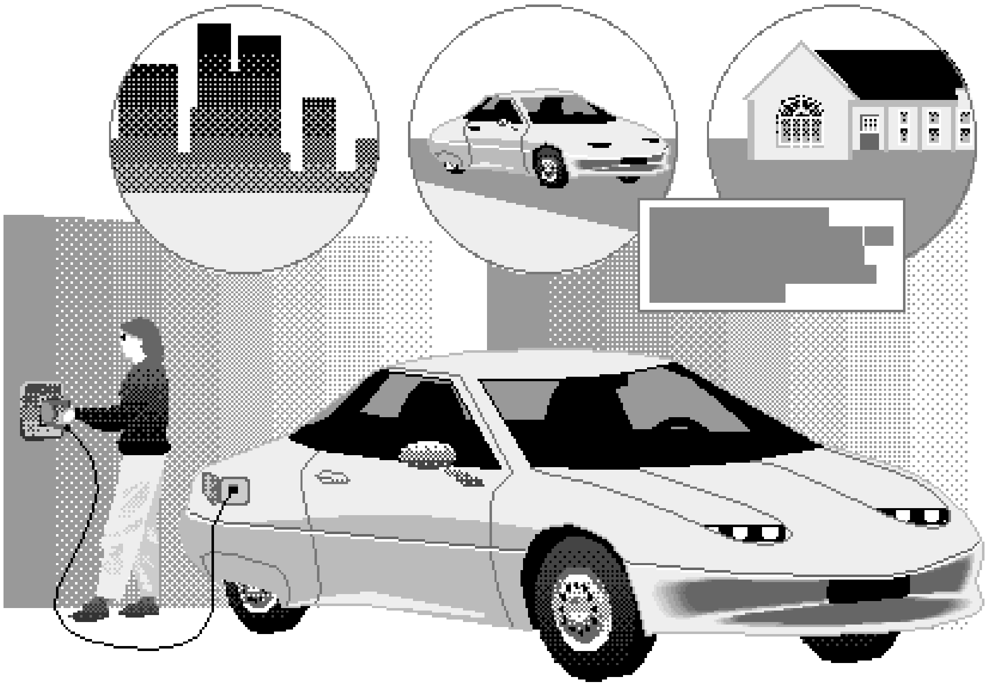
## Elements of ATS: Advanced Vehicles

### Alternative Fuels and Alternative Vehicles

Caltrans' primary role in the development of ATS is developing the supporting infrastructure that promotes the effective and widespread use of efficient transportation technologies, including the use of alternative fuels and alternative vehicles. The New Technology and Research Program will stay informed of developments in alternative fuels and vehicles technologies to assure that system and program planning includes these changing technologies and that the impact these technologies have on the infrastructure is analyzed on a timely basis.

Alternative vehicles include narrow-width commuter vehicles, neighborhood or station vehicles, and vehicles with advanced propulsion systems such as electric, electric hybrids, and fuel cells. The technologies currently being developed include advanced vehicles that utilize innovative designs to promote efficient energy and space utilization, and advanced energy systems including fuel cells.

Alternative fuels include electricity, ethanol, liquefied petroleum gas, methanol, natural gas, and hydrogen.



## High-Speed Ground Systems

Caltrans' initial focus for high-speed ground systems is high-speed trains, which travel in excess of 125 mph. Such systems can use steel-wheel-on-steel-rail technology or magnetic levitation (maglev), whereby the train travels on a magnetic cushion generated by electricity. A number of high-speed wheel/steel rail systems are in operation around the world, the fastest being the French TGV which operates at 186 mph, in revenue service. Maglev systems are being tested in Germany and Japan at test speeds over 300 mph.

## Intercity High-Speed Ground Transportation Commission Studies

Caltrans is working to develop the most feasible and effective plan for implementing high-speed ground transportation in California. The ATS Program supports these efforts by conducting complementary research to address pressing technical questions, financial implications and issues pertaining to safety and environmental matters.

## Air Transportation

Air transportation is one of the most popular means of transportation. With this popularity often comes extremely high, and often conflicting, expectations. Travelers want a wide variety of flight options with easy access to and from airports, yet generally have little tolerance for the things that are often associated with air transportation—aircraft noise, perceived high ticket prices, congested roads/terminals and delayed flights. The need for improvements in the air transportation system in California and elsewhere is widely recognized.

The problems and opportunities surrounding the improvement of air transportation systems are of particular concern to the ATS Program. Growth in air transportation is leading to increasing levels of air traffic congestion and delay. New aircraft types are being developed; new airport concepts are being proposed; and extensive efforts are being made to increase the levels of automation in the air traffic control system and to utilize new sensor, guidance and communications technologies.

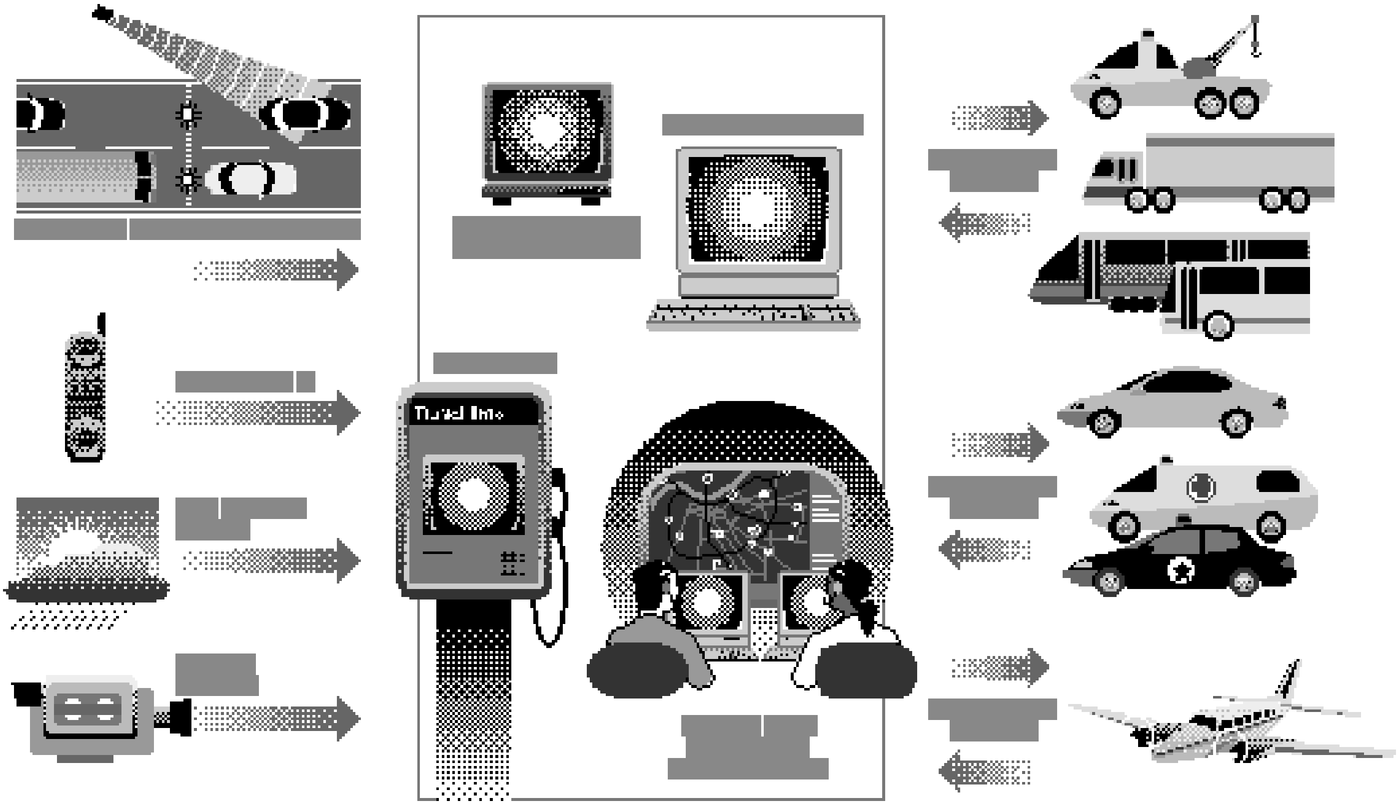
To effectively utilize new developments and meet future needs, the ATS Program established a collaborative Air Transportation Research Center (ATRC) at UCB's Institute for Transportation Studies. The combined strengths of Caltrans and the university permit a coordinated systems approach to air transportation problems. The ATRC is a cooperative activity to develop programs for air transportation technology research that will be mutually beneficial to California and the national air transportation network.

## Elements of ATS: Transportation Management Systems

### Multimodal Traffic Management

The most immediate benefit of advanced transportation management systems is the integration of freeway and surface arterial operations so that travel corridors and areas can be efficiently managed while retaining local community goals. **Travel demand management** applications include monitoring high-occupancy-vehicle lane use, parking control and road access pricing and prioritization schemes to reduce roadway congestion and air pollution.

California's roadway infrastructure is "getting smarter" with many segments now containing video surveillance cameras, ramp meters, and changeable message signs, etc. Caltrans is developing plans for Transportation Operations Systems (TOS) in every major urban area in California. These will enable centralized surveillance and control of freeways in coordination with other system (local, transit) operations.



## Elements of ATS: Transportation Management Systems

### Multimodal Traffic Management

Managing the movement of traffic on streets and highways, including the control of signal systems and freeway control techniques such as ramp metering, falls under **traffic control** technologies. Functions include traffic monitoring, incident detection, ramp meter control and dissemination of traffic information to the public through changeable message signs; Highway Advisory Radio (HAR), Highway Advisory Telephone (HAT) and other Traveler Information Systems (TIS) features; and, links to commercial TV and radio. TOS implementation is expected to take place over the next decade in California.

With the addition of advanced driver information systems, traffic can be diverted from over-saturated segments (typically freeways) to underutilized segments (typically arterials parallel to freeways), and the transportation network optimized for this balanced demand with the consent of local communities. Vehicles diverted from congested freeway segments to arterials because of route guidance from the transportation management center can then be "green waved" through the arterial network. This capability is particularly important during incidents which account for more than half of the traffic congestion in California. Automatic speed limitations can reduce the effect on local communities.

Existing capabilities for detecting incidents and taking the appropriate actions in response to them will be enhanced using **incident response and management** techniques. **Emergency notification and personal security systems** will permit immediate notification of an incident and send an immediate request for assistance after an incident has occurred.

**Public travel security** needs innovative applications of technology to improve the security of public transportation including the detection, identification, and notification of security incidents.

**Electronic payment systems** may soon eliminate the need for toll plazas and other roadside equipment. A German Global Positioning System (GPS) based road pricing and toll collection system which requires no road infrastructure is being tested by the European Union (GPS, World, Mar 95, p.36).

## Elements of ATS: Transportation Management Systems

### Advanced Fleet Management

**Control systems, such as those envisioned by the ATS Program, can reduce energy requirements and traffic congestion while improving service to producers, shippers and their clients.**

**The application of smart vehicle technology to truck, rail, planes and buses will improve the safety and operation of any transportation system.**

The effectiveness of goods movement systems within California and the nation determines what goods are available, what will be imported, where manufacturing facilities will be located, where people will live, and what other transportation systems will be required. **Commercial fleet management** will enhance real-time communications between commercial vehicle drivers, dispatchers, and intermodal transportation providers, thus reducing delays and providing commercial drivers and dispatchers with real-time routing information in response to congestion or incidents.

Special requirements for the application of smart traveler and smart vehicle technologies to heavy vehicles (e.g., trucks) may include the need for point-to-point non-stop operation while satisfying regulatory requirements such as the issuance of licenses and permits, record keeping, tax collections, and inspection and weighing across multiple jurisdictions and national borders. Commercial vehicle preclearance technologies will enable automatic weight, credential, and safety checks thus eliminating the need for vehicles to stop and undergo similar checks a number of times.

**Commercial vehicle administrative processes** consist of the electronic purchase of credentials permitting carriers to file applications electronically for registration, trip permits, oversize/overweight permits, or hazardous materials permits. Automated mileage and fuel reporting and auditing will permit carriers to automatically record the vehicle trip miles and fuel purchased in each state. Advanced vehicle electronic systems can also be applied to various public transportation modes through **public transportation management.**

Safety and emergency responses will be greatly enhanced using advanced technologies. **Automated roadside safety/emissions inspections** will provide communication and automation support to inspectors, making the inspection process more efficient. Automatic vehicle identification/location technology will be of immense help in emergency response operations. Reducing the time from receipt of notification of an incident by a operator to arrival of the emergency vehicles on the scene will be expedited using **emergency vehicle management** technologies. Emergency vehicles, such as ambulances or tow trucks, could reach the scene of an incident faster, potentially saving lives and more quickly resolving the incident. Once at the scene, emergency vehicle operators could also provide on-line surveillance for the traffic control center using a roadway-vehicle communications system.

## Elements of ATS: Infrastructure Construction and Maintenance

Successful achievement of the ATS vision implies the presence of an infrastructure capable of meeting the needs of tomorrow's traveling public. The demand for transportation resources will continue to grow with our ever increasing population. At the same time, the construction of new facilities will diminish as new right-of-way becomes scarce and prohibitively expensive. The increased demand for transportation resources will also reduce the time available for performing maintenance operations. These are just some of the problems that Caltrans will face in managing California's transportation system in the future.

For future infrastructure construction projects, a high priority must be given to increasing the durability of building materials and to developing better methods of construction. Plastic or composite construction materials may prove to be more durable than conventional materials at a comparable cost. Modular construction techniques, where the necessary components are pre-fabricated and are then assembled at the project site, will save time and money on construction projects. These improvements will lead to a longer lifetime and a reduced life cycle cost for the infrastructure. They will also increase the system's reliability and minimize the amount of maintenance necessary to keep it operating. In addition, better test methods for evaluating the performance of a construction project should be developed to determine in advance if it will meet the needs of the public.

Future transportation systems will be increasingly dependent on computer and sensor technologies to enable them to make traffic management decisions based on data collected from the system. Maintenance will play a critical role in keeping the system operating, since failure of key components could result in a system shut-down or a reduced level of service. Developing the ability to perform maintenance on the infrastructure without affecting the free flow of traffic will also be vitally important. Maximizing the reliability of the infrastructure through improved maintenance operations will result in more time between required maintenance and fewer lane closures, reducing highway congestion.

Current research efforts concentrate on developing products and processes that improve the efficiency and safety of traditional highway construction and maintenance operations in both urban and rural environments. This research provides a foundation on which to further develop the materials, methods, and equipment appropriate for an ATS. Recent advances in industrial manufacturing and computing capabilities, coupled with the adaptation of many military technologies to civilian use, have created a vast technology base from which to re-evaluate many conventional construction and maintenance operations.

Future research projects will employ the

**Highway users will benefit from reduced congestion and incidents as a result of more efficient operations.**

## Elements of ATS: Infrastructure Construction and Maintenance

**Highway workers will benefit from improved safety resulting in fewer fatalities and reduced injuries.**

**Highway operation costs will decrease and efficiency will increase significantly.**

latest in technological developments, such as automation and robotics, to perform tasks quickly, efficiently, reliably, and safely. The introduction of automated equipment into a traditionally manual field has set a precedent for further technological advancement in the areas of infrastructure construction and maintenance, with the technologies developed for traditional operations being applied to ATS operations. Automated and robotic equipment developed through the ATS Program will evolve from manually controlled systems to teleoperated systems, then to supervisory controlled systems, and finally, to autonomous systems. A wide variety of new operations will be necessary as the ATS is designed and deployed. These new operations could include such tasks as modular construction of roadway and structural elements, embedded sensor installation, remote roadway/roadside infrastructure diagnostics and management, electronic maintenance fleet dispatch, and embedded roadway integrity sensing. As the ATS deployment has a 15-year horizon, the schedule for deployment of complementary infrastructure construction and maintenance operations shows a 15-year cycle, as well.

## Deployment Estimates/Milestones

The following charts illustrate the anticipated deployment schedule for ATS user services, six of which depict major transportation environments typically referred to as User Services Bundles by ITS America. These charts are: Public Transportation, Goods Movement, Private Vehicle, Rural, Transportation Demand Management, High-Speed Intercity and Infrastructure Construction and Maintenance. **The milestones shown are for approximate initial deployment of user services in a given environment and do not represent the entire deployment period.**

Deployment of ATS is oriented toward serving the needs of transportation customers through user services and the user services bundles. Caltrans and other participants in ATS deployment are continuously working to ensure that ATS is serving user needs. Current nationwide efforts that specifically address this issue include the National ITS Architecture Development Program and consumer acceptance research being done at the Volpe National Transportation Systems Center. In California, several public/private partnerships, such as the Southern California Economic Partnership, are engaging in studies and outreach that will help identify local needs that can be served by ATS and the capacity of the public and private sector to meet those needs.

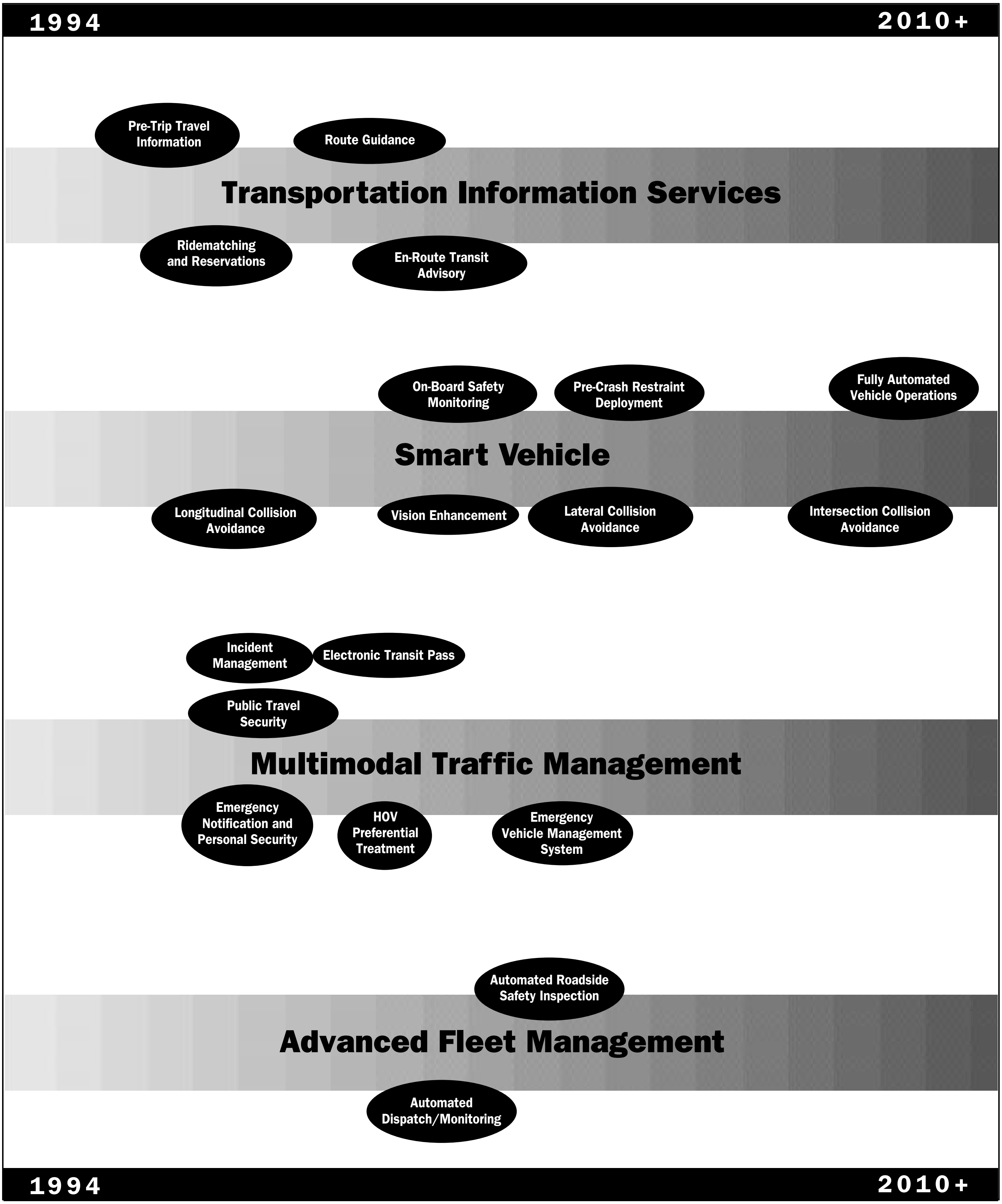
In most cases deployments will occur over several years, often starting in one environment before being adopted in others. Also, initial deployments will typically be first-generation products and services, becoming more sophisticated over the deployment period (and extending the deployment period). For example, early transportation information systems will generally involve the best-available information services, with latter generations incorporating real-time information, as well as transactional services.

In addition to the ATS user services for the six major transportation environments, the program includes a robust Automated Highway Maintenance Construction Technology (AHMCT) element. A program milestone chart which illustrates the development and deployment of these technologies follows the ATS user services deployment milestone charts. This program differs from the remainder of the program in that these technologies are not part of the "user services" within the national program definition.

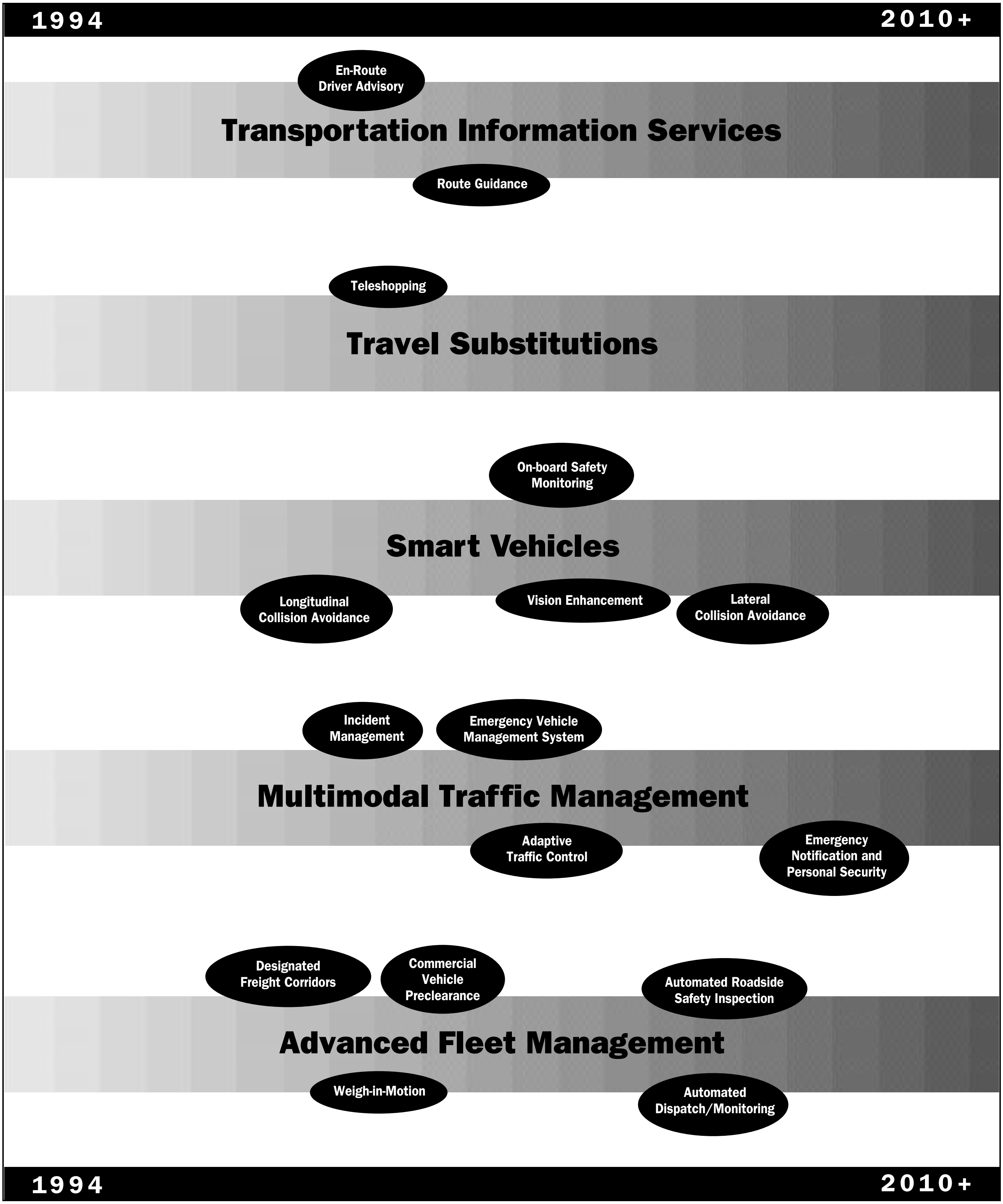
Deployment estimates are based on a scenario that assumes that all ATS partners, public and private, play their full roles; and that Caltrans aggressively pursues the policy and legislative initiatives which fully support the ATS Program, as outlined in this document.

**The milestones shown are for approximate initial deployment of user services in a given environment and do not represent the entire deployment period. In most cases deployments will occur over several years.**

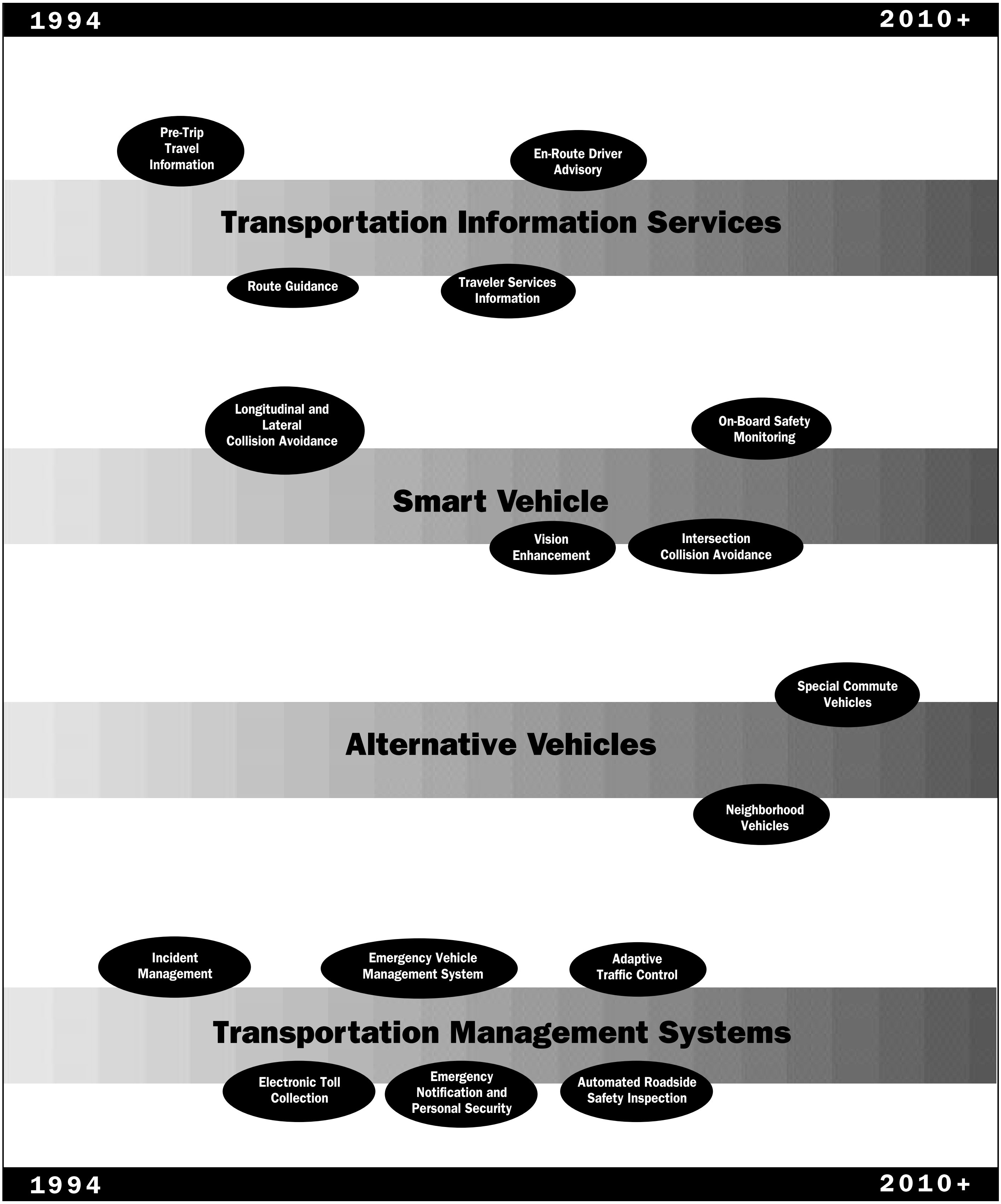
# Public Transportation



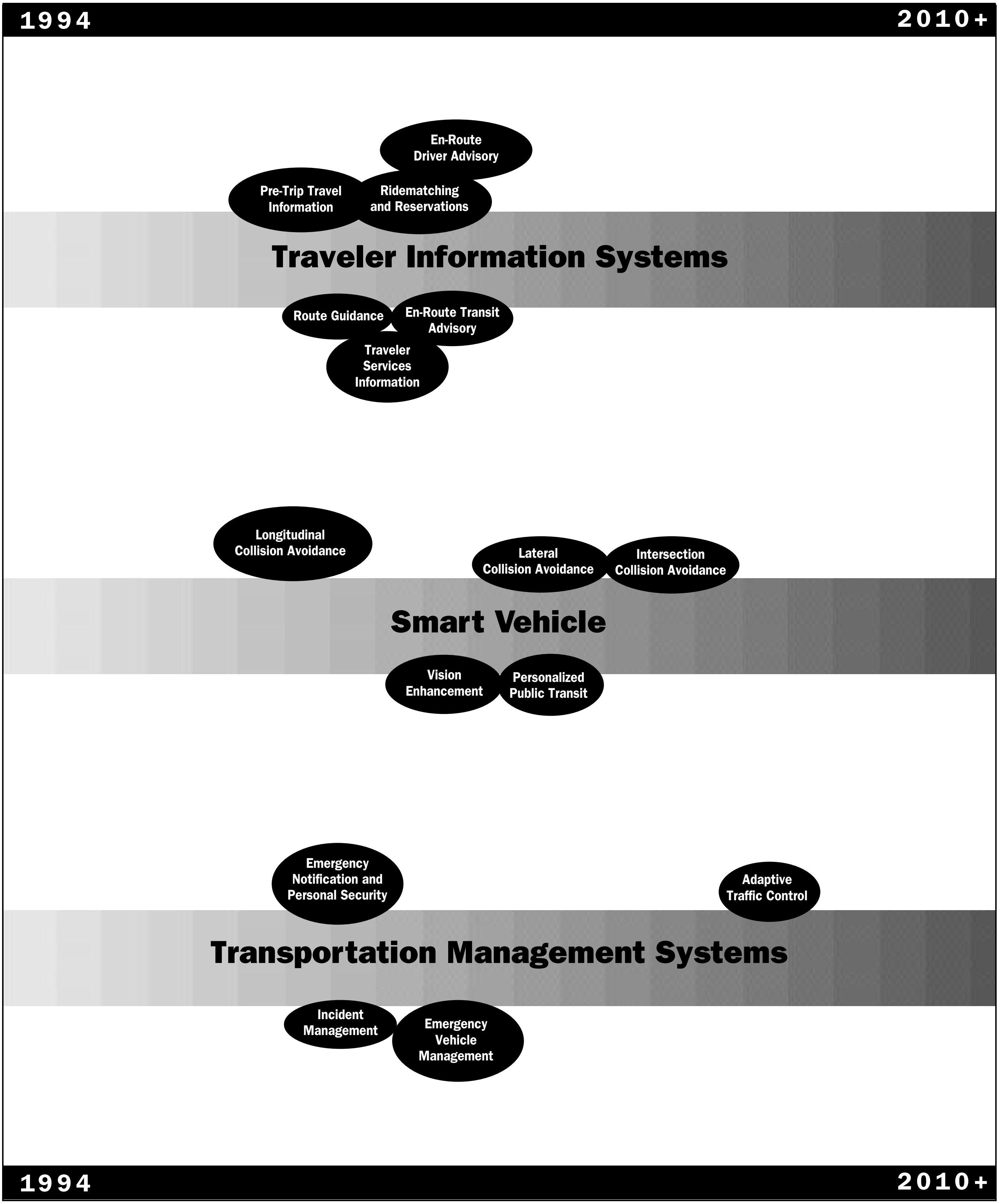
# Goods Movement



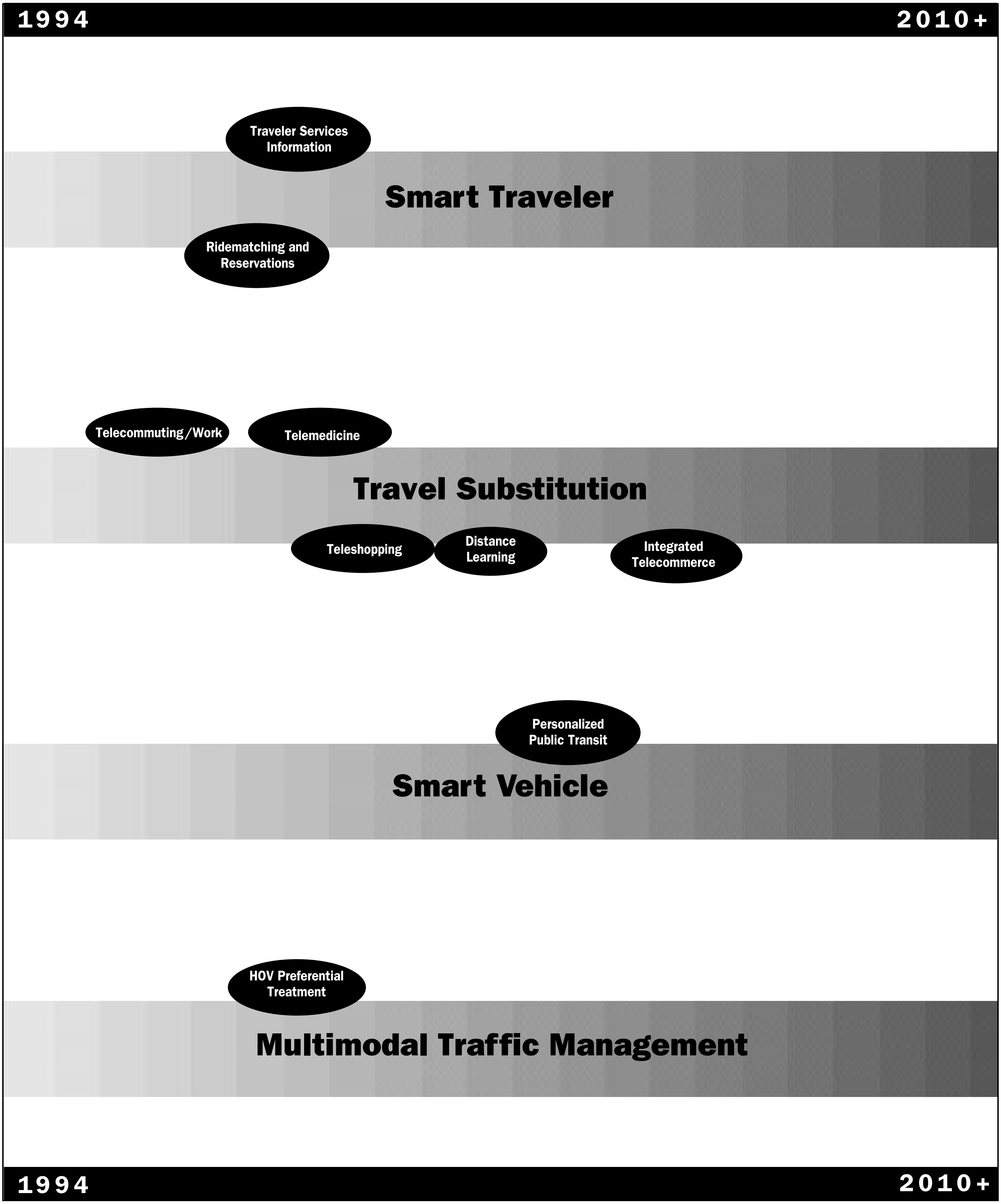
# Private Vehicle



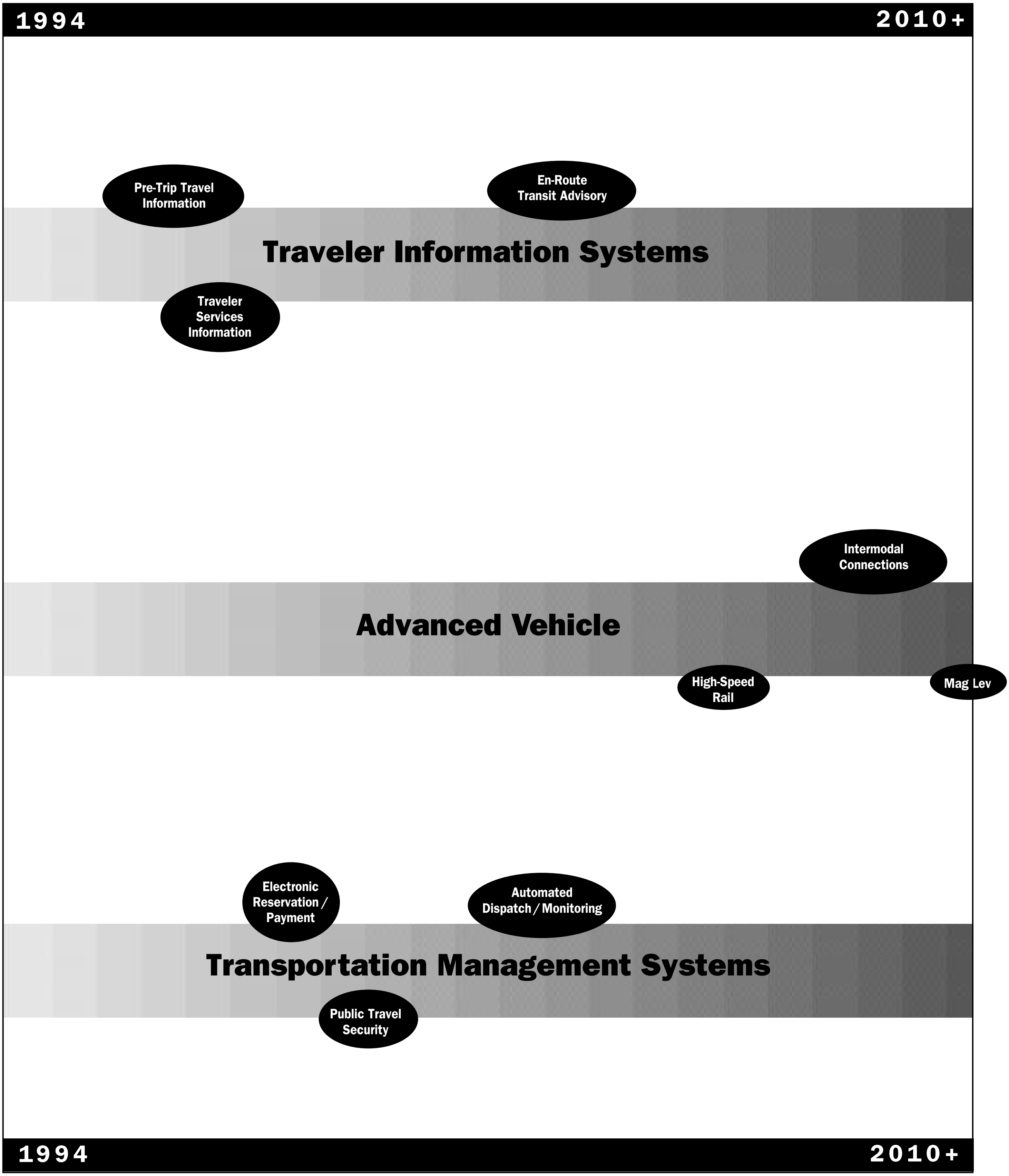
# Rural


1994
2010+
En-Route Driver Advisory
Pre-Trip Travel Information
Ridematching and Reservations
Traveler Information Systems
Route Guidance
En-Route Transit Advisory
Traveler Services Information
Longitudinal Collision Avoidance
Lateral Collision Avoidance
Intersection Collision Avoidance
Smart Vehicle
Vision Enhancement
Personalized Public Transit
Emergency Notification and Personal Security
Adaptive Traffic Control
Transportation Management Systems
Incident Management
Emergency Vehicle Management
1994
2010+

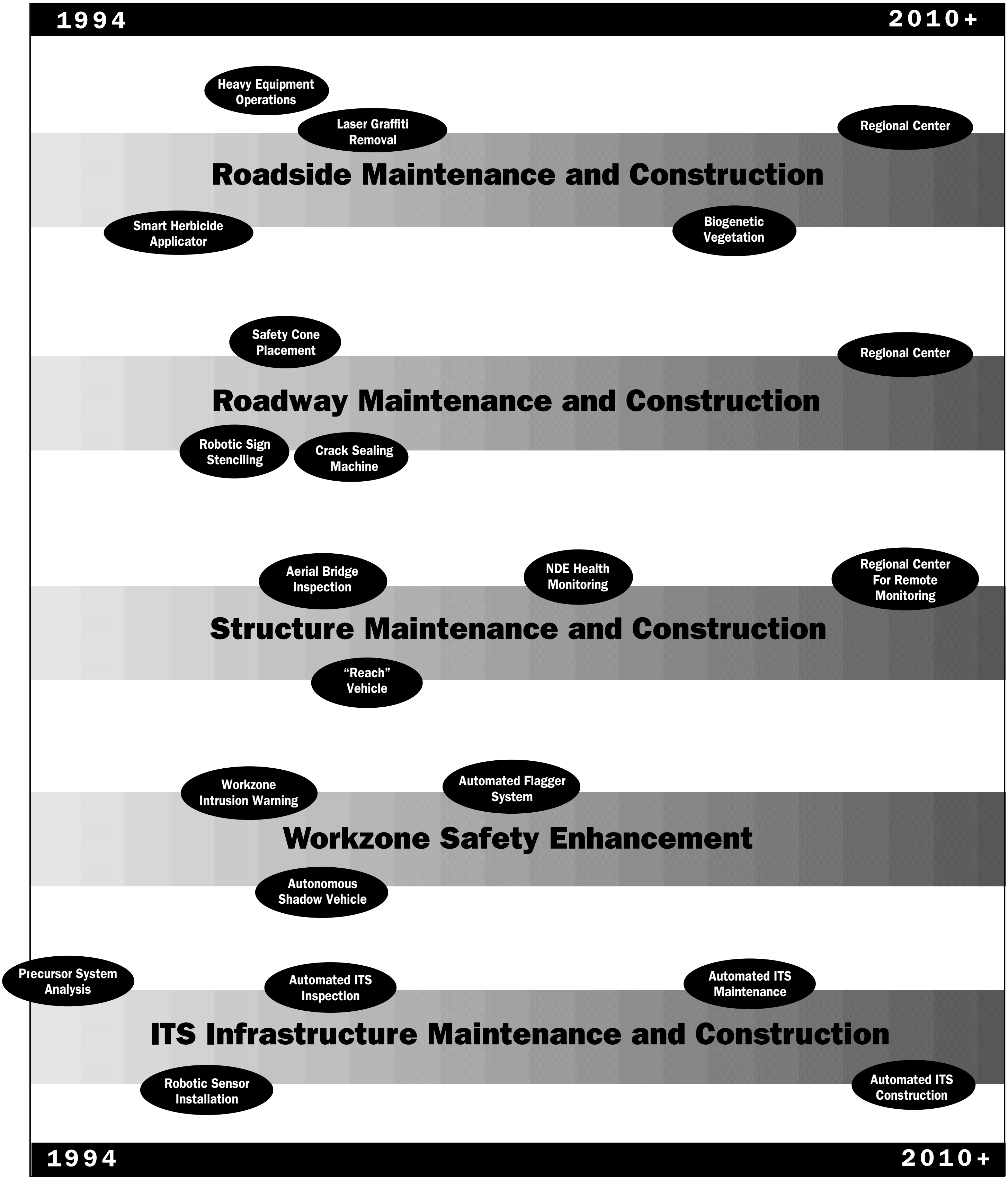
# Transportation Demand Management



# High-Speed Intercity



# Infrastructure Const. and Maint.



**Deployment Evolution**

**The ATS Program will support the deployment of new products and services as public and private roles are delineated.**

## Building Blocks and Their Integration

Much of ATS deployment involves technologies such as telecommunications, sensors, information and map databases, computers and various user interfaces (phone, TV, control panel, etc.) which form building block systems to provide stand-alone user services in the near-term. These include pre-trip planning services, real-time traffic management/incident response and vehicle-based collision warning. Because of the building block nature of these systems, initial user services can be upgraded and combined in the longer term to provide more comprehensive and effective mobility. For example, the vision of a public transportation service that is truly competitive with the single-occupant automobile involves the deployment of advanced fleet management, traffic management and traveler information systems. Integrating these building block systems will be made possible by adherence to interface standards and protocols organized by an overall systems architecture now in development (see next sections). This evolutionary "packaging" of services is illustrated on the following pages for three development scenarios which encompass public and private transportation and both people and goods movement:

- Personalized Public Transportation,
- Integrated Goods Movement and Travel; and,
- Private Vehicle Transportation.

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An estimate of the cost-effectiveness of advanced technological approaches is important to decision makers who must allocate limited transportation resources efficiently. However, most of the technologies addressed in the Caltrans ATS Program are still in relatively early stages of development, making estimates of costs and benefits extremely speculative. Indeed, one of the strongest arguments for continuing research into technology opportunities in transportation is to be able to estimate costs and benefits more accurately. Nevertheless, by using experience in operational improvements and technology research results to date, and making some fairly broad assumptions and extrapolations, magnitudes of costs and benefits and cost-effectiveness ranges can be scoped. Within this context, the following discussion and estimates are offered.

### General Benefits

The benefits to be gained will depend on what technology packages policy makers decide to deploy. The technologies included in the Caltrans ATS Program, when combined, have the potential to produce the following benefits:

- Better utilization and increased productivity of existing roadway and transit systems making travel easier, safer and more accessible;
- Reduced number and severity of traffic accidents;
- Improved responses to accidents and other incidents;
- Expansion of transit/paratransit service options;
- Expanded options for transportation demand management;
- More efficient trucking and other commercial vehicle operations;
- Integration of transportation modes into a truly intermodal/multimodal system;
- Improved fuel efficiency and reduced reliance on petroleum for transportation energy;
- Enhanced health of California’s defense and electronics industries;
- Improved air quality through reduced trips (telesubstitution) and reduced Vehicle Miles Traveled (VMTs) (from more efficient travel and better connectivity);
- Greater financial benefits for business through better system efficiency leading to a reduction in costs; and,
- Enhanced economic competitiveness.

### Nature Of Costs Incurred

The costs associated with the ATS Program are initially, and primarily, those related to research, development, testing, and evaluation of advanced technology applications in transportation. Generally, these costs will be minor in comparison to the capital, operating and maintenance costs involved in deploying advanced transportation systems.

In the case of “smart” technology, deployment will involve incremental costs over those that will be incurred with increasing vehicle electronic content, and the implementation of transportation operations systems for freeway management and advanced traffic signal control systems. These are baseline improvements that will continue to be made in vehicles and in the transportation infrastructure, and form the foundation on which ATS can be built.

**Benefits and Costs**

**Deployment of ATS technologies will occur both on the public infrastructure and in the marketplace. Total estimated cost for the 15-year period would be: public–$4.6 billion and private–$19 billion.**

## Cost Distribution

### California's Share of Research Costs

The ATS Program seeks to share research and development costs for transportation technology with other state and local agencies, the federal government, and the private sector. A basic program objective is to achieve a one-third state funding share with the balance coming from other sources.

### User Costs

It is difficult to estimate distribution of user costs before determining how technology applications will be packaged and deployed. It is Caltrans' intent to address equity issues as its technology program advances. However, a few general observations can be made now.

Transportation technology applications seek to build on technological advances already in the pipeline and, therefore, will involve mostly incremental costs to the user.

Since incremental ATS infrastructure improvements could be funded through existing program categories, costs could be distributed in the same way baseline costs are distributed. Distribution of user costs will, therefore, reflect policy decisions on how transportation revenues are collected and distributed, what modes are subsidized and by how much, etc. New products, such as the small commuter car, might require separate funding. In this case, user cost distribution would depend on how the separate funding was provided (again, a policy decision).

Deployment Cost Estimates for five-year periods [ITS only]
(in millions of dollars)

| Sector | 5 Years | 5-10 Years | 10-15 Years | Total |
|---|---|---|---|---|
| Public | 400 | 1500 | 2,700 | 4,600 |
| Private | 1000 | 5,200 | 12,800 | 19,000 |
| TOTAL | 1400 | 6700 | 15,500 | 23,600 |

The market will likely drive vehicle technology cost distribution. At the vehicle end, therefore, ATS products and service costs will be borne by those who will use these products and services. Given past trends in the vehicle industry, these technologies will penetrate at the higher end of the market and at a higher cost, but quickly become pervasive throughout the market at much lower costs as economies of scale and technological advances are made. Finally, ATS market penetration will continue to occur in commercial vehicle operations and other fleet operations (including transit) in advance of personal transportation.

### Cost Estimates

Deployment of ATS technologies will occur both on the public infrastructure and in the marketplace. Given that ATS efforts are still in research and testing stages, overall deployment costs cannot be estimated with a high level of certainty or precision. However, the magnitude of these costs, and their public vs. private market shares, can be approximated by applying ITS America estimates to California. Such costs reflect ITS deployment only, and are exclusive of alternative vehicle/fuel, high-speed ground, air and intermodal facility deployments. Based on the ITS America estimates, the California deployment costs would be experienced over five, ten and 15 years (see table).

Deployment cost estimates will be refined as ATS Program research and testing progress. Also, public sector deployment costs will be identified by region as Early Deployment Plans are developed (see page 77).

### Cost-Effectiveness Considerations

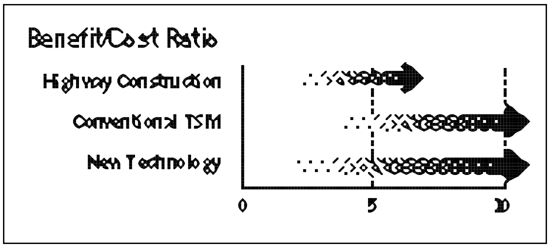
The ATS Program is primarily an applied research effort. Its objective is to capture the maximum productivity from existing transportation resources, as well as any new resources that may be added in the future. The approach is to leverage, with only incremental expenditures, substantial additional benefits out of baseline facilities and services that often entail large investments. The application of advanced technology to transportation is essentially advanced Transportation Systems Management (TSM). As such, Caltrans envisions that it should realize the same high benefit/cost ratios as conventional TSM, at a higher level of overall cost and benefit. The chart (below) illustrates gross benefit/cost ranges for conventional transportation measures compared with what is expected from advanced technology initiatives.

Beyond the TSM analogy, longer-term synergies from advanced technologies could lead to very different types of transportation systems. One example of this, already cited, would be the development of a type of personalized rapid transit to service most passenger travel in the state. It is almost impossible to speculate about the benefits and costs of such synergism at this time. However, as research progresses, Caltrans will evaluate and report on these broader options and impacts. This constant and continuing evaluation of research findings and deployment testing will help eliminate the possibility of a misdirection of limited future resources, which could have significant consequences in realizing objectives.

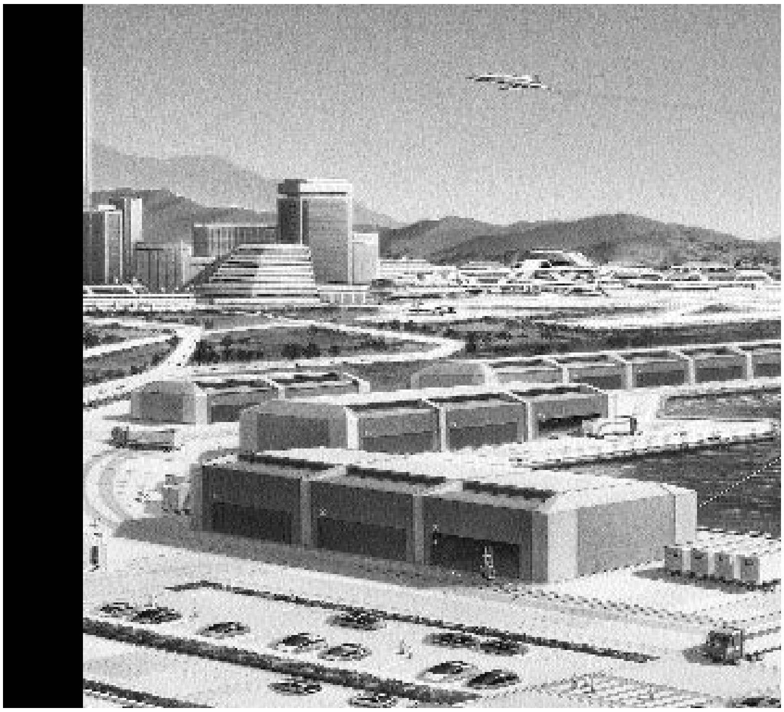
### Evaluation of Benefits and Costs

One of the fundamental objectives of the ATS Program is to identify actual benefits and costs associated with the full range of ATS applications. As technology development moves from research into field testing, vigorous evaluations will be performed under the direction of Partners for Advanced Transit and Highways (PATH) and other experts. Individual evaluations will progressively add to the body of knowledge of overall ATS cost effectiveness. An area of particular interest will be the maintenance and operational requirements of new systems. Life cycle benefit-cost profiles will be developed for each ATS user service before full deployment is pursued.

Individual project evaluations will be combined with new area-wide land use and transportation tools to give an improved understanding of the broad range of effects and interactions, including the interactions between modes that will occur with the implementation of the project.



# REALIZING THE VISION



## Introduction

Making the services described in the preceding section a reality will take unprecedented cooperation between all levels of government and between the public and private sectors. A big challenge will be to develop systems that are compatible across geographical areas and that can be integrated across modes and link public infrastructure with consumer and commercial products. This challenge and some solutions are discussed under "Systems Integration." Realizing technology's promise will also take a new approach to doing business in transportation, and that will entail overcoming some critical legal and institutional barriers. These are summarized in "Institutional and Legal Issues." The state can play a key role in setting the stage for ATS partners to work together, helping meet California's mobility challenges and positioning California's industries favorably in emerging, international markets. A number of state policy and legislative initiatives are proposed in this regard. Finally, Caltrans, as the state's transportation steward, must attract and keep successful efforts to provide enhanced mobility in California.

**Systems Integration**

**Issues**

## Systems Integration

**Issues**

- Public Infrastructure & Private Markets
- Modal/System Interfaces
- Geographically Compatible Systems
- Adaptation to Existing Infrastructure
- User Service Compatibility and Synergy

**Solutions/Approaches**

- Systems Modeling and Compatibility Planning
- Advanced Planning Tools
- Cooperative Research, Development, and Testing
- Cooperative Systems Architecture Development
- Building Block Deployment
- Standards Setting

Deployment of ATS will occur as the result of decisions made by individual consumers; those in the private sector providing goods and services; transportation providers, and government. Market research, deployment plans, outreach and evaluations of field tests and demonstrations are among the resources the general public, industry and public agencies will use when deciding to deploy ATS.

Deriving the greatest benefit from ATS will require integration on a systemwide basis. One of the major ways in which the ATS Program Plan addresses and responds to this challenge is through the identification of need and opportunity for partnerships. Partnerships (public, public/private, private) are required because deployment will be accomplished by many different organizations responding to different user/customer needs, and each participant has something unique to give to the integration effort. Experience with and opportunities for partnerships can readily be seen throughout this ATS Program Plan.

The ATS integration challenge has a number of facets:

- **Public Infrastructure & Private Markets -** Technologies deployed on public facilities and services and those made available to commercial and consumer markets need to be mutually supporting. That is, public technology investments must consider technical compatibility with, and support for, market products and services so that integrated, effective systems result. In addition, transportation decision makers will have to be aware of technological opportunities emerging in the marketplace that might forward mobility goals, even those beyond traditional transportation markets. Nowhere is this more evident than in the budding telecommunications revolution that will almost certainly open entirely new avenues for delivery of mobility services in vehicles, homes, offices, and other locations.

  Equally important will be stimulating market responses that forward California's broad mobility goals. Technical compatibility is only one aspect. A more difficult challenge is providing products and services that allow transportation providers, public and private, to better manage their systems and that result in enhanced, better integrated, mobility services for Californians. Realizing the ATS vision will require careful consideration of the operational characteristics and impacts of market products and services. Those with positive attributes will need to be encouraged without overly managing the marketplace.

- **Modal/System Interfaces** - ATS visions, such as personalized public transportation (with its "door-to-door" connectivity); corridor and areawide traffic management, and "seamless" intermodalism require, by their very definition, that different modes/systems, be connected and coordinated. This is very different from the way the transportation system currently works.

Today, many investment decisions and technology selections are made independently by transportation providers, with little thought given to integration, or enhanced or multiple-use opportunities. In the private sector, market-edge considerations and separation from public sector decisions underlie this independent approach. In the public sector, modal and jurisdictional competition for funds, years of inflexible funding categorization, and general jurisdictional fragmentation (see "Institutional and Legal Issues") have resulted in disconnected and often incompatible transportation systems. This has also resulted in very narrow and closed definitions of transportation modes, which often ignore and even discourage pursuit of integration opportunities and new modal service options.

ISTEA and conforming state legislation address these shortcomings, and start to clear the way for ATS approaches. Nevertheless, a key challenge will be to cooperatively develop interface and operational specifications in an environment that, although improving, is not particularly suited to such endeavors.

- **Geographically Compatible Systems** - Disparity of ATS approaches and technologies is to be tolerated and even encouraged through research, development, testing and evaluation stages to ensure that the best possible user service systems are identified. However, it is vital that ATS deployments across California and the nation are connected and compatible. ATS market opportunities are best pursued on the national and international scale. A "California-only" approach, separate from the other 49 states, is not proposed. What is being proposed is an ATS vision that works for all people in both urban and rural California. This vision of compatible systems positions California business at the cutting edge of national and international markets, and provides for the connectivity and compatibility of transportation systems across the nation.

## Systems Integration

### Issues

- **Adaptation To Existing Infrastructure** - The evolutionary nature of ATS deployment, as described in the previous section, means that these technologies must also be integrated into the existing transportation infrastructure. This, in turn, means that ATS services must be able to function simultaneously with other systems and services that do not necessarily have similar or even current technology. This aspect of system integration is especially important in the vehicle control and automation elements of ATS.

- **User Service Compatibility And Synergy** - Finally, the myriad user services described in the previous section, and their evolutionary integration, will require that substantial examination be given to how these services might interact with one another. Some will be mutually supportive, while others might cancel each other out. This issue is similar to that regarding TSM measures and the TSM "toolbox" which has been discussed and researched for over a decade. Many ATS approaches could be considered TSM, enhanced with very powerful and robust technological tools. Potential impacts (positive and negative) and opportunities for synergy are, therefore, much greater than with traditional TSM. Of course, the system level analysis required here will need to address mobility, safety, and environmental and economic impacts.

Some approaches that are being taken to address these five aspects of system integration include:

- **Systems Modeling And Compatibility Planning** - New modeling tools are being developed by Partners for Advanced Transit and Highways (PATH) to analyze the system-level aspects of ATS technologies and strategies. Data from research and operational field tests around the world will be put into these models as results become available. Using these models, mobility, safety, environmental, and economic impacts can be quantified and issues more precisely framed for decision makers. User services interactions and synergies can be better identified, leading to the development of consistent and compatible user service "packages" to address the range of policy (mobility, air quality, equity, etc.) and market objectives. Together with work under the auspices of the Transportation Research Board (National Academy of Sciences) and the United States Department of Transportation's (USDOT's) technology program, these models will also enhance ATS Program managers' ability to plan for the joint research, development and testing of logically grouped user services. Related research at PATH and elsewhere is addressing technical integration issues such as interface requirements, communications, system design, operational optimization and reliability (including maintenance requirements), automation, and phased introduction of technologies into existing facilities and services.

  The products of these efforts, along with the results of early and strategic deployment plans (see Early Deployment Plans and Southern California ITS Priority Corridor, pages 77-78), will be available for regional agencies to use in preparation of their regional plans and programs. They will also be available for use by other governmental agencies, the private sector and academia.

- **Advanced Planning Tools** - Along with new techniques that expand travel possibilities, new tools are required to understand the effects of these new technology systems and their use. Research is needed for improving the decision support tools that are used in short- and long-range transportation and land use planning, to encompass a holistic approach to statewide and regional system design and management. It is particularly important to identify and define the elasticities that exist between the various modes, and the corresponding time and costs related to those modes. The decision maker needs to know how improvement of one mode will affect another mode in order to make decisions that are best for the total system.

## Systems Integration

### Solutions and Approaches

- **Cooperative Research, Development And Testing -** Cooperation between all involved parties, public and private, in the research, development and testing phases will be critical to successful systems integration. These are the phases when public policy objectives, mobility approaches, technological capabilities, system requirements, and market considerations can be jointly discussed and explored, leading to mutually supportive and compatible technology deployments across sectors and jurisdictions. Cooperative research and development is a basic feature of the Caltrans ATS Program and USDOT. A number of institutional barriers must be overcome in this regard, however. These are discussed later in this chapter, followed by a discussion of state initiatives and ATS Program delivery strategies to allow and engender cooperative efforts.

- **Cooperative Systems Architecture Development -** Systems architecture presents the total perspective to aid in the analysis, design and integration of the individual technology building blocks while taking into consideration the needs and constraints of the transportation system as a whole. Within this context, both technical and institutional issues are addressed. Also, results from ATS compatibility planning, research and testing are incorporated.

  Caltrans is participating on one of four teams that are helping define a national Intelligent Transportation System (ITS) architecture by 1996. Each team is comprised of ATS partners from government, industry and academia. Each is charged to:

  - Define an integrated ITS design and operational framework that will determine not only the functions of individual components, but their connectivities (design) and interrelationships (operation); and,
  - Synthesize and integrate the various components and subsystems as they are being developed, produced, and deployed to ensure their connection, the correction of deficiencies, and elimination of duplication and unwanted redundancies.

  By 1996, therefore, California and the nation should have a mutually agreed-upon framework in which to pursue broad ATS deployments in both public infrastructure and private markets.

- **Building Block Deployment -** In the meantime, the ATS Program's building block approach to technology will allow for near-term deployment of useful products and services from "stand-alone" systems that, with a system architecture in place, can evolve into more comprehensive services enabled by more powerful and integrated systems. Even in the longer term, this modular approach will improve flexibility and effectiveness in tailoring ATS deployments to special conditions and/or objectives.
- **Standards Setting -** A final critical element in meeting the system integration challenge is the widespread acceptance of standards by ATS partners. Under legislative direction (Title 21, CCR, Section 21 [chapter 16; article1]), Caltrans has already developed a standard specification for automated vehicle identification that is enabling electronic toll collection on toll facilities statewide and that will facilitate the deployment of other ATS applications that involve vehicle-roadway communications. Caltrans is now working with USDOT, ITS America and others to explore ATS standards issues and to coordinate standards setting. This is an area that needs careful planning to avoid premature, overly constraining standards on the one hand, and lost market and system integration opportunities from delayed standards on the other.

The challenge to past efforts to add electronic functions and devices to vehicles has not been the ability to specify and procure devices, but rather how to get an assortment of devices from different manufacturers to integrate and work together as a system on the vehicle. Further troublesome issues often developed around sole source procurements encountered when initial investments were made in proprietary systems and the initial provider was the only source who could furnish additional devices or enhancements. To alleviate this situation, a joint Intelligent Vehicle-Highway System (IVHS), Federal Transit Administration (FTA), and Society of Automotive Engineers (SAE), standard for a Vehicle Area Network (SAE-J-1708 "Serial Data Communications Between Micro-Computer Systems in Heavy Duty Vehicle Applications") has been issued. This standard has already seen many successful applications by bus manufacturers.

The national systems architecture effort is expected to drive national standards in the following areas:

- Vehicle/infrastructure interfaces which will help public infrastructure/private market integration; and,
- Infrastructure standards to facilitate the introduction of ATS technologies into existing infrastructure and their deployment across modes and jurisdictions and between public and private transportation providers.

These standards will represent the implementation of a national system architecture for much of ATS, but are not the whole story. Current national efforts only address ITS, not all ATS elements, which include a strong infrastructure construction and maintenance element; high-speed ground transportation; and, air and marine transport. Also, standards setting is always a dynamic process, with new needs and technological opportunities continually demanding consideration. There is no reason to believe it will be any different for ATS.

## Institutional and Legal Issues

Broad policy endorsements from ISTEA and supportive state legislation have smoothed the way for the design and development of innovative and visionary technology. Today's picture is bright although some legal and institutional barriers exist which could delay the realization of the ATS vision. Caltrans has identified several areas requiring attention. There are issues that must be addressed in the early research and development phases at different levels of government. Some will require joint resolution. The following issues and objectives are currently being explored:

### National or Joint Resolution:

- **Anti-Trust** - Develop cooperative research, development, and production agreements to enable public/private joint ventures which will facilitate commercialization, and provide for anti-trust protections;
- **Tort/Product Liability** - Promote joint research and development and technology commercialization by managing liability exposure to private and public organizations;
- **Privacy Issues** - Develop state policy to ensure that the privacy of the citizens of California is protected in their use of any and all ATS deployments in California involving governmental entities;
- **Product Qualification** - Develop efficient and defensible product qualification processes to spur commercialization of appropriate technologies;
- **Air Quality and Other Environmental Concerns** - Develop cooperative research and development programs to determine air quality and other environmental impacts of new technology; and,
- **Market Uncertainties and Risk** - Identify potential markets for products and services. This task is different from outreach and should include an assessment of the willingness of prospective purchasers, both public and private, to pay for ATS. Among possible benefits for public agencies is an estimation of lowered costs or increased revenues from deployment of ATS.

### State Resolution:

- **Planning and Programming** - Strengthen close coordination between Caltrans, regional and local agencies throughout California, and the transportation planning and programming process to achieve mutually inclusive objectives of both programs and to pursue coordinated ATS testing and demonstration, evaluation and deployment. Cooperative partnerships are the key element in the planning and programming of transportation. This cooperative interaction enables agencies at various levels of government to conduct long-range multimodal planning and negotiate a variety of projects best suited to serve the traveling public and the transportation system;
- **Partnering And Collaboration** - Establish workable mechanisms for joint public/private collaboration in a true partnership (versus contractor) environment;
- **Government Procurement** - Develop state procurement processes that encourage the use of ATS technologies on public infrastructure which have the lowest life-cycle cost, replacing current low bid, minimum compliance approaches that discourage effective innovation; and,
- **Competitiveness of California Companies** - Implement processes to enhance competitiveness of California firms by supporting their efforts in new technology development.

## State Policy and Legislative Initiatives

California enjoys real opportunities and strengths in assuming leadership to overcome institutional barriers and to set the stage for a 21st century transportation system. With the decline in the defense industry, many qualified, technologically advanced companies are taking an interest in the transportation market. This interest can lead to meaningful and beneficial partnerships between the public and private sectors to solve growing transportation problems. A balanced leadership role for California consists of developing and demonstrating advanced systems in cooperation with the federal government, other states, and private companies.

California's opportunities and strengths for ATS leadership include:

### Opportunities

- Obtaining federal funding authorized by ISTEA;
- Sharing the potential federal resources from economic stimulus and defense conversion initiatives;
- Influencing emerging national standards for ATS technology;
- Helping California companies develop exports of transportation products for potentially large international markets;
- Encouraging development of transportation systems with positive effects on mobility, safety, air quality, energy, and quality of life; and,
- Establish a stable funding environment for the Caltrans ATS Program which can be used to encourage broad partnership involvement in ATS activities.

### Strengths

- California's historic leadership role in advanced technologies, research and development;
- A large and diverse industrial base for advanced technology development;
- A high level of consumer acceptance for new and innovative products;
- An existing, major transportation management systems development program;
- Partnerships with outstanding educational institutions;
- Highly trained professionals in the educational and technical fields; and,
- California's early recognition of the importance of applying advanced technologies to improving transportation (an existing world-class ATS Program at Caltrans).

To enable California to be a leader in realizing the ATS vision, state government must assume a leadership role itself. First, through its broad policy-making and legislative powers and authorities, the state of California, and its agencies, need to set the stage for successful collaborative efforts among public and private partners in this field. The state has already taken on this role, establishing clean fuel programs at its energy and air quality agencies, charging its trade and commerce and other agencies with pursuing defense conversion opportunities, and chartering a comprehensive exploration of economic opportunities in transportation technologies through the "Project California" initiative.

## State Policy and Legislative Initiatives

Secondly, the state must ensure that a foundation is established in the public infrastructure for building broader ATS mobility systems and markets. The state has also assumed leadership by establishing and funding an anchor ATS Program at Caltrans (Chapter 352, Statutes of 1992, AB3096-Katz). How Caltrans has and will carry out this charge is explored in the ATS Program Overview beginning on page 22.

Immediately following are recommendations for state policy and legislative initiatives that, in Caltrans' view, will support ATS and related economic endeavors as identified in Project California; help overcome many of the institutional barriers cited earlier; greatly facilitate ATS Program delivery by Caltrans; and, solidify California's leadership in transportation and advanced technology development.

**Recommendations for state policy and legislative initiatives:**

### • Streamlined Partnering Arrangements for Caltrans ATS Program

Pass legislation to:

- Allow Caltrans to use cooperative agreements with other public agencies for ATS projects regardless of mode or involvement of a state highway element; and,
- Establish flexible, streamlined solicitation and contracting procedures for involving the private sector in ATS Program activities.

This initiative would maximize the leverage of ATS Program funds by allowing Caltrans to efficiently pursue multi-jurisdictional and public/private partnerships (including those with the corporate entity proposed below), and other cost-sharing opportunities. Proposed legislative language will be developed by Caltrans to initiate this concept.

- **Grants and Loans for ATS Innovations by Small Business**

It may be advisable to establish and fund a program of grants and loans for small California businesses to develop marketable products which are consistent with the goals of the ATS Program. Caltrans, or another appropriate entity could administer this program. Caltrans will monitor this issue.

- **Liability Containment for ATS Research and Testing in California**

California has the potential to be a magnet for advanced transportation research and development if it can provide private industry with liability protection beyond what is available elsewhere during development and testing phases. Options include legislatively containing liability exposure, establishment of a liability pool or superfund, and/or providing partial governmental coverage on selected research and development activities. The establishment of clear, justified design standards in order to reduce liability is an essential component in liability containment. Caltrans will carefully study this issue in concert with its ATS partners and develop specific recommendations and guidelines at a later date.

- **Regulation of Telecommunication Technologies and Regulation-free Test Zone**

The California Public Utilities Commission (CPUC) should review regulations governing the telecommunications industry and recommend appropriate changes to laws that restrict the introduction of innovative new telecommunication technologies. As a precursor, and if feasible, the CPUC should establish a regulation-free test zone in California to allow demonstration and evaluation of state-of-the-art telecommunication products with potentially beneficial mobility impacts.

**State Policy and Legislative Initiatives**

### State Strategic Initiatives

- Streamlined Partnering Arrangements for Caltrans ATS Program
- Non-profit Corporation for ATS Commercialization
- Research and Development Center
- Grants and Loans for ATS Innovations by Small Business
- Liability Containment for ATS Research and Testing in California
- Regulation of Telecommunication Technology and Regulation-free Test Zone
- AVI Procurements for Public Fleet Vehicles
- Privacy Protection in ATS Deployment

### • Automated Vehicle Identificaiton (AVI) Procurements for Public Fleet Vehicles

A significant barrier in delivering ATS services to the people of California is the lack of accurate and timely (real-time) information on transportation system conditions in most regions in the state. A particularly cost-effective way to overcome this barrier would be to equip public fleet vehicles (buses, cars, vans, etc.) with electronic tags for Automated Vehicle Identification (AVI) consistent with the current, legislatively mandated state standard for AVI. The vehicle-based equipment would be of negligible cost to fleet operators, and, together with tag readers on the transportation infrastructure, could provide real-time level of service information to transportation and fleet management centers throughout California. By taking advantage of this existing technology, fleet managers could realize considerable benefits in terms of both time and safety in being able to direct drivers around congested/trouble spots while enabling them to maintain their schedules. This is a benefit to both fleet operators and the traveling public.

Approximately 200,000 AVI tags will be made available in the San Francisco Bay Area early in 1996. Some of these tags will be applied to public transportation vehicles and vehicle fleets. Although the purpose of this demonstration program is to study the impact the use of the tags will have on relieving congestion at toll plazas, it should give Caltrans valuable information about the use and acceptance of this technology. Caltrans should also be able to discern from the results and evaluation of this demonstration, the applicability and effectiveness of extending the use of these tags to gather real-time service information throughout the area.

Assuming that it is determined that the use of these tags can be successfully extended into this arena, a proposal can be made that all new vehicle procurements by the state (including those for other jurisdictions) require such equipment, and that the Department of General Services study ways of quickly retrofitting public fleet vehicles currently in use in California.

### • Privacy Protection in ATS Deployment

To avoid any ambiguity as to intent, it should be made state policy that any and all ATS deployments in California involving governmental entities will ensure that the privacy of the citizens of California is protected. Under this policy, ATS designers will, to the extent feasible, design for privacy protection, as well as to primary application parameters. Any compromise of such protection on a specific product or application (for specific utility and/or convenience gains) should be knowingly, willfully and voluntarily agreed to by users of that product or application.

## Program Delivery Strategies

To attain the ATS vision, the collaborative effort necessary between federal, state, regional and local agencies, the private sector and research institutions will require management to use contractual and institutional approaches for which there are few, if any, U.S. models. The Caltrans management team will face challenges to:

- Test new transportation technologies in complex and developing systems environments to achieve near-term results that adequately demonstrate the program's lasting benefits to society;
- Facilitate commercialization of transportation technologies;
- Raise and selectively pool private matching funds and other resources to meet state and federal cost-sharing requirements;
- Cooperate in the management of large and complex projects supported both financially and technically by a variety of sources;
- Develop public/private partnerships with the ability to resolve differences in proprietary issues;
- Coordinate actions of state, regional, and local governmental agencies to plan, program, deploy, maintain and operate advanced systems;
- Operate successfully within changing political environments;
- Use risk management techniques when facing legal challenges;
- Gain consumer acceptance of new transportation products;
- Coordinate numerous and varied roles of governmental jurisdictions; and,
- Change the existing infrastructure which often limits options for new systems.

The ATS Program delivery strategies that follow address these challenges and also support broad state initiatives listed on page 74.

### • Regional Teaming

Caltrans is working with its partners throughout the state in establishing coordination teams to oversee ATS Programs and activities in each region. Typically, these operate under memoranda of understanding with state, regional and local agencies and have advisory groups involving private industry and other participants.

These teams will also help facilitate the consideration of ATS deployment opportunities within mainstream transportation planning and programming processes (see Early Deployment Plans on page 77).

**ATS Program Delivery Strategies**

- **Regional Teaming**
- **PATH Research Support**
- **Joint UC/California Testbed**
- **Program Element on Institutional and Market Issues**
- **California Advanced Public Transportation Systems Element**
- **Use of Federal ITS Programs:**
  - **Early Deployment Plans**
  - **Field Operational Tests**
  - **Southern California ITS Priority Corridor**
  - **Automated Highway Prototype**
  - **ITS Architecture Development**
  - **Use of Federal Defense Conversion and other Programs**

- **Partners for Advanced Transit and Highways (PATH)**

Ongoing research support for the ATS Program is provided by the PATH Program, ensuring continuity in the ATS research and development phases. Relevance and application of research products to transportation needs is ensured by ATS Program oversight of PATH.

- **California Testbed**

Using existing transportation facilities and services, Caltrans is helping establish testbeds for evaluating ATS technologies in real-world environments. The "California Testbed" initiative provides private industry and others opportunities to work with transportation practitioners and PATH researchers in developing useful ATS products. The first such testbed started operation in 1994, in Orange County, in partnership with the CHP, the cities of Anaheim and Irvine, the Orange County Transportation Authority, the University of California, Irvine and California Polytechnic State University, San Luis Obispo.

- **Environmental, Institutional and Market Issues Resolution**

Within their respective programs, Caltrans and the University of California are actively exploring approaches and solutions to the environmental, institutional and market issues discussed on the previous pages. New tools are being developed to conduct adequate and comprehensive ATS technology assessments, including socioeconomic and environmental consequences of ATS deployment.

- **ATS Program Planning**

Caltrans will regularly update and revise its ATS Program Plan to reflect changing conditions, needs and opportunities. In doing so, the department will solicit input from its partners and other interested parties. Caltrans is committed to coordinating the ATS Program with mainstream plans, programs, and operations (see Roles and Responsibilities, State Government, page 20).

Under AB 3096, Caltrans will regularly report to the administration and legislature on ATS Program progress.

- **Outreach Program**

Caltrans is recognized as a leader in the National ITS Program and holds membership on a variety of state and national committees including: the Transportation Research Board (TRB) Intermodal Transfer Facilities and Aircraft/Airport Compatibility Committees; the National Cooperative Highway Research Program (NCHRP); the ITS Rural Traveler Information Systems Expert Panel; the Western Transportation Institute's Board of Directors; the American Association of State Highway and Transportation Officials (AASHTO) Research Advisory Committee; ITS America; and PATH. These activities are important in providing a forum to inform the public, program partners and other stakeholders about the scope, direction and benefits of the ATS Program and to receive valuable feedback about their needs and concerns.

In addition, ATS Program staff are members and/or chairpersons of a variety of Caltrans committees which promote and foster the discussion of ongoing and future projects related to transportation system concepts, direction and integration. Discussion with the production staff of major educational channels is also underway to feature information about Automated Vehicle Control System (AVCS) projects as part of their curriculum dealing with future transportation technologies.

- **California Advanced Public Transportation Systems (CAPTS)**

With support from the Federal Transit Administration (FTA) and Federal Highway Administration (FHWA), Caltrans is aggressively pursuing ITS applications in public transportation, ridesharing and paratransit operations through its California Advanced Public Transportation Systems (CAPTS) initiative. This ATS Program element has helped highlight the full multimodal range of ITS and ATS opportunities.

- **Advanced Highway Maintenance and Construction Technology (AHMCT)**

In partnership with UCD and FHWA, Caltrans seeks to reduce the cost of doing business through its AHMCT Program. This ATS Program element directs efforts towards implementing products and processes that improve the safety, efficiency and cost effectiveness of highway maintenance and construction operations.

**Caltrans is taking advantage of a number of federal programs under ISTEA:**

- **Early Deployment Plans**

With support from USDOT, Caltrans is working with regional teams in the Sacramento Metropolitan Area, the San Francisco Bay Area and Southern California to develop cooperative plans for deploying ATS products and services. These plans will address consistency with existing transportation and air quality plans and programs, as well as identifying fiscal requirements and sources for ATS deployment. This planning effort will be expanded to other areas in California, including rural areas.

- **Federal ITS Field Operational Tests**

California captured six of 16 projects awarded in the first round of USDOT's ITS Field Operational Test Program in 1993. These ongoing field tests address a variety of traveler information and transportation management system services and technologies, some utilizing the testbed capabilities outlined earlier in this section. The tests are being conducted in the San Francisco Bay Area, Los Angeles, Orange County and San Diego.

Caltrans participated in the second round by offering to provide matching funds to companies submitting proposals.

## Program Delivery Strategies

### • Southern California ITS Priority Corridor

Significant portions of Los Angeles, Orange, San Diego, Riverside and San Bernardino counties have been designated by USDOT as the Southern California ITS Priority Corridor, one of four in the nation. This designation allows the region to compete with other corridors for some $250 million (through 1997) in special ISTEA funding to showcase ITS applications and promote early ITS deployment. Caltrans is working with the regional teams to develop a Priority Corridor deployment plan and demonstration projects in the corridor.

### • Automated Highway System Prototype

Caltrans is a core participant in the National Automated Highway System Consortium (NAHSC). The NAHSC will define, specify, and develop a prototype working automated highway system by the year 2001. See page 125 for a more detailed discussion of this federal initiative.

### • Defense Conversion

In 1993, the Advanced Research Projects Agency (ARPA), of the Department of Defense, released the first Technology Reinvestment Project (TRP) solicitation. The objective of the TRP is to fund dual-use projects that benefit both the military and commercial markets. Caltrans has participated in both solicitations released by the TRP by providing matching funds to partnerships with projects that address the needs of the ATS Program.

As a result of the 1993 solicitation, 85 projects were submitted to Caltrans. Twenty-one were selected to receive matching funds and 26 were endorsed. Four projects were selected to receive federal funding. ARPA selected two and the US Department of Energy (USDOE) was interested in two others. Subsequently these four projects were funded, and are currently underway.

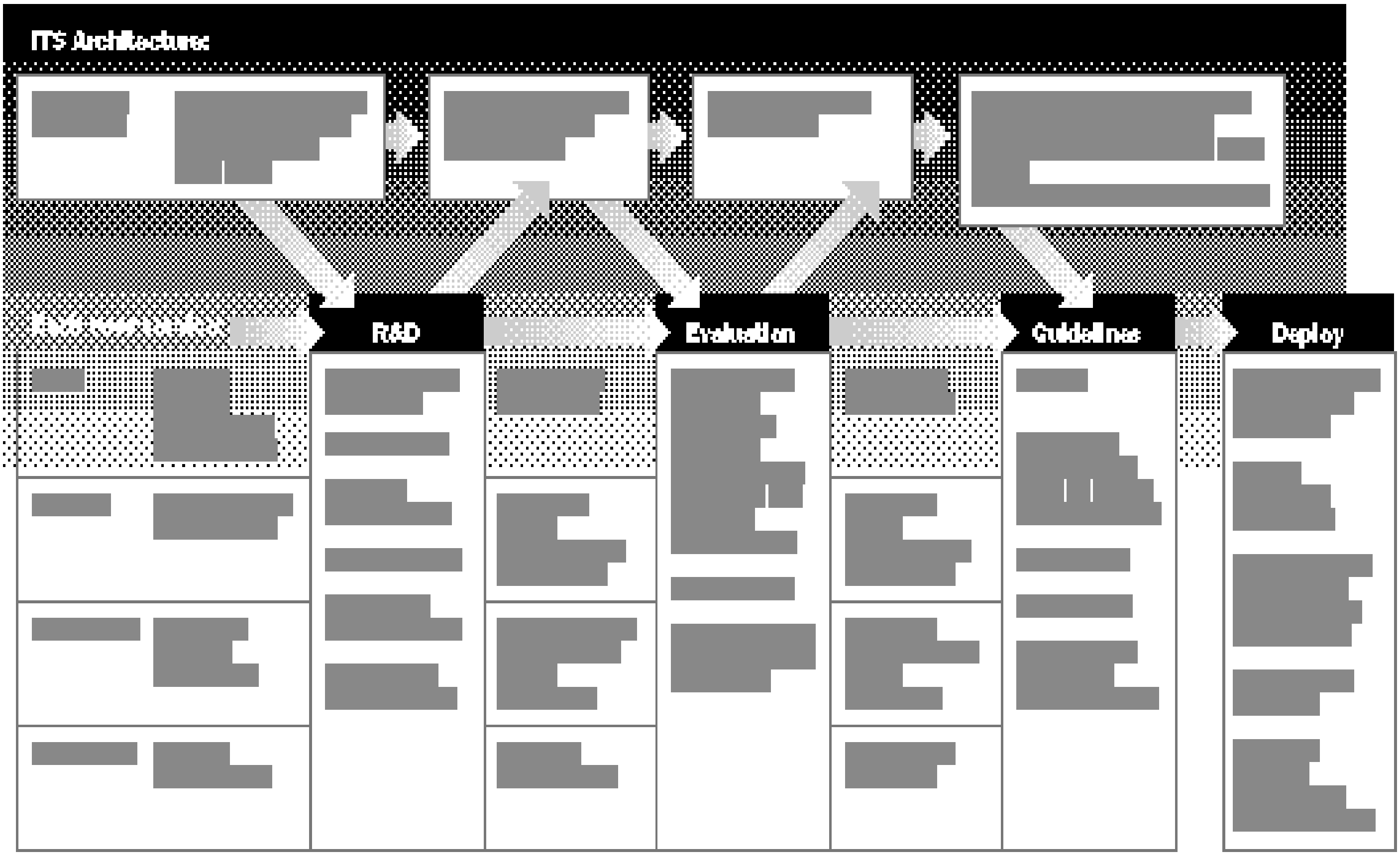
### • ITS Architecture

As discussed on page 68, Caltrans is participating in the development of a national architecture for Intelligent Transportation Systems (ITS).

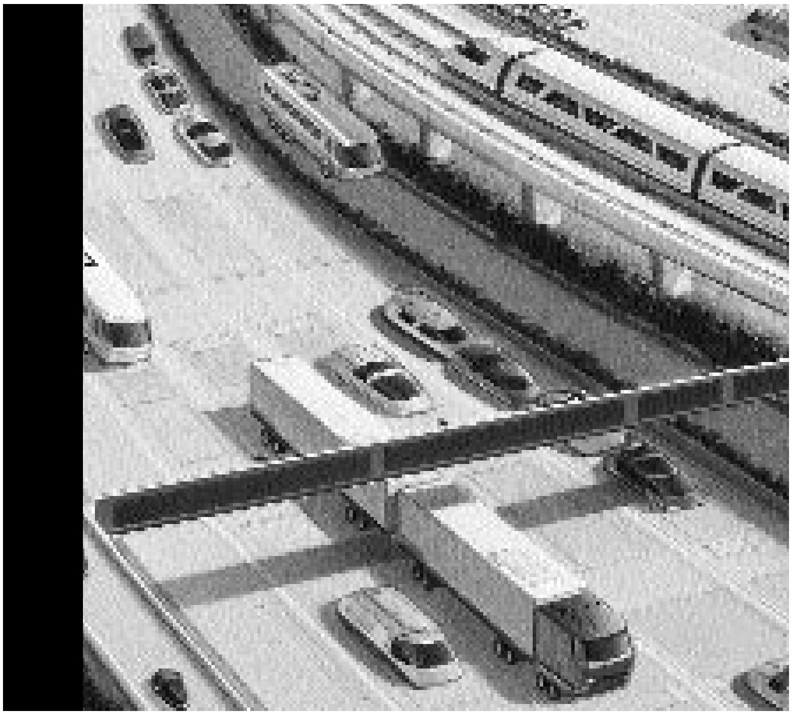
The ATS Program is designed as an integrated approach for deployment of ATS technologies:

- User needs will be identified and filled through research and development and resulting systems evaluated via field operational tests; and,
- Development of guidelines, standards and protocol setting and consideration of ATS in transportation plans and programs will facilitate deployment.

## Integrated approach



# THE FIVE-YEAR PROGRAM



California's ATS Program is comprised of six major program areas. Within these program areas a significant level of activity is underway. The areas are:

- **Transportation Information Services**
- **Advanced Vehicles**
- **Transportation Management Systems**
- **Rural**
- **Infrastructure Construction and Maintenance**
- **Systems Development, Integration and Implementation**

The five-year program contains research, testing and early deployment activities described by major program area which are linked to the user services discussed earlier in the "Fifteen-year Deployment Overview." In addition, current ATS Program tests and demonstrations are summarized and some significant projects highlighted.

Activity charts are also included for each program area. The charts are located between each scope and project highlights section and depict activities necessary to accomplish deployment of a user service. **Accordingly, the charts also reflect work done by all partners necessary to accomplish the Caltrans ATS Program**.

Several of the activities described such as: traveler-based detection/call boxes, transportation management center/initiated route guidance for incident management, commercial vehicle projects, and prototype high-occupancy vehicle enforcement systems, will require the California Highway Patrol or other public and/or private entities to actively participate in the development and deployment of these systems. Caltrans will work cooperatively in partnerships with various entities to assist with these activities through deployment. The following is a discussion of each major program area and the related elements (user services or components) though 2000.

# TRANSPORTATION INFORMATION SERVICES

## Smart Traveler/Modal Services

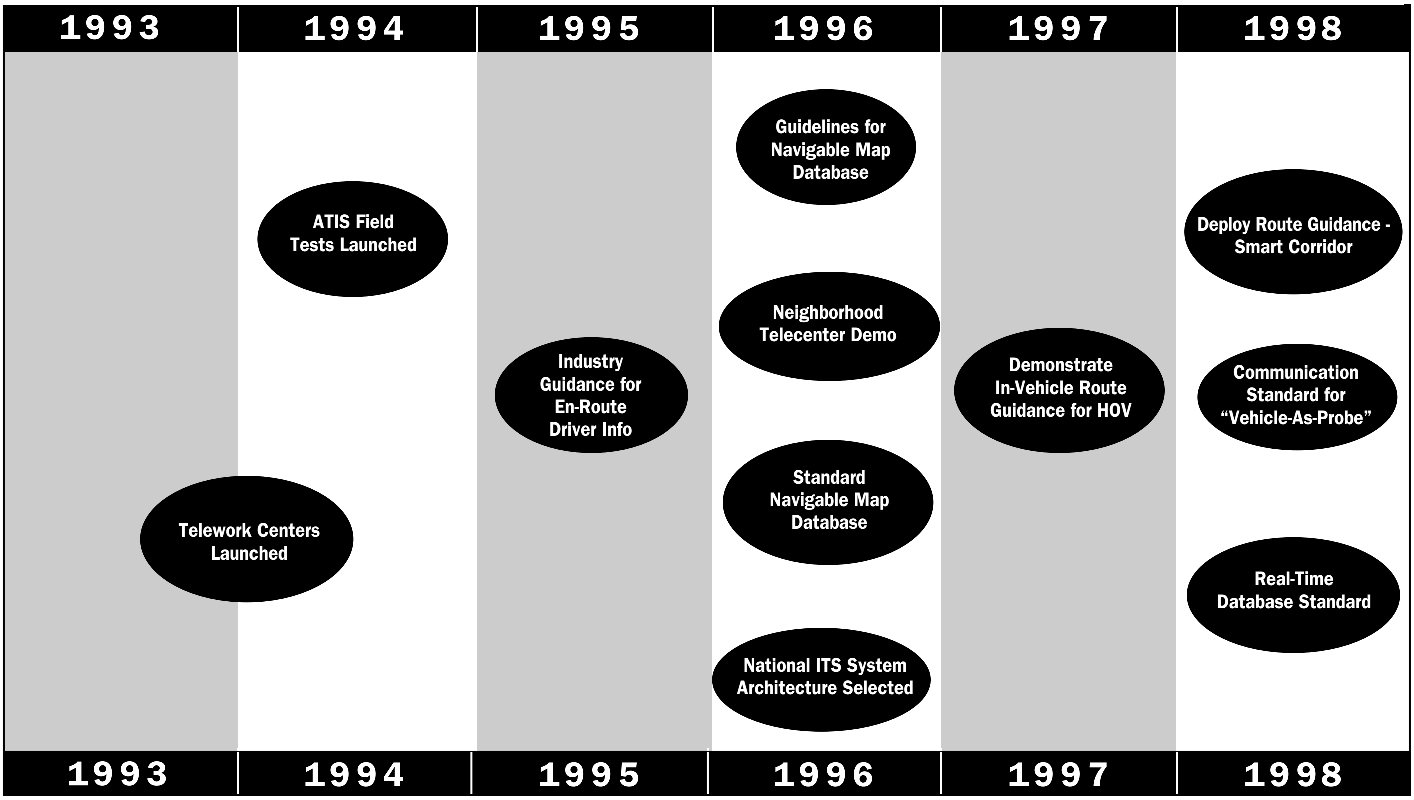
- *Pre-Trip Travel Information*
- *En-Route Driver Advisory*
- *En-Route Transit Advisory*
- *Traveler Services Information*
- *Route Guidance*
- *Ridematching and Reservations*

## Travel Substitution

**Transportation Information Services is a package of user services which are cost-effective ways to improve mobility and provide travel substitution.**

**The milestones, scope of services, activities and specific project highlights for Transportation Information Services are discussed on the following pages.**

# Transportation Information Services



## Transportation Information Services

**Smart Traveler/Modal Services — Scope**

**The concept of the "Smart Traveler" relies heavily on the effective use of a variety of advanced communication technologies that can collect, process, and present transportation data to the traveler when and where it is needed.**

Smart Traveler/Modal Services applications generally fall into these broad user services categories:

### • Pre-Trip Travel Information

**Provides information for selecting transportation modes, travel times, and route decisions before departure.**

Pre-trip travel information allows travelers to access a complete range of intermodal transportation options at home, work, and other major sites where trips originate. For example, timely information on transit routes, schedules, transfers, fares, and ride matching services are included. Updates of real-time information on accidents, road construction, alternate routes, traffic speeds along given routes, parking conditions, event schedules, and weather information complete the service.

This capability gives a prospective traveler a quick picture of important conditions and services at a given time. Optional itineraries can be presented based on factors including time of departure, time of arrival, routes and modes, and intermediate stops. In its more advanced forms, user profiles will enable customized interfaces to better address multicultural and general variations.

### • En-Route Driver Advisory

**Driver advisories and in-vehicle signing for safety, convenience and efficiency.**

Driver advisories are very similar to pre-trip travel information, once travel begins. Audio and visual technologies convey information about incidents, construction, congestion, parking availability, rideshare requests, and weather conditions to drivers. In-vehicle signing, the second component of en-route driver information, would provide the same types of information found on physical road signs today, directly to the vehicle. Vision-impaired individuals and drivers of rental vehicles are potential users. The service would be extended to include indications of road conditions and safe speeds for specific types of vehicles (e.g., autos, buses, vans).

### • En-Route Transit Advisory

**Provides information to travelers using public transportation after they begin their trips.**

En-route transit information is similar to the pre-trip travel information available (noted above) to those using public transportation. Real-time, accurate transit network information helps travelers make effective transfer decisions and itinerary modifications as needed while a trip is underway. Accordingly, en-route driver information is useful to public transportation drivers, while en-route transit information focuses on transit riders.

### • Traveler Services Information

**"Electronic Yellow Pages" integrated with pre-trip and en-route information system.**

Traveler services information provides quick access to travel related services and facilities in the vicinity of a planned trip or one already underway. These services will be accessible in the home or office to help plan trips, and with some limitations, while en-route. The location, and availability of food, lodging, parking, automotive services, hospitals, and police facilities are a few examples of pertinent information included. When fully deployed it will connect users, sponsors, and providers interactively, allowing the users to request and provide needed information. A comprehensive, integrated traveler services information system could support financial transactions like automatic billing for purchases.

### • Route Guidance

**Provides travelers with simple instructions on how to reach their destinations.**

Route guidance closely relates to en-route driver information, potentially using the same information as its foundation. Route guidance services, however, will use information on travel conditions to provide directions. For example, a map display with areas of congestion highlighted, qualifies as en-route driver information. A route guidance service would process this data to derive a suggested route and associated instructions.

When fully deployed, route guidance systems will provide travelers with directions to selected destinations. This service can be tied to multimodal traffic management for the purpose of balancing the demand placed upon the system and for incident response.

### • Ride Matching and Reservations

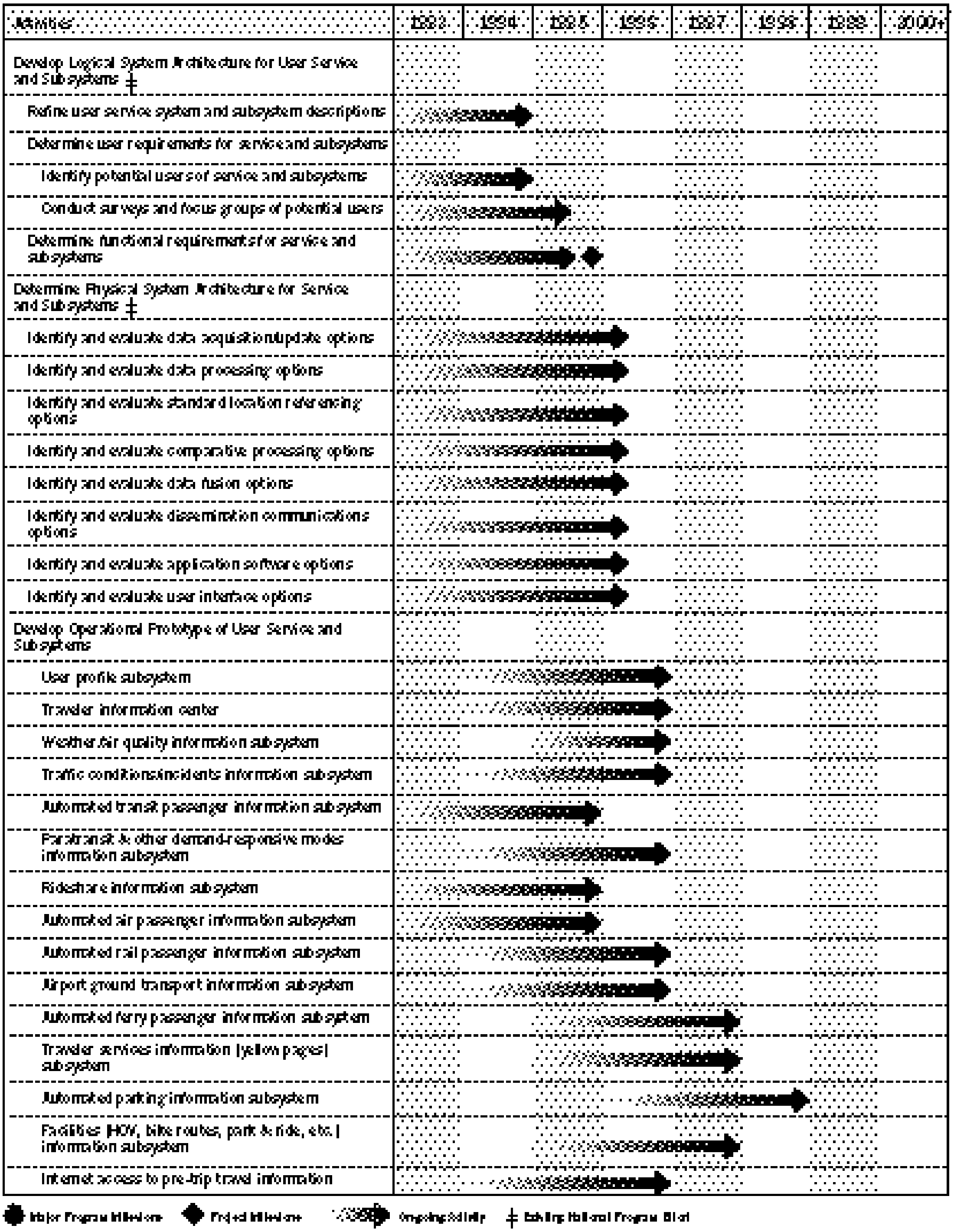
**Provides for dynamic or single-trip rideshare matching.**

Rideshare matching currently provides opportunities for commuters traveling between similar origins and destinations. This user service will allow for single-trip rideshare matching and en-route pickups.

## Transportation Information Services

### Smart Traveler/Modal Services - Activity Charts

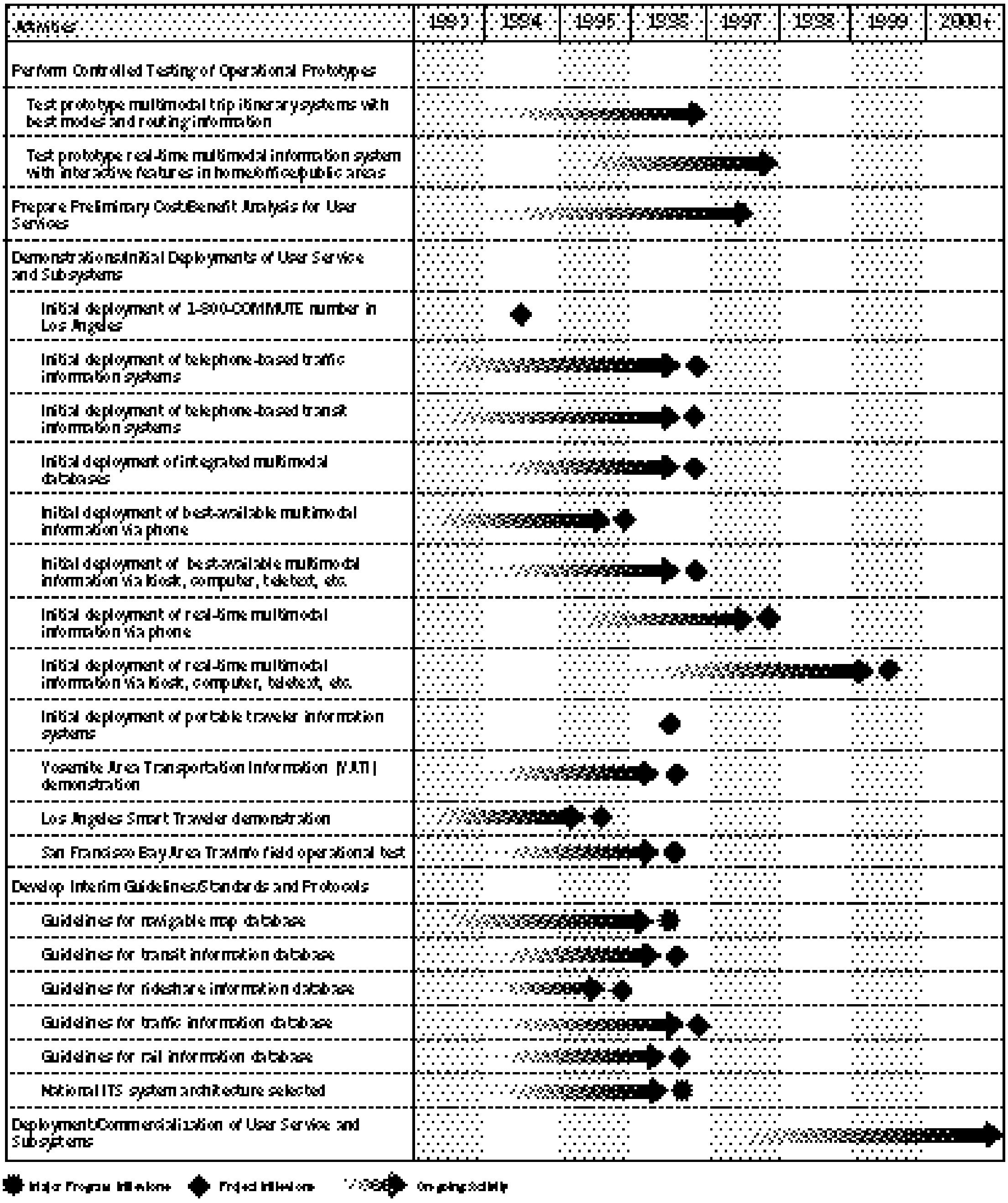
Pre-Trip Travel Information



## Transportation Information Services

### Smart Traveler/Modal Services - Activity Charts

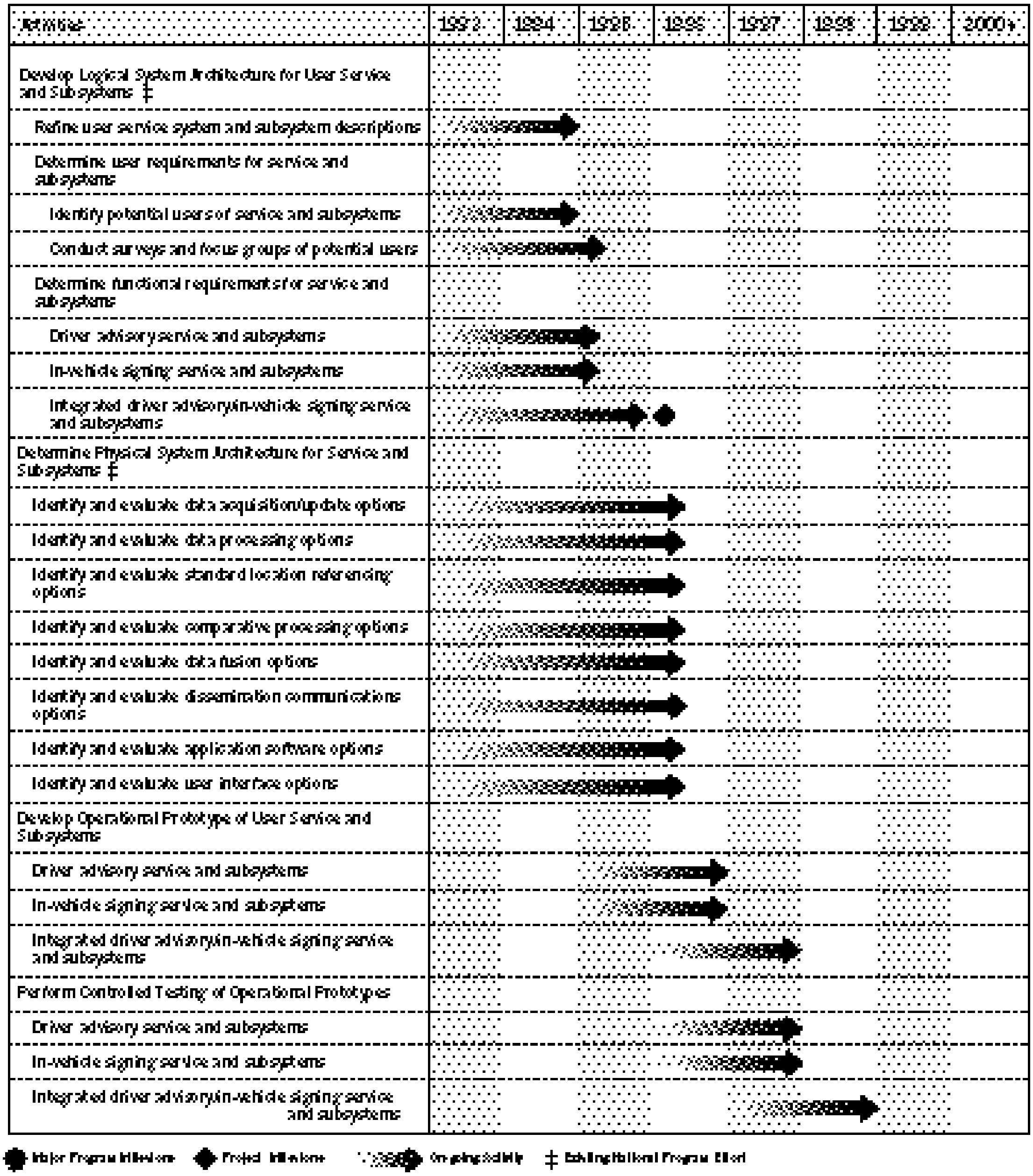
Pre-Trip Travel Information contd



## Transportation Information Services

### Smart Traveler/Modal Services - Activity Charts

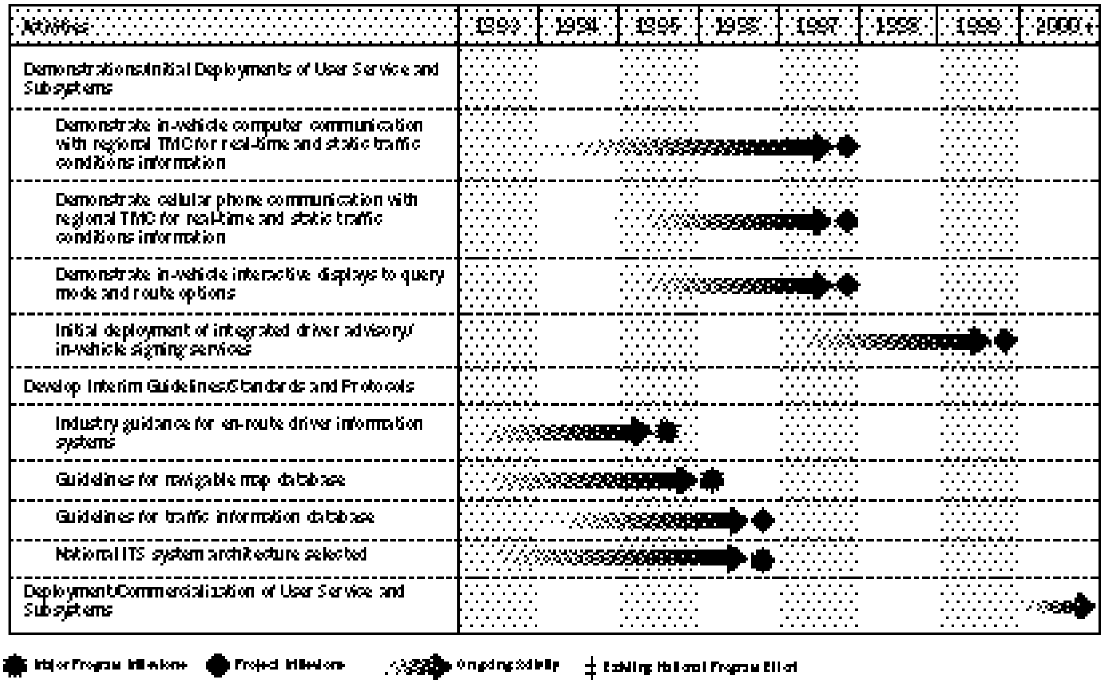
En-Route Driver Advisory



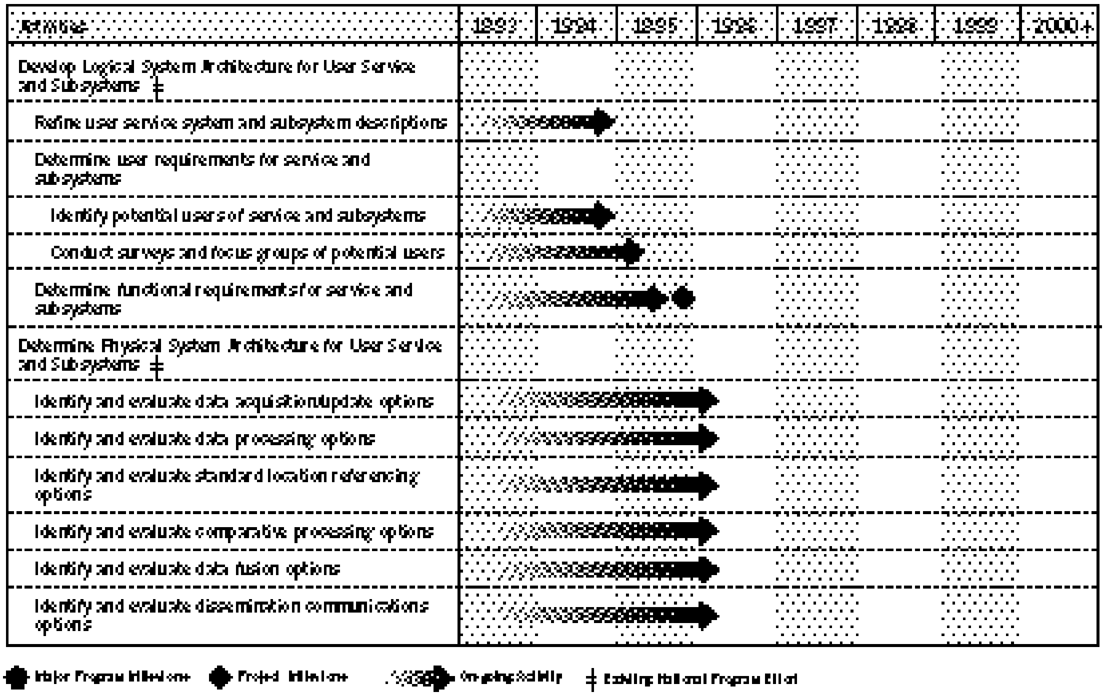
## Transportation Information Services

### Smart Traveler/Modal Services - Activity Charts

En-Route Driver Advisory contd

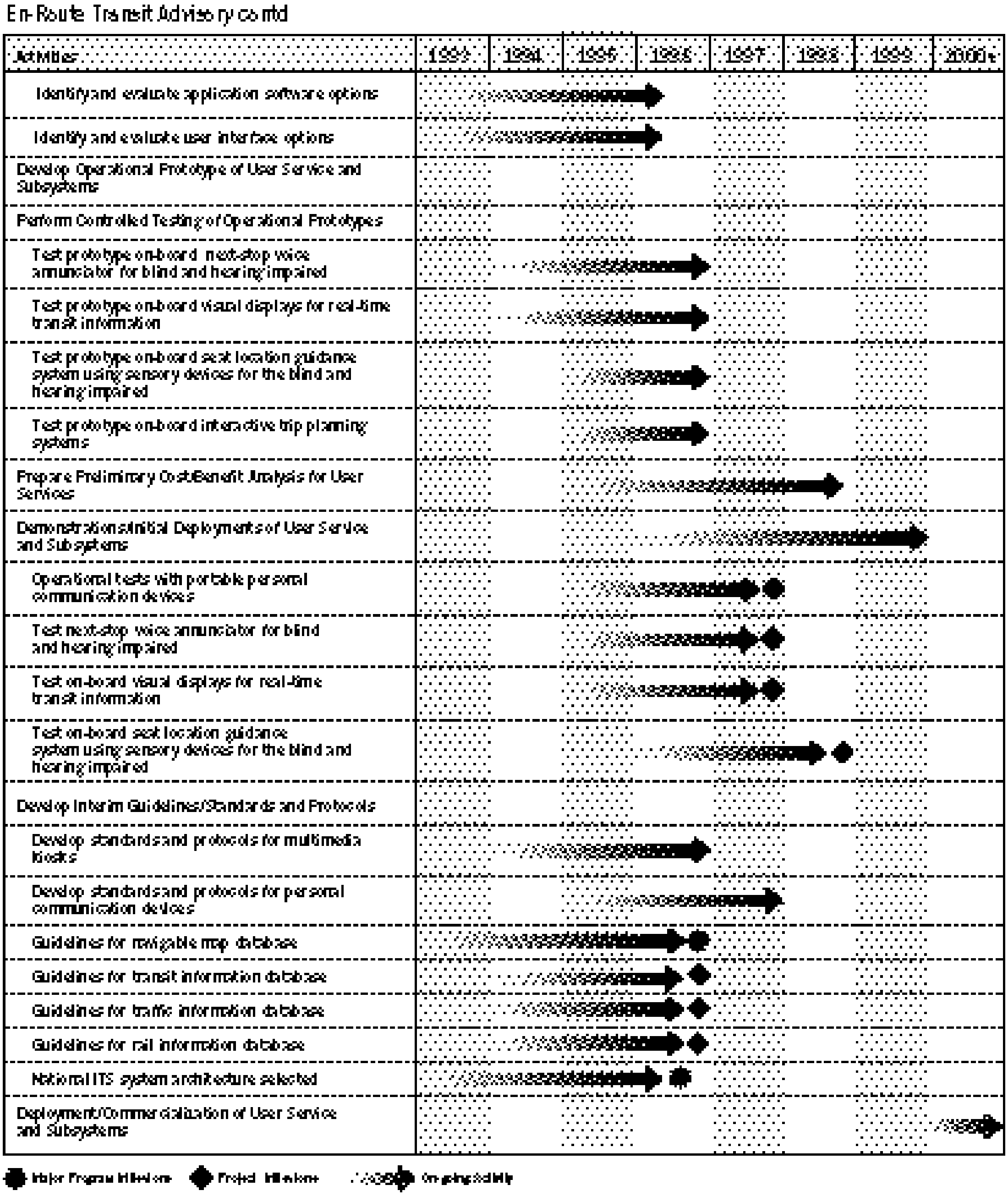



En-Route Transit Advisory



## Transportation Information Services

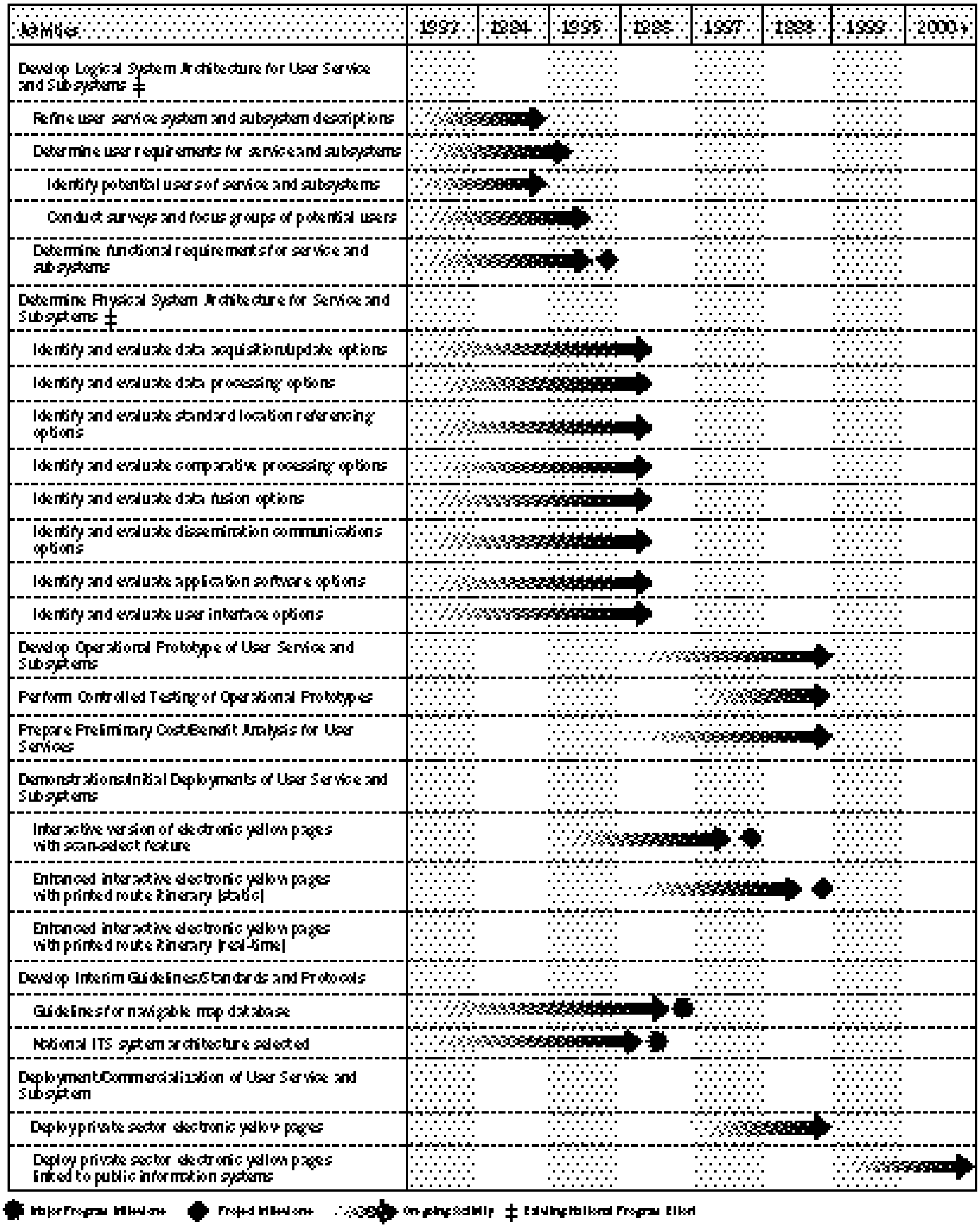
### Smart Traveler/Modal Services - Activity Charts



## Transportation Information Services

### Smart Traveler/Modal Services - Activity Charts

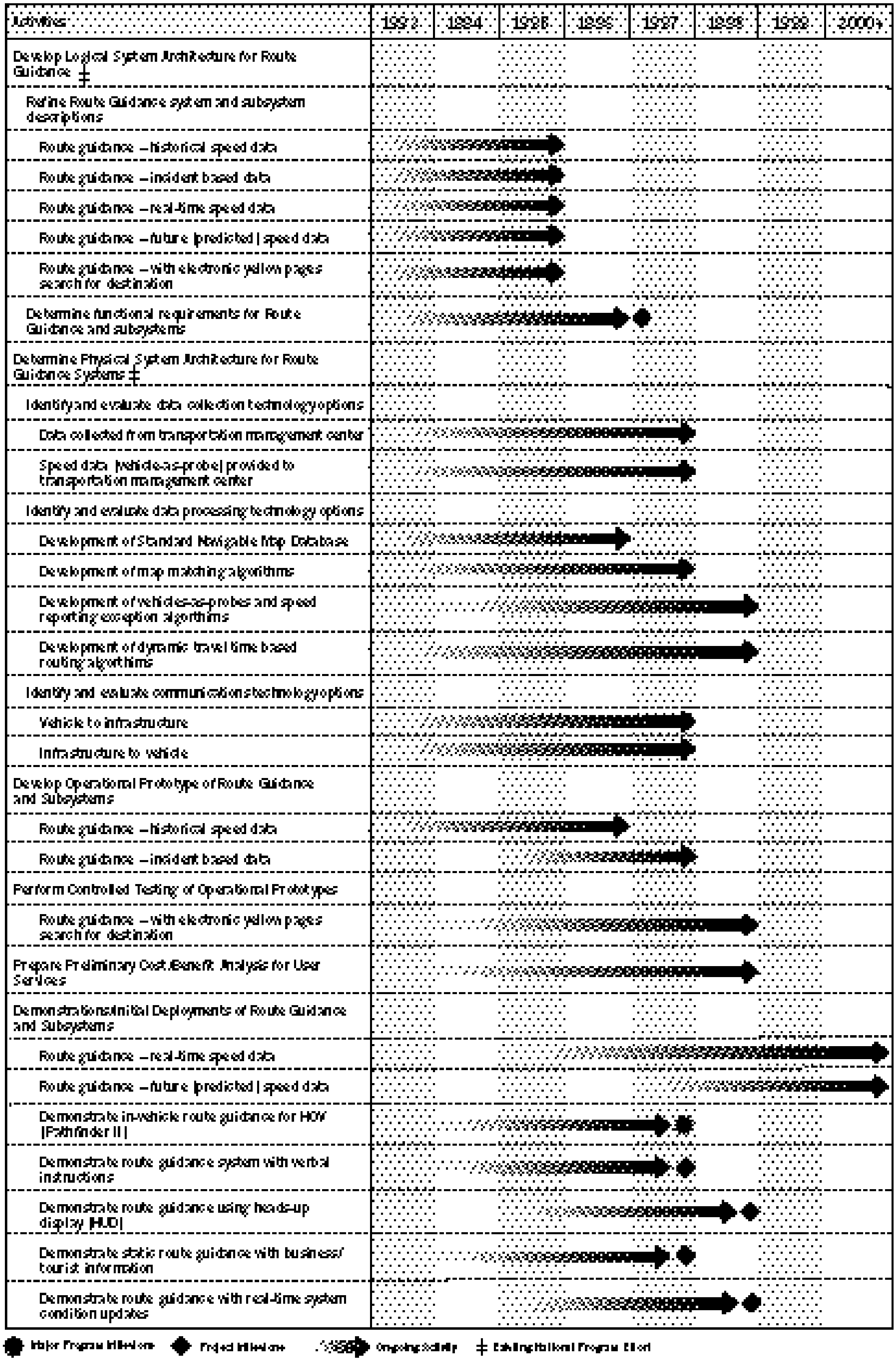
Traveler Services Information



## Transportation Information Services

### Smart Traveler/Modal Services - Activity Charts

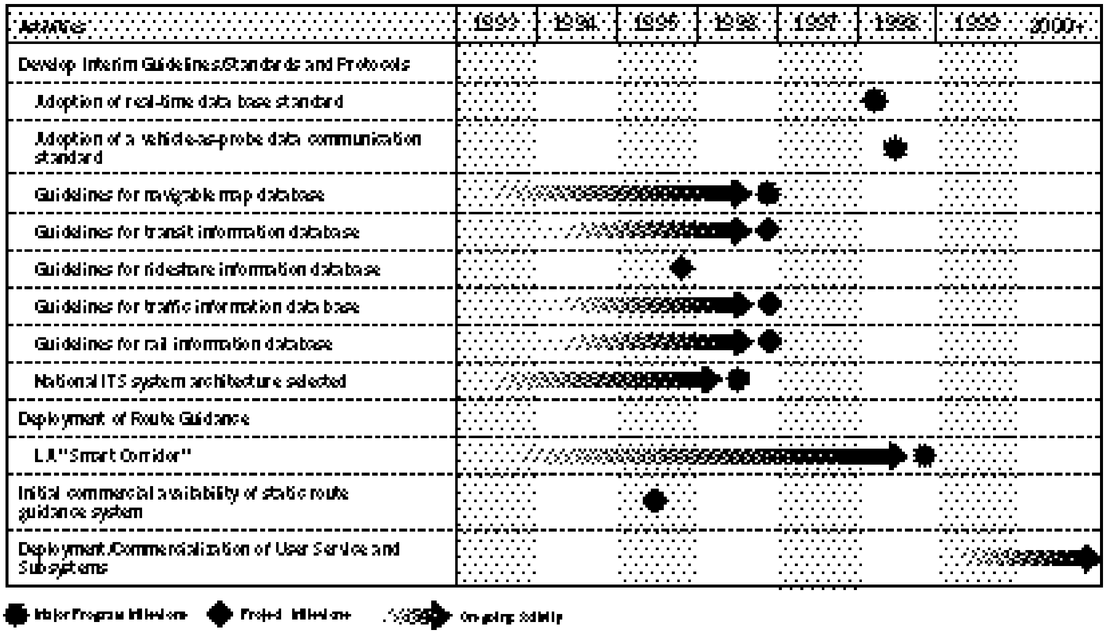
Route Guidance



## Transportation Information Services

### Smart Traveler/Modal Services - Activity Charts

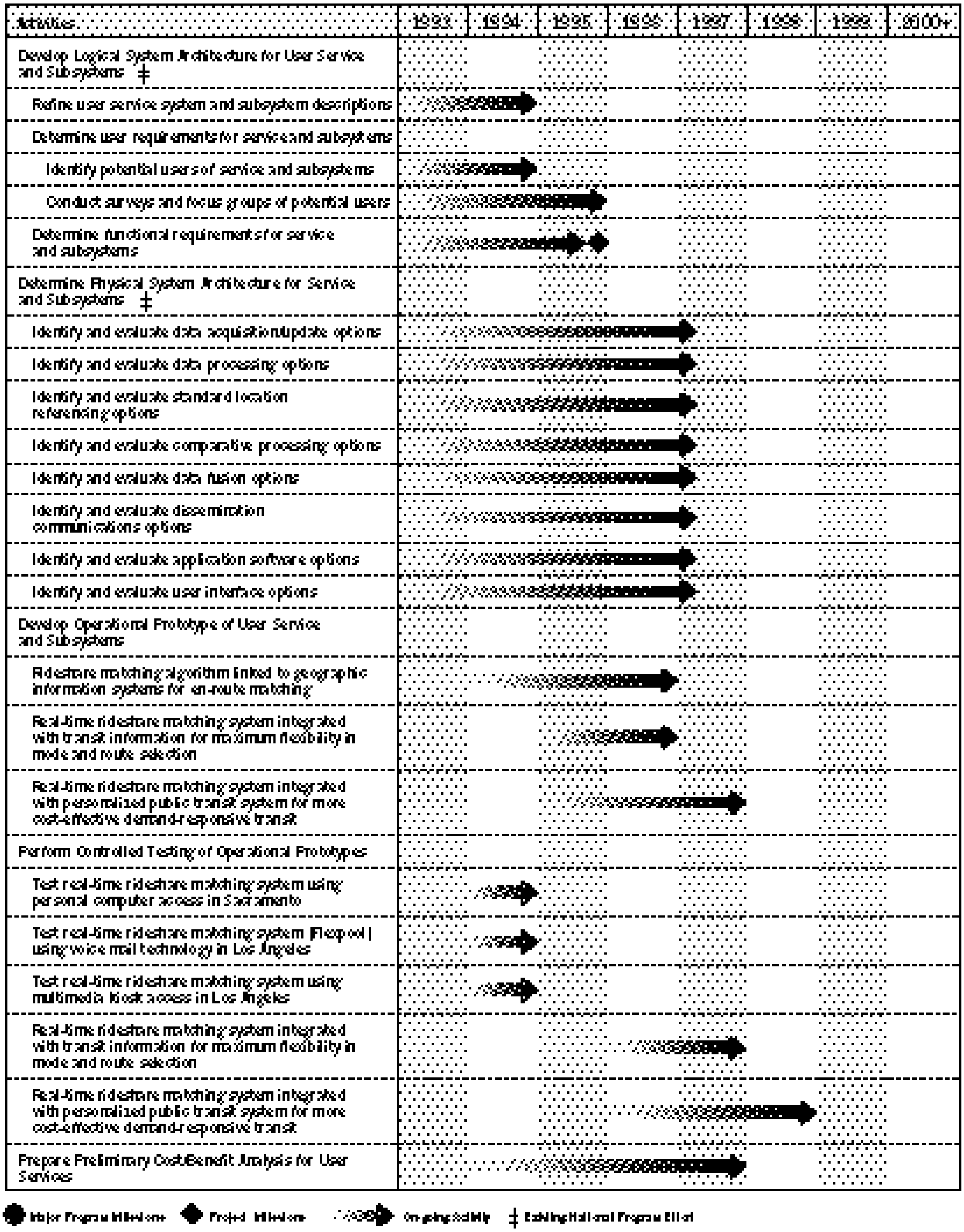
Route Guidance cont'd



## Transportation Information Services

### Smart Traveler/Modal Services - Activity Charts

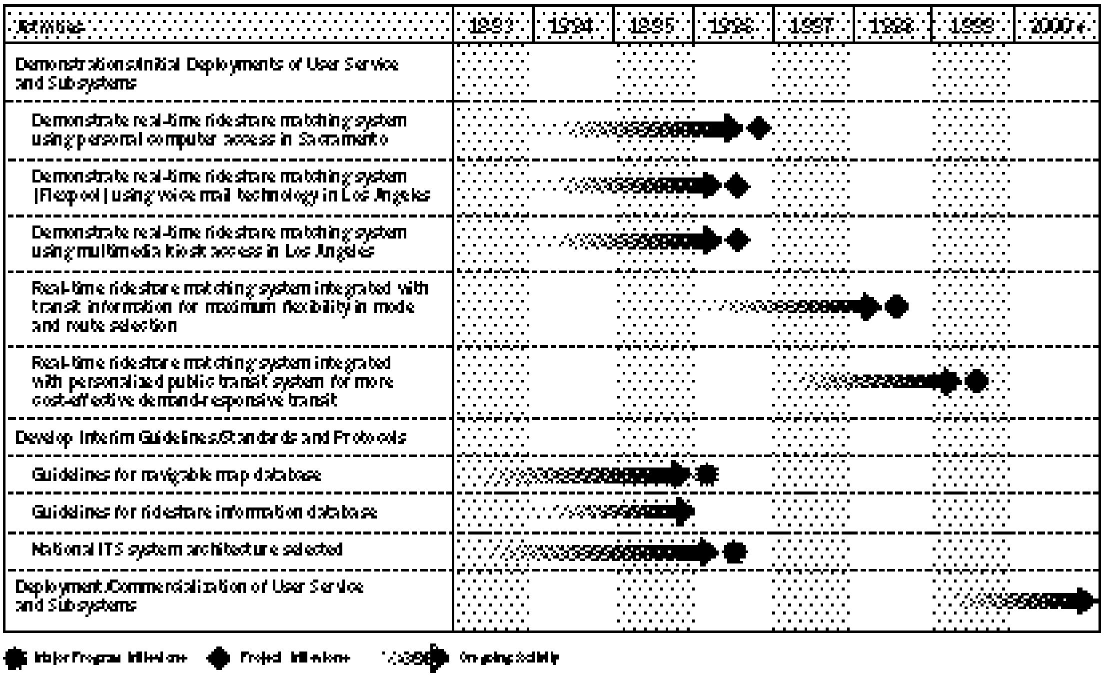
Ride Matching and Reservations



## Transportation Information Services

### Smart Traveler/Modal Services - Activity Charts

Ride Matching and Reservations contd



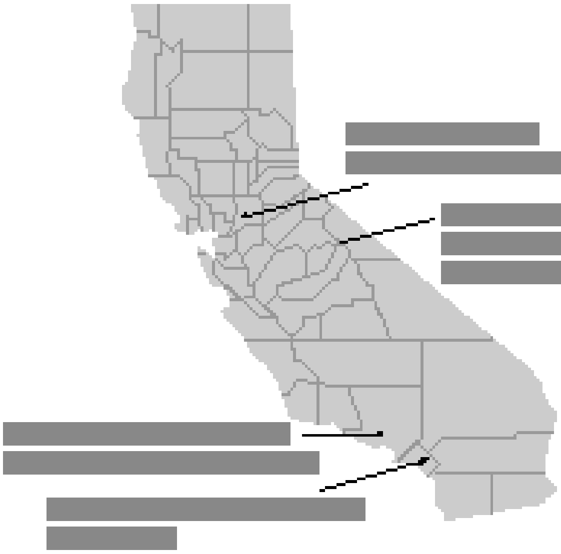
## Transportation Information Services

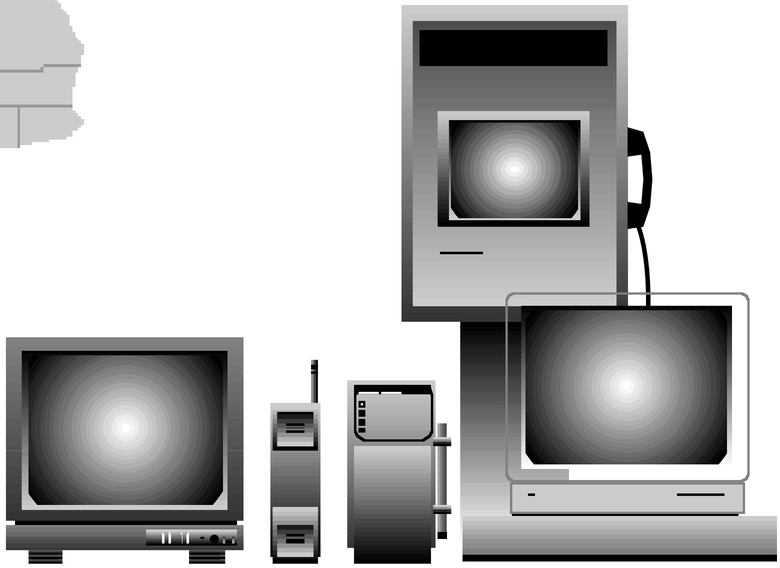
**Smart Traveler/Modal Services - Project Highlights**

### A Travel Technology Project

TravInfo, a large-scale FHWA-sponsored operational test, being conducted in the San Francisco Bay Area, is an early model of a merged information system. TravInfo is designed to collect data from multiple transportation-related sources including: airline schedules; transit schedules, routes and fares; intercity rail schedules and fares; CHP computer-aided dispatch systems; Freeway Service Patrol reports; Transportation Management Centers (TMCs), and many others. The data will be collected, processed and made available to system users. The users, including the original information providers, can access the information in whatever detail their operation requires. Private vendors may use the data as a device to market transportation services. The evaluation of the test will include user opinion of private sector services, and the effects the use of the information has on the system's overall efficiency.

The success of the operational tests and fully functional demonstrations will be used to initiate deployment of a full function Advanced Transportation Management Information System (ATMIS) throughout California.





Cable TV/Cellular Phone/Palm-top Computer/Desk-top Computer/Infor mation Kiosk

## Transportation Information Services

### Travel Substitution - Scope

In addition to the movement of people and goods, the transportation system includes the movement of information and services. Rapid advancements in telecommunications technology are leading towards the fulfillment of Caltrans' vision for California's transportation future wherein telecommunications either enhance or substitute for the mobility of people and goods. This new approach to mobility, challenges transportation system managers to adequately plan for the telecommunications infrastructure as they would for other modes of transportation.

Telecommunications technology is essential to successful Transportation Demand Management (TDM) strategies that Caltrans is using to address traffic congestion, air quality issues and energy conservation, while increasing the mobility potential of Californians without an increase in motor vehicle trips. Specific travel substitution areas being addressed by the ATS Program include:

- Telecommuting (Home and Telework Centers)
- Teleconferencing
- Teleshopping
- Telebanking
- Tele-education

The five-year horizons for the deployment of new technologies are challenging Caltrans to establish a systematic, phased plan of action towards achievement of goals and objectives relative to deployment. Currently, the Caltrans Office of Transportation Demand Management has been following a strategy oriented towards determining the trip-making behavior associated with teletrip substitution as a TDM strategy. The strategy involves research, feasibility studies, demonstration projects and other activities aimed at determining the utility of information transfer towards meeting the department's objectives.

**Telecommuting represents a major innovative strategy in the new process because it expands the definition of home-to-work transportation to include telecommunications.**

**Several projects have been undertaken to test the effectiveness of telecommunications as a TDM strategy. These projects emphasize cooperative arrangements between Caltrans, other agencies, developers and the business community.**

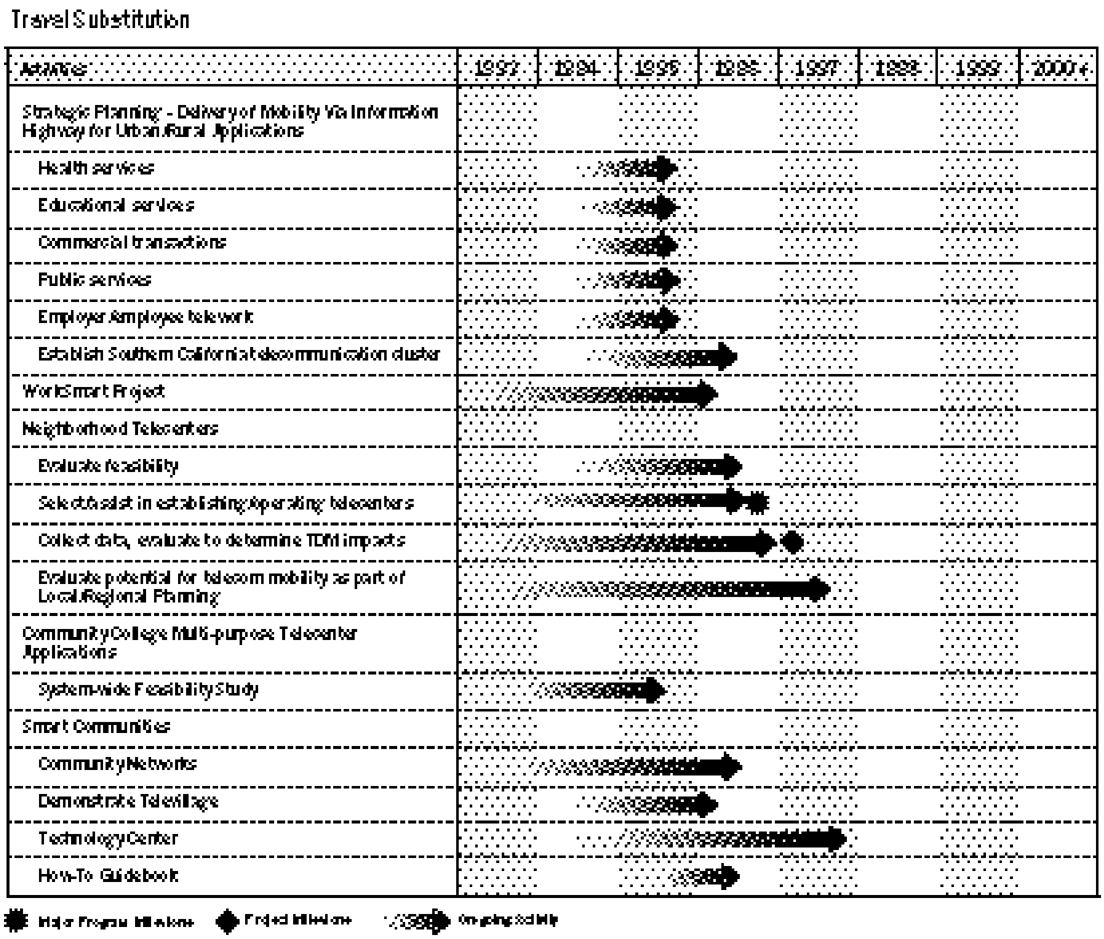
**Public utilities are supportive of the use of telecommunications technologies. Recent announcements by public utilities that all digital networks will be in place by 1997 will help set the stage for the deployment of a full-service broadband infrastructure in California.**

**Caltrans Telecommunications Mobility Projects**

*(All projects involve extensive public and private sector partnerships)*

## Transportation Information Services

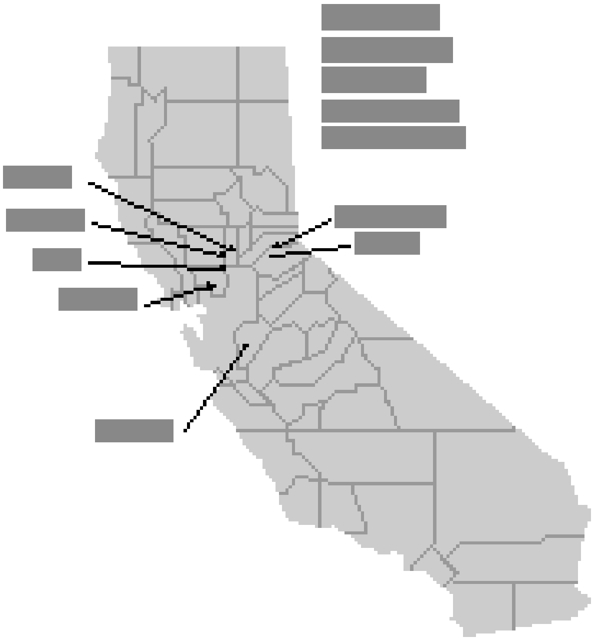
**Travel Substitution - Activity Chart**



The Work Smart Project provides the opportunity to fulfill transportation needs through telework by capturing trends in office facility design and operations.

Organizations that utilize new information technologies and management practices to develop a wide array of time/space work options that expand the boundaries of the conventional workplace can achieve what seem like contradictory goals: reducing costs, increasing performance, enhancing flexibility, and improving air quality and traffic congestion. This project will help organizations identify which workplace and workforce strategies make the most sense for meeting their needs, and assist in developing plans for implementing the evolving workplace and managing it over time.

New approaches to mixed-use communities that are fully accessible via the information superhighway are anticipated.



## Davis Community Network

Caltrans is working with UCD to develop a testbed community network which will support telework, telelearning, teleshopping, telemedicine, telebanking, electronic democracy, etc., as a means of determining the effect of such a network on trip demand.

The project requires a feasibility study of three new networking technologies for support of the community network: Integrated Services Digital Network (ISDN), wireless and cable television. Negotiations are underway with vendors for each type of technology. The project also coordinates the development of the community network and training of the network users. At least 500 test participants must be initially recruited in order to provide a sufficient research population. Up to 2,000 community network users (not necessarily directly involved in the research effort) are expected by January 1996.

The Davis Community Network Project is researching wide area networking amenities and support for neighborhood telecen- throughout the Central Valley and ıills (see map). Instead of driving to , people are encouraged to walk, bike, de a shuttle to a neighborhood office ity which could provide computers, ers, faxes, phones with voice mail, as as support for electronic mail and teleconferencing. These facilities supent the use of home-based telecommuions devices.

**Caltrans has assumed a leadership role in the development and implementation of telecommunications strategies.**

**UC Davis is researching various aspects of telecommuting.**

# ADVANCED VEHICLES

## Smart Vehicles

- *On-Board Safety Monitoring*
- *Personalized Public Transit*
- *Longitudinal Collision Avoidance*
- *Lateral Collision Avoidance*
- *Intersection Crash Warning and Control*
- *Vision Enhancement for Crash Avoidance*
- *Impairment Alert*
- *Pre-crash Restraint Deployment*
- *Fully Automated Vehicle Operations*
- *Transit, School Bus and Commercial Operations*

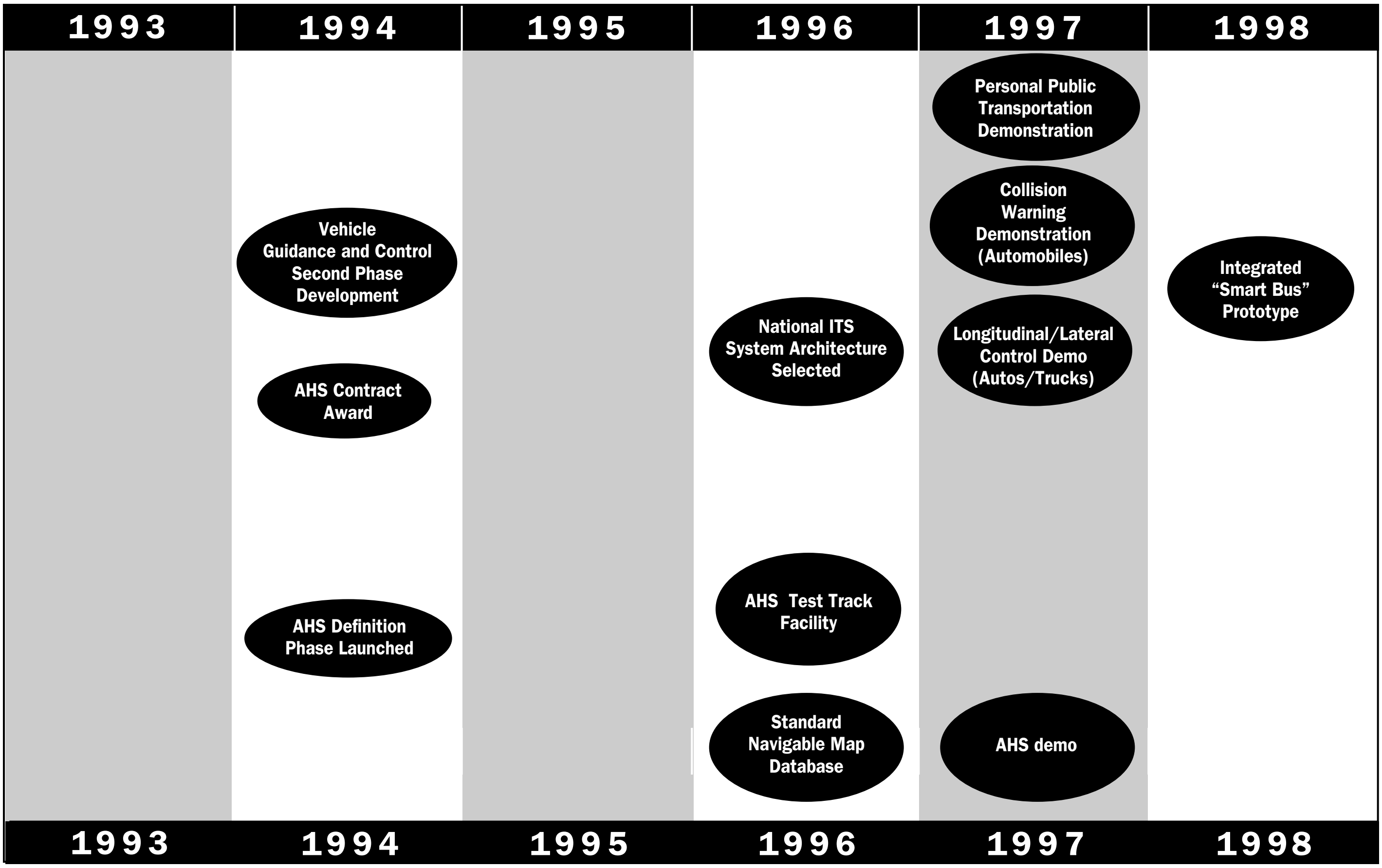
## Alternative Vehicles

- *High-Speed Ground Transportation*
- *Air Transportation*

**Advanced Vehicles is a package of smart vehicles whose operation is based on communications technologies; alternative vehicles; and high-speed systems, such as rail and air.**

**The milestones, scope of services, activities and specific project highlights for Advanced Vehicles are discussed on the following pages.**

# Advanced Vehicles



## Advanced Vehicles

### Smart Vehicles - Scope

Smart vehicle applications generally fall into these broad user services categories:

- **On-board Safety Monitoring**

  **On-board safety monitoring service focuses on enhancing safety for commercial motor carrier transportation, although this technology will be available for private automobiles also.**

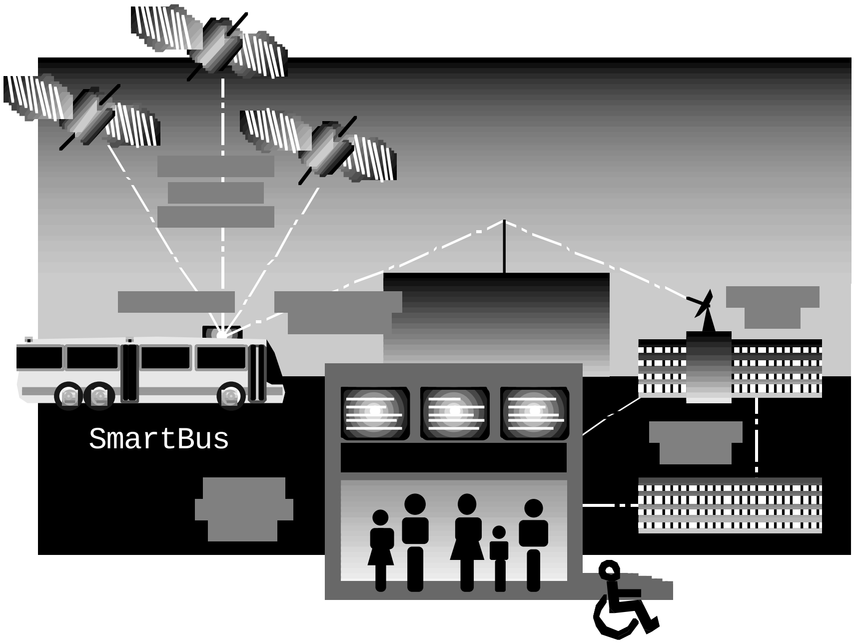
Such capabilities apply to pre- and post-trip inspections, as well as warnings while underway. Communicating this safety information while in motion is a part of the commercial vehicle preclearance service and automated roadside safety inspection services.

The most effective safety program will occur if the automated roadside safety inspections, commercial vehicle electronic clearance, and on-board safety monitoring services operate interactively and are compatible with carrier on-board safety systems. Implementation of all three services simultaneously is achievable as long as the ITS system architecture provides for phased deployment.

- **Personalized Public Transit**

  **Flexibly routes transit vehicles to provide cost-effective personalized services which can be truly competitive with the private auto.**

These transit vehicles can consist of small buses, vans, taxicabs, or other small shared-ride vehicles. They can essentially provide door-to-door service, expanding a route's coverage area in less populated locations and neighborhoods. This type of service can offer shared-ride transportation at lower cost and with greater convenience than conventional fixed route transit. The principal characteristic of this service is that multiple passengers share vehicles. Small publicly or privately operated vehicles operate on demand assignments to pick up passengers who have requested service and deliver them to their destinations.



- **Longitudinal Collision Avoidance**

**Longitudinal collisions involve head-on and rear-end collisions between vehicles, including collisions involving pedestrians.**

Longitudinal collision avoidance will help reduce the number and severity of collisions. This involves sensing potential collisions, prompting a driver's avoidance actions, and temporarily controlling the vehicle to help minimize damage and injury. Longitudinal collision avoidance includes sensing obstacles both in front of, and behind, the vehicle. The forward-looking sensors will likely be active all the time, whereas the rear-looking sensors are expected to be activated whenever the vehicle is in reverse. The rear-looking sensor will aid in preventing backup accidents in parking lots and restricted areas, and will be especially helpful where there is a high probability of pedestrian traffic behind or between vehicles.

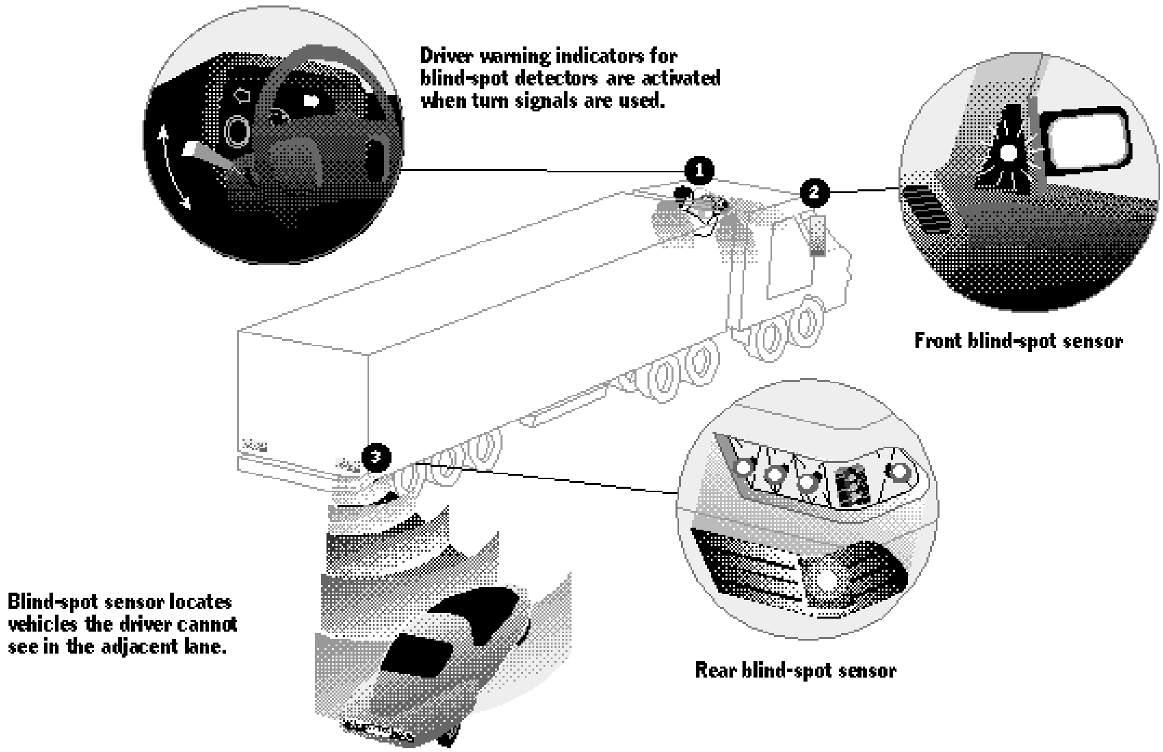
- **Lateral Collision Avoidance**

**Lateral collisions involve vehicles leaving their own lane of travel while moving forward.**

Lateral collision avoidance technology will help reduce the number of lateral collisions by providing crash warnings and controls for lane changes, blind spots and road departures. Lateral collisions include two-vehicle and single-vehicle collisions.

There are degrees of control to both types of crash warning and control capabilities. For lane changes, a situation display can continuously monitor a vehicle's blind spot; drivers can be actively warned of an impending collision, and automatic control can effectively respond to situations very rapidly. For road departures, warning systems can cue a driver to an impending road departure; assist in lane keeping, and provide automatic control of steering and throttle in dangerous situations.

**Collision warning systems, currently being tested, can be adapted to longitudinal control.**



**Advanced Vehicles**

**Smart Vehicles - Scope**

**The goal of this effort is to ensure safe, alert drivers.**

- **Intersection Crash Warning and Control**

  **Accident avoidance at intersections where there is a frequency of accidents and violations involving ambiguous right-of-way laws.**

Intersection collision avoidance closely relates to two other collision avoidance services: lateral and longitudinal collision avoidance. Intersection collision avoidance could combine information about crossing traffic with information about signals ahead, improving situational awareness.

- **Vision Enhancement for Crash Avoidance**

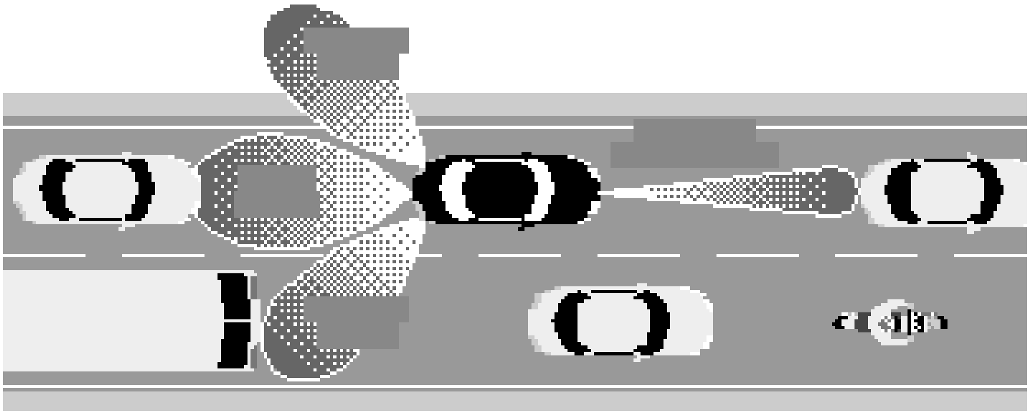
  **Improves the driver's ability to see objects in and around the travelway.**

Improved visibility would allow the driver to avoid potential collisions with other vehicles or obstacles in the line of travel and help the driver to comply with traffic signs and signals. This service requires in-vehicle equipment for sensing potential hazards (such as fog, dust, and smoke), processing this information, and displaying it so that it is useful to a driver.

- **Impairment Alert**

  **Provides warnings regarding the condition of the driver, vehicle, and roadway infrastructure.**

In-vehicle equipment could unobtrusively gauge a driver's condition and provide a warning of drowsiness or otherwise impaired conditions. This service would also internally monitor critical components of a vehicle beyond standard oil pressure and engine temperature. Lastly, equipment within a vehicle could detect unsafe system conditions in real-time, including bridge icing, standing water on a roadway or rail track discontinuity.



- **Pre-Crash Restraint Deployment**

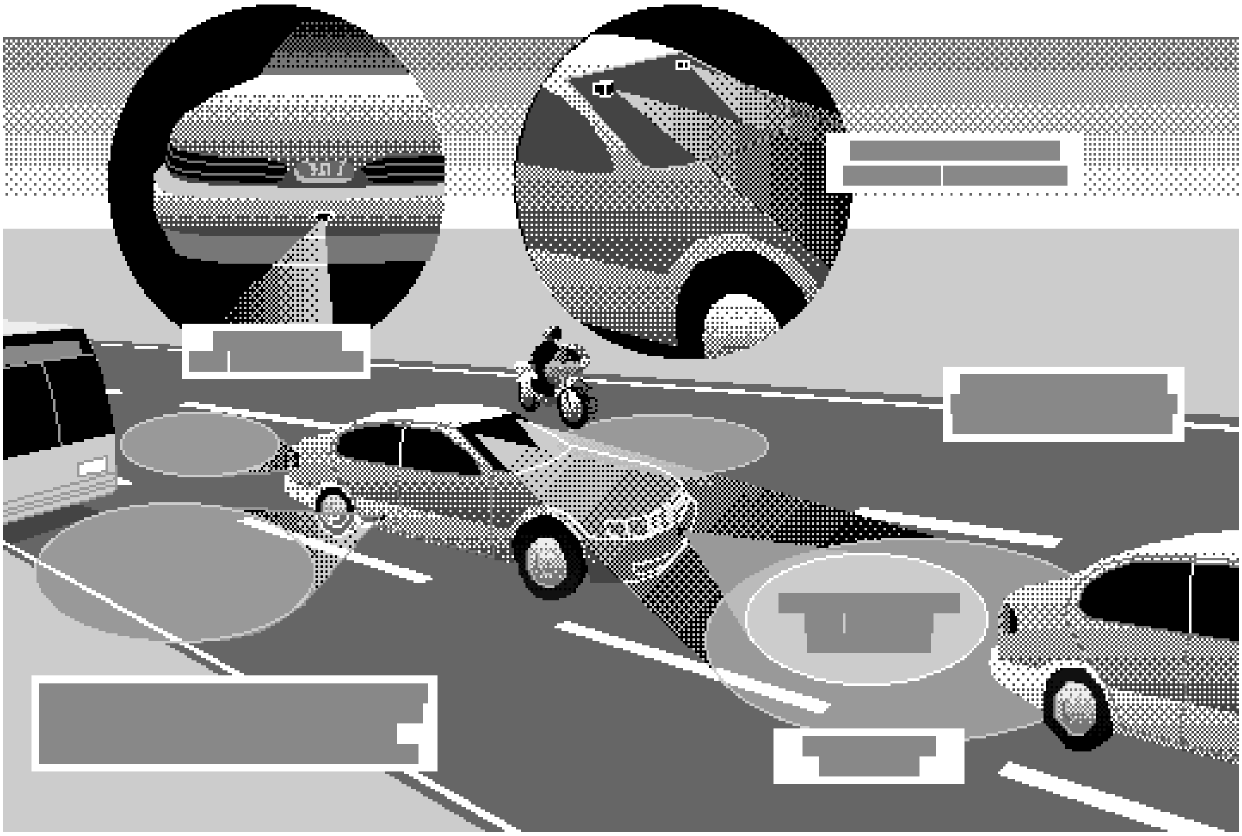
  **This technology is applied to devices which anticipate an imminent collision and activate passenger safety mechanisms prior to collision, based on details of vehicles and/or objects involved.**

Details can include velocity, mass, and direction of the vehicle and objects involved, as well as the number, location, and physical characteristics of any occupants. Responses include tightening lap-shoulder belts, arming and deploying air bags at an optimal pressure, deploying rollbars, and restraining wheelchairs.

- **Fully Automated Vehicle Operations**

  **Fully automates vehicles on instrumented facilities, significantly improving today's safety, efficiency, and comfort standards**.

Automated vehicle operations remain an ITS objective. Drivers could buy vehicles with the necessary instrumentation or retrofit an existing vehicle. Vehicles that are incapable of automated operation could continue to operate on conventional facilities for many years.



- **Transit, School Bus, and Commercial Operations**

**Initial research by Caltrans into vehicle control and vehicle automation has been in automobiles, primarily due to the lower cost of experimenting with autos as compared to buses or trucks.**

However, Caltrans recognizes that the early deployment of automation and automation technologies will probably need to be in transit and commercial operations.

This will be driven by the fact that the most economic deployment in the early stages will be in the transit and commercial area, due to the lower relative cost of instrumenting commercial vehicles when compared to private automobiles. Caltrans' vision includes a full-scale, evolutionary approach to automation of transit, school buses, and commercial vehicles.

The evolutionary approach involves taking early results from sensor studies, lateral and longitudinal control studies, and related automobile research, and adapting and evolving that into a series of bus and truck research projects. That research moves from instrumentation of large vehicles to driver assistance in the form of collision warning (both lateral and longitudinal), and then to simple driver assistance (such as lane keeping assistance) and finally to full automation. The same approach will be used for transit, school buses, and commercial trucks. The transit automation research will be fully coordinated with the "smart bus" research and experiments to provide an integrated, incremental approach leading to warning, then assistance, and eventually, perhaps full automation.

Commercial trucks will follow a similar path giving the driver and owner increasing driver assistance and automation, also coordinated with the "smart vehicle" research that includes weigh-in-motion, electronic permits and fee collection, and automated fleet management.

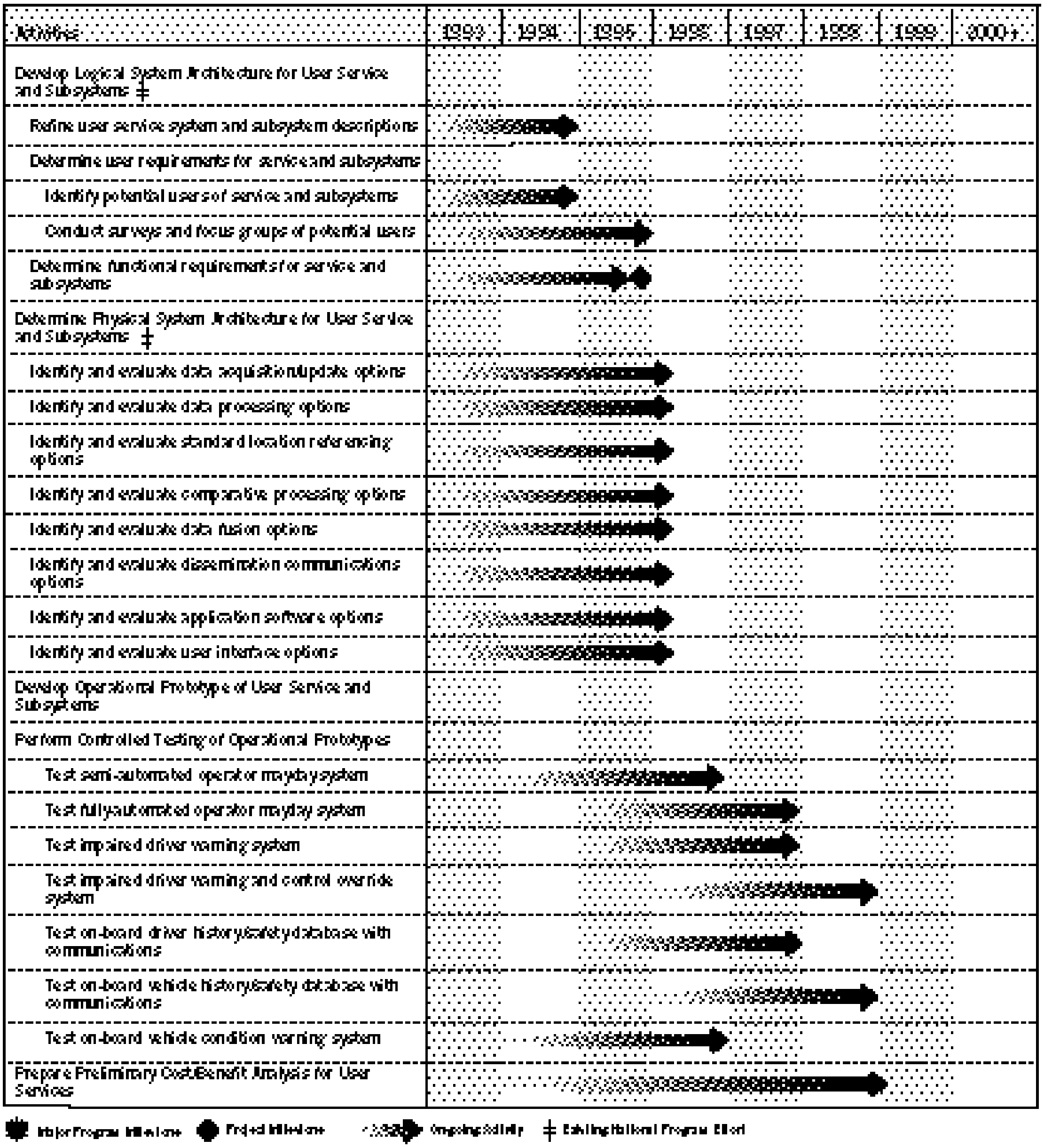
School bus automation will take a more conservative approach, with early research providing driver enhancements for both lateral and longitudinal collision warning, and fleet management, followed by partial automation of functions such as lane keeping. Full automation of school buses remains a topic that will require investigation to determine if it will be accepted because of the higher level of safety sensitivity involved with children on school buses. Technically, it is as feasible as transit automation, but public acceptance may evolve more slowly.

In all cases of transit, school buses, and commercial vehicles, the key is to build on automobile and other related research to develop an integrated, incremental approach, with each step adding features that will bring the commercial operators a clear advantage and return on investment. Features which may be salable on automobiles to the general driving public may not be marketable in the commercial arena unless there is a clear advantage to the commercial owner/operator.

## Advanced Vehicles

### Smart Vehicles - Activity Charts

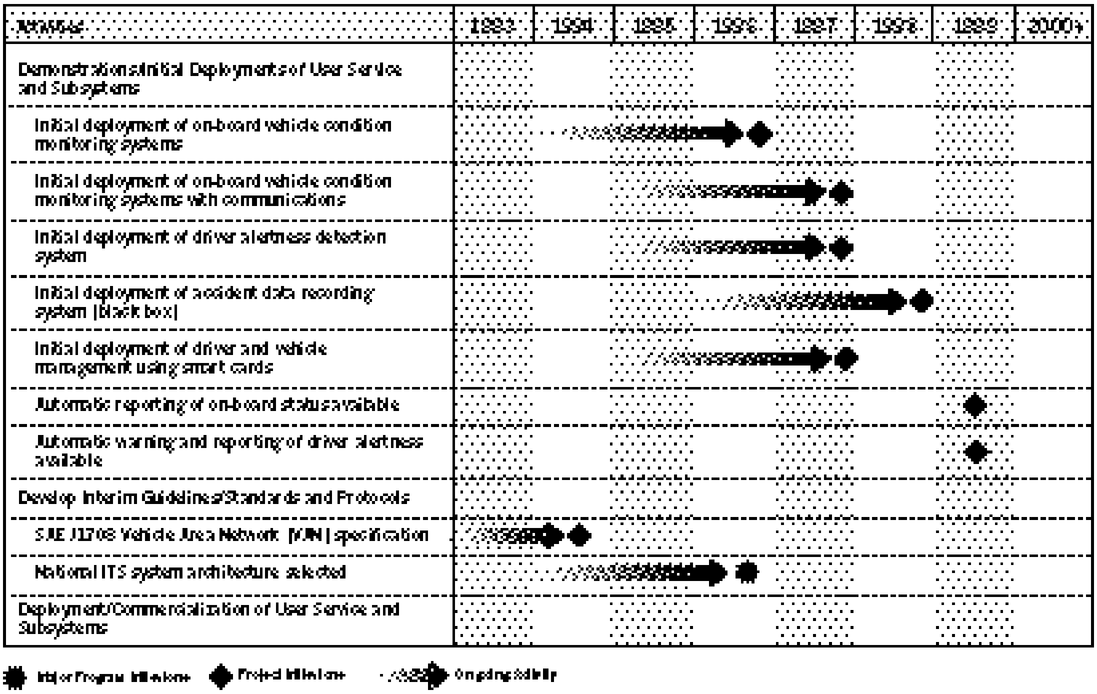
On-Board Safety Monitoring



## Advanced Vehicles

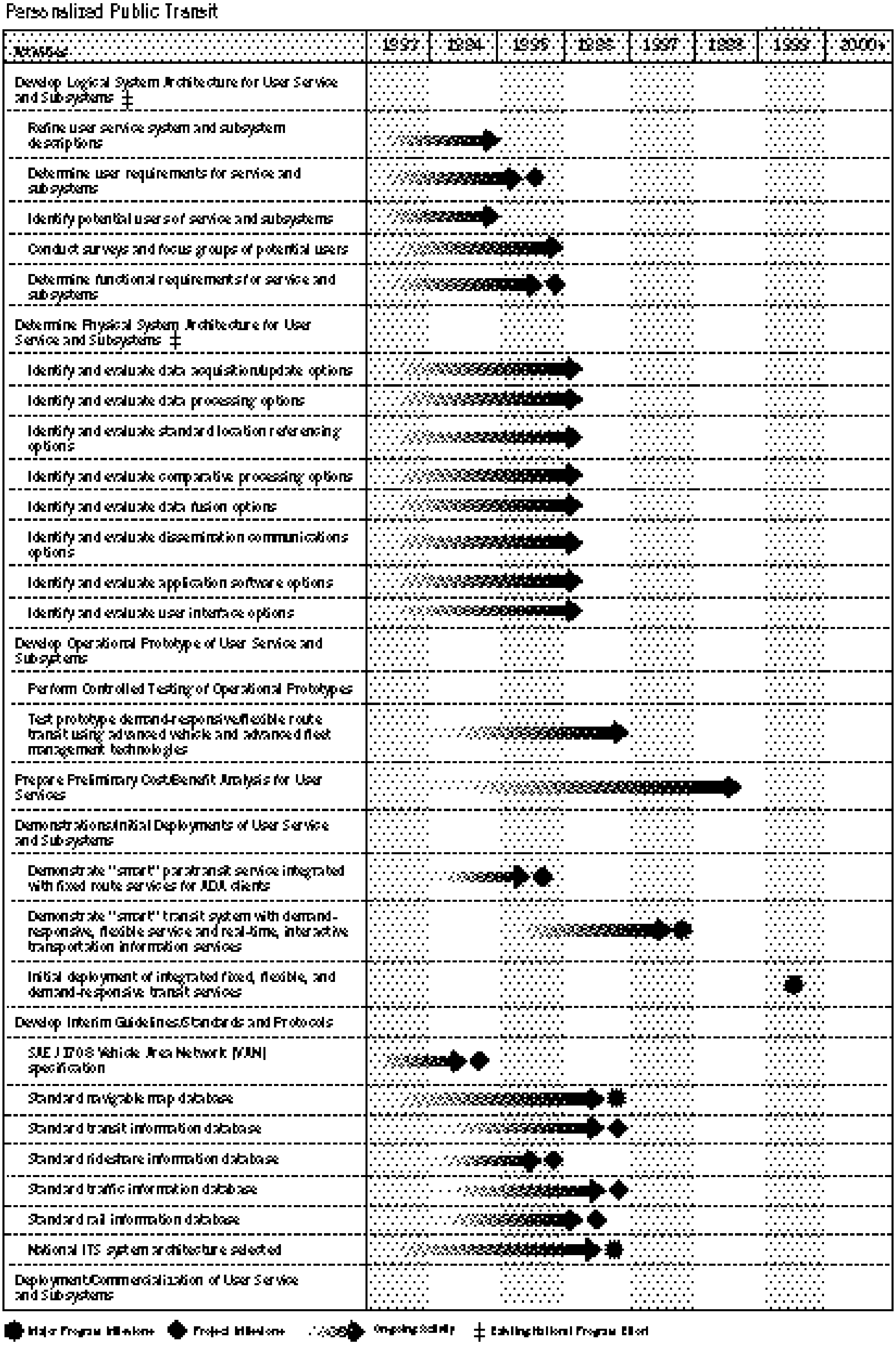
### Smart Vehicles - Activity Charts

On-Board Safety Monitoring cont'd



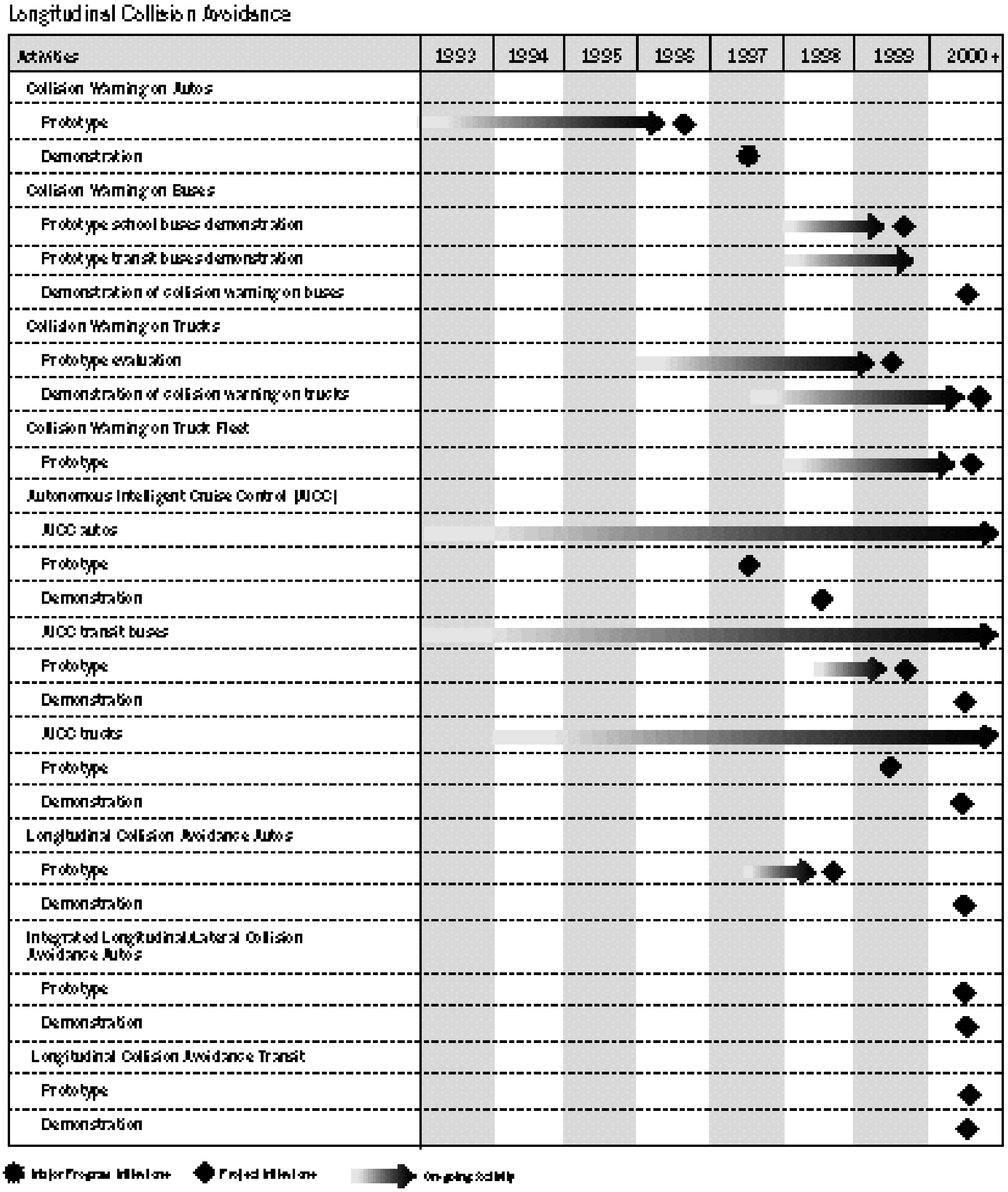
## Advanced Vehicles

### Smart Vehicles - Activity Charts



# Advanced Vehicles

## Smart Vehicles - Activity Charts



## Advanced Vehicles

### Smart Vehicles - Activity Charts

Longitudinal Collision Avoidance contd

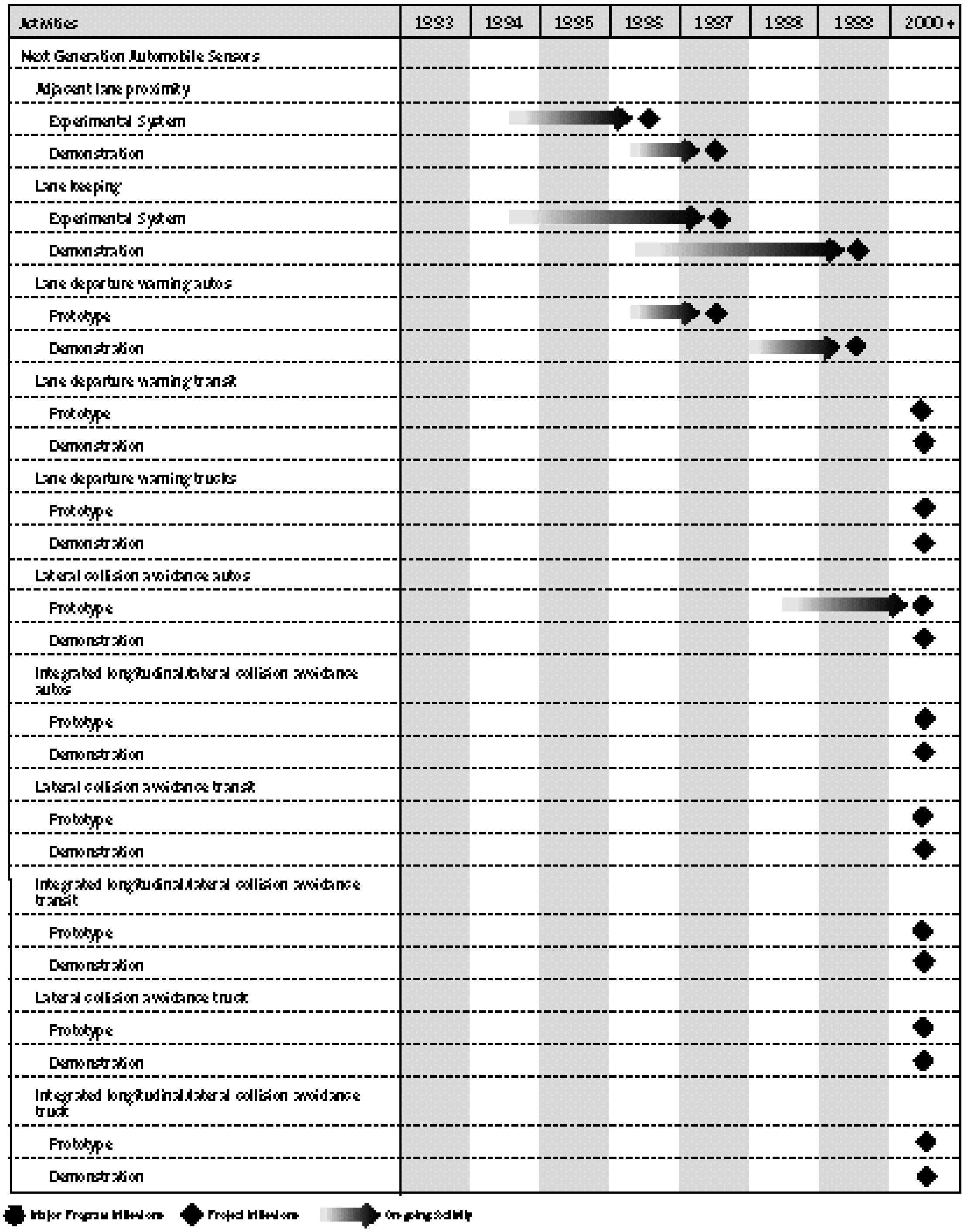
| Activities | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000+ |
|---|---|---|---|---|---|---|---|---|
| Integrated Longitudinal/Lateral Collision Avoidance Transit | | | | | | | | |
| Prototype | | | | | | | | ◆ |
| Demonstration | | | | | | | | ◆ |
| Longitudinal Collision Avoidance Truck | | | | | | | | |
| Prototype | | | | | | | ◆ | |
| Demonstration | | | | | | | | ◆ |
| Integrated Longitudinal/Lateral Collision Avoidance Truck | | | | | | | | |
| Prototype | | | | | | | | ◆ |
| Demonstration | | | | | | | | ◆ |

Major Milestone · Project Milestone · On-going activity

## Advanced Vehicles

### Smart Vehicles - Activity Charts

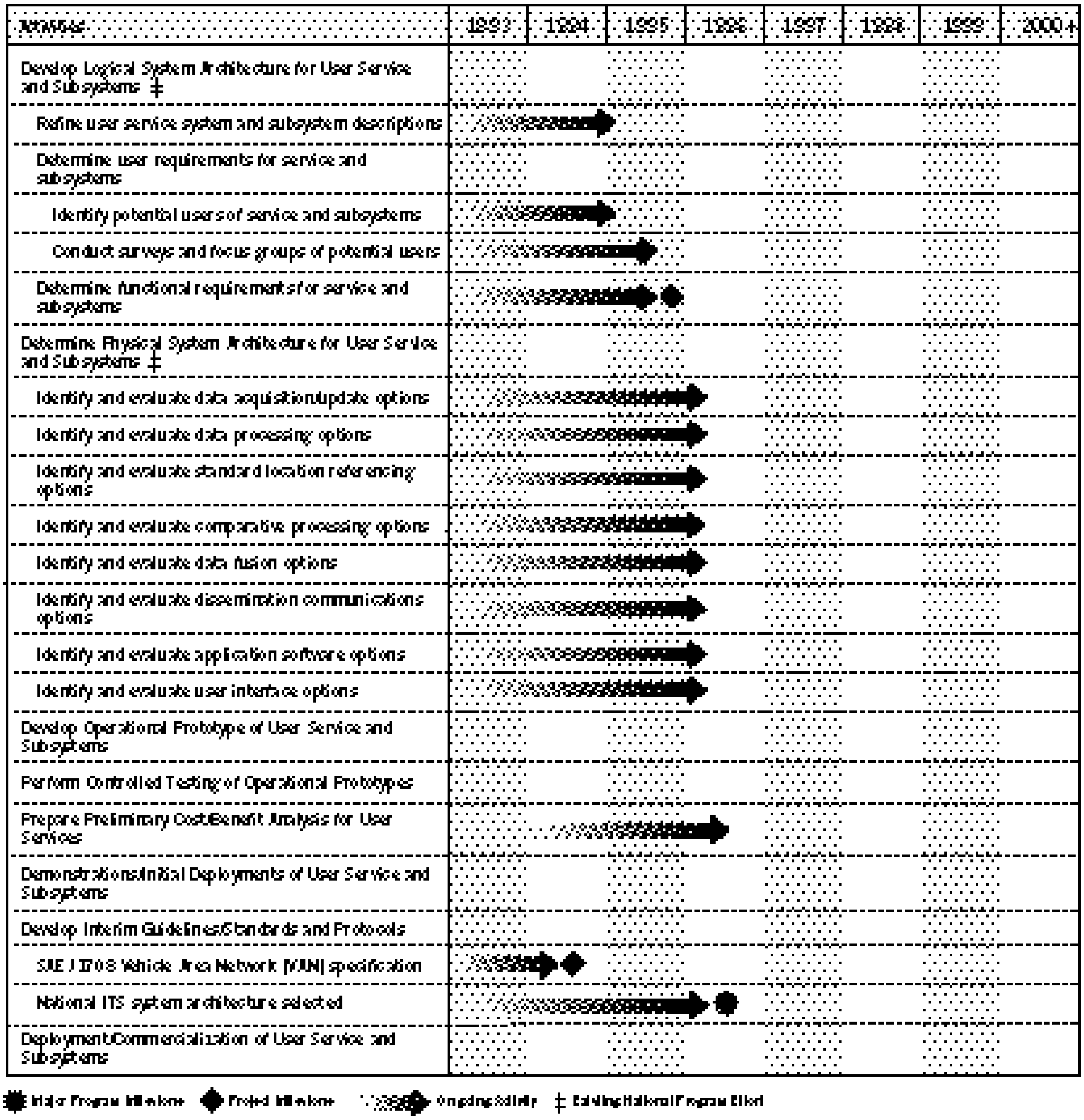
Lateral Collision Avoidance



**Advanced Vehicles**

## Smart Vehicles - Activity Charts

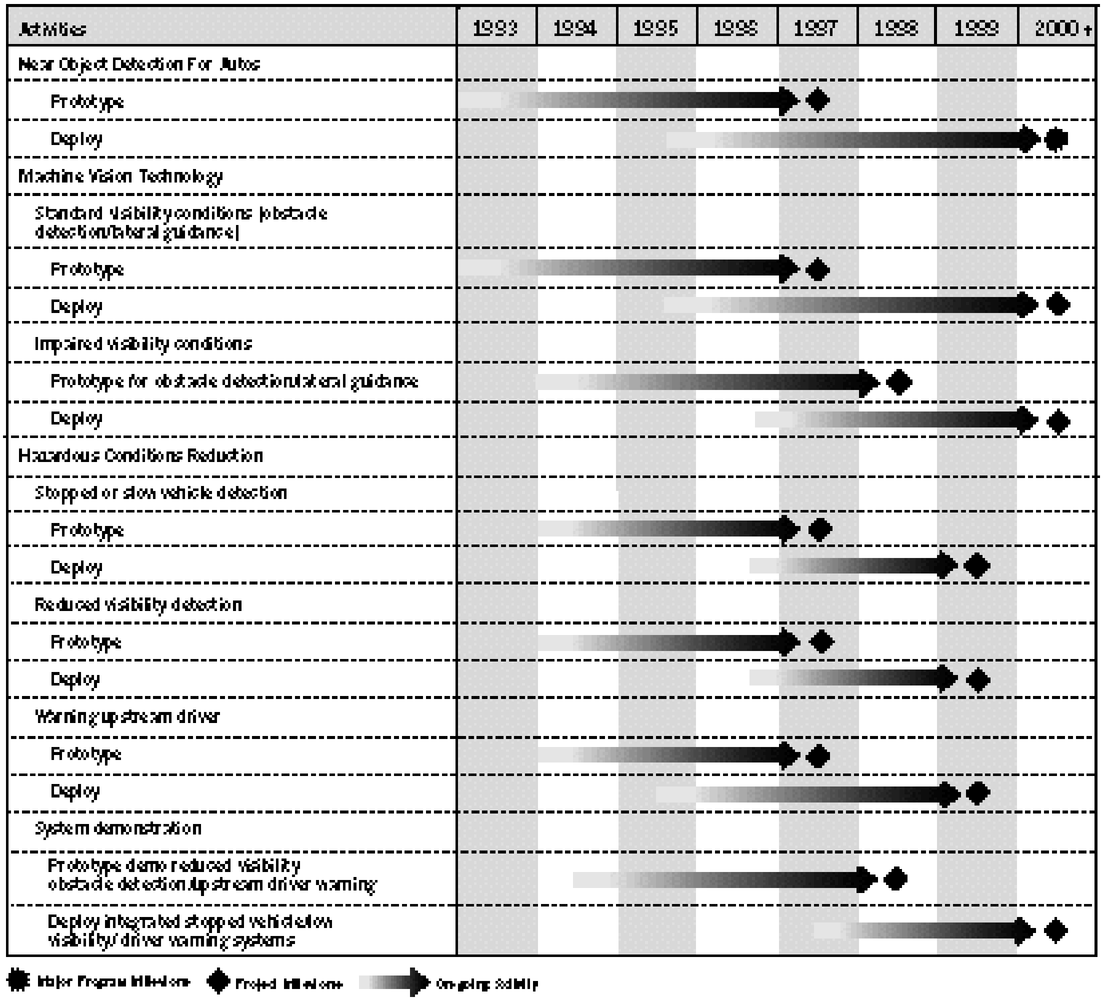
### Intersection Crash Warning and Control



## Advanced Vehicles

### Smart Vehicles - Activity Charts

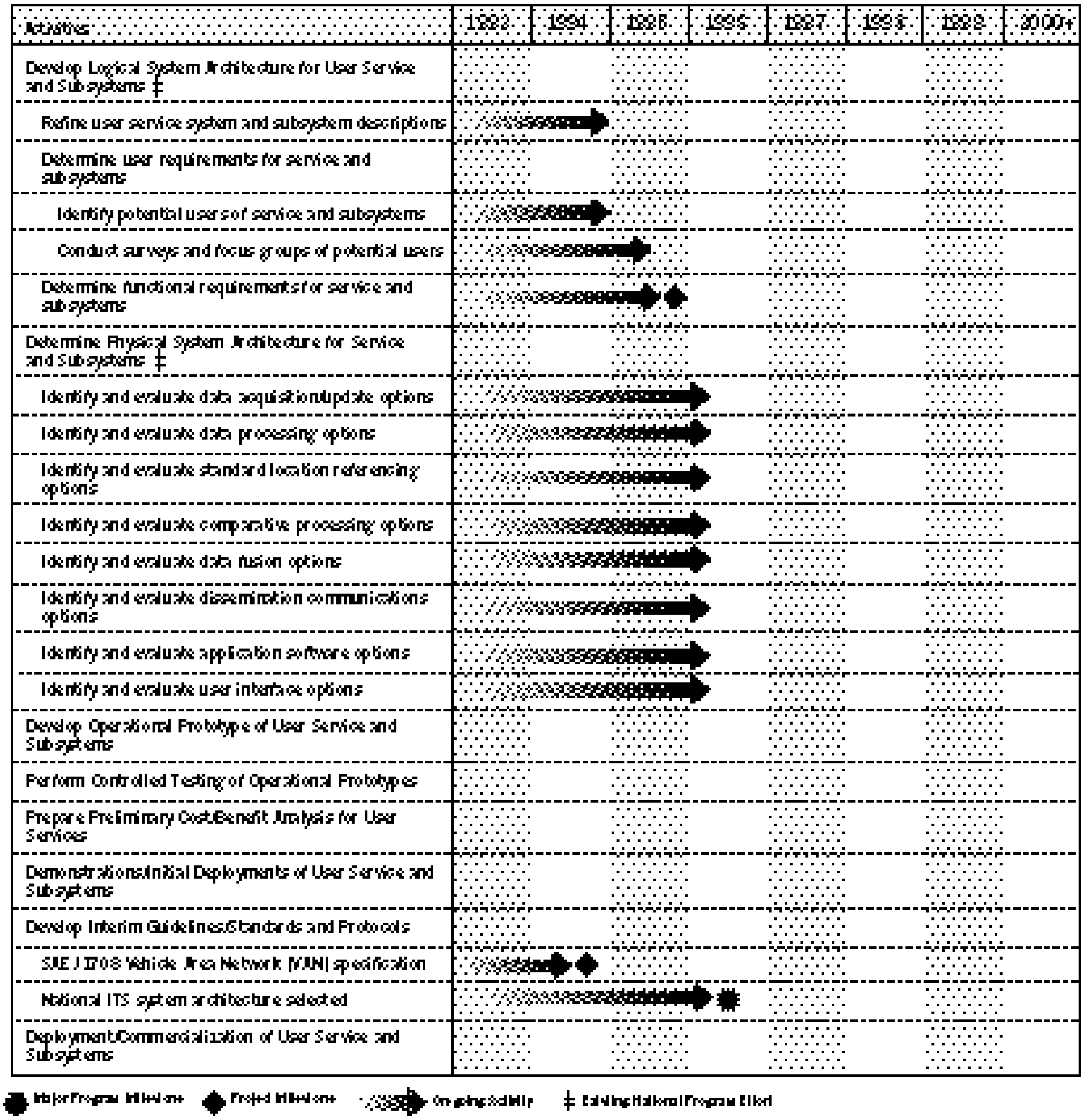
Vision Enhancements



## Advanced Vehicle

### Smart Vehicles - Activity Charts

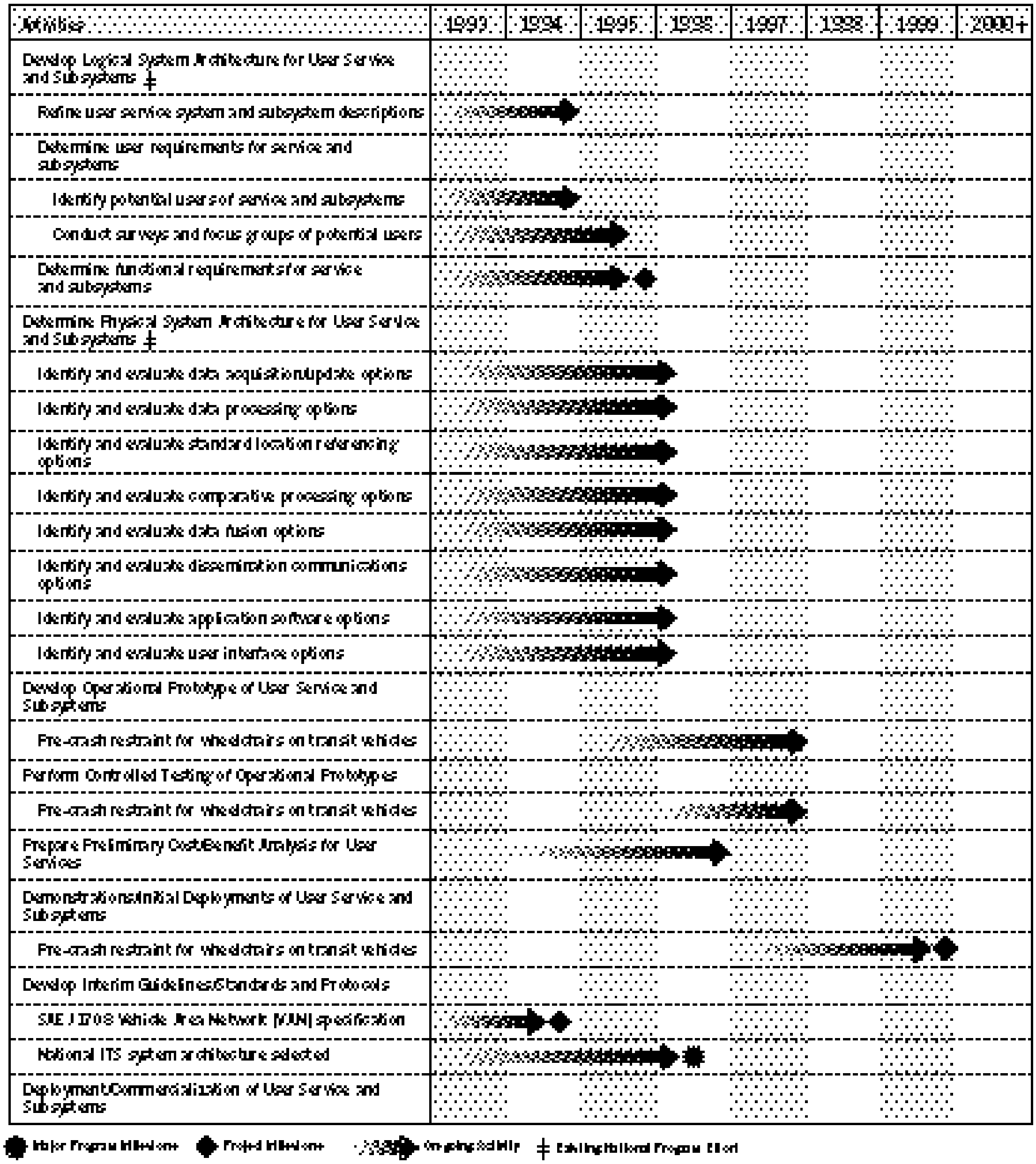
#### Impairment Alert



## Advanced Vehicles

### Smart Vehicles - Activity Charts

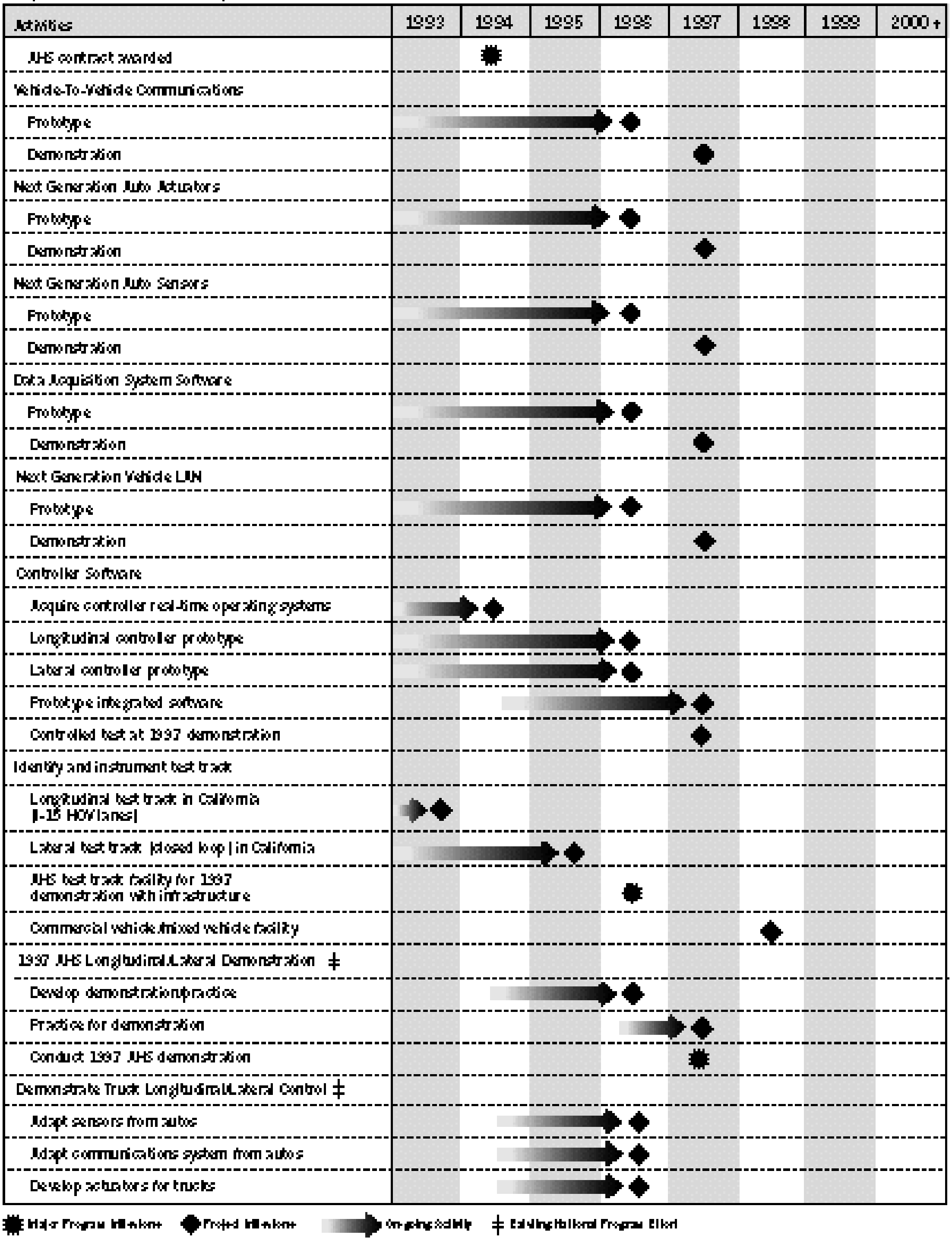
Pre-Crash Restraint Deployment



**Advanced Vehicles**

**Smart Vehicles - Activity Charts**

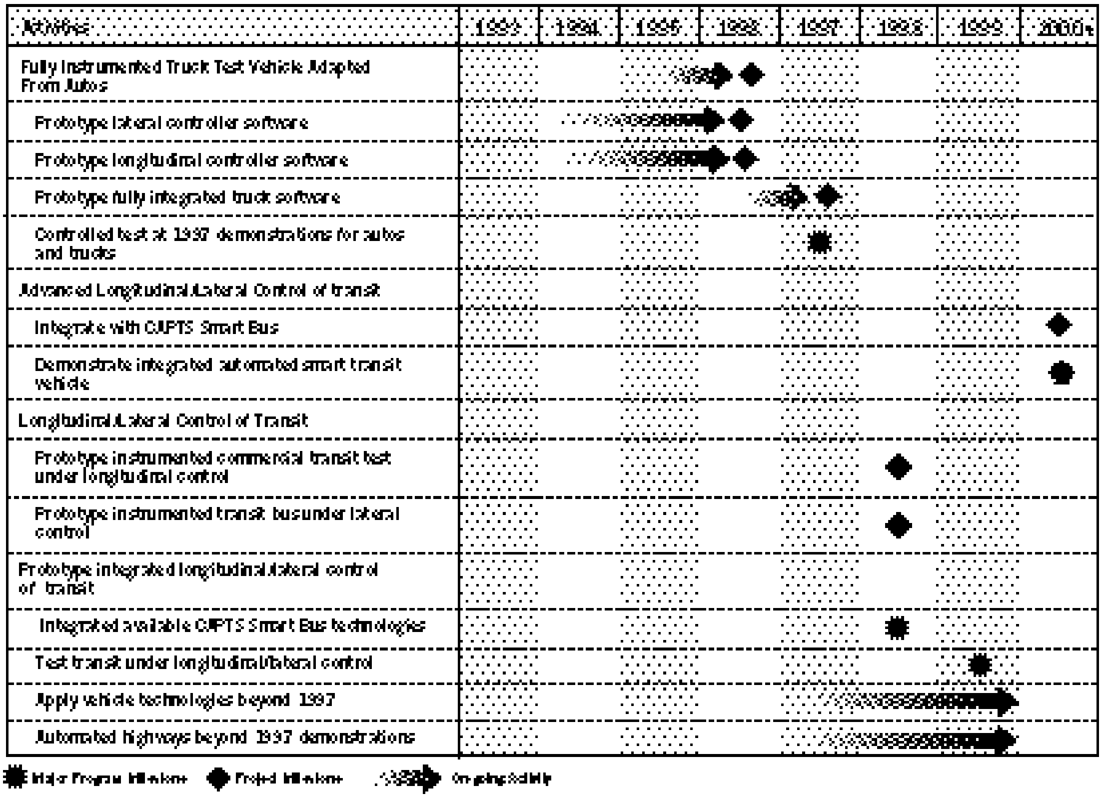
Fully Automated Vehicle Operations



## Advanced Vehicles

**Smart Vehicles - Activity Charts**

Fully Automated Vehicle Operations contd



## The Automated Highway System (AHS) Program

The ITS concept was developed to address the challenges of transportation system improvements which are required to meet the diverse needs of our mobile society. ISTEA (1991) Title VI, requires that "the Secretary of Transportation shall develop an automated highway and vehicle prototype from which fully automated intelligent vehicle highway systems can be developed. Such development shall include research in human factors to ensure the success of the man-machine relationship. The goal of this program is to have the first fully automated roadway or an automated test track in operation by 1997." The AHS development program is broadly structured into three phases:

- The Analysis phase;
- The Systems Definition phase; and
- The Operational Evaluation phase.

- **The analysis phase** was completed in November 1994, and the results were distributed to the interested stakeholder groups. This analysis phase will provide the analytical foundation for efforts to be conducted in the systems definition phase, which will include a human factors study analyzing key AHS requirements and issues; and, National Highway Traffic Safety Administration (NHTSA) sponsored collision avoidance-oriented vehicle warning and control services/devices which may evolve into an automated highway system.
- **The second, or systems definition phase** will identify system goals and identify, evaluate, and demonstrate selected AHS system concepts. Early products of this phase will be a Proof of Feasibility Demonstration in 1997 (mandated by ISTEA), a prototype demonstration in 2001, and a complete system specification and supporting documentation for the selected AHS configuration in 2002. The systems definition phase contract was awarded on October 7, 1994, to the National Automated Highway System Consortium (NAHSC) led by General Motors. The NAHSC consists of teams from Bechtel, Caltrans, Carnegie Mellon University, Delco Electronics, General Motors, Hughes Aircraft, Lockheed Martin, Parsons Brinckerhoff, the PATH Program, and the Mitre Corporation, which represents the Federal Highway Administration (FHWA). The seven-and-a-half year contract totals $200 million, with $160 million from FHWA and $40 million as cost sharing from the core participants. Funding is approved by Congress on a year-by-year basis.
- **The third, or operational evaluation phase**, will operationally evaluate one or more AHS implementations, with public participation. To be successful, the AHS must address and adequately resolve such issues as surface street capacity and gridlock. Simply adding a new source of vehicles to already overcrowded urban areas is not an acceptable alternative. Consortium teams are already working to include such items as full coordination with local and regional traffic management and planning agencies to insure these problems are dealt with in a satisfactory manner. The ultimate solution will include full coordination of all traffic management strategies.

**Caltrans is actively working in partnership with other state and federal organizations, academia and private industry to research and develop advanced technologies that will be applied and demonstrated on an AHS.**

## Advanced Vehicles

### Smart Vehicles - Project Highlights

Caltrans is fully committed to the AHS Program and anticipates active involvement in all three phases.

As a core member of the NAHSC, Caltrans has the unique privilege of representing the state and local highway operators stakeholder group. Additionally, Caltrans has the lead role for the consortium's test and demonstration activities. To support this role, Caltrans has one full-time system engineer in the NAHSC Program Office as the Test and Demonstration Coordinator. This engineer directs all activities related to testing of vehicles and technologies, the selection of all test facilities, and the planning and execution of the 1997 Proof of Feasibility Demonstration.

Caltrans participation in the NAHSC includes ten full-time staff engineers working on the various teams and tasks. The test and demonstration team is working to develop the I-15 reversible HOV lanes in San Diego as the site for the 1997 demonstration. Caltrans is the lead partner for this activity and heads all tasks related to tests and demonstrations, both from the New Technology and Research Program and from the NAHSC Program Office. Bringing the 1997 demonstration to California will provide an ideal "real world" facility for this demonstration, not just a closed loop "test track." Using this facility will allow for needed testing of advanced lateral and longitudinal control in a real world environment, and will accommodate ongoing testing as the state of the art develops.

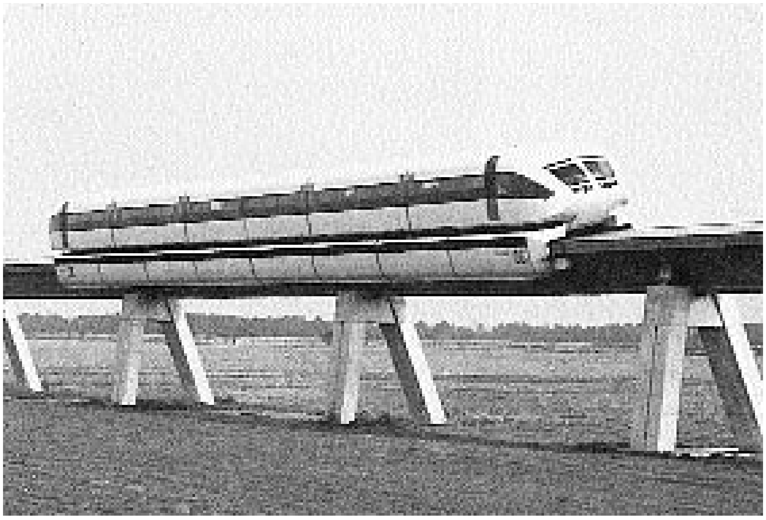
Caltrans also has major roles on the System Engineering; Canvassing and Outreach; Societal and Institutional Issues; Technology Assessment; Concept Development, and Business teams. Caltrans involvement on the Societal and Institutional issues team is particularly critical to insure proper assessment and development of the plans to address legal, environmental, land use, growth, and traffic management issues.

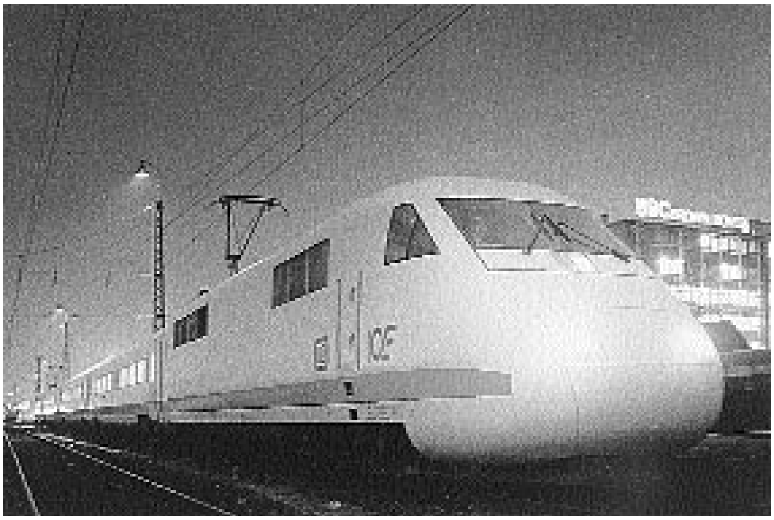
In addition to the full-time staff personnel in the New Technology and Research Program, Caltrans is drawing upon expertise from Traffic Operations, Central Design, and District 11 to perform various tasks. Of particular importance are the Caltrans District 11 personnel directly involved in the day-to-day operation of the I-15 HOV facility.

### High-Speed Ground

The California passenger rail situation poses a unique challenge for locomotive and system designers. The general topography of the state consists of a series of valleys ringed by mountainous terrain. While high speed is needed, because intercity distances are great, especially along the San Francisco-Los Angeles line, the locomotive must also be able to climb. The Tehachapi “grapevine” section north of Los Angeles poses a challenge to any high/super-speed ground system. To avoid costly tunnels or time-consuming route circuity, it is preferable that the locomotive developed could climb five percent, or possibly greater, grades.

Existing high-speed rail systems are capable of traversing five percent grades with minor modifications to existing power units, but climbing grades in excess of five percent would require development of new kinds of locomotives and/or related systems. By conducting research and development, there is a good possibility that California products could be used. The recommended processes would result in creating new California High-Speed Ground Transportation (HSGT) suppliers while generating many blue- and white-collar high tech job opportunities. Once tested and proven, California-built equipment could be operating on selected California high-speed ground transportation corridors, as well as in corridors nationwide and internationally.





**Advanced Vehicles**

**Alternative Vehicles - Scope**

## Air Transportation

Air transportation is another element of the ATS Program. The need for improvements in the air transportation systems in California and elsewhere is widely recognized. Deregulation has resulted in many changes in the transportation system, including shifts in traffic between modes, changing patterns of service, and increased dominance by major carriers. Many transportation problems and challenges are evident, such as deteriorating and inefficient ground access, inadequate system capacity, increasing congestion, international competition, lack of public and private sector response to problems, environmental impacts, dependence on imported fuels, economic opportunity losses, and a lack of an overall systems analysis approach. While at the same time, these changes and the need to respond to the growing problems create opportunities for technological innovation.

To effectively utilize new developments and respond to future opportunities, the ATS Program established a collaborative Air Transportation Research Center (ATRC) at the University of California's Institute for Transportation Studies, at Berkeley. The combined strengths of Caltrans and the university permit a coordinated systems approach to air transportation problems. The ATRC is a cooperative activity to enhance Caltrans' role in aviation and the mitigation of aviation related congestion. An additional purpose of the ATRC is to bring together partners to leverage private and public funds. The ATRC has addressed complex air transportation issues needed to make decisions, such as improving the management of ground access and intermodal transfers, increasing passenger and freight air travel, improving air quality, and facilitating economic development.

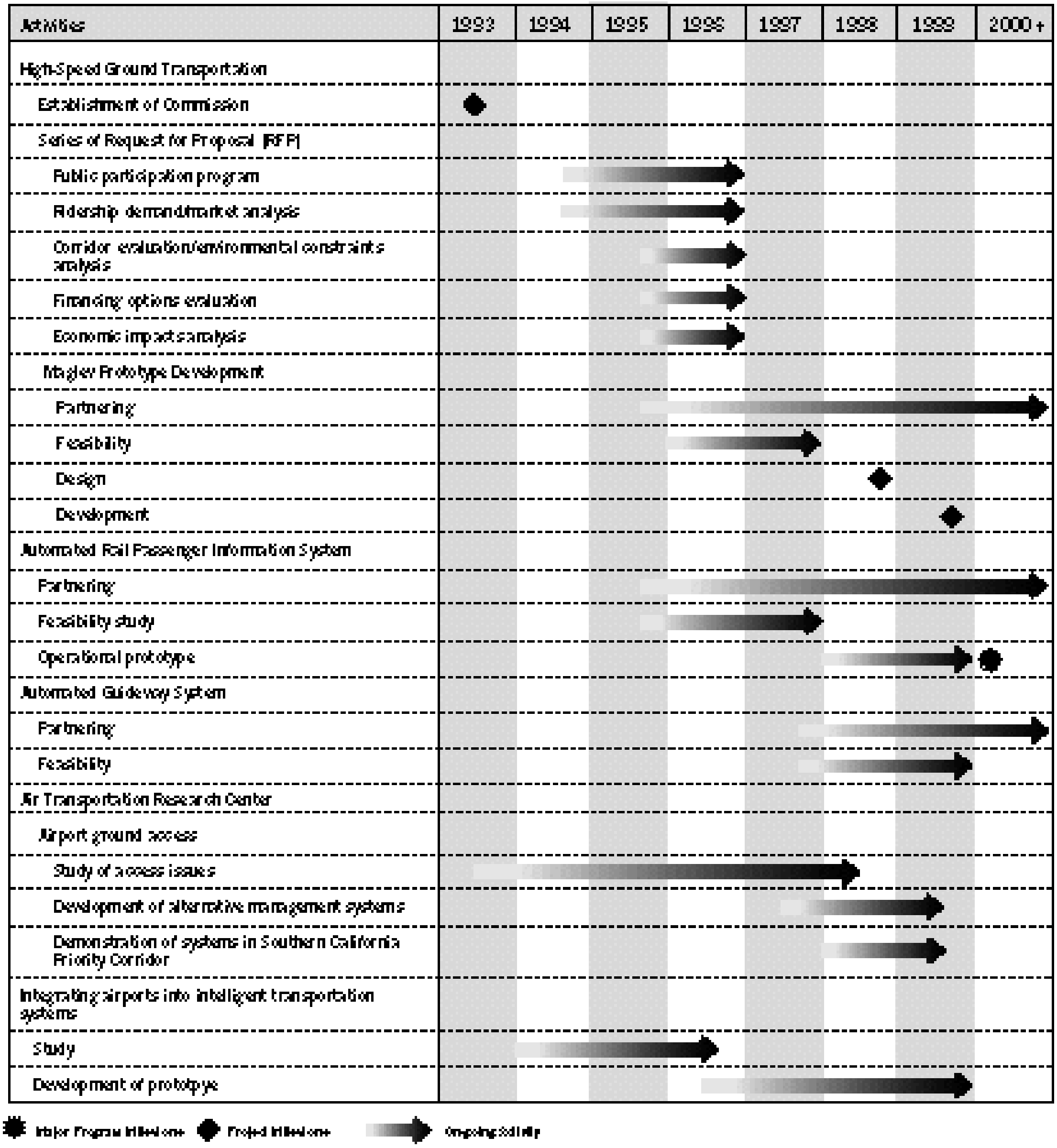
As the air transportation system continues to change, the ATRC agenda changes with it. Growth in air traffic is leading to increasing levels of congestion and delay. Extensive efforts are also being made on the land side of airport operations to utilize new communication and information technologies that will assist travelers, as well as managers of the airport facilities.

New aircraft types and concepts are being proposed, and extensive efforts are being made to increase the levels of automation in the air traffic control system and utilize new sensor, guidance, and communication technologies. Effective utilization of these new developments and those to come will provide Caltrans an opportunity to expand its research and development role in air transportation while working cooperatively with the Federal Aviation Administration, and NASA-Ames.

## Advanced Vehicles

### Alternative Vehicles - Activity Charts

High-Speed Ground & Air



**Advanced Vehicles**

**Alternative Vehicles - Project Highlights**

### California High-Speed Ground Transportation

On March 30, 1993, Governor Pete Wilson issued Executive Order W-48-93 establishing an Intercity High-Speed Ground Transportation (HSGT) Task Force. Subsequent to the Governor's Executive Order, the Legislature approved SCR (Senate Concurrent Resolution) 6 (Resolution Chapter 56/93) requesting the Governor to establish a nine-member Intercity High-Speed Ground Transportation Commission. SCR 6 requests that Caltrans, under the direction of the High-Speed Ground Transportation Commission, develop a 20-year high-speed ground transportation plan. SCR 6 also states that by year 2020 a high-speed ground transportation service should be operating between Sacramento, the San Francisco Bay Area, the Los Angeles area, San Bernardino/Riverside, Orange County and San Diego. SCR 6 stipulates that the Los Angeles to San Francisco Bay Area Corridor shall be the first corridor developed and that construction shall begin by 2000.

The department is working to develop the most feasible and effective plan for implementing HSGT in California. In concert with the Governor's Executive Order and SCR 6, Caltrans selected the Los Angeles to San Francisco Bay Area Corridor, with future expansions to San Diego, Orange County, Sacramento and Riverside/San Bernardino (Corridor) as its primary focus. This corridor is one of the most heavily traveled corridors in the United States; is considered one of the most viable candidates for a HSGT system; and has been designated as one of the five high-speed rail corridors in the United States by USDOT.

ISTEA legislation defined research agendas for both high-speed rail and maglev in an attempt to solve intercity transportation problems and to develop America's capability to supply products for possible corridors. Federal funding was also made available for selected high potential high-speed corridors. The San Diego-San Francisco Corridor was identified as one of five to start the incremental upgrade of existing rail routes to provide for safe high-speed rail grade crossings.

Since ISTEA was enacted into law, the federal government has appropriated less funding than authorized for the high-speed rail and maglev programs. The administration, however, is proposing to create a transportation infrastructure investment program that would include $1 billion in discretionary funds that states could use for high-speed rail. USDOT is also recommending an additional $35 million for high-speed rail research and development for fiscal year 1995-96 under the Next Generation High-Speed Rail Program.

Against this background, the California Intercity High-Speed Rail Commission continues to examine the feasibility of a high speed rail system (including the option of maglev) in California. As part of its examination, the Commission has authorized the preparation of four important studies.

They are:

- Corridor Evaluation and Environmental Constraints Analysis
- Ridership Demand/Market Analysis
- Economic Impacts Analysis and Mode Cost Comparison
- Institutional Analysis and Financing Options Evaluation

The fourth study, Institutional Analysis and Financing Options will include insight into proposed federal funding of high-speed rail programs after 1997. In addition, it would include models for entering into successful public/private partnerships.

The final plan should be completed by the end of calendar year 1996.

# TRANSPORTATION MANAGEMENT SYSTEMS

## Multimodal Traffic Management

- *Incident Management*
- *Travel Demand Management*
- *Traffic Control*
- *Electronic Payment Services*
- *Public Travel Security*
- *Emergency Notifications and Personal Security*

## Advanced Fleet Management

- *Automated Roadside Safety Inspection*
- *Public Transportation Management*
- *Commercial Fleet Management*
- *Commercial Vehicle Preclearance*
- *Commercial Vehicle Administrative Processes*
- *Emergency Vehicle Management*

## Intermodal Facilities

**Transportation Management Systems is a package of technologies that enables the integration of freeway and surface arterial operations so that travel corridors and areas can be efficiently managed and will enhance communications for commercial vehicle operations.**

**The milestones, scope of services, activities and specific project highlights for Transportation Management Systems are discussed on the following pages.**

# Transportation Management Systems

| 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|
| California Specification - AVI | | Electronic Toll Collection Deployment | Advanced Transit Fleet Management Demonstration | Real-Time Adaptive Traffic Control Demonstration | Multimodal TMC Demonstration |
| | | “Smart Corridor” Demonstration | National ITS System Architecture Selected | HOV Route Guidance Test | Public Travel Security Demonstration |
| | | ATMS Test Bed Established | Prototype HOV - TMC Interaction | Emergency Notification (Mayday) Demonstration | |
| | | H.E.L.P. Implementation | Guidelines for Navigable Map Database | | |
| 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |

## Transportation Management Systems

**Multimodal Traffic Management — Scope**

Transportation Management Systems - Multimodal applications can be defined in these user services terms:

- **Incident Management**

  **Helps officials quickly identify incidents and implement a formalized set of procedures to minimize impacts on the transportation system.**

Incident management will also help schedule or forecast predicted incidents to minimize impacts. Predicted incidents include road construction and maintenance, road closures, and certain severe weather conditions. Verification and response activities apply to both predicted and unpredicted incidents once they occur. Incident management will support the development and implementation of appropriate response actions including changing traffic control. In some cases, where incident management is closely integrated with other user services, automation will improve the speed and effectiveness of responses.

- **Travel Demand Management**

  **Supports policies and regulations such as the 1990 Clean Air Act.**

The act requires employers with over 100 employees in designated areas of severe or extreme ozone pollution to implement a travel demand management program. The concept includes:

- Reducing the number of single-occupancy vehicles commuting to work;
- Increasing the use of high-occupancy vehicles for selected user group markets;
- Mitigating the impact of highly polluting vehicles; and,
- Providing a wide array of mobility options.

Government and private industry can use travel demand management dynamically, depending on congestion and pollution conditions in a given area, at a given time. Applications include enforcing HOV lane use, parking control, and road access pricing and prioritization schemes.

- **Traffic Control**

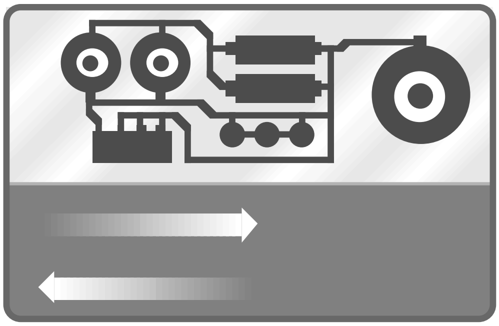
  **Manages the movement of traffic on the transportation system.**

Traffic control services optimize and coordinate freeway and signalized street operations with public transportation operations to balance demand with capacity within the transportation system. In its more advanced forms, preferred treatment can be given to high-occupancy vehicles through traffic signal and adaptive traffic control.

- **Electronic Payment Services**

  **Allows travelers to pay for transportation services with electronic cards or tags.**

The goal is to provide travelers with a common electronic payment medium for all transportation modes and functions including tolls, transit fares, and parking. A common service fee and payment structure, employing multi-use SmartCards, could integrate all modes of transportation, including roadway pricing options.



- **Emergency Notification and Personal Security**

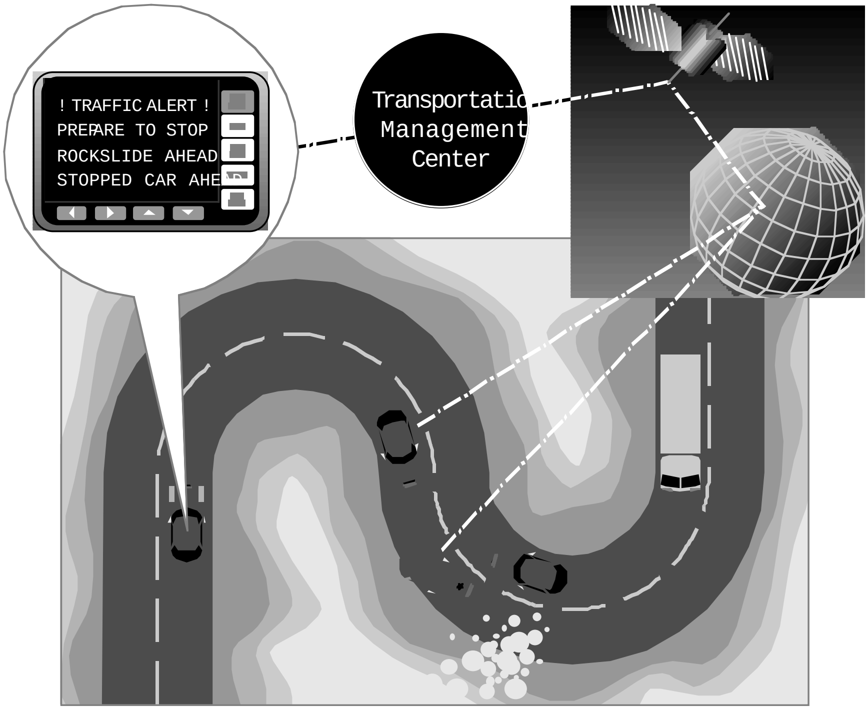
  **Provides immediate notification of an incident and immediate request for assistance.**

Emergency notification and personal security includes two capabilities: driver/personal security, and automatic collision notification. Driver and personal security capabilities provide for user initiated distress signals for incidents like mechanical breakdowns and carjackings. The message will include vehicle location and the receiver will send an acknowledgment signal back to the user. Automatic collision notification identifies a collision and automatically sends information regarding location, nature, and severity to emergency personnel.

- **Public Travel Security**

  **Creates a secure environment for public transportation patrons and operators.**

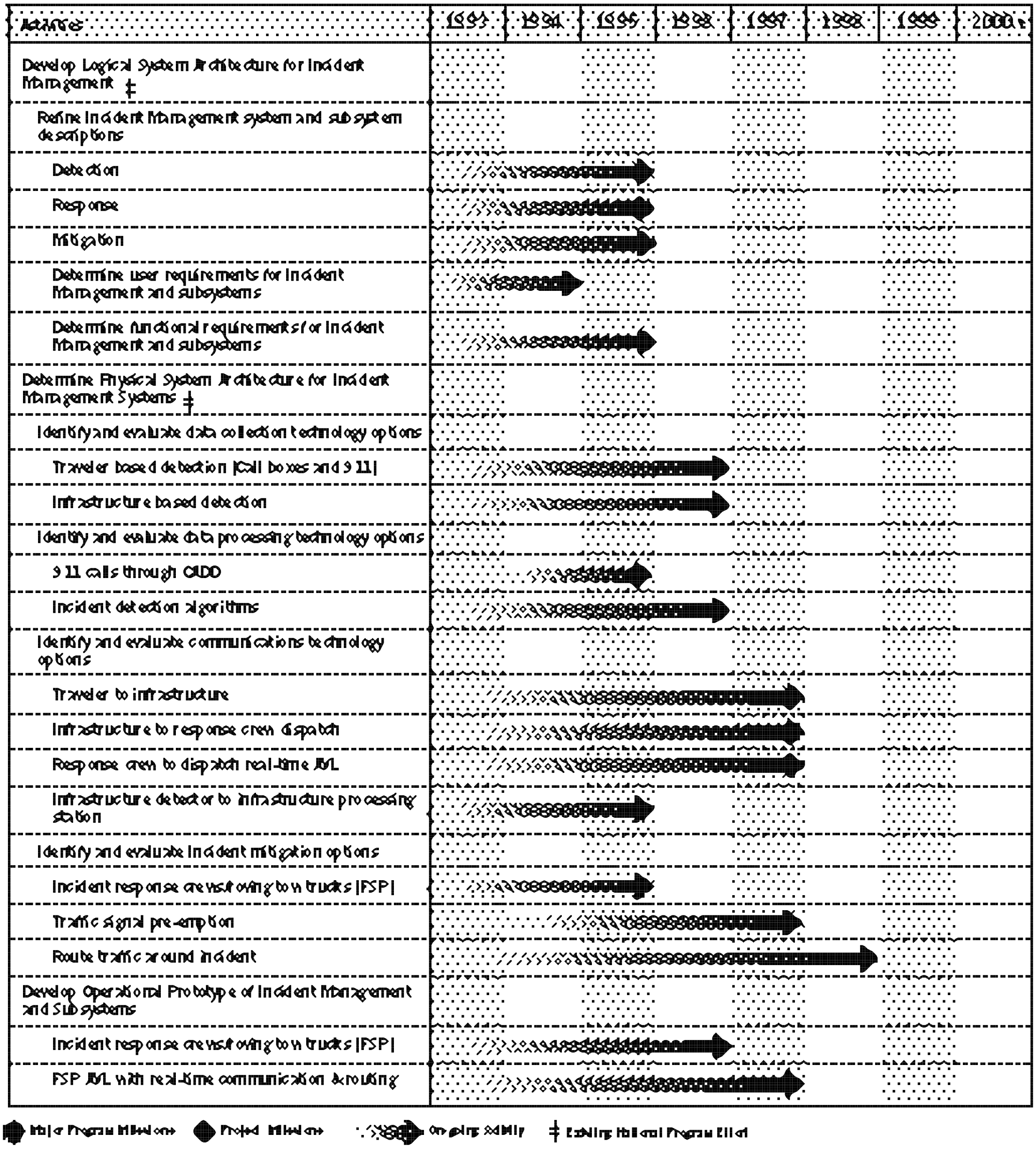
The automobile separates its passengers from the surrounding environment and provides a perception of security and personal control. Public transportation users must trust control of their environment to the operator and local police.



## Transportation Management Systems

### Multimodal Traffic Management — Activity Charts

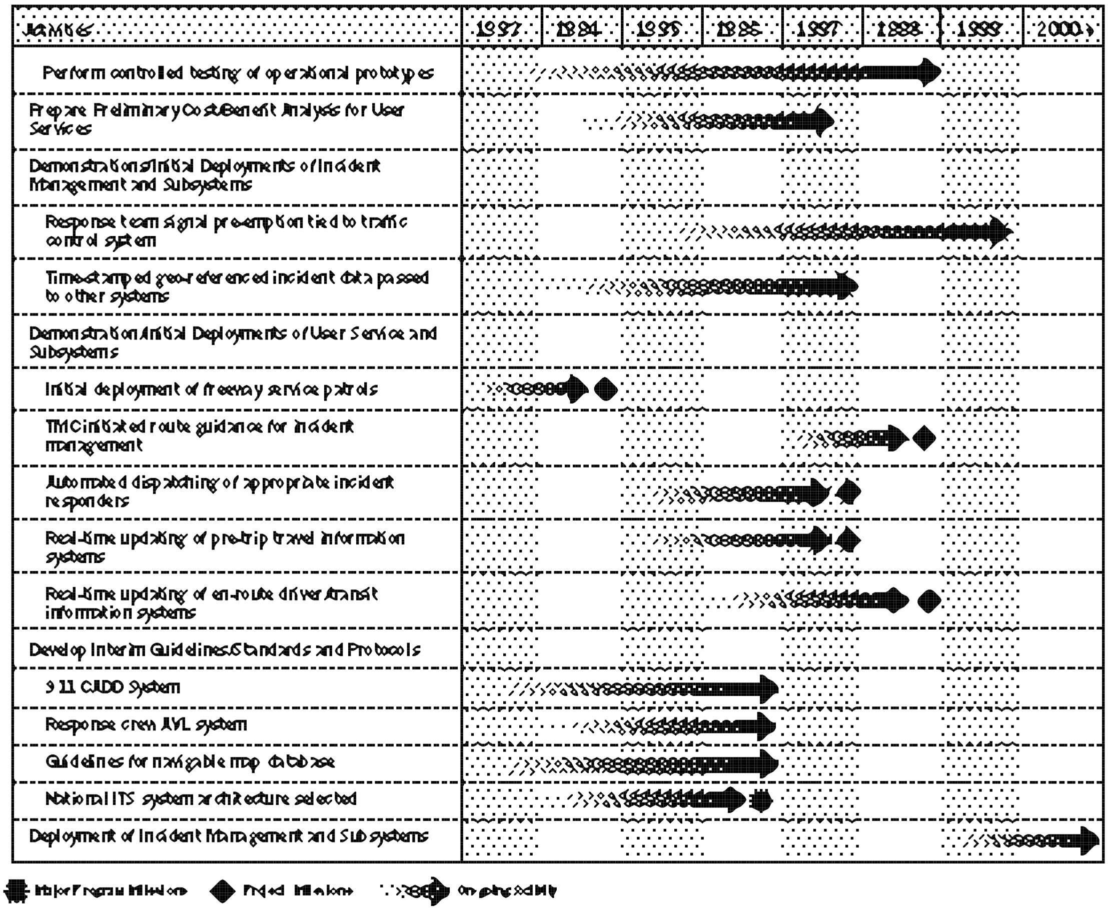
Incident Management



## Transportation Management Systems

### Multimodal Traffic Management — Activity Charts

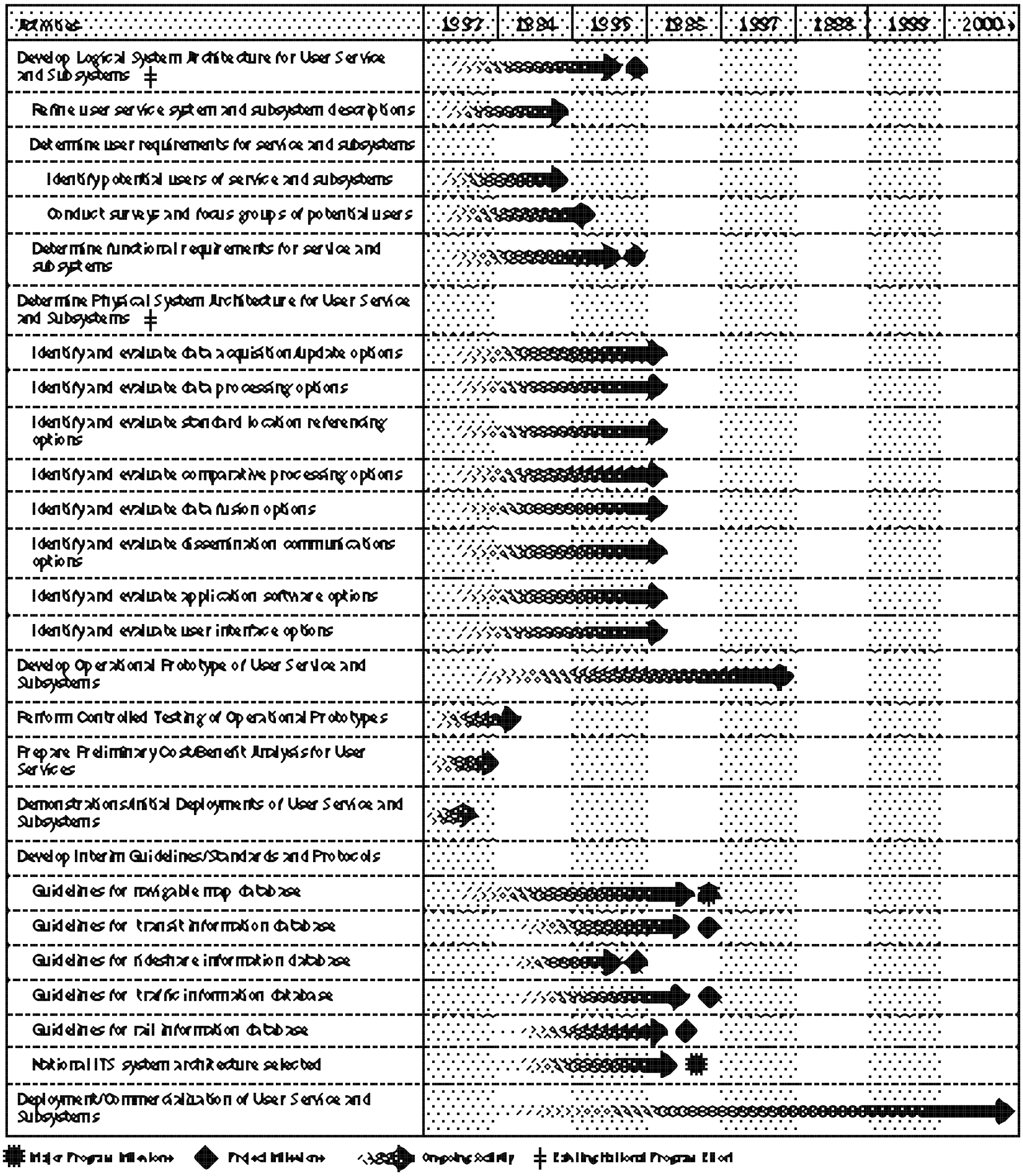
Incident Management contd



## Transportation Management Systems

### Multimodal Traffic Management — Activity Charts

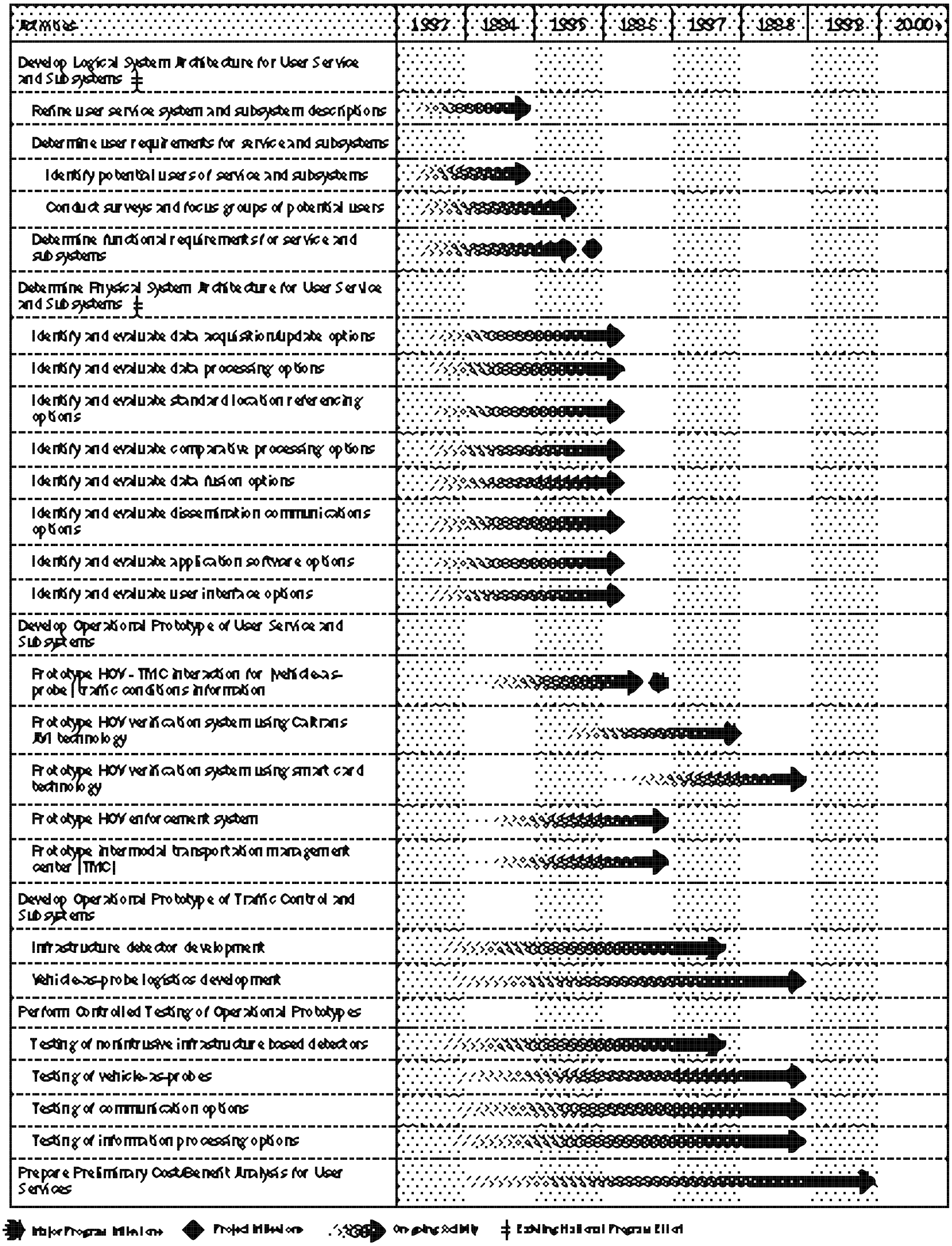
Travel Demand Management



**Transportation Management Systems**

**Multimodal Traffic Management — Activity Charts**

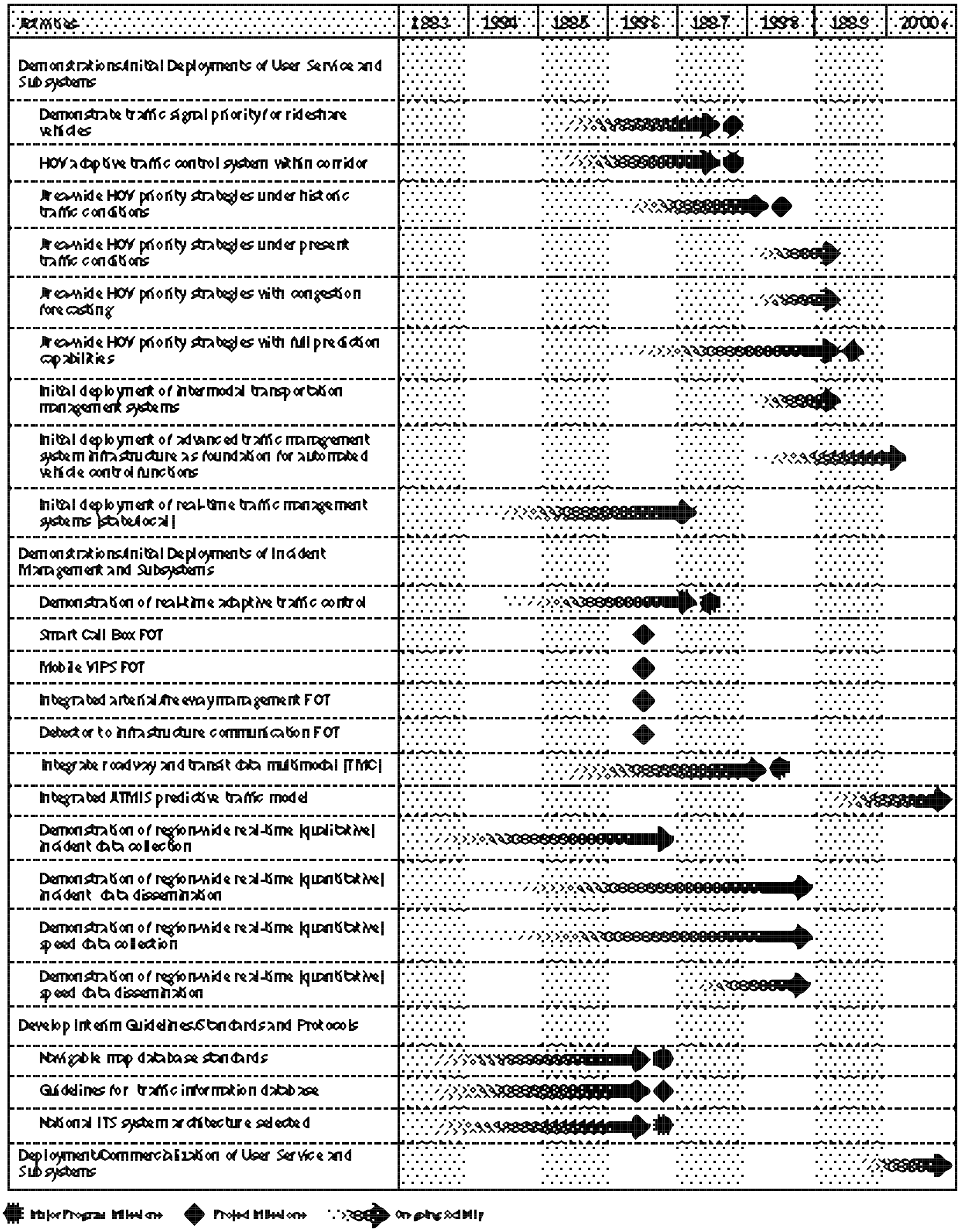
## Traffic Control



# Transportation Management Systems

## Multimodal Traffic Management — Activity Charts

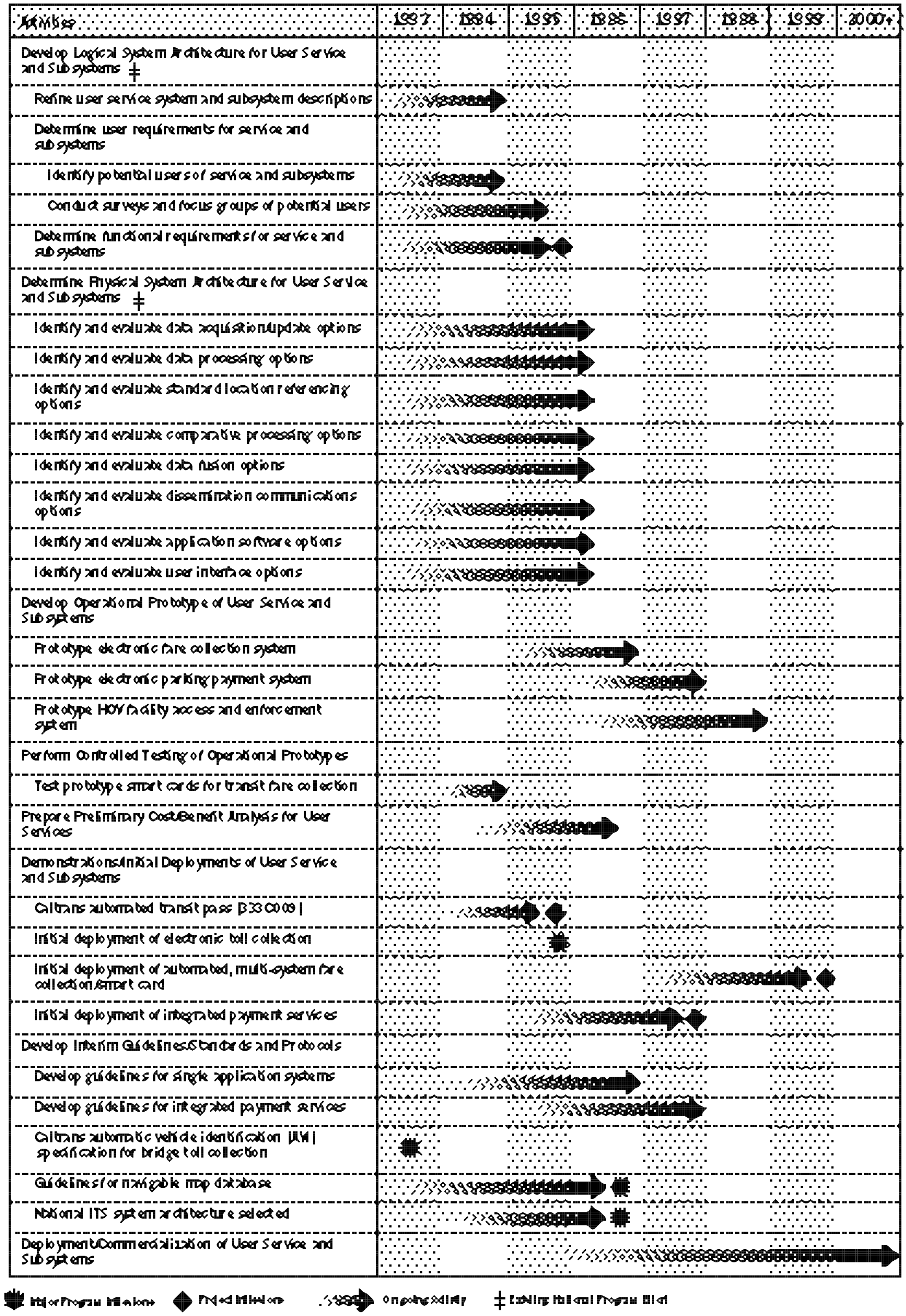
Traffic Control cont'd



## Transportation Management Systems

**Multimodal Traffic Management — Activity Charts**

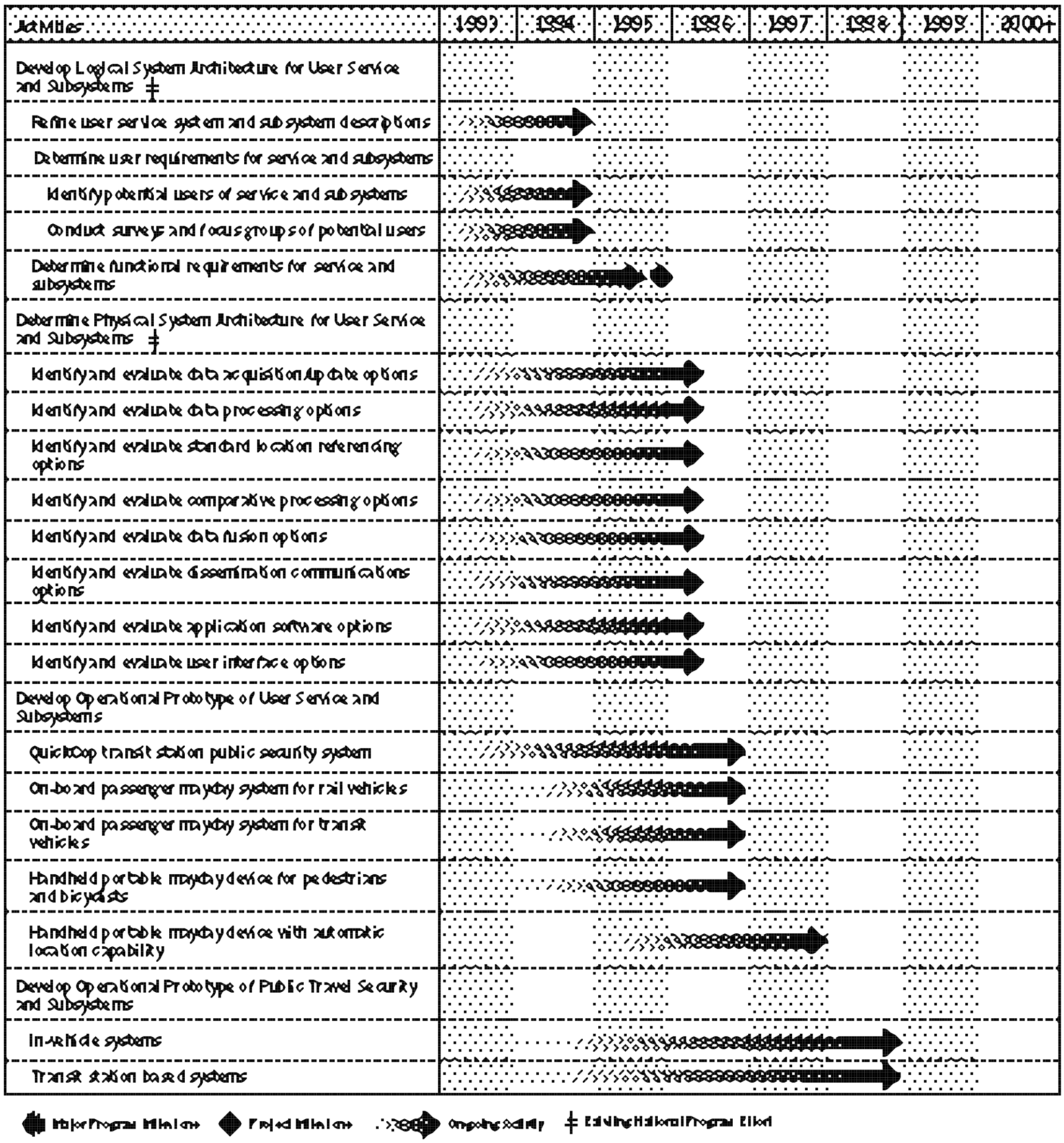
### Electronic Payment



## Transportation Management Systems

### Multimodal Traffic Management — Activity Charts

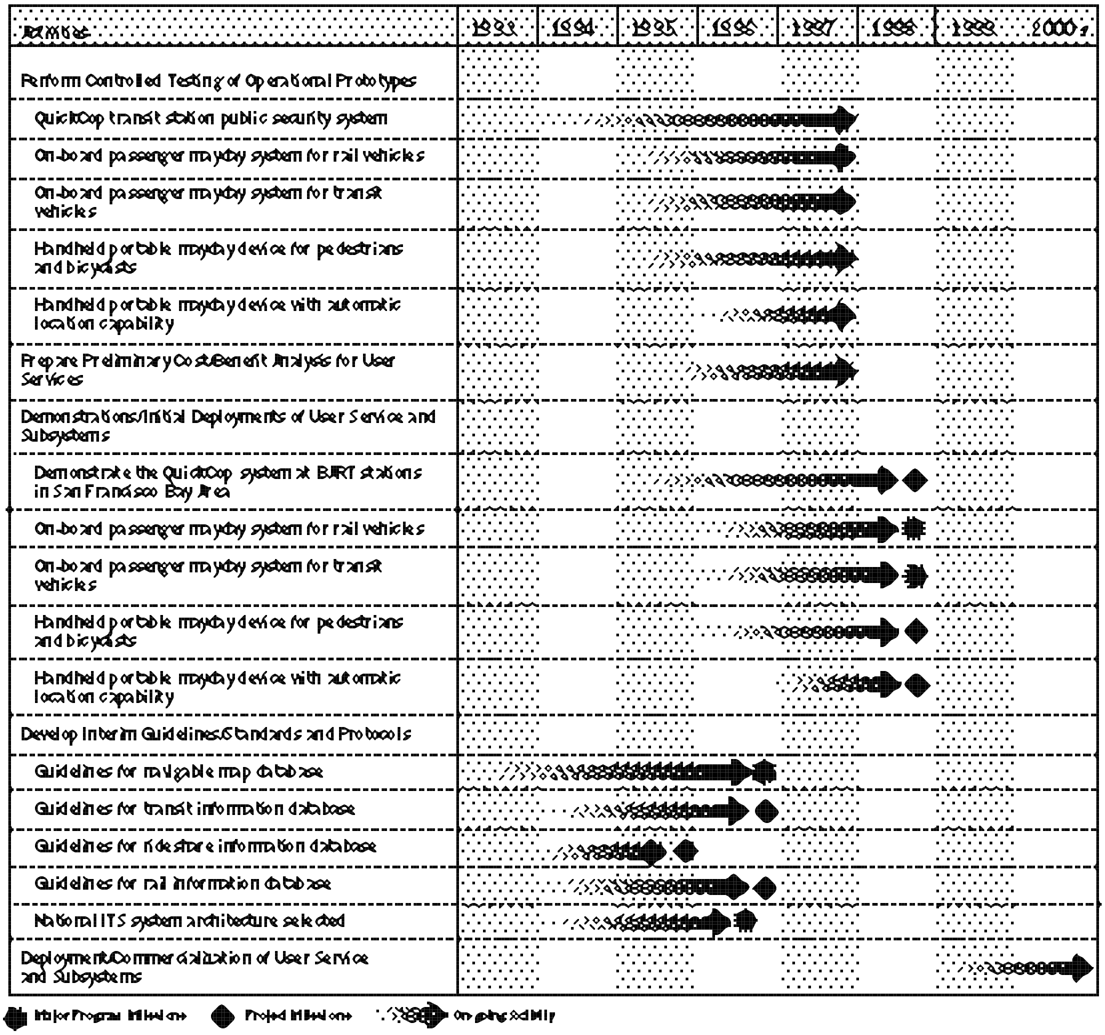
Public Travel Security



## Transportation Management Systems

### Multimodal Traffic Management — Activity Charts

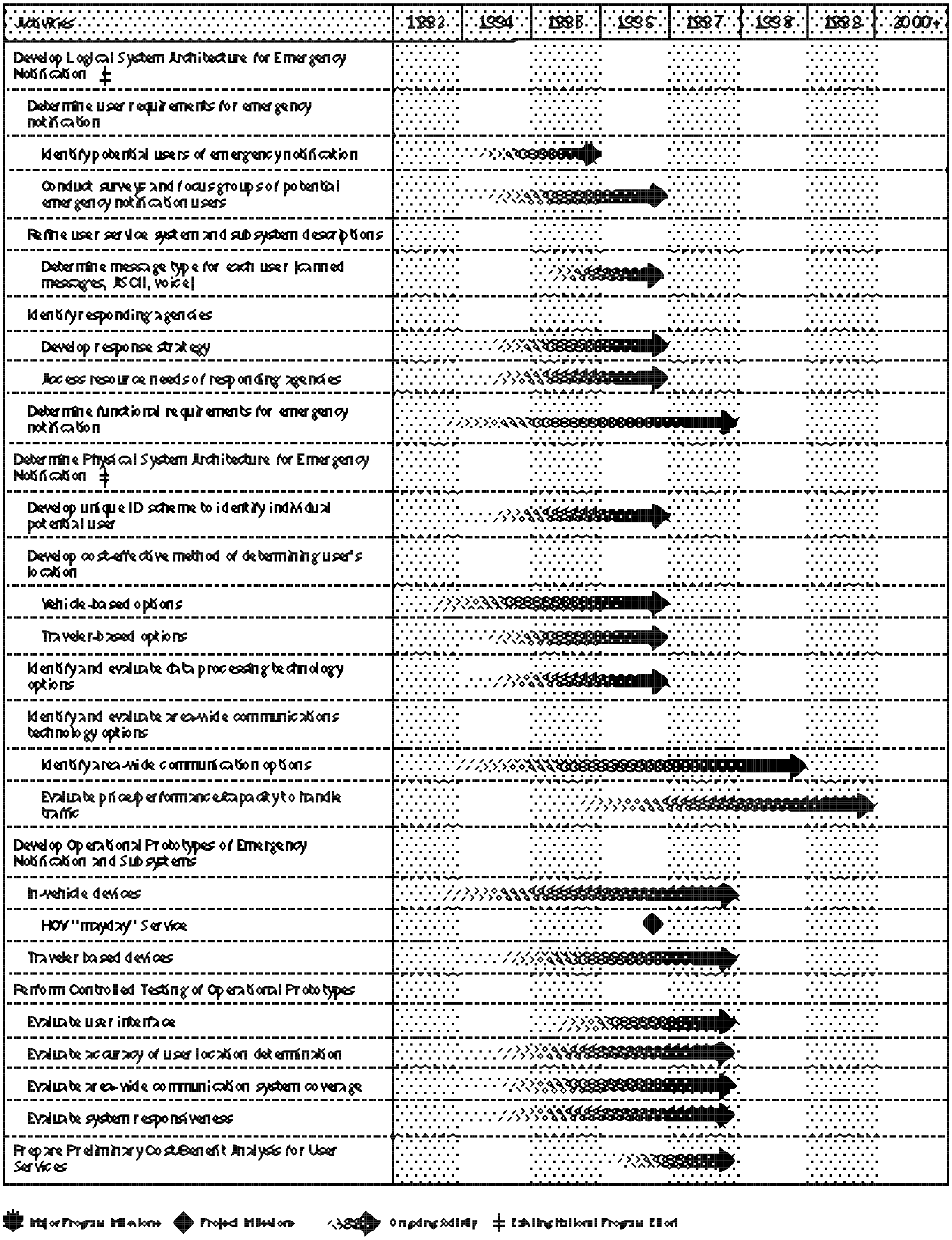
Public Travel Security contd



# Transportation Management Systems

## Multimodal Traffic Management — Activity Charts

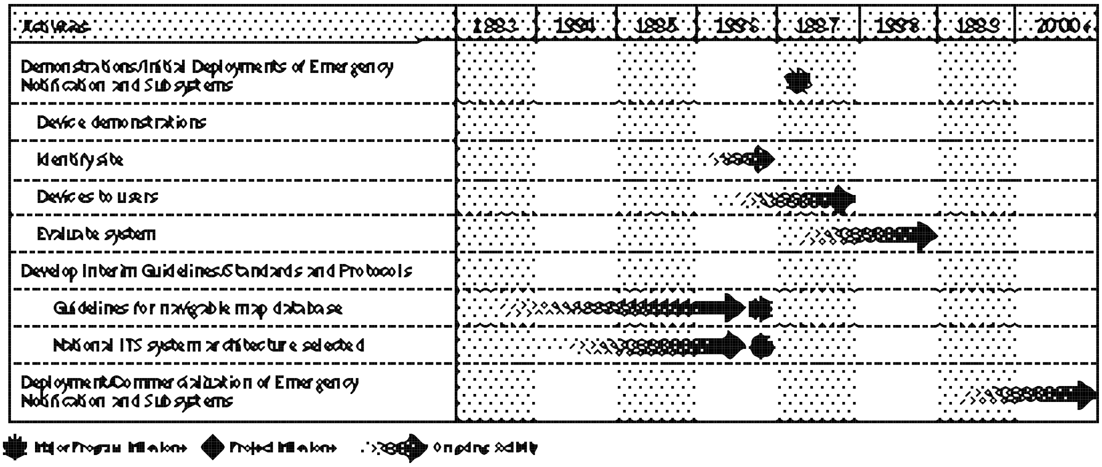
Emergency Notification and Personal Security



## Transportation Management Systems

### Multimodal Traffic Management — Activity Charts

Emergency Notification and Personal Security contd



## Transportation Management Systems

**Multimodal Traffic Management — Project Highlights**

### Transportation Management Systems/Centers

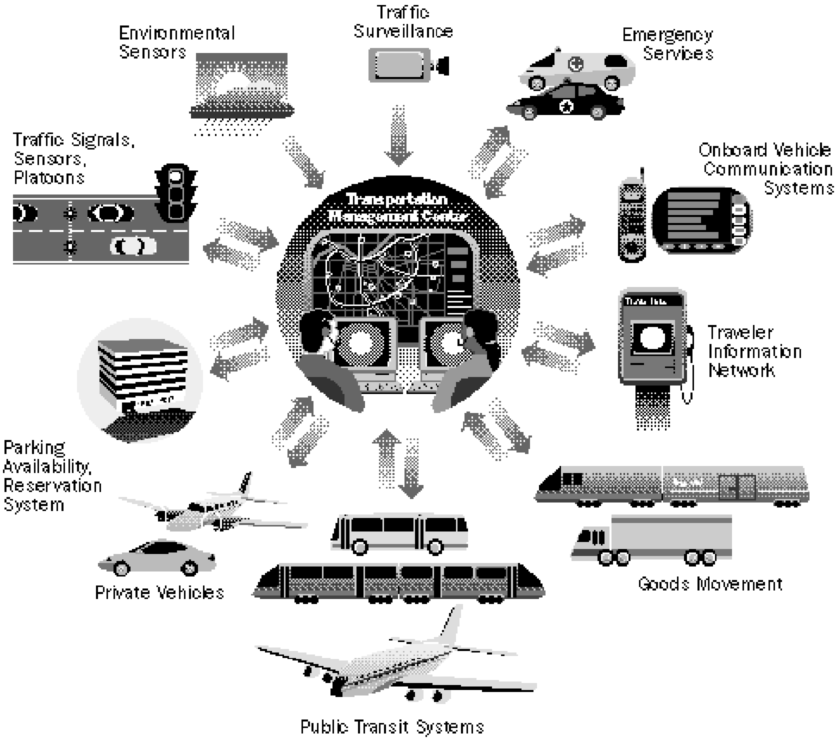
For the past 20 years, Caltrans has been utilizing state-of-the-art technology to manage over 750 miles of southern California freeways. Ramp metering, now commonplace in many areas of the state, was first implemented in southern California in 1970. Plans, which included a Traffic Operations Center (TOC), for traffic mitigation for the 1984 Olympics, were developed starting in 1976 and made history in the field of traffic management. The importance of traffic surveillance in managing traffic was clearly demonstrated during this monumental undertaking.

**A Transportation Management Center (TMC) simulator is in place at California Polytechnic State University, in San Luis Obispo**

The Los Angeles TOC, the first in the state, is still its most advanced and has become a blueprint for those being developed in major metropolitan areas throughout California. Formerly TOCs, they are now called Transportation Management Centers (TMCs) because they encompass so much more than just traffic operations. TMCs are jointly developed and staffed by the California Highway Patrol and Caltrans—the first partnership of its kind in the country.

The next logical step in this progression is the development of an Intermodal Transportation Management and Information System (ITMIS) (see page 192). An ITMIS is a building block for the transportation system. There are two major approaches for its design. In Orange County (Caltrans District 12), efforts are focused on developing a distributed system of centers linked by communications and data. The new TMC in San Diego (opened in July 1995) includes the California Highway Patrol and Caltrans Maintenance and Operations Communications Center all in one location. In the future, the center will include transit and commercial fleet operators and other local transportation providers.

Caltrans has already established a TMC simulator at California Polytechnic State University in San Luis Obispo to help train traffic managers and TMC operators in optimal TMS strategies. Computer-based expert systems will also help TMC operators handle accidents, hazardous material spills and other incidents and emergencies, and would enable automation of routing management functions now performed by humans. Fiber optics and satellite communications can provide the broad bandwidth necessary for video image and high volume data transmission from field to control center, and among control centers (state and local).



Advanced Fleet Management applications can be defined in the following user services terms:

- ### Automated Roadside Safety Inspection

**Focuses on improving safety in all commercial vehicle operations.**

Automated roadside safety inspections include roadside access to records of carriers, vehicles, and driver safety. Such convenient and thorough access will be helpful in determining what should be checked and how to maximize resources spent on safety. Advanced diagnostics will efficiently check critical vehicle systems and driver fitness for duty.

These capabilities will provide safer, more efficient, and more accurate inspection of commercial vehicles. Enforcement personnel will have access to important safety information and records for all commercial vehicles. Automated inspections could provide pass/fail assessments of critical systems, as well as expected life projections. Carriers could also apply rapid automated safety checks in their preventive maintenance programs.

- ### Public Transportation Management

**Automates operations, planning, and management functions.**

Computer analysis of real-time vehicle and facility status will improve operations and maintenance. The analysis identifies deviations from schedule and provides potential solutions to dispatchers and drivers. Integrating this capability with traffic control services can help maintain transportation schedules and assure transfer connections in intermodal transportation. Automated planning and scheduling capabilities will use archived data for analyzing trends. Information regarding passenger loading, bus running times, and mileage accumulated can be applied to route and service improvement. Automatically recording and verifying performed tasks will help with personnel management.

- ### Commercial Fleet Management

**Provides the same capabilities and performs the same functions in the commercial goods movement area as in public transportation management.**

Technological advances in public transportation management are directly applicable to commercial vehicles providing goods movement. Caltrans is heavily involved in promoting advanced technologies that facilitate improved fleet operations. Currently, there is a research project to determine the most appropriate role for government in furthering fleet management services and their applications for improving intermodal transfers.

**Caltrans and the CHP will continue development efforts in these areas and will collaborate with companies that transport goods in developing new transportation systems.**

## Transportation Management Systems

### Advanced Fleet Management — Scope

- **Commercial Vehicle Preclearance**

  **Facilitates domestic and international border preclearance, minimizing stops.**

This user service provides for point to point non-stop operation while satisfying regulatory requirements such as the issuance of licenses and permits, record keeping, tax collections, and inspection and weighing across multiple jurisdictions, including domestic and international borders.

- **Commercial Vehicle Administrative Processes**

  **Provides electronic purchasing of credentials and automated mileage and fuel reporting.**

Electronically purchasing credentials gives carriers the option to select and purchase annual and temporary credentials via computer link with the appropriate jurisdictions. Automatic deductions from the carrier's account with a jurisdiction will also streamline processing. There is a potential for synergy with commercial vehicle preclearance services.

For registration and auditing purposes, carriers maintain accurate mileage and vehicle information for every trip. Automating this procedure with the commercial vehicle administrative processes service enables participating interstate carriers to electronically capture mileage, fuel purchase, trip, and vehicle data by state. Electronic logs eliminate the need to manually prepare quarterly reports for fuel taxes and annual reports for registration.

- **Emergency Vehicle Management**

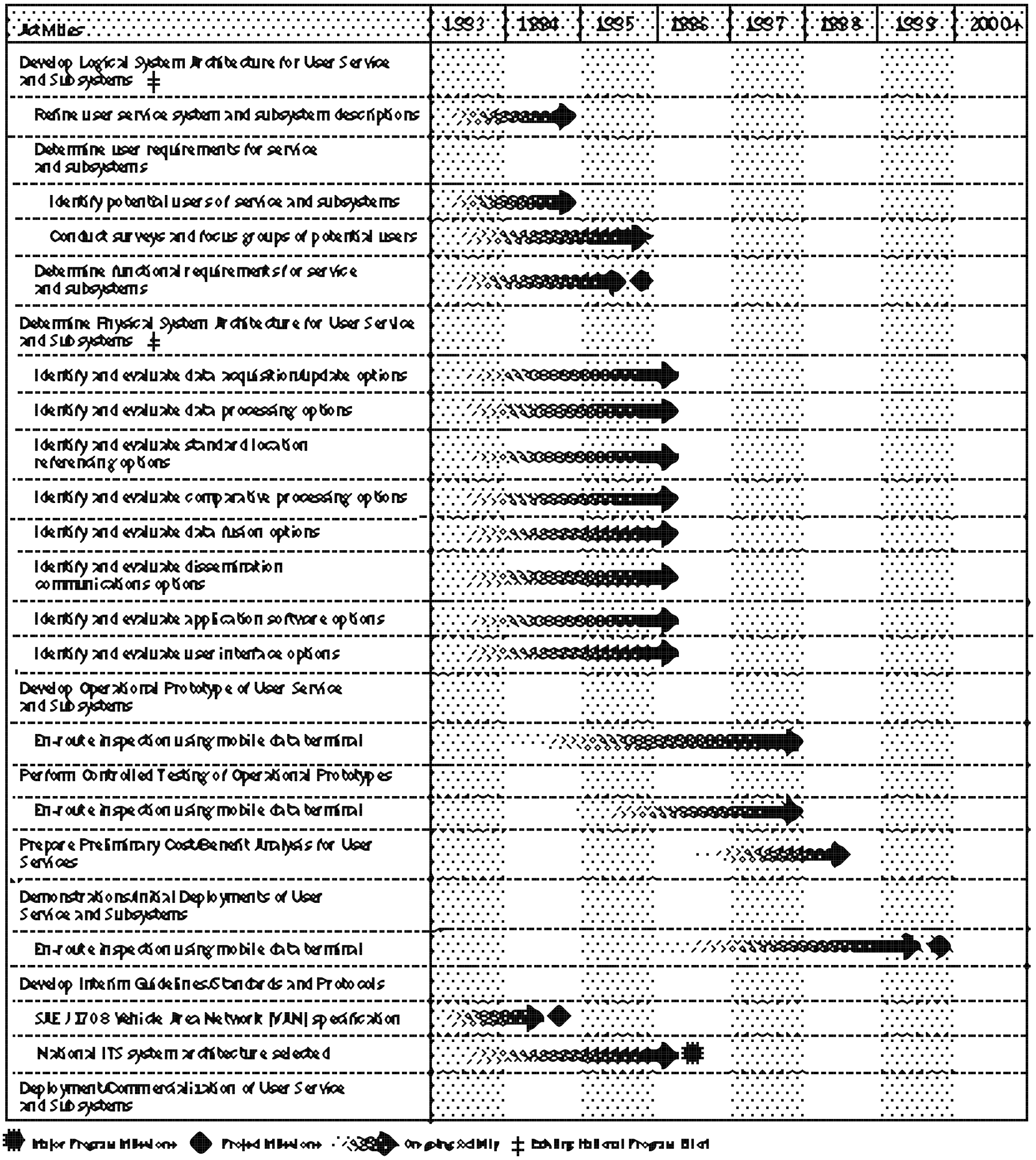
  **Reduces the time it takes to respond to incident notification and arrive on the scene.**

This user service is closely related to the hazardous material incident management user service, within the commercial vehicle operations category. Primary users include police, fire and medical units. The service comprises three capabilities: fleet management, route guidance, and signal priority. Fleet management will improve the display of emergency vehicle locations and help dispatchers efficiently send the unit that can most quickly reach an incident site. Route guidance directs emergency vehicles; signal priority clears traffic signals on an emergency vehicle's route.

## Transportation Management Systems

### Advanced Fleet Management — Activity Charts

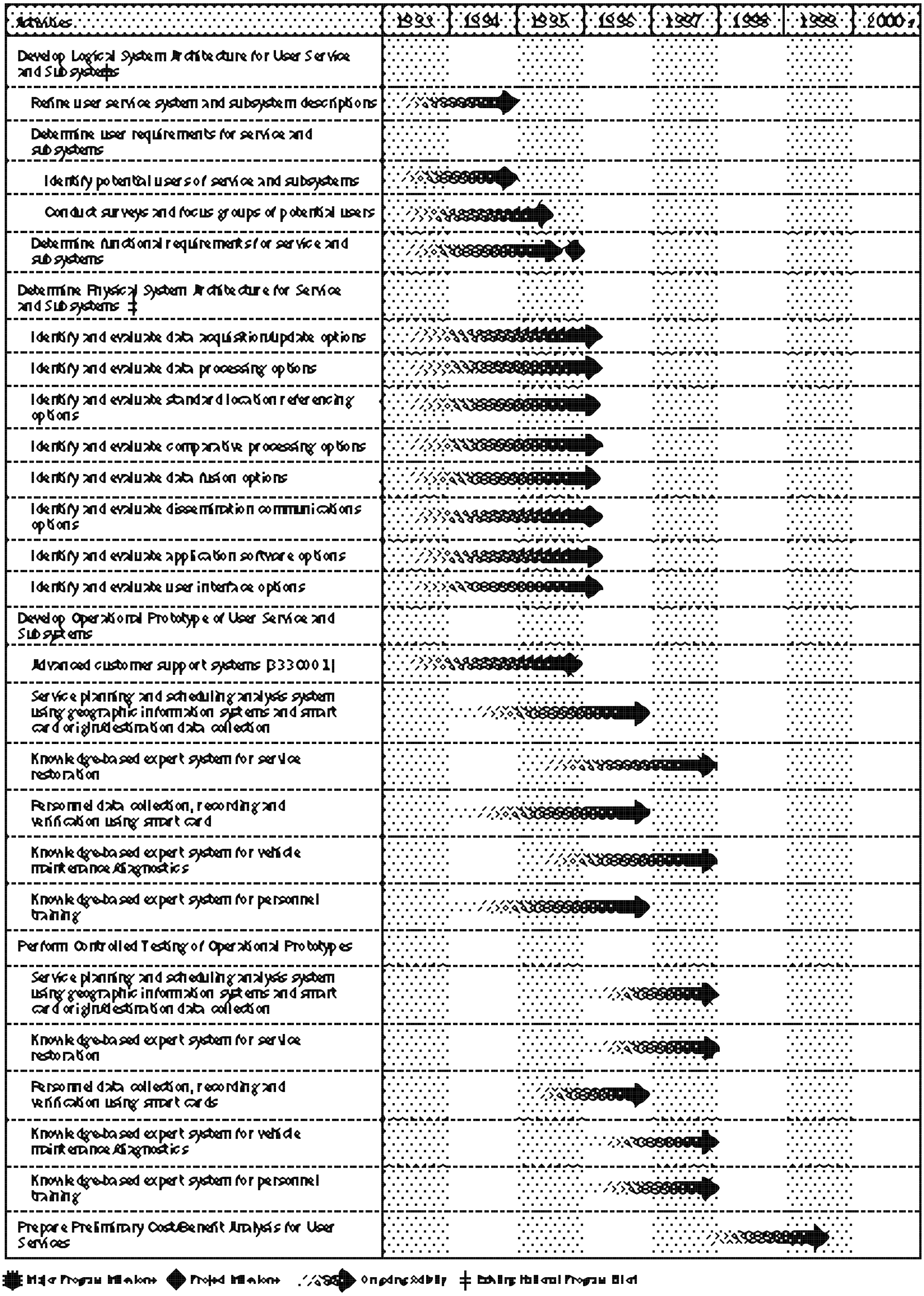
Automated Roadside Safety Inspection



## Transportation Management Systems

### Advanced Fleet Management — Activity Charts

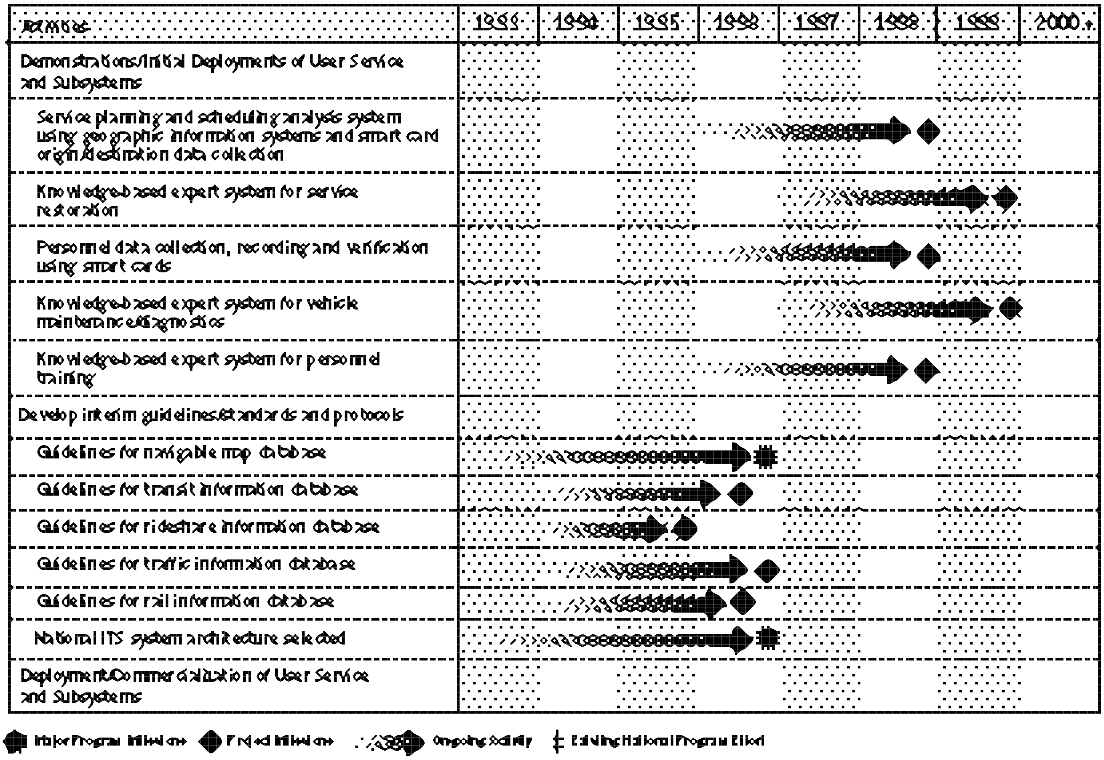
Public Transportation Management



## Transportation Management Systems

### Advanced Fleet Management — Activity Charts

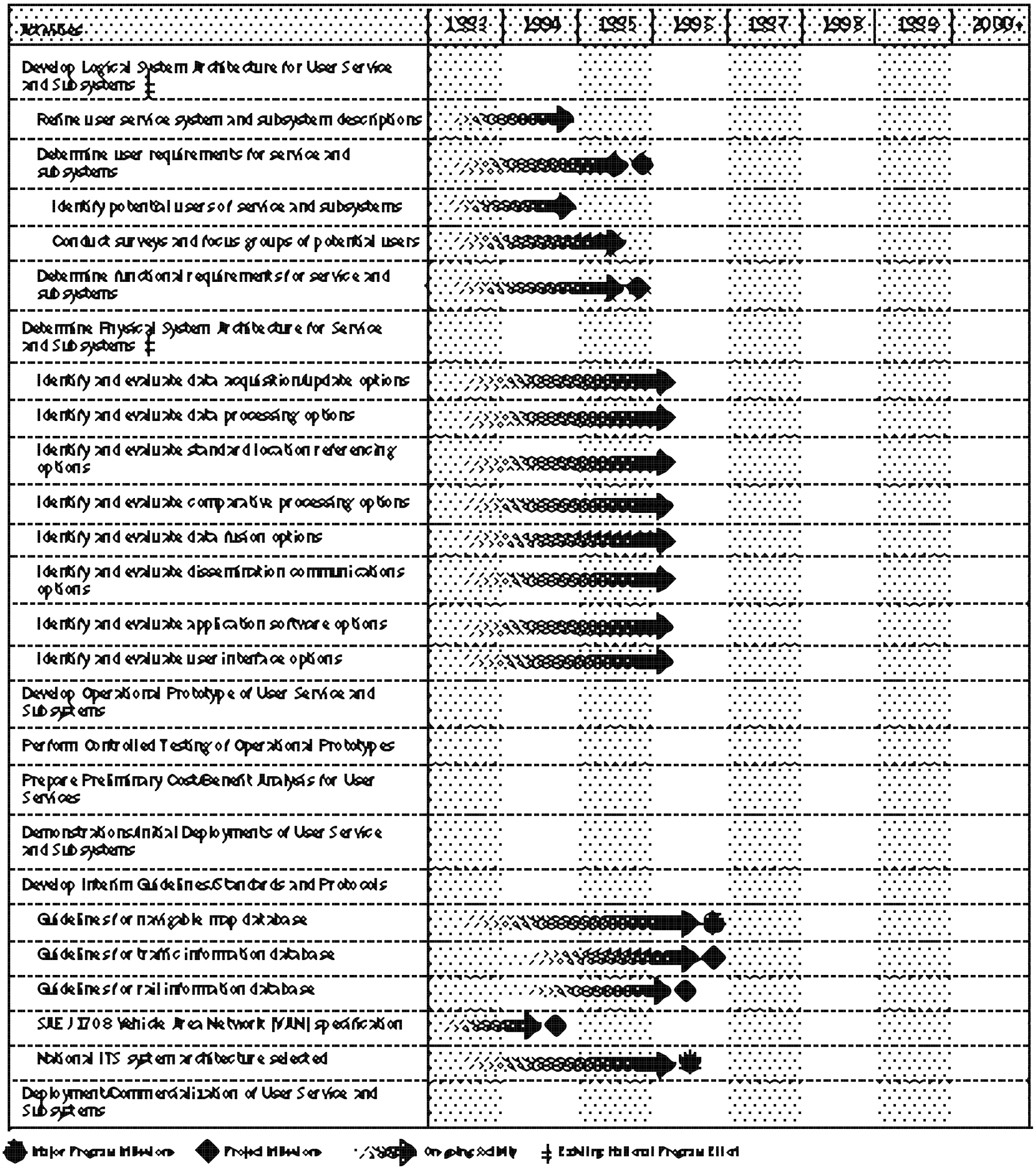
Public Transportation Management cont'd



## Transportation Management Systems

### Advanced Fleet Management — Activity Charts

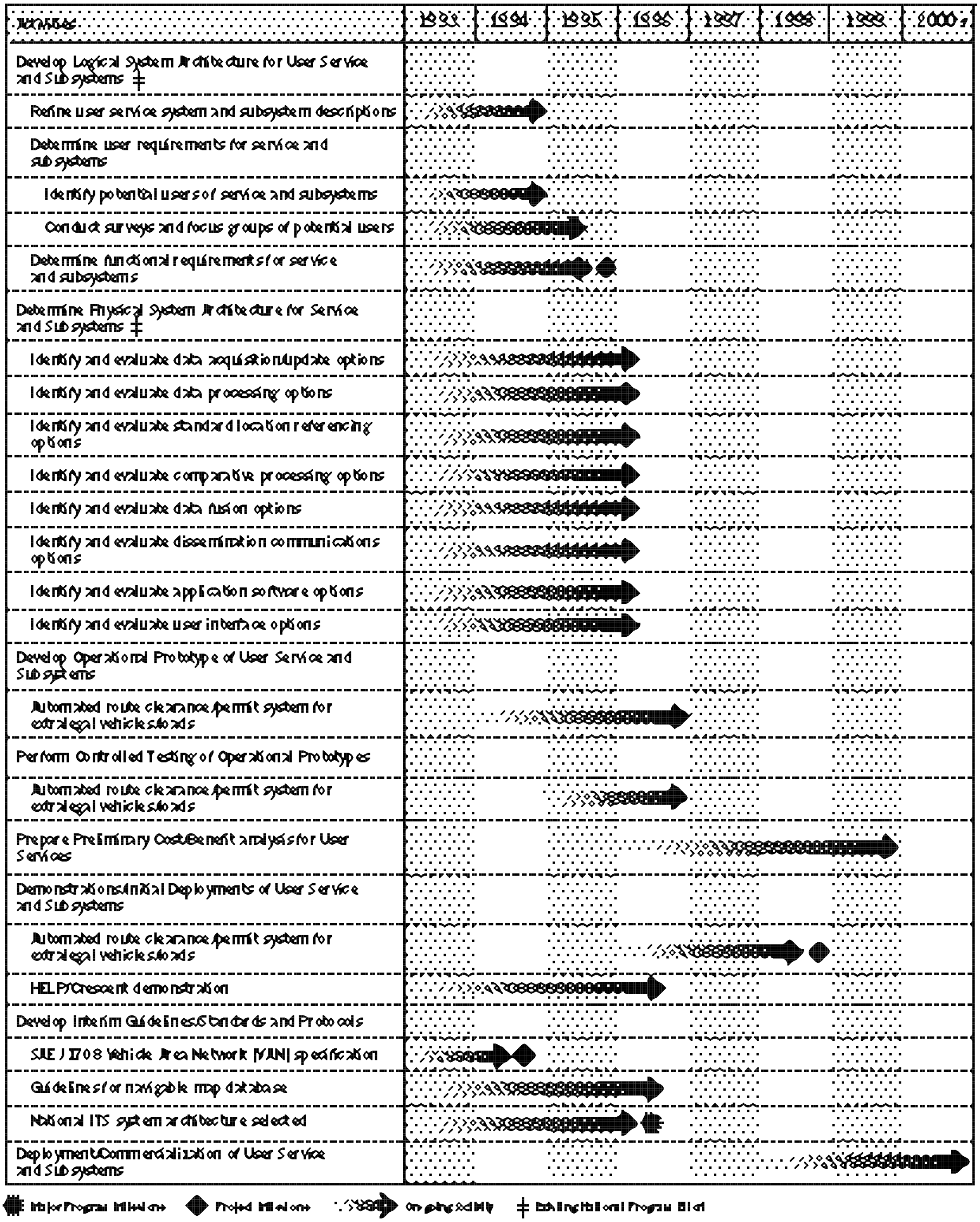
Commercial Fleet Management



## Transportation Management Systems

### Advanced Fleet Management — Activity Charts

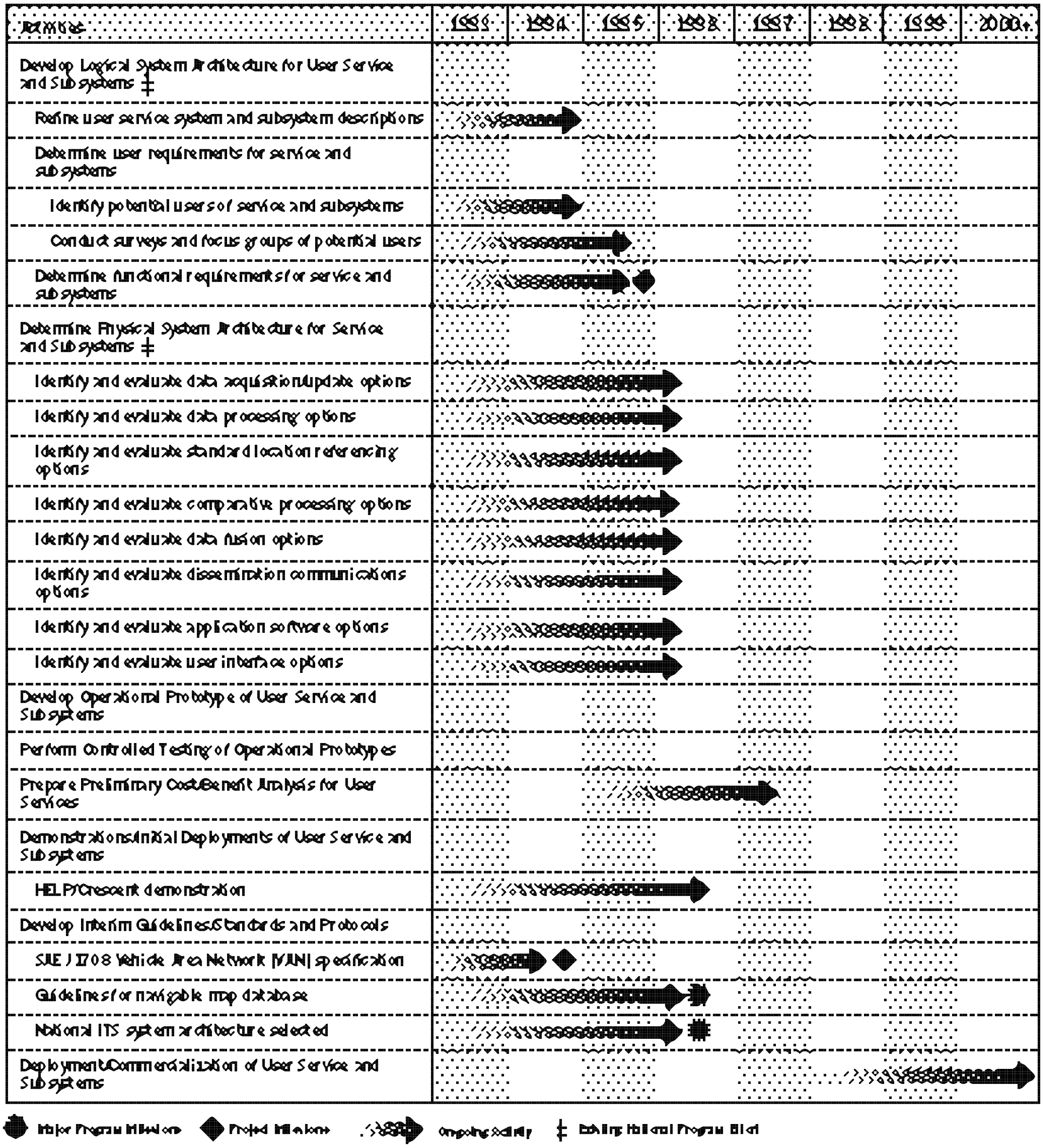
Commercial Vehicle Preclearance



## Transportation Management Systems

### Advanced Fleet Management — Activity Charts

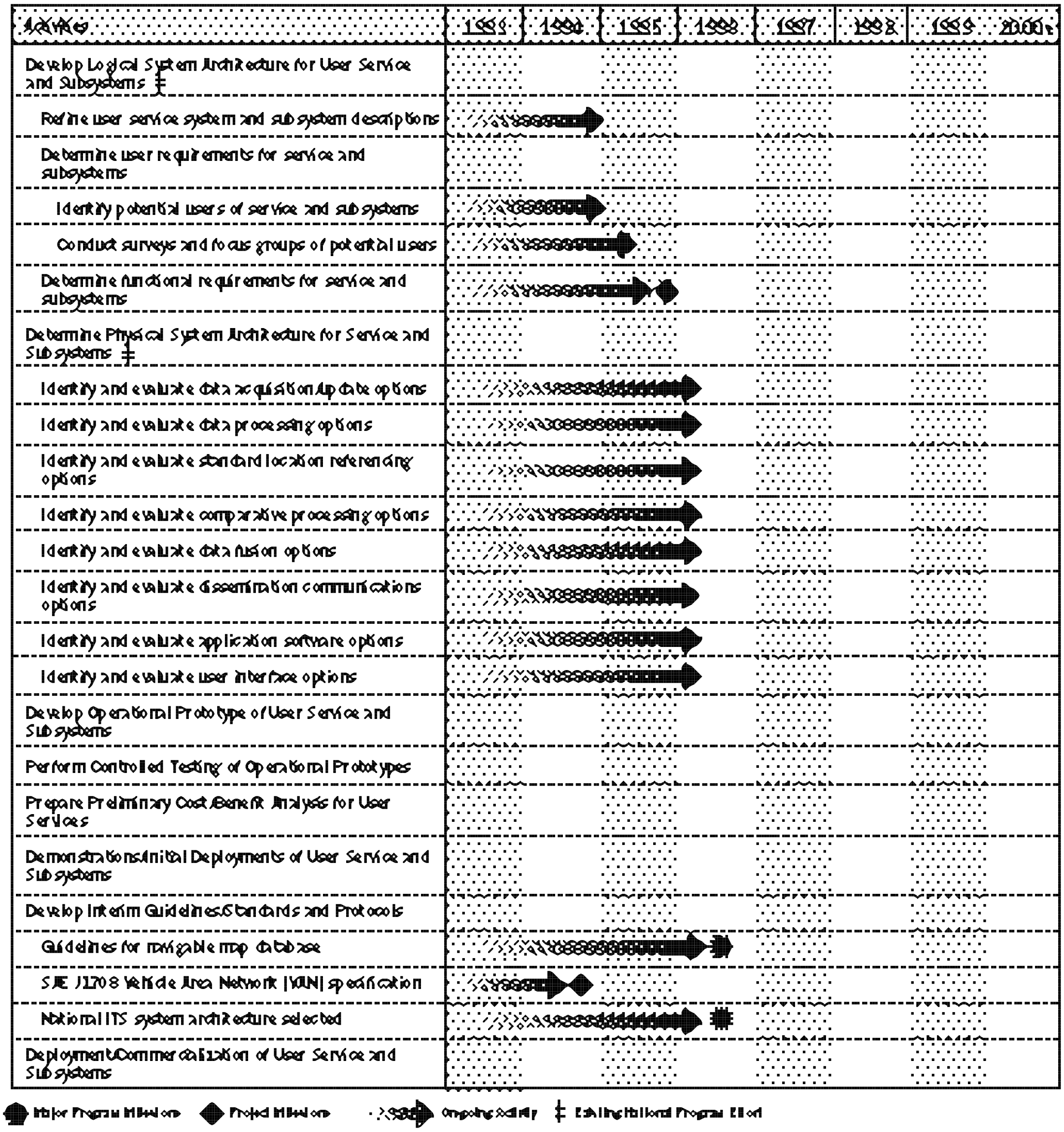
Commercial Vehicle Administration Processes



## Transportation Management Systems

### Advanced Fleet Management — Activity Charts

Emergency Vehicle Management

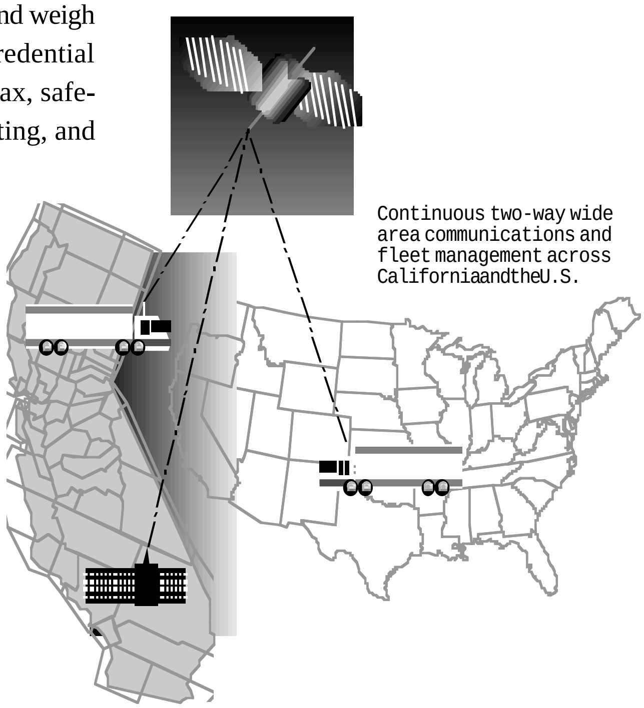


## Transportation Management Systems

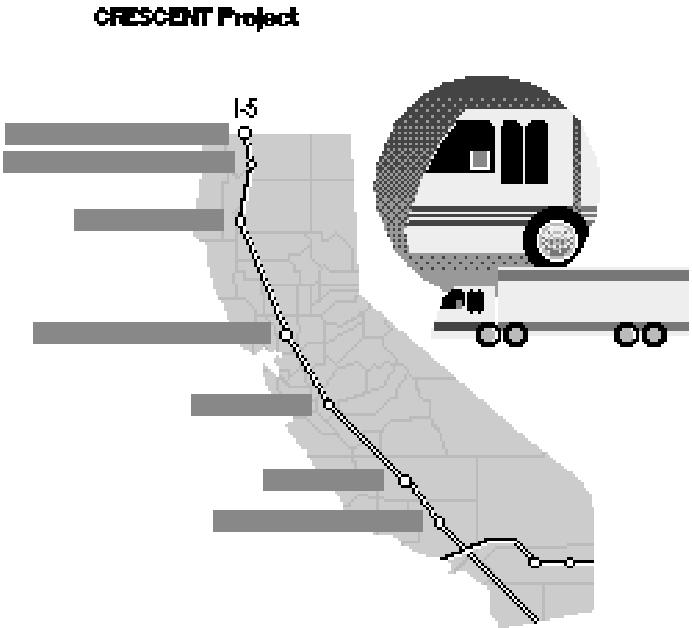
**Advanced Fleet Management — Project Highlights**

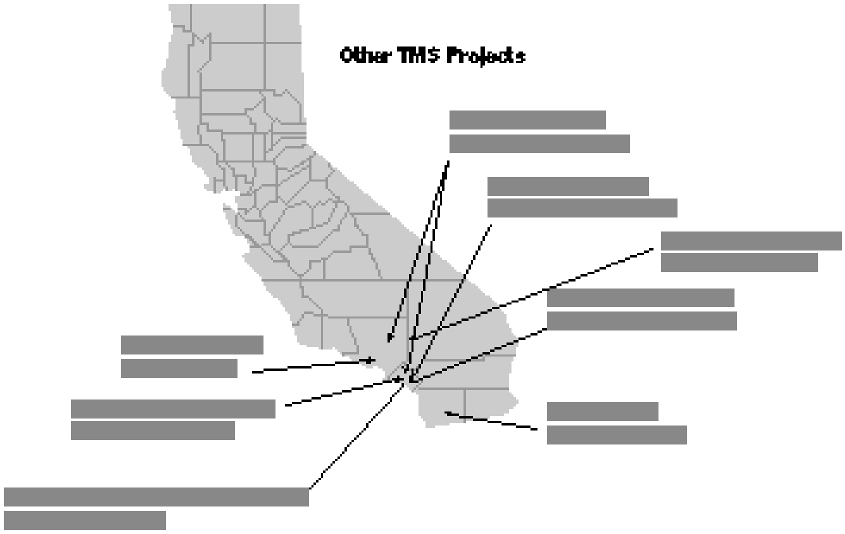
### H.E.L.P. Project

The Heavy Vehicle Electronic License Plate Program (H.E.L.P.) is a multistate, multinational research effort to design and test an integrated heavy vehicle monitoring system. Using Automatic Vehicle Identification (AVI), Automatic Vehicle Classification (AVC) and Weigh-In-Motion (WIM) technology, the H.E.L.P. project permits trucks to bypass ports of entry and weigh stations by providing automated credential verifications of registrations, fuel tax, safety, oversize and overweight permitting, and a central data base for fleet information and management. It is expected to be completed in 1996, when it will include preclearance sites in ten states. H.E.L.P. facilities are being installed in California on I-5 and I-10, and are proposed in several other areas, including I-880 in the San Francisco Bay Area.



Continuous two-way wide area communications and fleet management across California and the U.S.



## Transportation Management Systems

### Intermodal Facilities — Scope

Connectivity of the various modes for people and goods movement can be enhanced through terminal facilities where travelers can transfer from one mode to the other with a minimum of discomfort or where goods can be efficiently moved from one mode to another.

Approaches that will assist with intermodal connectivity are:

- Bringing bus stops, with easily understood signage, close to the disembarkation areas of planes and trains;
- Bringing trains into air terminals to facilitate transfers of passengers and baggage from one mode to the other;
- Establishing safe bicycle storage facilities at transfer points for cyclists to transfer to buses, trains or planes;
- Designating routes on the National Highway System to be "Freight Corridors" to establish design, construction, and maintenance priorities; and, to reduce congestion; and,
- Working at the national level, with public and private organizations, to design programs and secure funding for the advancement of intermodalism as an equal partner in the transportation fabric of California and the United States.

Work to redesign, improve the technology and automate California ports and terminals will be required to realize the full benefits of the ATS highway, rail, waterway and airway infrastructure. Application of ATS at the transfer point ("interfaces") will increase the efficiency and effectiveness of intermodalism for both passengers and goods.

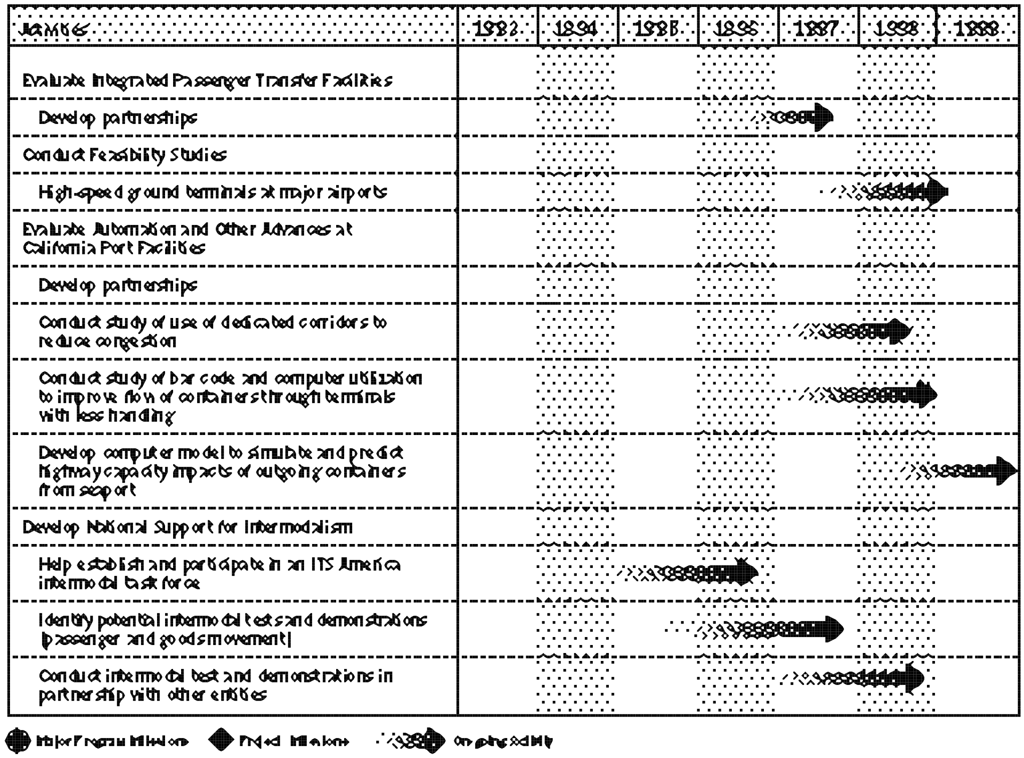
California's extensive port (air/waterway) and waterway system could benefit greatly from the same ATS technologies and coordination being applied to other ground systems. Among the benefits would be improved ground access and maximized efficiency of the "landbridge" across the state and the North American continent (movement of goods inland from seaports and across the continental United States). Examples of applicable technologies are:

- Ship collision avoidance, such as in low visibility areas using digital maps, global positioning systems, computers and wireless communications;
- Vessel routing, tracking and scheduling;
- Vessel fitness monitoring;
- Automated cargo monitoring; and,
- Next-generation port/intermodal transfer facilities.

## Transportation Management Systems

### Intermodal Facilities — Activity Charts

Intermodal Facilities



In March 1994, ITS America's Coordinating Council established a new task force to investigate including other modes of transportation (rail, air, sea) into an integrated, effective, intermodal transportation system. Caltrans was involved in an Intermodalism Conference late in 1994, to discuss research, development, and demonstration agendas; new initiatives; and, the future direction of "Intermodalism."

Application of information and communication technologies to the interfaces (e.g., terminals) of modal exchange will increase efficiencies, resulting in lower costs and improved safety. This scenario would be especially true in the goods movement area when coupled with management system and logistics planning. With respect to passenger systems, improvement at the interfaces will also increase the attractiveness of using public transportation.

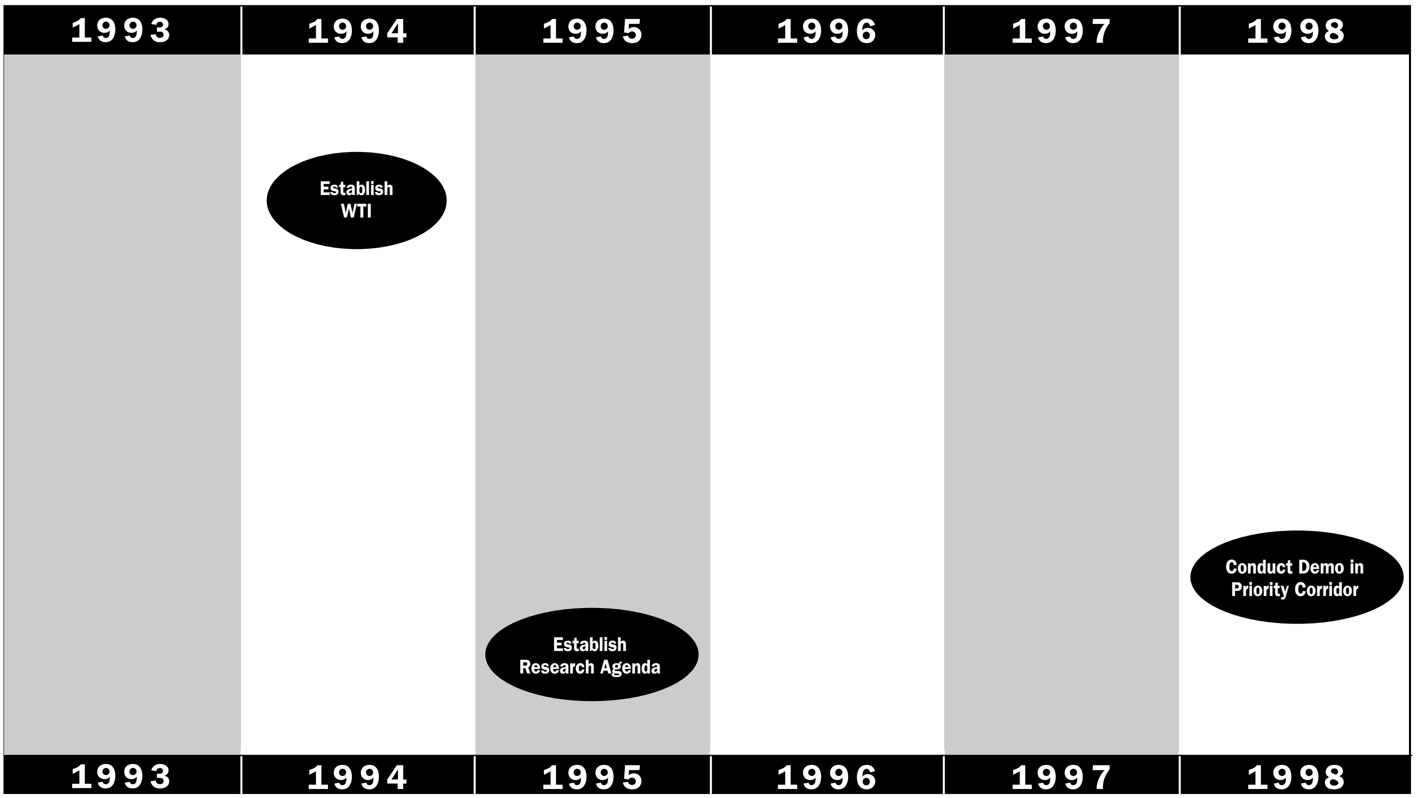
Projects being sponsored to encourage intermodal transportation usage by the public will include "off-airport terminals" construction, operation and evaluation to provide congestion relief at airports; studies and recommendations to extend rail facilities into or closer to air terminals to encourage use of alternate modes of transportation; and, studies to determine ways to lessen the impact of port side operations that affect truck usage of adjacent roads and highways.

# RURAL

**The rural transportation program focuses on the transportation concerns of rural California to assure the appropriate application of advanced transportation technologies to rural transportation problems.**

**The milestones, scope of services, activities and project highlights for Rural Transportation are discussed on the following pages.**

# Rural Transportation



## Rural Transportation

### Scope

Increased interest in rural transportation issues in the new technology/intelligent transportation systems arena is a fairly recent development. Because federal, state and local officials have been overwhelmed by the problems plaguing urban transportation, such as traffic congestion, and related air quality, noise and energy issues, little time, or resources have been devoted to rural transportation issues.

Two-lane rural highways are the backbone of the rural transportation network. These roads carry local traffic, as well as commercial vehicles, transit vehicles, school buses, and recreation and commuter traffic. Additionally, there is a system of multi-lane divided highways that serve metropolitan centers and traverse rural areas. Like urban transportation, rural transportation is also concerned with air quality control and energy conservation. While the primary focus of urban transportation may be traffic congestion, the primary focus of rural transportation technology is safety.

In 1992, the Caltrans New Technology and Research Program embarked on a research study, the “Program for Advancing Rural Transportation Technology” (PARTT). The purpose of PARTT is to focus proper attention on the transportation concerns of rural California and to assure the appropriate application of advanced transportation technology to rural transportation problems.

Directly attributed to this research study are the following successful results:

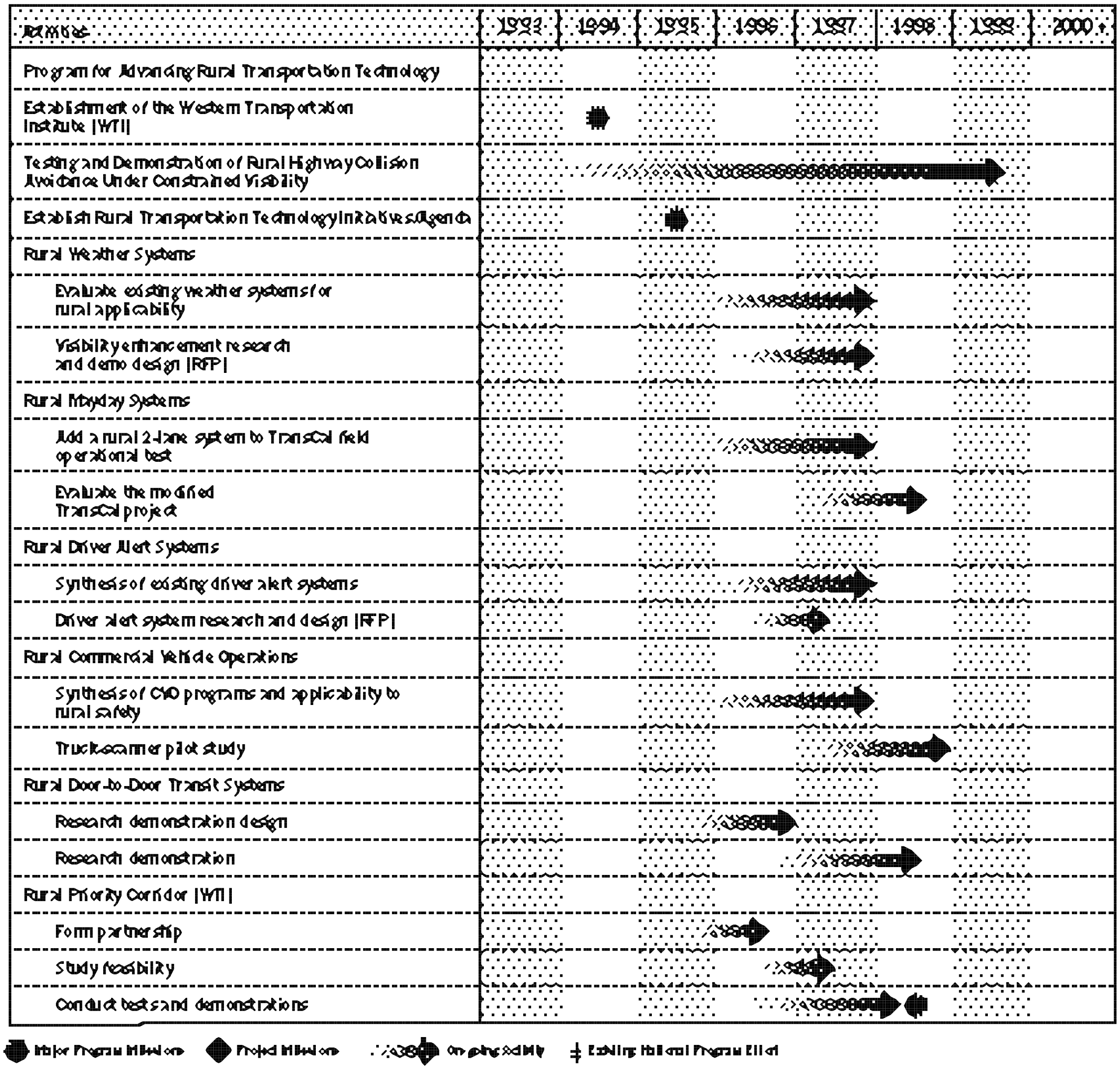
- The first national discussion on advanced rural transportation technology in the second draft of the “ITS America Strategic Plan” (January 1992);
- Establishment of an ITS America Committee to deal specifically with rural transportation technology concerns (ITS America Advanced Rural Transportation Committee, April 1992);
- The first rural transportation technology conference sponsored by Caltrans (Redding, California, September 1992); and,
- The Western Transportation Institute (WTI) established in 1994.

In addition, with ITS America, the WTI and other partners, Caltrans will help establish a formal rural technology research agenda.

## Rural Transportation

**Activity Charts**

Rural Transportation



**Rural Transportation**

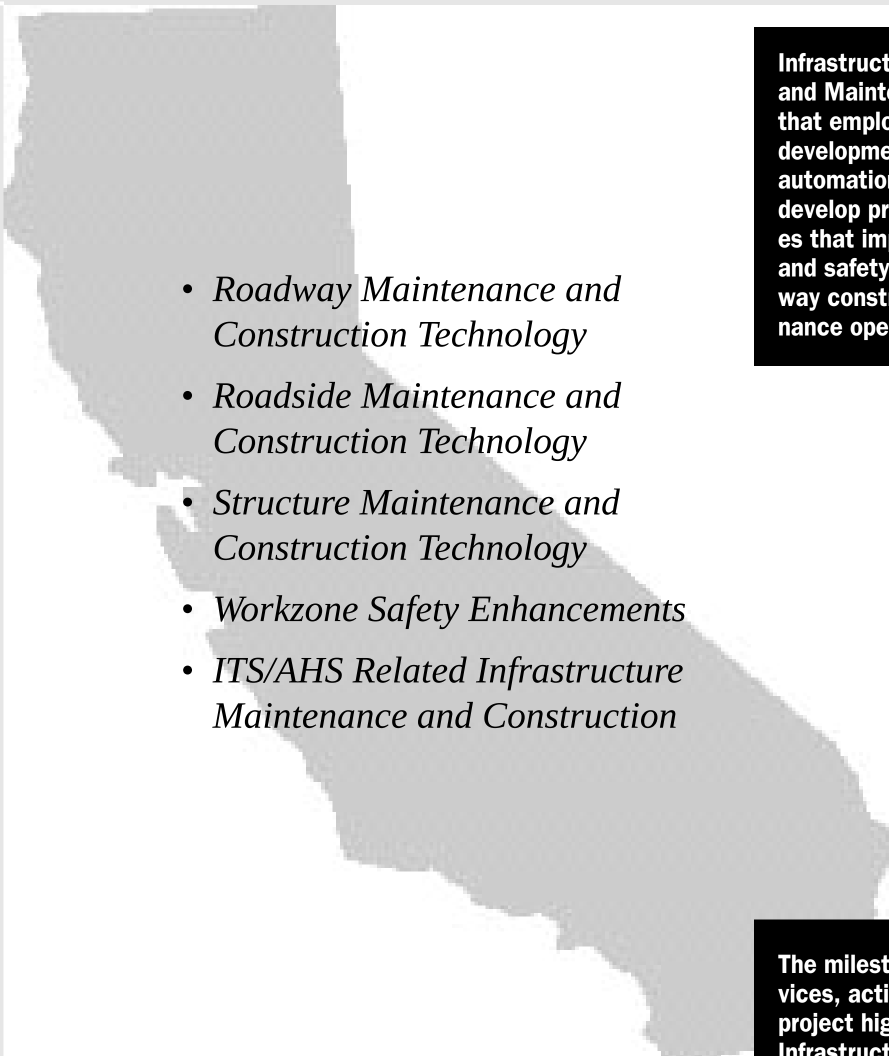
**Project Highlights**

## The Western Transportation Institute — A Western Center for Rural Transportation Excellence

The Western Transportation Institute (WTI) was established in 1994, to pursue research and education in Intelligent Transportation Systems (ITS) and other rural transportation matters. WTI maintains close ties with other ITS programs nationally, including PATH.

WTI is also affiliated with many national ITS programs and organizations including the NAHSC, the National ITS System Architecture Program and ITS America. WTI, with participation from government, industry and academia, is currently working to establish a national ITS rural priority corridor for demonstration and deployment of promising rural transportation technology.

# INFRASTRUCTURE CONSTRUCTION AND MAINTENANCE



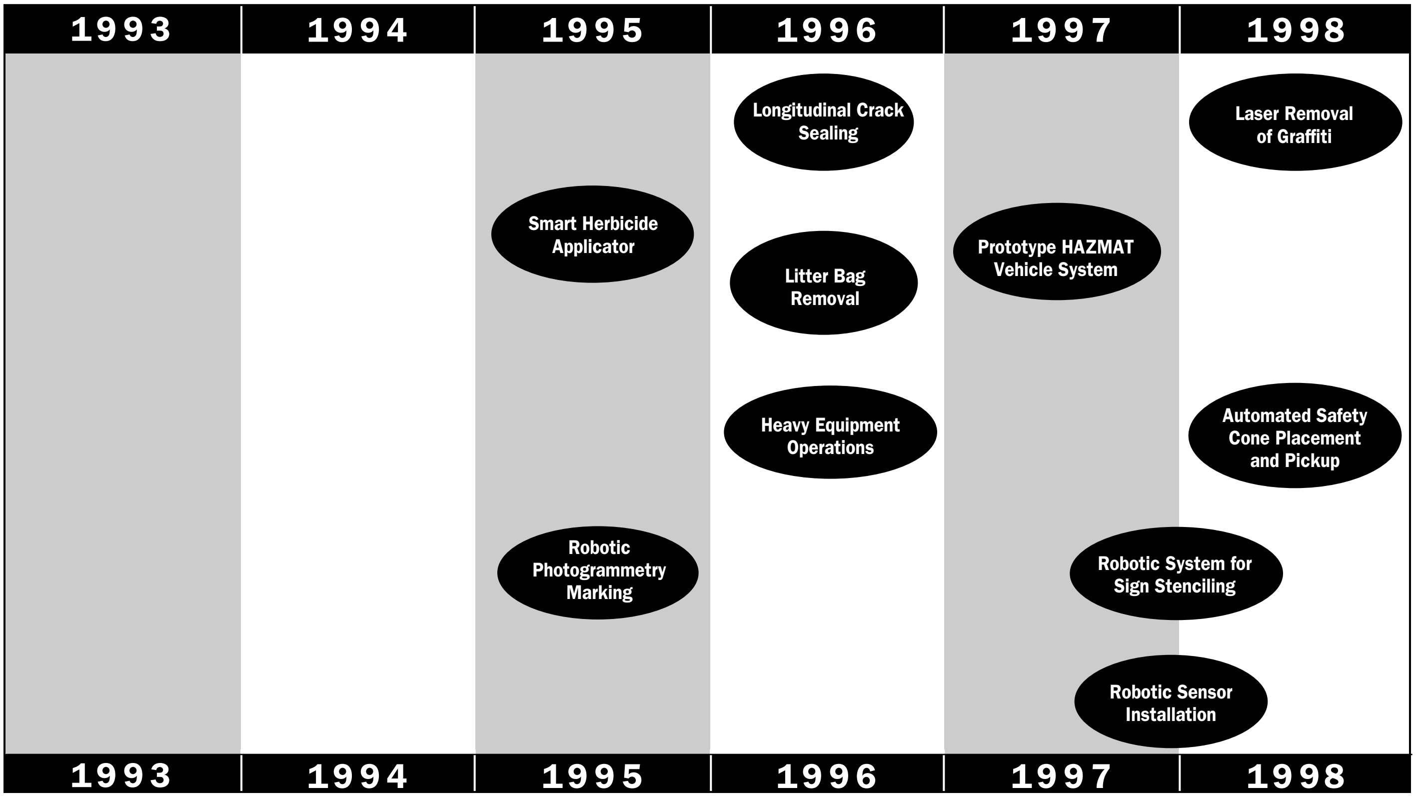
- *Roadway Maintenance and Construction Technology*
- *Roadside Maintenance and Construction Technology*
- *Structure Maintenance and Construction Technology*
- *Workzone Safety Enhancements*
- *ITS/AHS Related Infrastructure Maintenance and Construction*

**Infrastructure Construction and Maintenance is a program that employs technological developments, such as automation and robotics, to develop products and processes that improve the efficiency and safety of traditional highway construction and maintenance operations.**

**The milestones, scope of services, activities and specific project highlights for Infrastructure Construction and Maintenance are discussed on the following pages.**

**MAJOR PROGRAM MILESTONES**

# Infrastructure Construction/Maintenance



## Infrastructure Construction & Maintenance

**Scope**

Current efforts by the Advanced Highway Maintenance and Construction Technology (AHMCT) Center include the development of technologies such as external sensing systems, manipulation systems, control and coordination systems, communication systems, material storage and retrieval systems, mobility systems, and human-machine interfaces. These technologies are critical to the development of automated or robotic equipment intended for transportation maintenance and construction.

The jointly staffed University of California, Davis/Caltrans AHMCT Center has developed expertise in these areas; has an understanding of current and emerging robotic and automation technology and has specifically researched future trends in technology applicable to automation of construction and maintenance tasks.

### • Roadway Maintenance and Construction Technology

Of prime importance to Caltrans is the effective maintenance of road surfaces and pavement delineations in the form of lane striping, pavement markers and pavement and roadside signage. Efforts are underway to introduce automation and robotic technology to conventionally slow, labor intensive and potentially unsafe operations. Examples of activities under investigation include: sealing pavement cracks; painting pavement markings, including survey premarks; and, placing raised pavement markers on the pavement at prevailing speeds. These technological advances will eliminate the exposure of maintenance personnel to moving vehicles and have the potential to transform a static lane closure into a moving operation.

### • Roadside Maintenance and Construction Technology

Caltrans is responsible for maintaining the roadside right-of-way, including landscape management, refuse and graffiti cleanup, and removal of hazardous materials. Landscape maintenance efforts are designed to limit employee exposure to the dangers of moving vehicles while performing landscape maintenance operations. Research is also aimed at substantially reducing water and herbicide usage and developing landscape vegetation suited to reduced maintenance and watering. Innovations in the areas of litter pickup equipment, remote landscape management systems, graffiti removal and prevention, and rapid and remote hazardous material spill identification and remediation are being researched. These developments will ultimately reduce employee exposure to highly toxic materials and reduce the time necessary for lane closures occurring during landscape maintenance operations.

- **Structure Maintenance and Construction Technology**

The development of methods and equipment for rapid and remote inspection of bridge components and other structures is critical to maintaining the safe condition of a deteriorating transportation infrastructure. The nation's large inventory of aging elevated structures mandates frequent and detailed inspections using equipment of increasing sophistication. Efforts in this area focus on the development of products that will allow remote inspection of structural facilities, while reducing human risk and improving efficiency.

- **Workzone Safety Enhancement**

A wide variety of devices and processes has been developed to enhance the safety of field workers, including such products as hard hats, highly visible garments, safety cones, equipment backup signaling, and lane closure procedures. These and many other products and procedures have been adopted by the construction industry with life-saving success. Products continue to be developed at a rapid pace, as the desire to improve workzone safety continues. Recently, many products, such as workzone intrusion warning systems, vehicle sensors to prevent equipment or equipment/human collisions, and garment sensors used to alert workers of the approach of heavy equipment, have become sophisticated through the advent of the computer and sensor revolution. While research in other areas is directed towards eliminating the necessity for workers to be exposed on the roadway, the mission of workzone safety research at the AHMCT Center is to substantially increase the safety of workers both on and off the roadway.

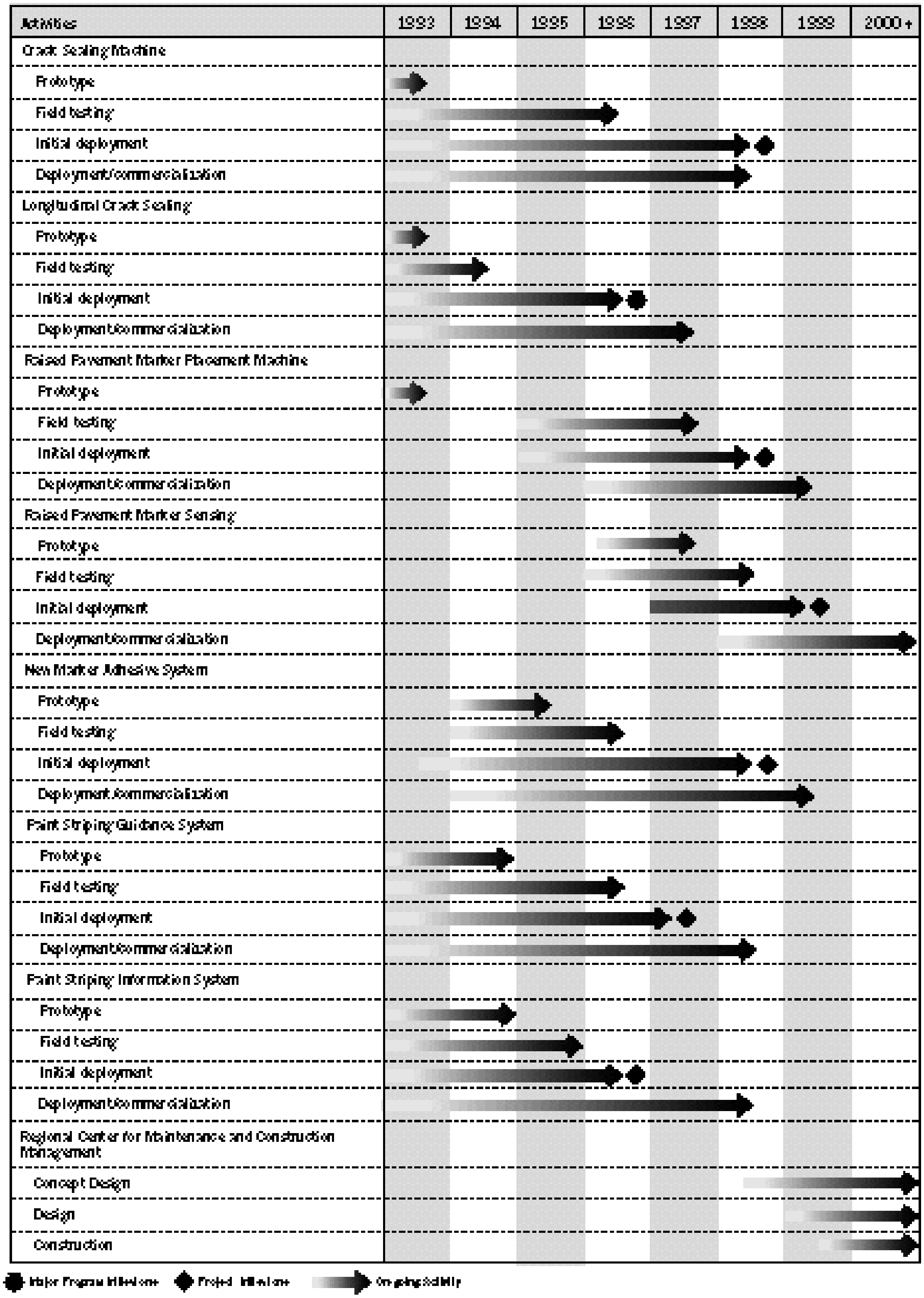
- **ITS/AHS Related Infrastructure Maintenance and Construction**

As more technologically advanced transportation systems are implemented, construction and maintenance operations will become more complex. ITS construction and maintenance will require accurate equipment positioning, frequent testing, and rapid repair of control and communication instrumentation. Such achievements will be critical to automated transportation systems. Recent advances in design for automated assembly, manufacturability, and life cycle, have sanctioned the evaluation and development of new concepts for automated construction and maintenance of a demanding ITS infrastructure.

## Infrastructure Construction & Maintenance

**Activity Charts**

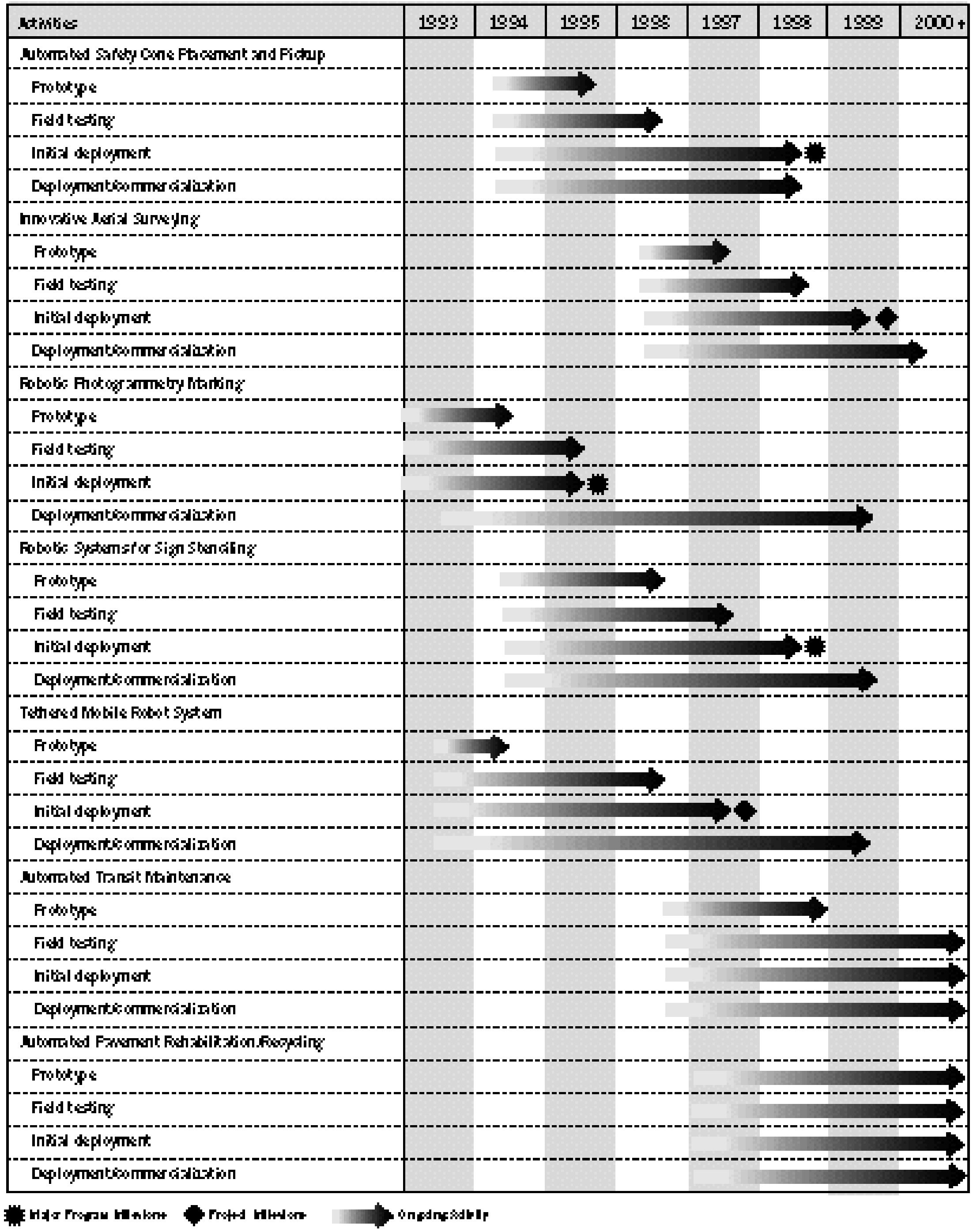
Roadway Maintenance & Construction



## Infrastructure Construction & Maintenance

**Activity Charts**

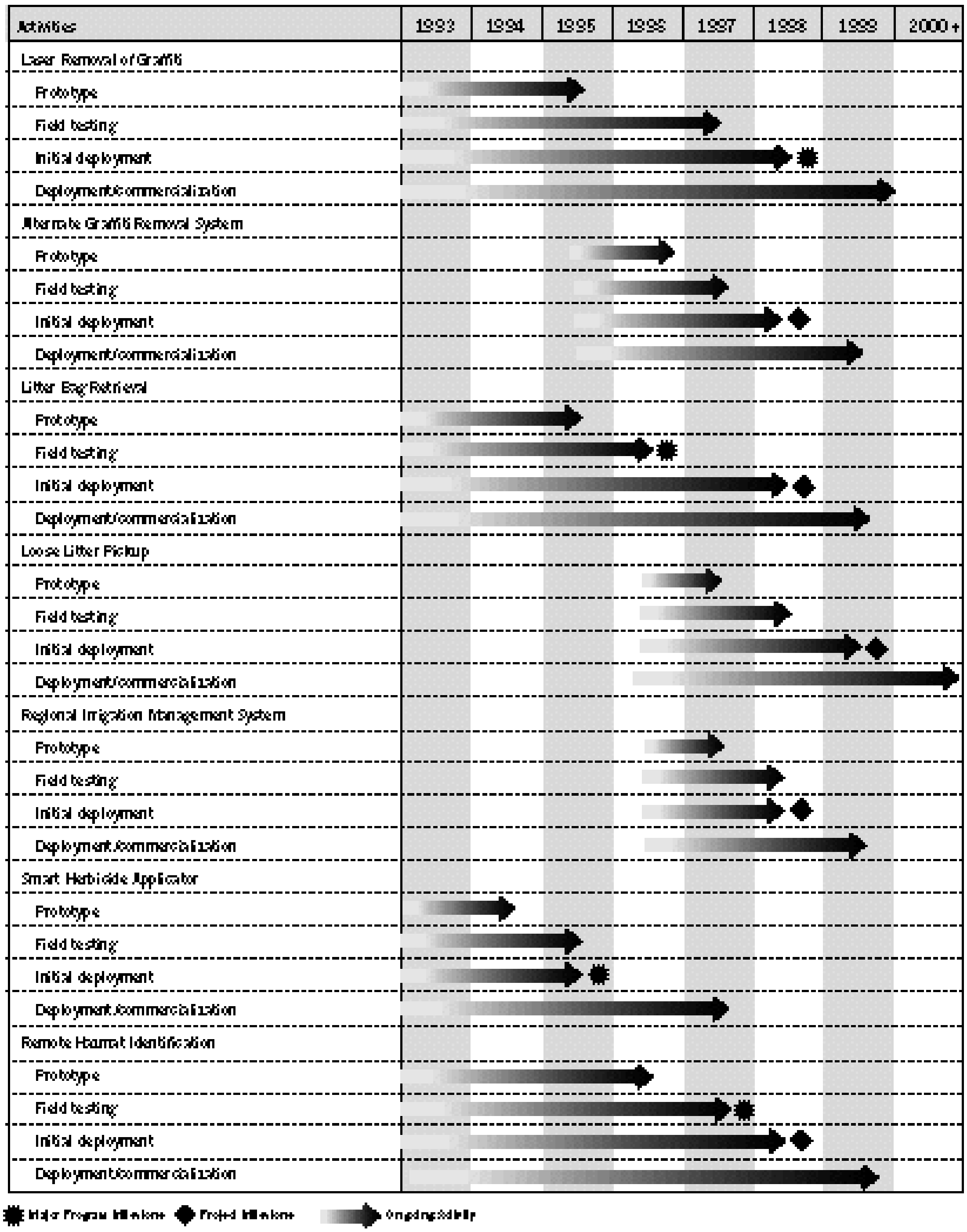
Roadway Maintenance & Construction contd



# Infrastructure Construction & Maintenance

## Activity Charts

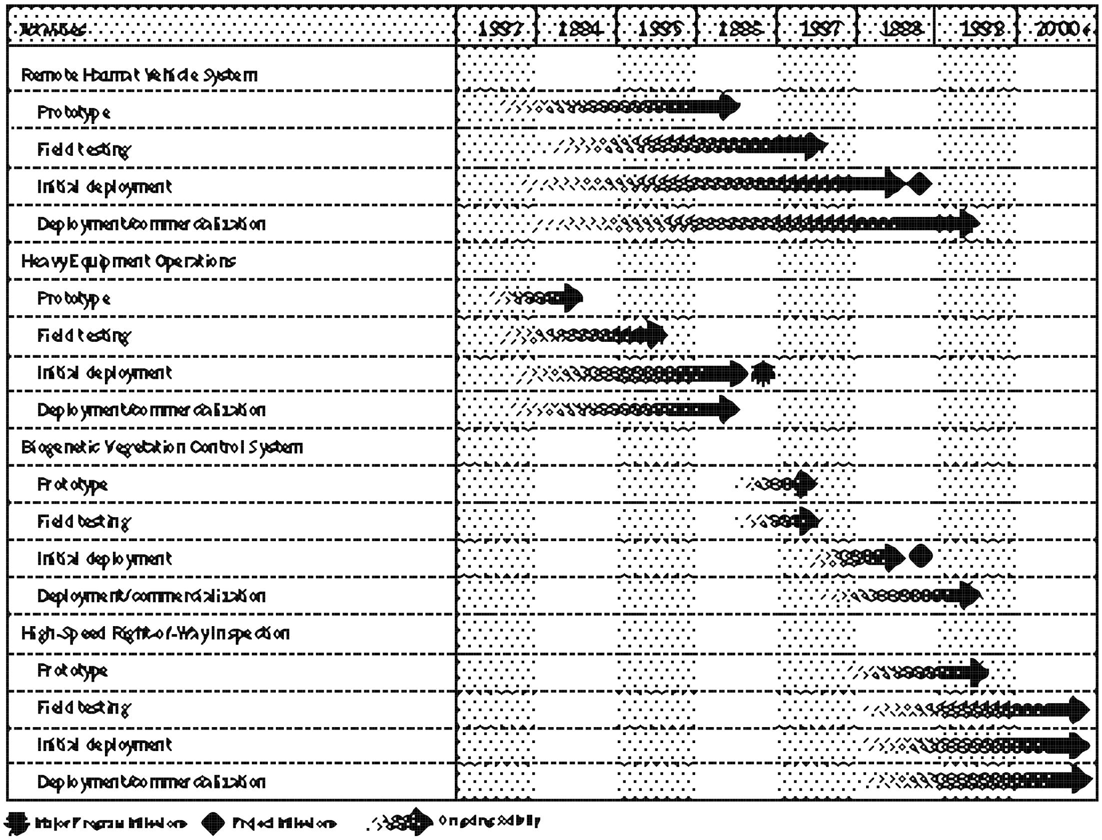
Roadside Maintenance & Construction



## Infrastructure Construction & Maintenance

**Activity Charts**

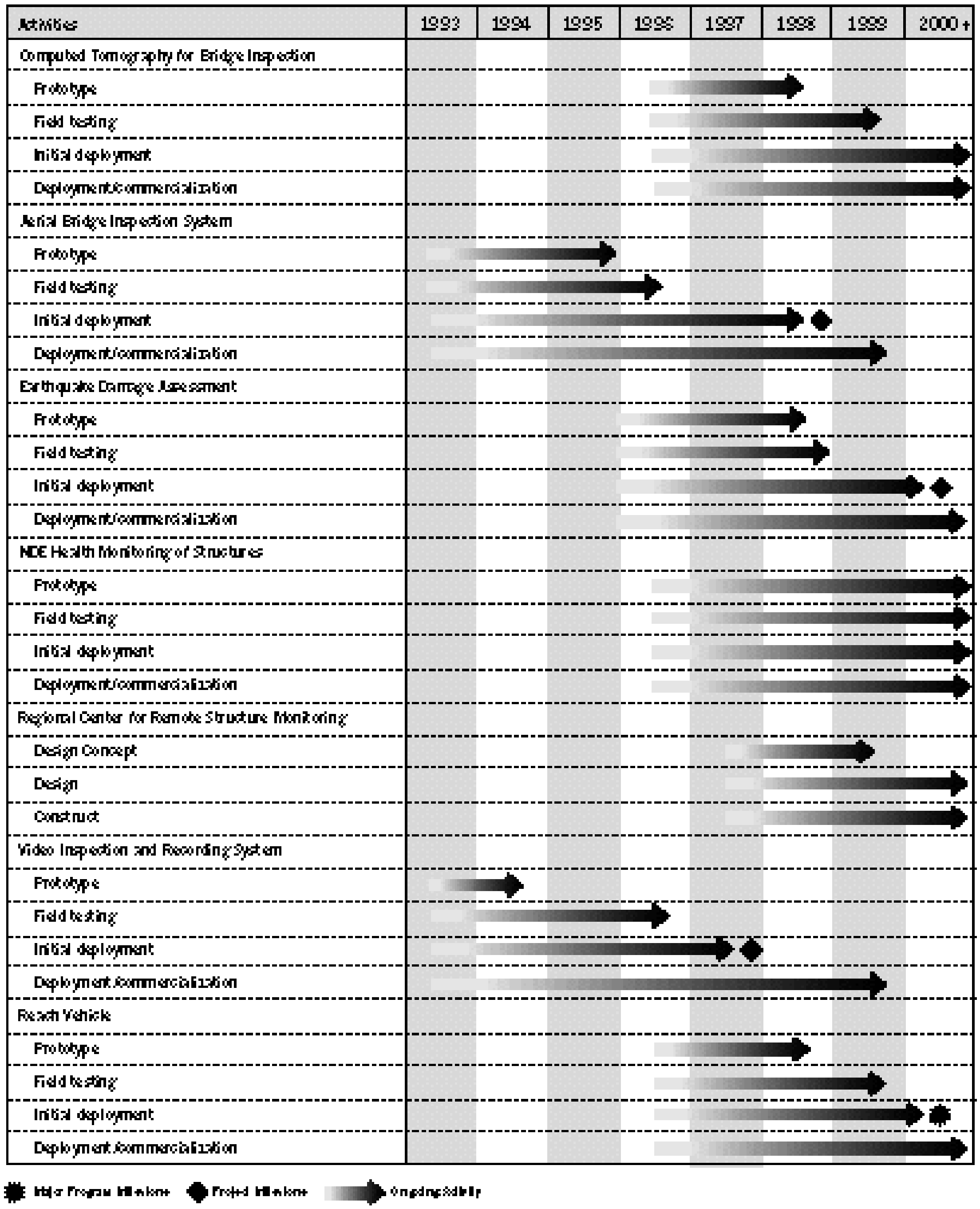
Roadside Maintenance & Construction contd



## Infrastructure Construction & Maintenance

**Activity Charts**

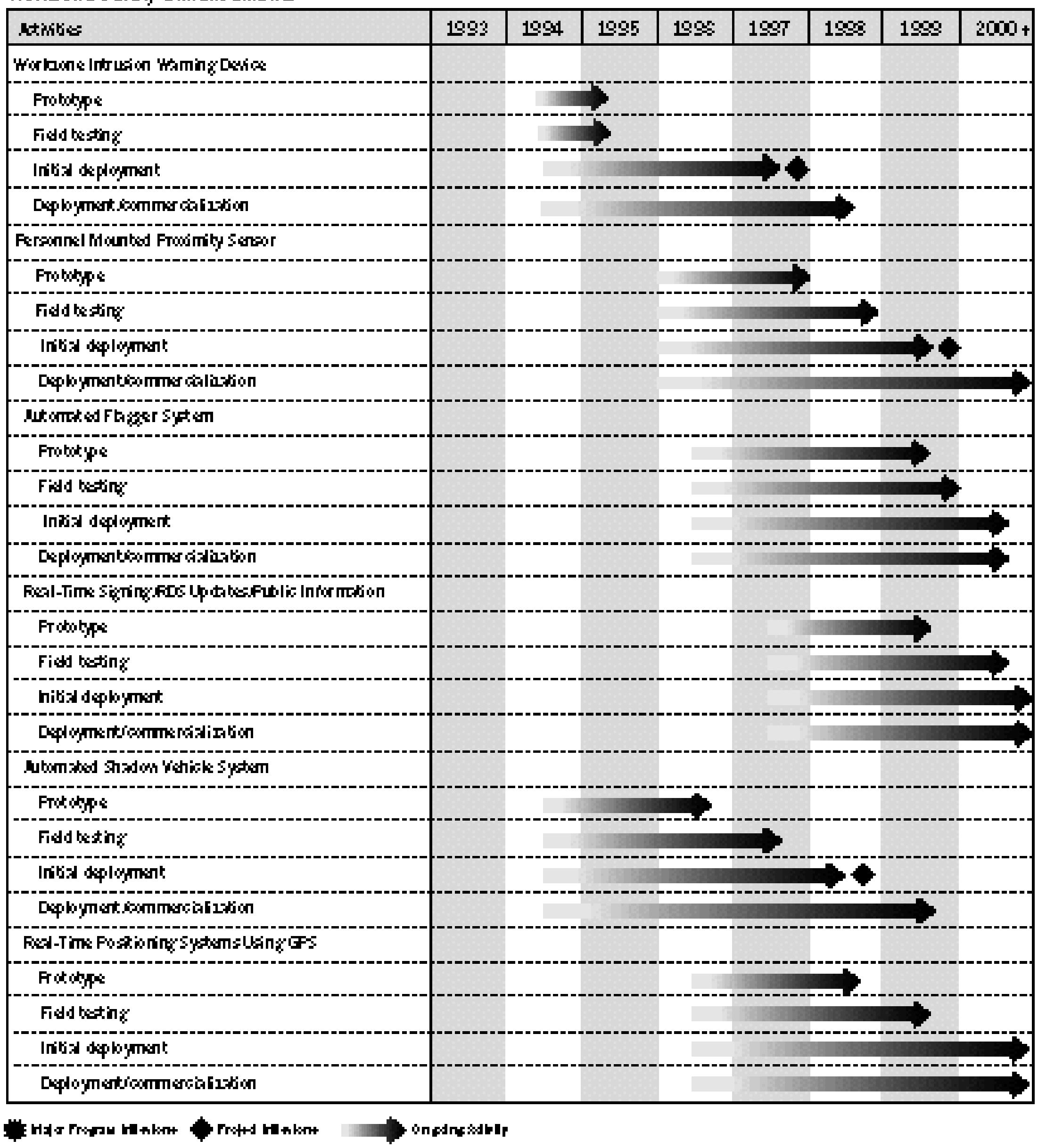
Structure Maintenance & Construction



## Infrastructure Construction & Maintenance

### Activity Charts

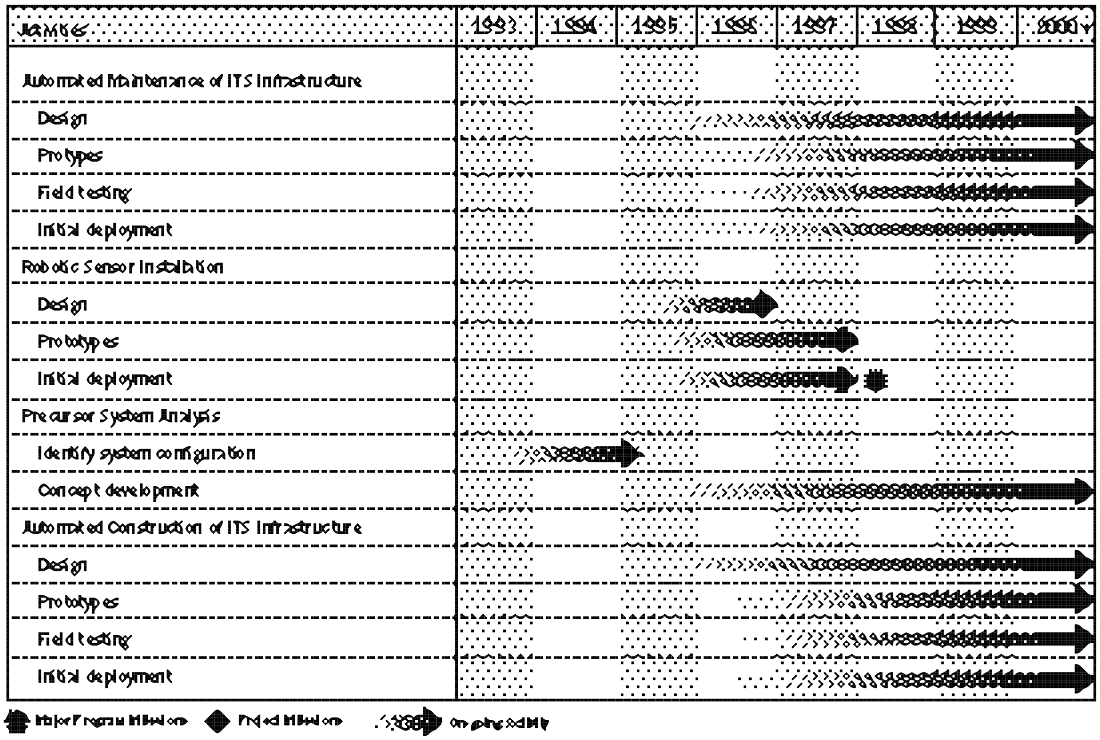
Workzone Safety Enhancements



## Infrastructure Construction & Maintenance

**Activity Charts**

ITS/AHS Infrastructure Maintenance and Construction



**The following AHMCT projects show the most immediate potential for commercialization or extensive field prototype operation:**

### Crack Sealing Machine

The Automated Crack Sealing Machine (ACSM) is a self-contained prototype vehicle for automatic identification, preparation, and sealing of roadway cracks—a conventionally dangerous, slow, and labor-intensive operation. This vehicle will increase the efficiency of crack sealing and enhance the safety of maintenance workers and the traveling public, as well as reduce the time necessary for lane closures.

The vehicle is equipped with a vision system, a robot positioning system, and computer and mechanical support systems. During automated operation, the vision sensing system detects the position of cracks, including their orientation, while the relative position of the vehicle is continuously monitored by a dead-reckoning system. The crack data is buffered and processed by modules which determine the order of cracks to be sealed as they become accessible in the sealing workspace and positions the robotic arm with a custom sealant head along the calculated crack positions. The sealant head, custom designed to fill and seal any size crack according to standard specifications, is so innovative that interest from maintenance and industry personnel has encouraged accelerated efforts to commercialize it as an independent material delivery module.

A longitudinal crack sealing vehicle has been developed to seal only the continuous pavement joints along lanes. The quick-moving vehicle uses the same custom sealant head as the general crack sealing machine, and has been tested in Caltrans District 2 (Redding), District 3 (Marysville) and District 11 (San Diego).

### Robotic System for Sign Stenciling

The traditional method of stenciling is a very slow, labor-intensive operation that requires manual placement of a stencil and paint, exposing maintenance workers and the traveling public to hazards. The goal of the new stenciling system is to improve the safety, reliability and efficiency of the roadway sign stenciling operation through the application of automation and robotic technologies. The first prototype resulting from this project focuses on the stenciling of survey premarks for photogrammetry. Using the automated stenciling system, a single operator can accurately complete the painting operation from within the cab of the maintenance vehicle in a fraction of the half-day-per-mile required by the traditional four-person survey crew. By eliminating or reducing the exposure of workers to traffic, the safety, speed, and efficiency of the stenciling operation is significantly improved.

**Crack sealing machine prototype testing, District 3 (Marysville)**

**Infrastructure Construction & Maintenance**

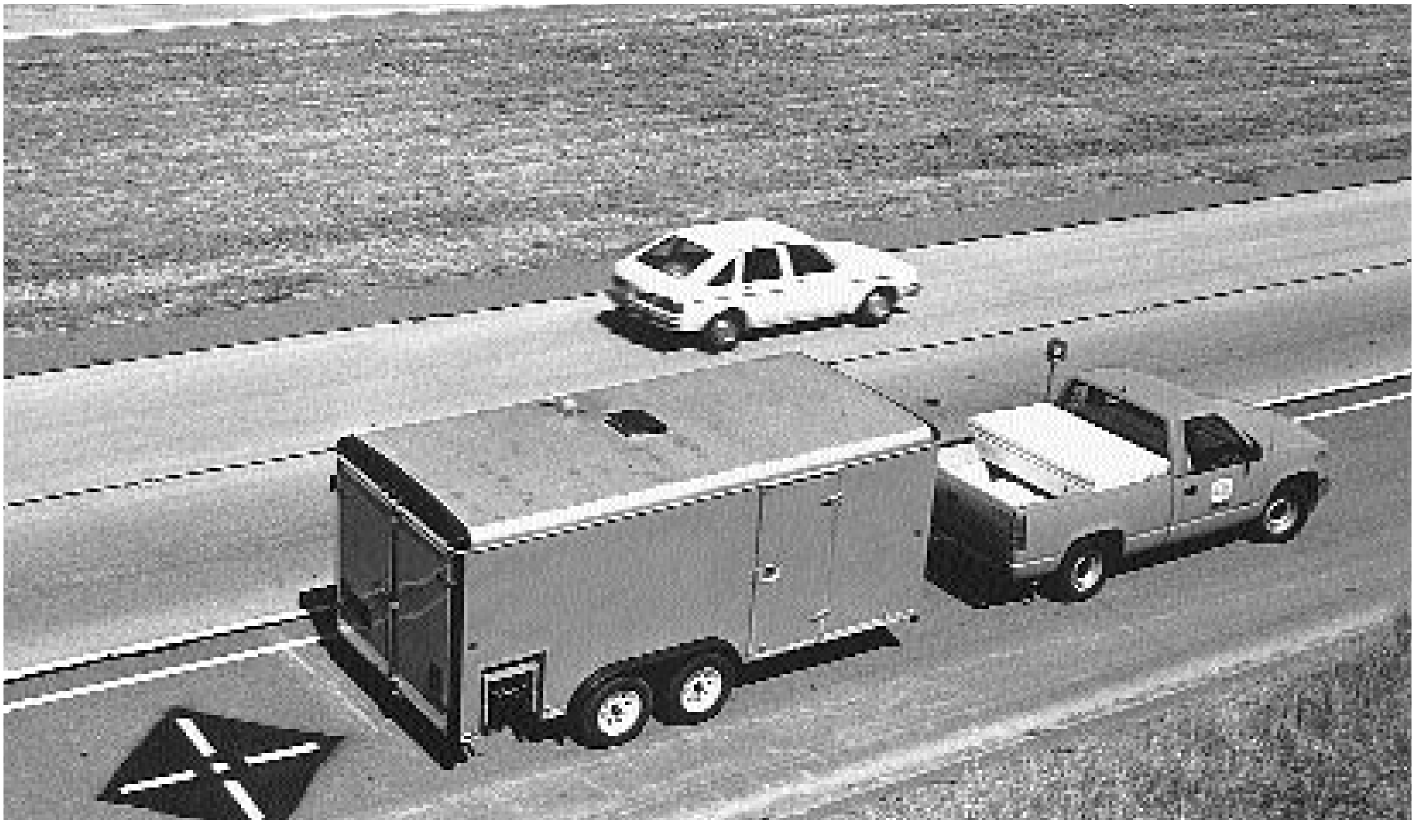
**Project Highlights**

**TAMER equipment in operation. Both of the methods shown, the backpack unit and stationary console, are available for remote operation.**

## Remote-Control Heavy Equipment

Heavy equipment such as crawler tractors, dozers, and loaders, are often used in hazardous situations such as clearing avalanches, landslides, and snow, as well as cleaning up hazardous materials. The respective equipment operators are by necessity exposed to this high-risk, unstable environment. Remote controlled capability permits the operator to control the equipment from a safe distance when the conventional operation is deemed dangerous. The remote distance for reliable operation is 488 meters (1600 ft).

Teleoperated and Automated Equipment Robotics (TAMER) technology has most recently been applied to a Caltrans front-end loader. It is anticipated that such a remote-control system could also be adapted to other existing maintenance and construction equipment.



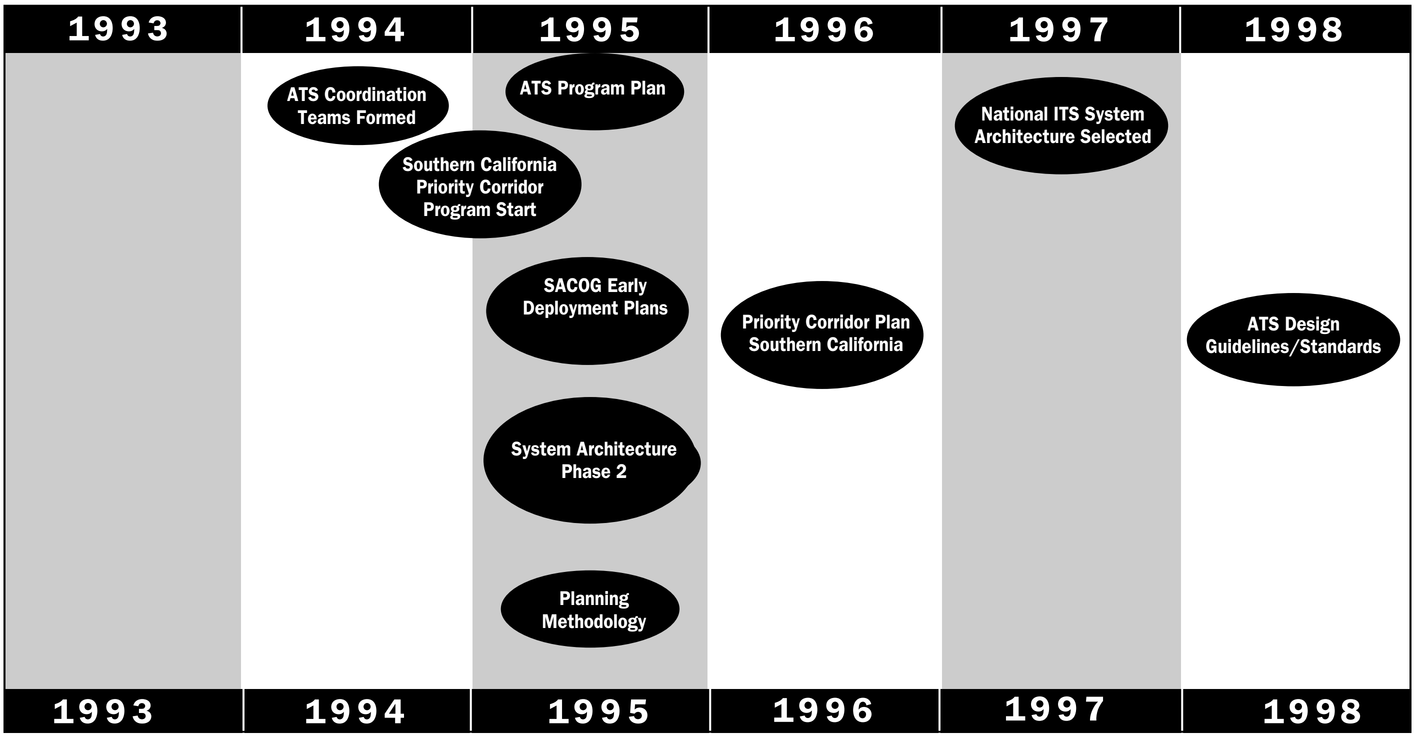
**Robotic System for Sign Stenciling in operation.**

# SYSTEMS DEVELOPMENT, INTEGRATION AND IMPLEMENTATION

**Systems Development, Integration and Implementation includes Caltrans involvement in integrated systems design and operation framework; planning, programming and environmental aspects, as well as legal and institutional issues associated with the deployment of advanced transportation technologies in California.**

**The milestones, scope of services, activities and specific project highlights for Systems Development, Integration and Implementation are discussed on the following pages.**

# System Development, Integration and Implementation



## Systems Development, Integration and Implementation

**System Architecture-Scope**

### ITS Architecture Definition

An ITS architecture is a framework that defines the system elements, determines their functions, and describes how the elements interact with each other. It describes the system operation by what data is collected, what information is distributed, and the means by which that is accomplished. The framework is presented via charts and diagrams, along with narratives. The architecture framework is *not* a system hardware or software design and it is not a policy decision or directive.

System architecture presents the total perspective to aid in the analysis and design of the individual ITS parts while taking into consideration the needs and constraints of the transportation system as a whole. Within this context, the objectives for the ATS Program are to:

- Define an integrated system design and operational framework. The best approach to designing such a framework is to develop an overall system architecture that will determine not only the functions of individual components, but more importantly, their connectivities (design) and interrelationships (operation);
- Analyze the system-level aspects that could create problems or have impacts on the system as a whole, and not necessarily on its individual parts. Such problems would apply to system modeling of interconnection/communications, design, human factors, reliability, optimization, openness, and full automation;
- Synthesize and integrate the various components and subsystems as they are being developed, produced, and deployed to insure their connection, the correction of deficiencies, and elimination of duplication and unwanted redundancies; and,
- Synchronize research and development, as well as deployment work across all programs to ensure efficient use of time and resources, as well as satisfactory progress and timely completion of tasks.

The degree to which these objectives are accomplished determines how timely and complete the intermodal advanced transportation system can be, as well as how efficiently and harmoniously it will operate.

## Significance of the ITS Architecture

The significance of the ITS architecture stems from its ability to allow nationwide deployment of compatible transportation systems and synergistic transportation services. The architecture's significance is manifested by its stated objectives which are:

- Promote national compatibility via determining and implementing national standards and protocols for vehicle-to-vehicle and vehicle-to-infrastructure communications;
- Facilitate ITS user service integration via a framework for integrating data collection, data transmission, information processing, information dissemination, traffic control, and intermodal transportation system functions;
- Accommodate new and evolving user services via a structural framework of basic building blocks for incorporating new systems and functions; and,
- Provide regional, institutional, and consumer decision-making flexibility in implementing ITS systems without weakening the above three objective benefits.

## Caltrans' Involvement in the National System Architecture Program

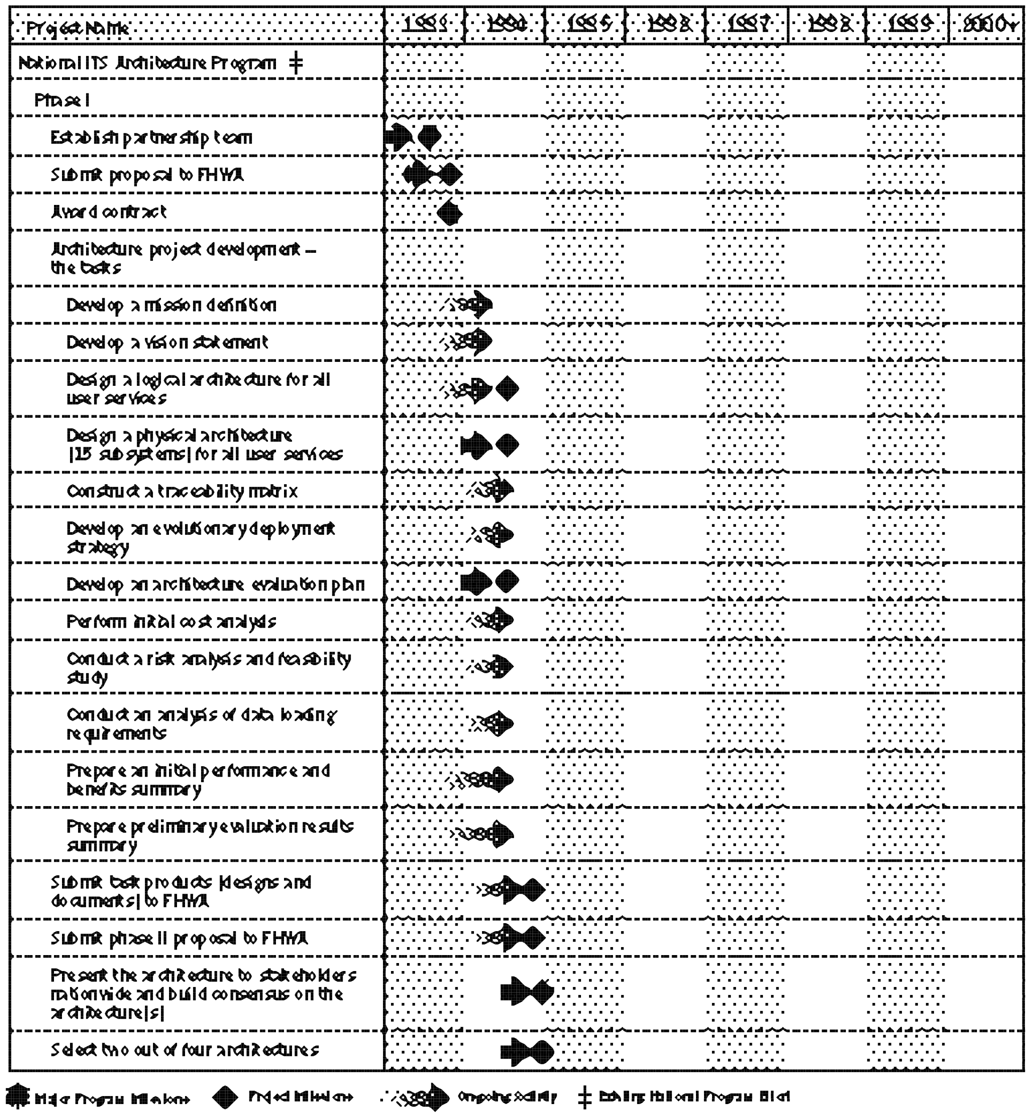
Caltrans is an active participant in the Architecture development process to:

- Insure that California traffic congestion problems and transportation system needs are well addressed;
- Influence the design of the national architecture so it leverages and maximizes the utilization of California's existing transportation infrastructure, as well as California's future plans and investments in the transportation systems;
- Insure that future transportation systems in California are designed/deployed to fit well within the emerging national ITS architectural framework; and
- Share Caltrans' experiences with, and provide expertise to, the FHWA, as well as to the rest of the states' DOTs.

## Systems Development, Integration and Implementation

### System Architecture-Activity Charts

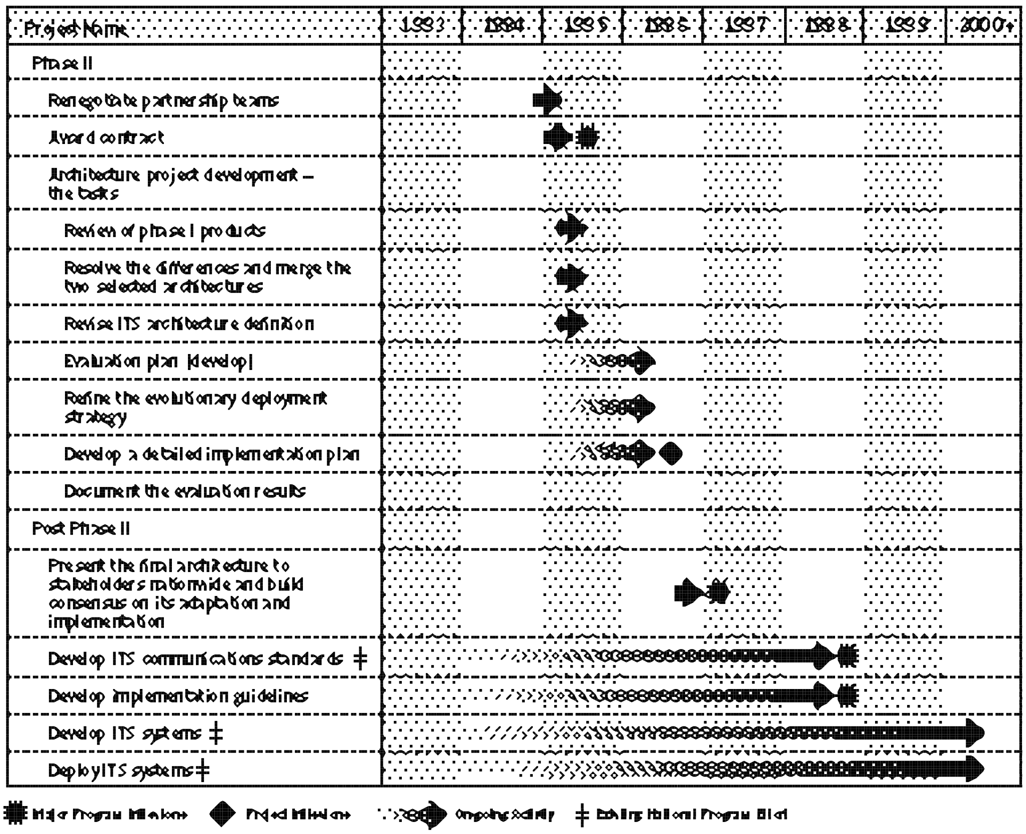
System Architecture



## Systems Development, Integration and Implementation

### System Architecture-Activity Charts

System Architecture contd



## Systems Development, Integration and Implementation

### Institutional and Legal Issues - Scope

For Caltrans, the scope of institutional and legal issues covers planning, programming and environmental needs, as well as legal and institutional barriers. Caltrans, in cooperation with all levels of government, the private sector, academia, and various interest groups, is working on several fronts to help assure timely and responsible deployment of advanced transportation systems in California. Examples include:

- Caltrans is working with its partners to establish regional teams throughout the state to coordinate ATS programs and activities and help facilitate ATS deployment;
- Caltrans, in cooperation with local and regional agencies, is preparing the Southern California Priority Corridor Plan as provided for in ISTEA to showcase ITS technologies in Southern California (see Project Highlights); and,
- Caltrans, in cooperation with ITS America and the Federal Highway Administration, co-sponsored a policy conference on air quality in June 1994. This was the third conference in a series addressing the relationship of ITS to air quality.

Caltrans is considering state policy and legislative initiatives that will support ATS and related economic endeavors such as:

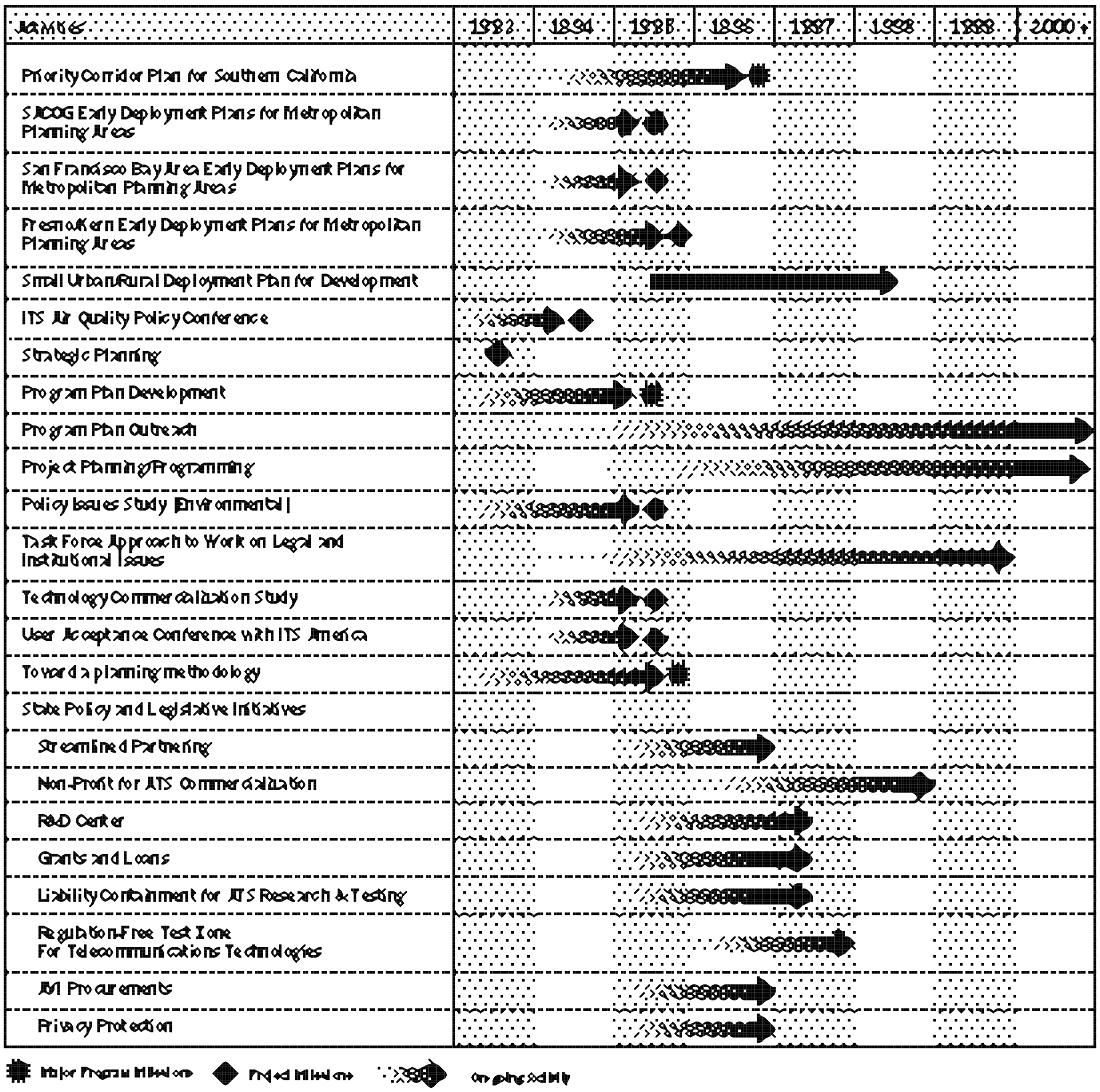
- Streamlined partnering arrangements for the program
- Non-profit corporation for ATS commercialization
- Grants and loans for ATS innovations by small businesses
- Liability containment for ATS research and testing in California
- Regulation-free test zone for telecommunication technologies
- AVI procurements for public fleet vehicles
- Privacy protection in ATS deployment

The five-year activity charts for these and other activities provide the institutional base for ultimate deployment of advanced transportation systems, products, policies and services.

## Systems Development, Integration and Implementation

### Institutional and Legal Issues - Activity Charts

Institutional Issues



**Systems Development, Integration and Implementation**

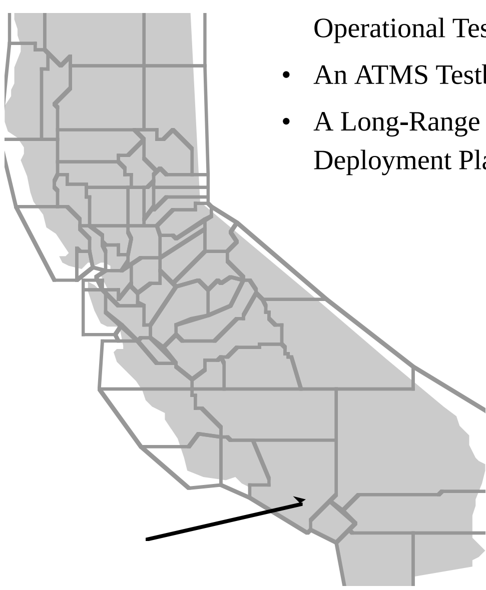
**Systems Architecture and Institutional Issues - Project Highlights**

### A Showcase of ITS Technologies and Stakeholder Cooperation

The Southern California Priority Corridor, one of four corridors identified in the nation, is to be a showcase for the deployment of intelligent transportation systems (ITS). Southern California is a major destination for international travel and goods movement. Travelers and goods flow to and through the corridor from Asia, Mexico, Central America, South America and Europe to destinations in Southern California and the rest of the nation. It is critical, therefore, that the transportation system supports the smooth flow of people and goods through the most populated area in the state.

The four major efforts occurring in the corridor are:

- An Intermodal Transportation Management and Information System (ITMIS) Showcase Project;
- Five Smaller-scale Field Operational Tests;
- An ATMS Testbed; and,
- A Long-Range ITS Strategic Deployment Plan.



An important component of the showcase of ITS is the institutional cooperation that is necessary to accomplish these objectives. The Southern California Priority Corridor partners have begun to lay a solid foundation by establishing cooperative agreements, regional teams, and a steering committee to assure the effective execution of the four initiatives. Local participation and leadership will be emphasized in the management of this effort.

### ITMIS Showcase Project

The showcase is a major effort to integrate intelligent transportation system technologies into a model intermodal transportation management system. The project will design, implement, operate and evaluate ITS user services which provide linking and optimization of multimodal transportation systems within the region. The showcase project will demonstrate an areawide interactive/integrated transportation management and information system based on real-time, computer-assisted transportation management and communications. User service will include:

- Real-time information to travelers and operators;
- Decision/management support to transportation management centers, traffic engineering/public safety departments and vehicle fleet operators (public and commercial); and,
- Information/communications network, linking transportation systems and modes which are presently uncoupled, including marine and air.

### Field Operational Tests

Five Field Operations Tests have been funded by FHWA in the corridor.

- In the city of Irvine, an integrated ramp metering/adaptive signal control project will evaluate the operational effects of balancing traffic flow between I-5/I-405 and the parallel arterial streets. The project will also demonstrate the effectiveness of collaborative action on the part of transportation management agencies to optimize their strategies to improve traffic flow.
- The city of Anaheim is testing Split, Cycle, Offset Optimization Technique (SCOOT) as an adaptive signal timing control package. SCOOT automates the data collection process and then automatically optimizes traffic signal timing based on real-time traffic conditions. Video Traffic Detection System cameras will be installed and evaluated in conjunction with the SCOOT system.
- At locations throughout Orange County, a Mobile Surveillance Field Operations Test will evaluate the use of a portable detection and surveillance system for highway construction, special events, and incident locations. Specially-equipped trailers will be placed at temporary traffic congestion locations. Trailer-mounted video image detectors will use spread spectrum radio for transmission of real-time information to state and local control centers.
- State, regional and local agencies in San Diego will take advantage of the extensive call box system to increase their functionality by adding an interface to traffic management devices. These “smart” call boxes will collect traffic census data; obtain traffic counts, flows and speeds for accident detection; detect and report hazardous weather conditions; control changeable message signs, and operate roadside closed-circuit television cameras.
- The city of Los Angeles is conducting a spread spectrum radio traffic interconnect project to evaluate wireless traffic signal communications. The radios will be tested in a network of signals to determine their ability to reliably re-route communications links, their ability to work in a variety of geographies, their ability to provide for large-scale once-per-second communications, and to determine the cost-effectiveness of using this technology.

**Systems Development, Integration and Implementation**

**Systems Architecture and Institutional Issues - Project Highlights**

### Testbed

The Advanced Transportation Management Systems (ATMS) Testbed is a cooperative program sponsored by Caltrans, PATH and local agencies in Orange County to enable ongoing research, testing and evaluation activities for development and operation of integrated multijurisdictional and multimodal transportation management systems. The testbed utilizes existing real-time, computer-assisted traffic and transportation management systems and PATH labs at the University of California, Irvine and California Polytechnic State University, San Luis Obispo.

The ATMS testbed is intended to:

- Provide an instrumented, multijurisdictional, multiagency transportation operations environment linked to university laboratories for real-time technologies and applications. It will enable off-line testing of products and further development of research prototypes prior to installation in the field;
- Provide a meeting ground for practitioners and researchers to try new approaches to transportation system management;
- Enable private industry to demonstrate and evaluate their prototyped technologies under real-world traffic conditions; and,
- Make available a continual testing ground for California and national ITS efforts.

### Strategic Deployment Plan

Early deployment planning for intelligent transportation systems in the Priority Corridor will occur over an 18-month period. A Strategic Deployment Plan, estimated to be completed in the summer of 1997, will address the 29 user services defined by ITS America as they would apply to the needs of Southern California. The plan will identify "early starts," as well as a 20-year plan/schedule and funding estimates for deployment of ITS elements. Public participation is an important element of the plan. To define the needs of the users of all transportation systems and modes, input will be solicited from commercial freight operators, transit operators and travelers.

Start-up activities in the corridor have already provided an exceptional opportunity to develop partnerships with stakeholders. These include MPOs, state agencies, air quality management districts, cities, counties, and transit districts. The opportunity to participate will continue to expand to include various modal operators, private industry, and others.

## ATS Program Resource Needs

Stability in state funding that parallels ISTEA is essential if California is to realize the vision set before it. Currently $12.9 million in state funds is annually budgeted to leverage, in conformance with AB3096, $20 million in federal funds and $10 million in cost sharing from Caltrans' partners.

This baseline budget provides Caltrans with the minimum state funding necessary to ensure viable California economic partnerships to continue current major program initiatives in the areas of the Automated Highway Systems (AHS) Prototype; Priority Corridor Showcase; Smart Traveler Deployments (urban); Deployment Planning (urban and rural); Transportation Management Systems Testing; and, Automated Highway Construction and Maintenance.

However, a more aggressive ATS market approach could have far reaching economic benefits for California in key market areas, such as: nearer-term vehicle safety products; multimodal traffic management; advanced fleet management; and, premium traveler services packaged for new multimedia and telecommunications markets.

This market approach requires aggressive institutional issues resolution to assure integrated public/private efforts, cooperative research, development, and testing, supporting technology deployments in the public infrastructure, and standards development to accelerate commercialization. Accordingly, adoption of state policy and legislative initiatives may be required.

The resource estimates for aggressive research, development and testing of technologies on an annual basis are:

- State - $30 million;
- Federal - $20 million; and,
- Partners - $30 million.

Public infrastructure improvements/deployments are estimated at $300 to $500 million from all sources.

A strong commitment to the ATS Program will further mobility and economic opportunities for California. The program's vision will be realized primarily through strategic deployment of technologies to the public transportation infrastructure. Private sector investment and commercialization will be necessary. This holds great potential for establishing new California businesses in international markets and the creation of jobs for Californians into the 21st century.

# TRANSPORTATION MANAGEMENT SYSTEMS

## Multimodal Traffic Management

- *Incident Management*
- *Travel Demand Management*
- *Traffic Control*
- *Electronic Payment Services*
- *Public Travel Security*
- *Emergency Notifications and Personal Security*

## Advanced Fleet Management

- *Automated Roadside Safety Inspection*
- *Public Transportation Management*
- *Commercial Fleet Management*
- *Commercial Vehicle Preclearance*
- *Commercial Vehicle Administrative Processes*
- *Emergency Vehicle Management*

## Intermodal Facilities

**Transportation Management Systems is a package of technologies that enables the integration of freeway and surface arterial operations so that travel corridors and areas can be efficiently managed and will enhance communications for commercial vehicle operations.**

**The milestones, scope of services, activities and specific project highlights for Transportation Management Systems are discussed on the following pages.**

# Transportation Management Systems

| 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|
| California Specification - AVI | | Electronic Toll Collection Deployment | Advanced Transit Fleet Management Demonstration | Real-Time Adaptive Traffic Control Demonstration | Multimodal TMC Demonstration |
| | | "Smart Corridor" Demonstration | National ITS System Architecture Selected | HOV Route Guidance Test | Public Travel Security Demonstration |
| | | ATMS Test Bed Established | Prototype HOV - TMC Interaction | Emergency Notification (Mayday) Demonstration | |
| | | H.E.L.P. Implementation | Guidelines for Navigable Map Database | | |
| 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |

## Transportation Management Systems

**Multimodal Traffic Management — Scope**

Transportation Management Systems - Multimodal applications can be defined in these user services terms:

- ### Incident Management

**Helps officials quickly identify incidents and implement a formalized set of procedures to minimize impacts on the transportation system.**

Incident management will also help schedule or forecast predicted incidents to minimize impacts. Predicted incidents include road construction and maintenance, road closures, and certain severe weather conditions. Verification and response activities apply to both predicted and unpredicted incidents once they occur. Incident management will support the development and implementation of appropriate response actions including changing traffic control. In some cases, where incident management is closely integrated with other user services, automation will improve the speed and effectiveness of responses.

- ### Travel Demand Management

**Supports policies and regulations such as the 1990 Clean Air Act.**

The act requires employers with over 100 employees in designated areas of severe or extreme ozone pollution to implement a travel demand management program. The concept includes:

- Reducing the number of single-occupancy vehicles commuting to work;
- Increasing the use of high-occupancy vehicles for selected user group markets;
- Mitigating the impact of highly polluting vehicles; and,
- Providing a wide array of mobility options.

Government and private industry can use travel demand management dynamically, depending on congestion and pollution conditions in a given area, at a given time. Applications include enforcing HOV lane use, parking control, and road access pricing and prioritization schemes.

- ### Traffic Control

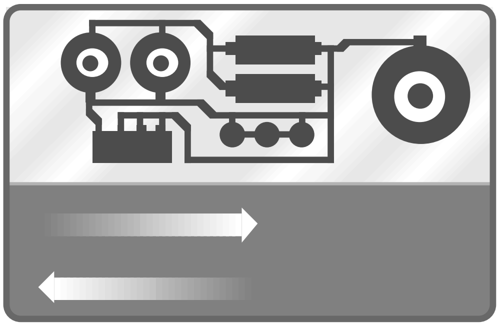
**Manages the movement of traffic on the transportation system.**

Traffic control services optimize and coordinate freeway and signalized street operations with public transportation operations to balance demand with capacity within the transportation system. In its more advanced forms, preferred treatment can be given to high-occupancy vehicles through traffic signal and adaptive traffic control.

- **Electronic Payment Services**

  **Allows travelers to pay for transportation services with electronic cards or tags.**

The goal is to provide travelers with a common electronic payment medium for all transportation modes and functions including tolls, transit fares, and parking. A common service fee and payment structure, employing multi-use SmartCards, could integrate all modes of transportation, including roadway pricing options.



- **Emergency Notification and Personal Security**

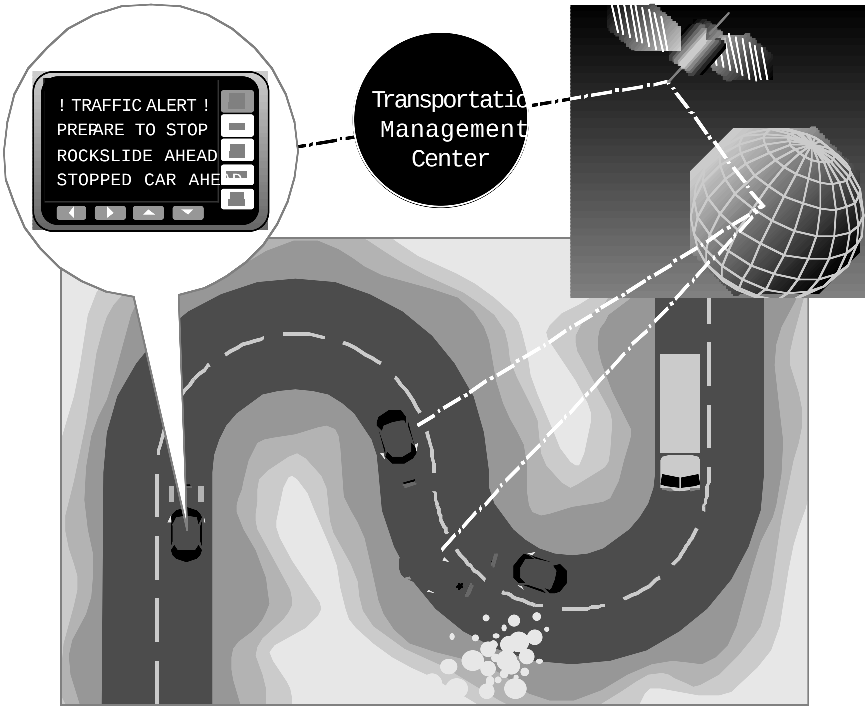
  **Provides immediate notification of an incident and immediate request for assistance.**

Emergency notification and personal security includes two capabilities: driver/personal security, and automatic collision notification. Driver and personal security capabilities provide for user initiated distress signals for incidents like mechanical breakdowns and carjackings. The message will include vehicle location and the receiver will send an acknowledgment signal back to the user. Automatic collision notification identifies a collision and automatically sends information regarding location, nature, and severity to emergency personnel.

- **Public Travel Security**

  **Creates a secure environment for public transportation patrons and operators.**

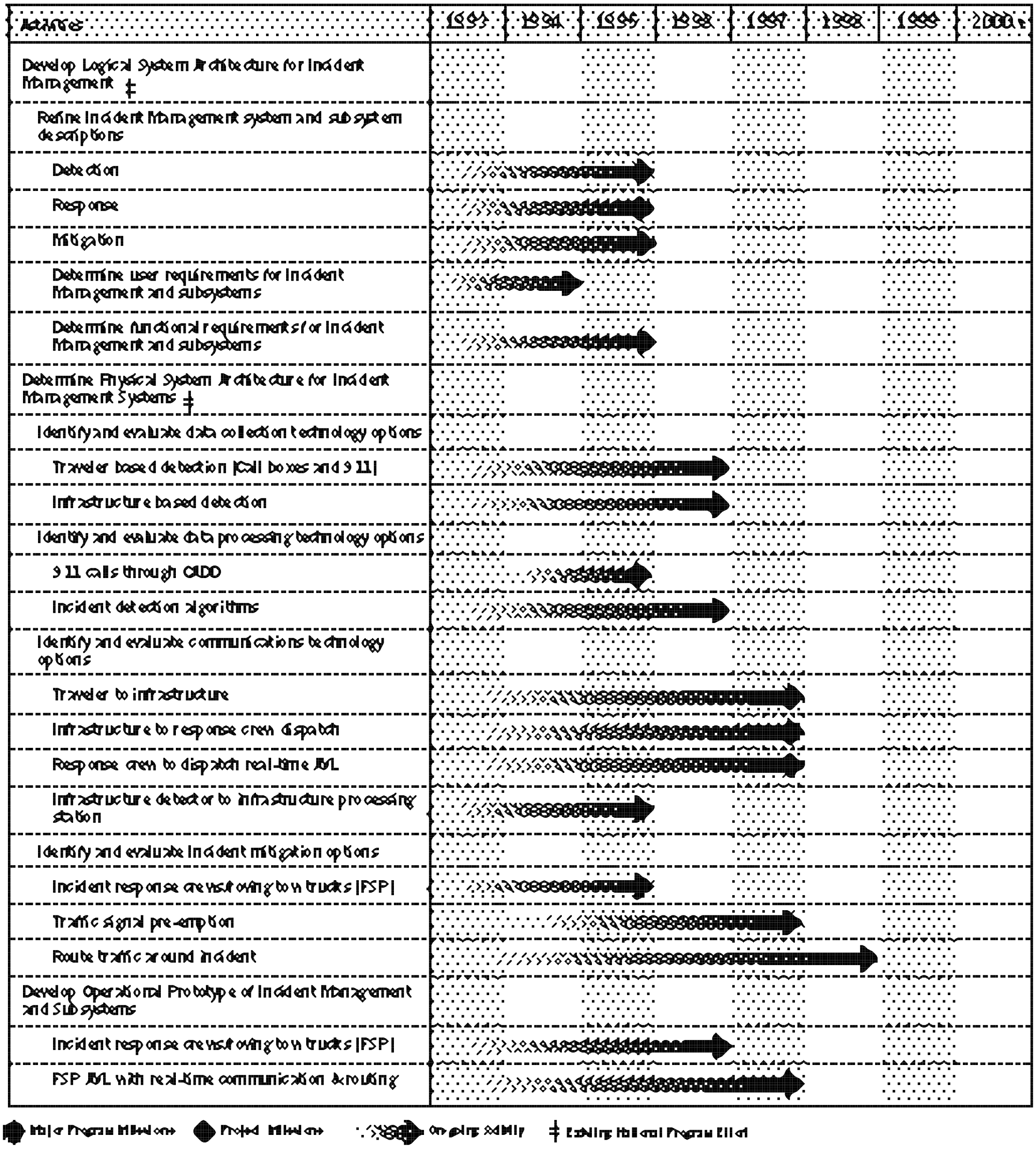
The automobile separates its passengers from the surrounding environment and provides a perception of security and personal control. Public transportation users must trust control of their environment to the operator and local police.



## Transportation Management Systems

### Multimodal Traffic Management — Activity Charts

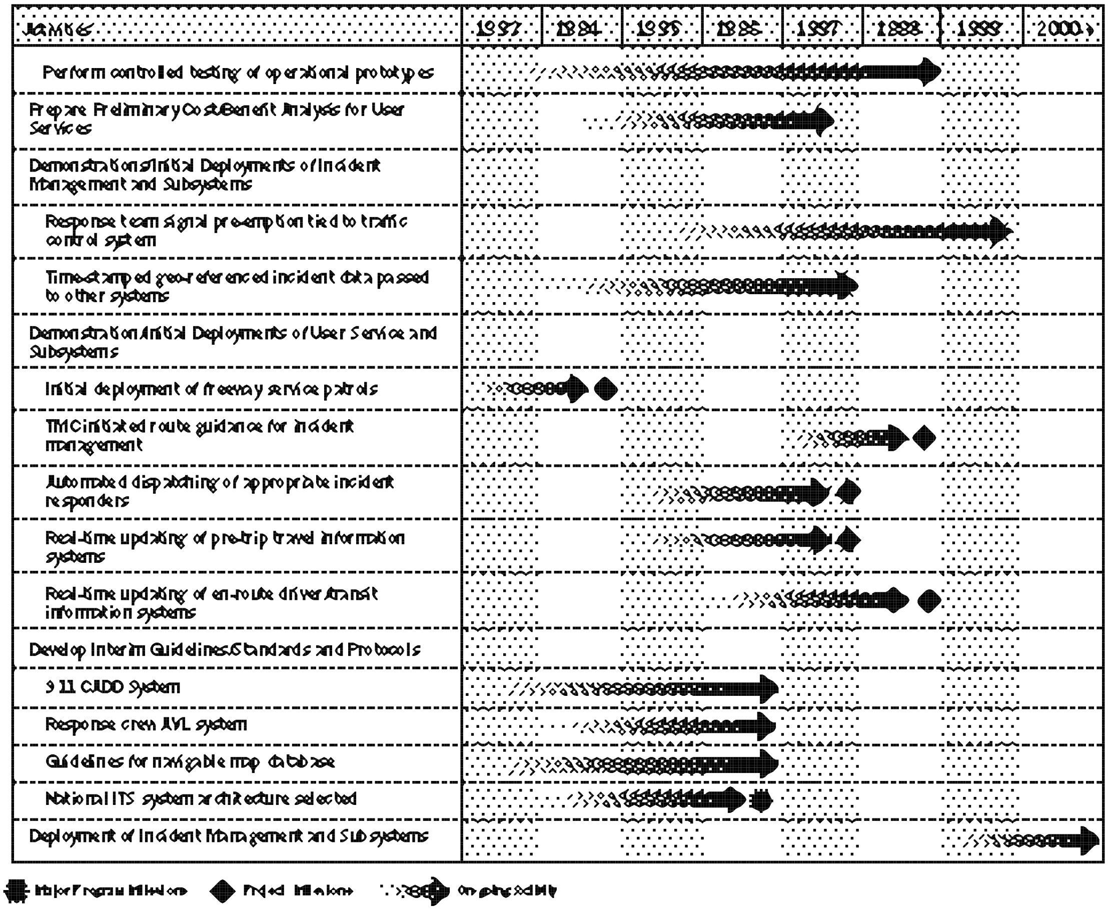
Incident Management



## Transportation Management Systems

### Multimodal Traffic Management — Activity Charts

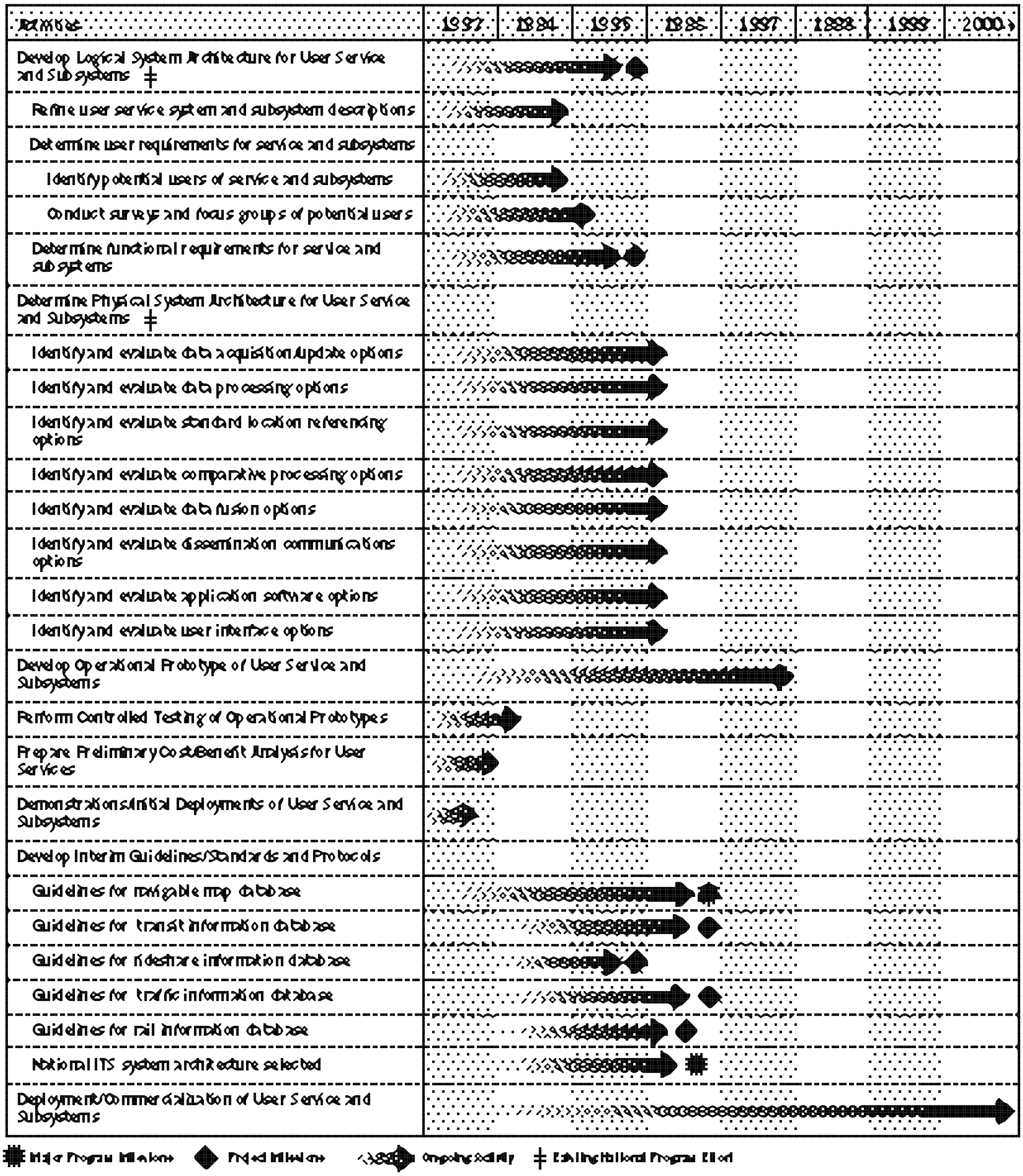
Incident Management contd



## Transportation Management Systems

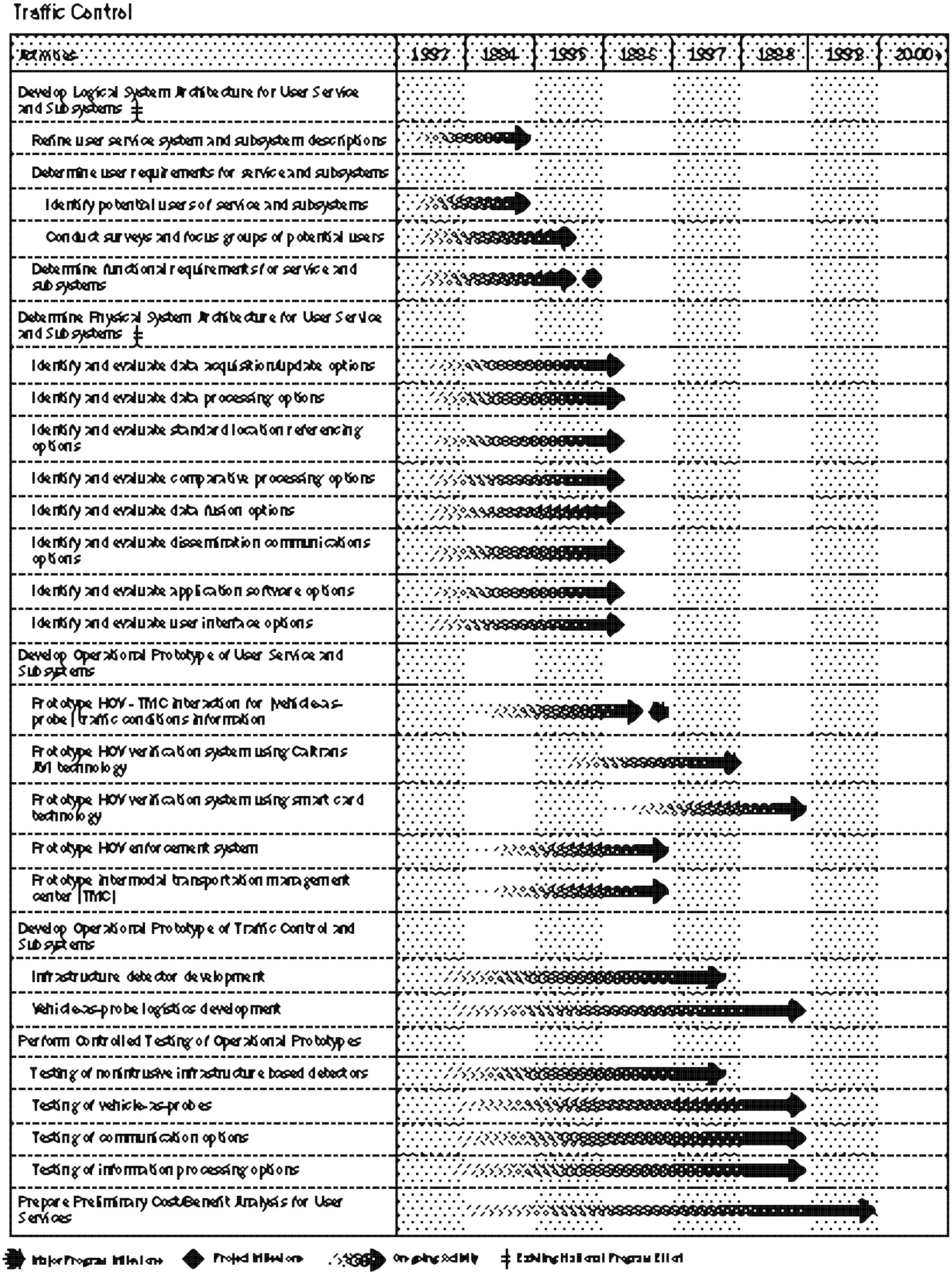
### Multimodal Traffic Management — Activity Charts

Travel Demand Management



## Transportation Management Systems

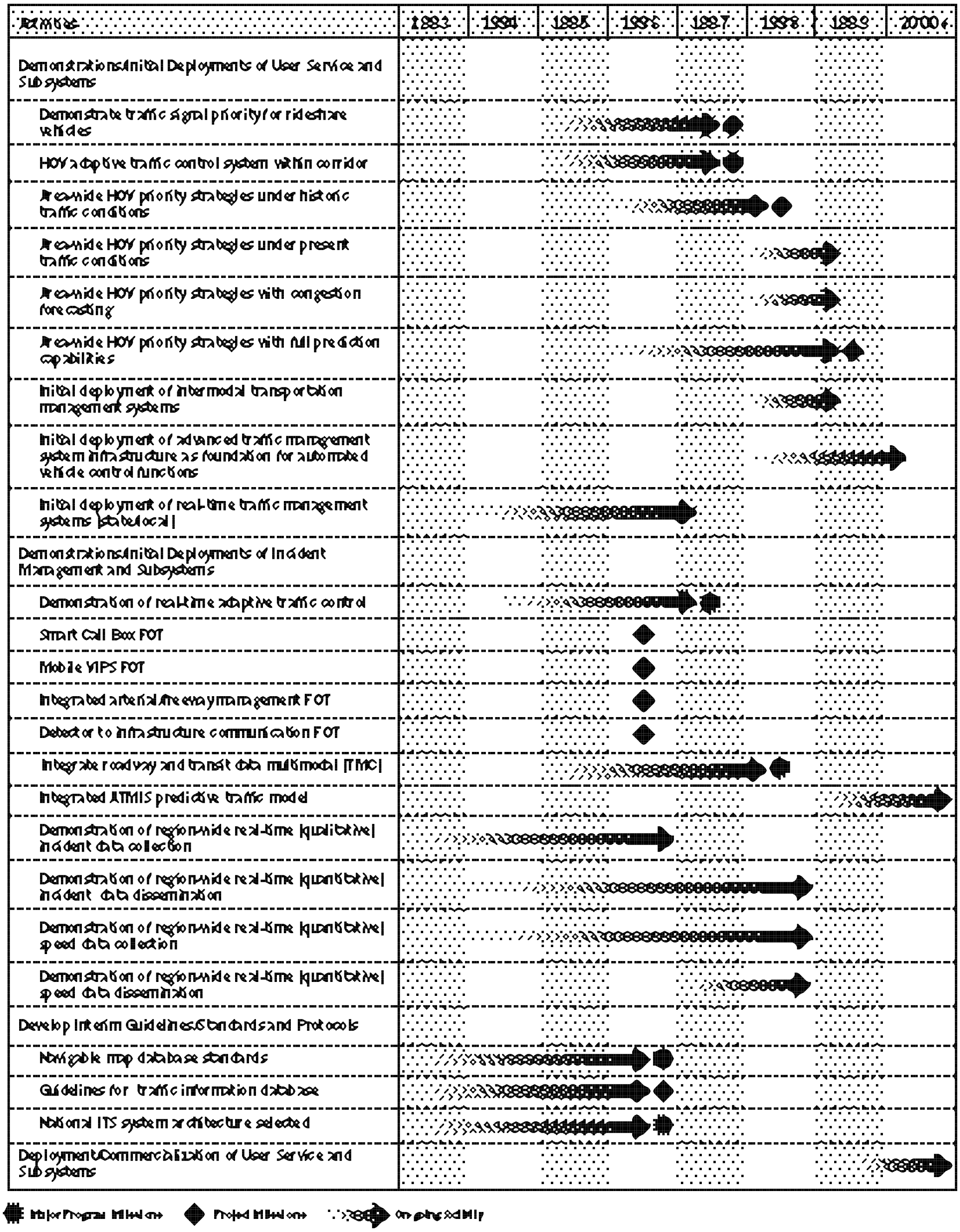
### Multimodal Traffic Management — Activity Charts



# Transportation Management Systems

## Multimodal Traffic Management — Activity Charts

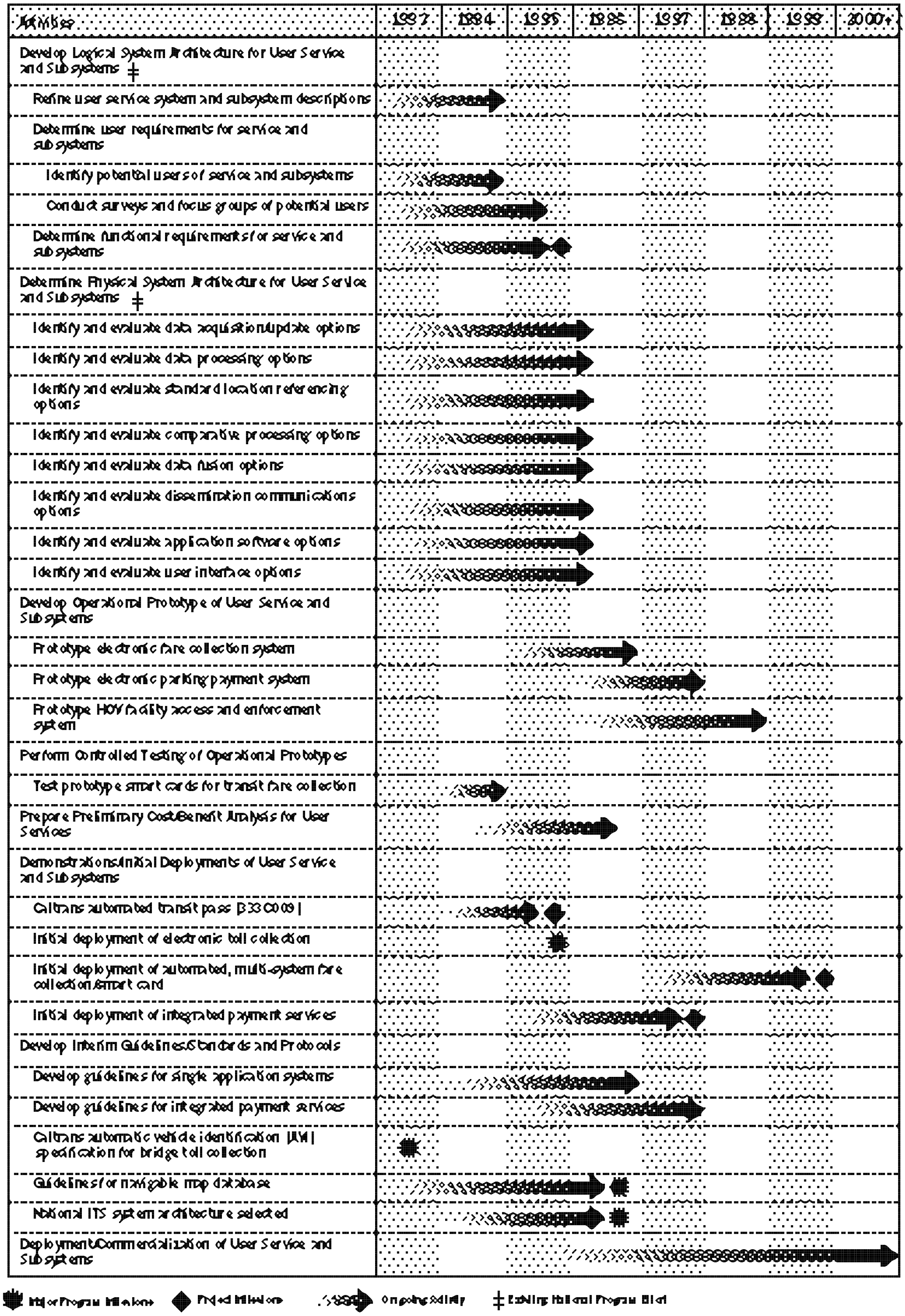
Traffic Control cont'd



## Transportation Management Systems

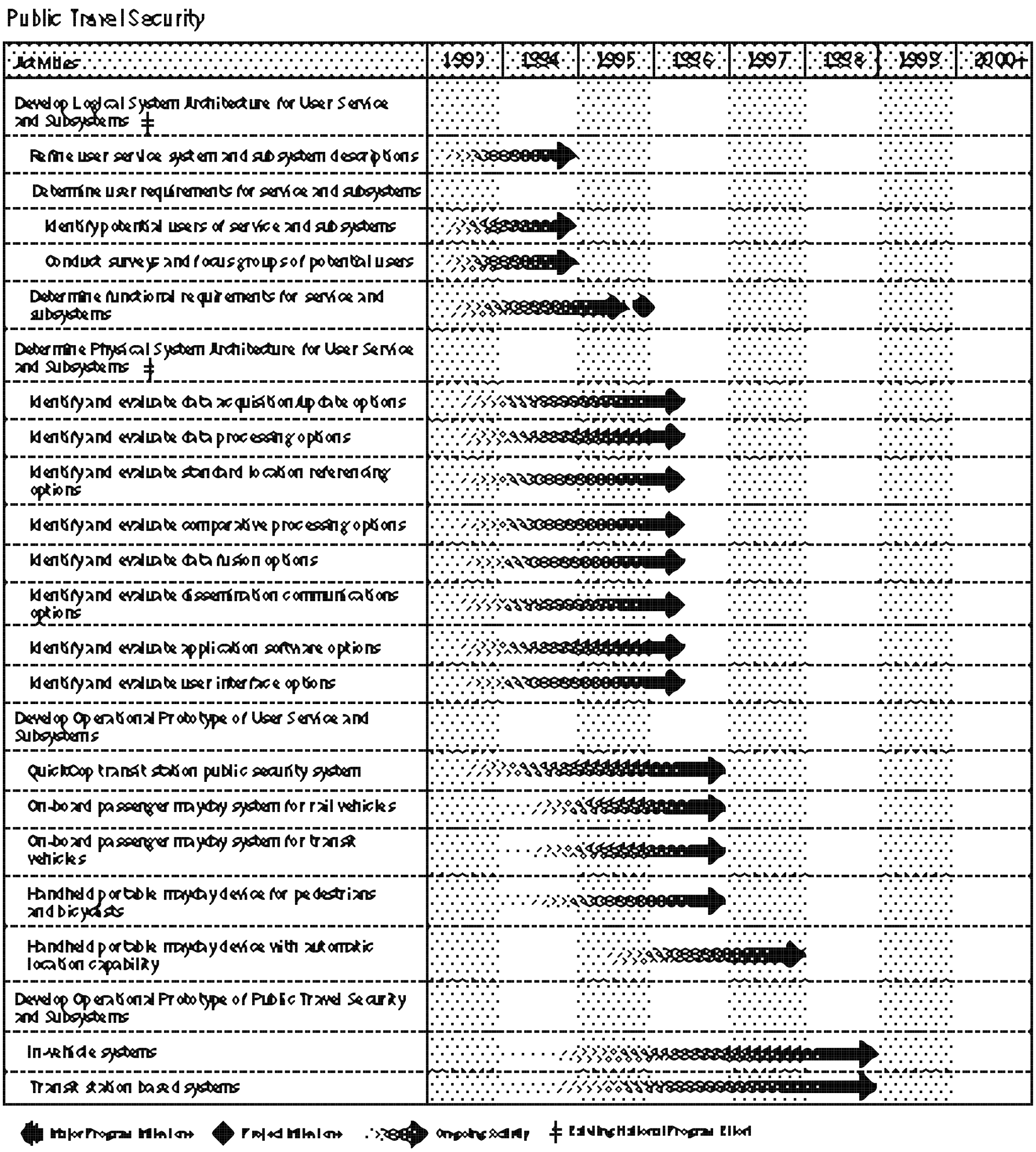
### Multimodal Traffic Management — Activity Charts

Electronic Payment



## Transportation Management Systems

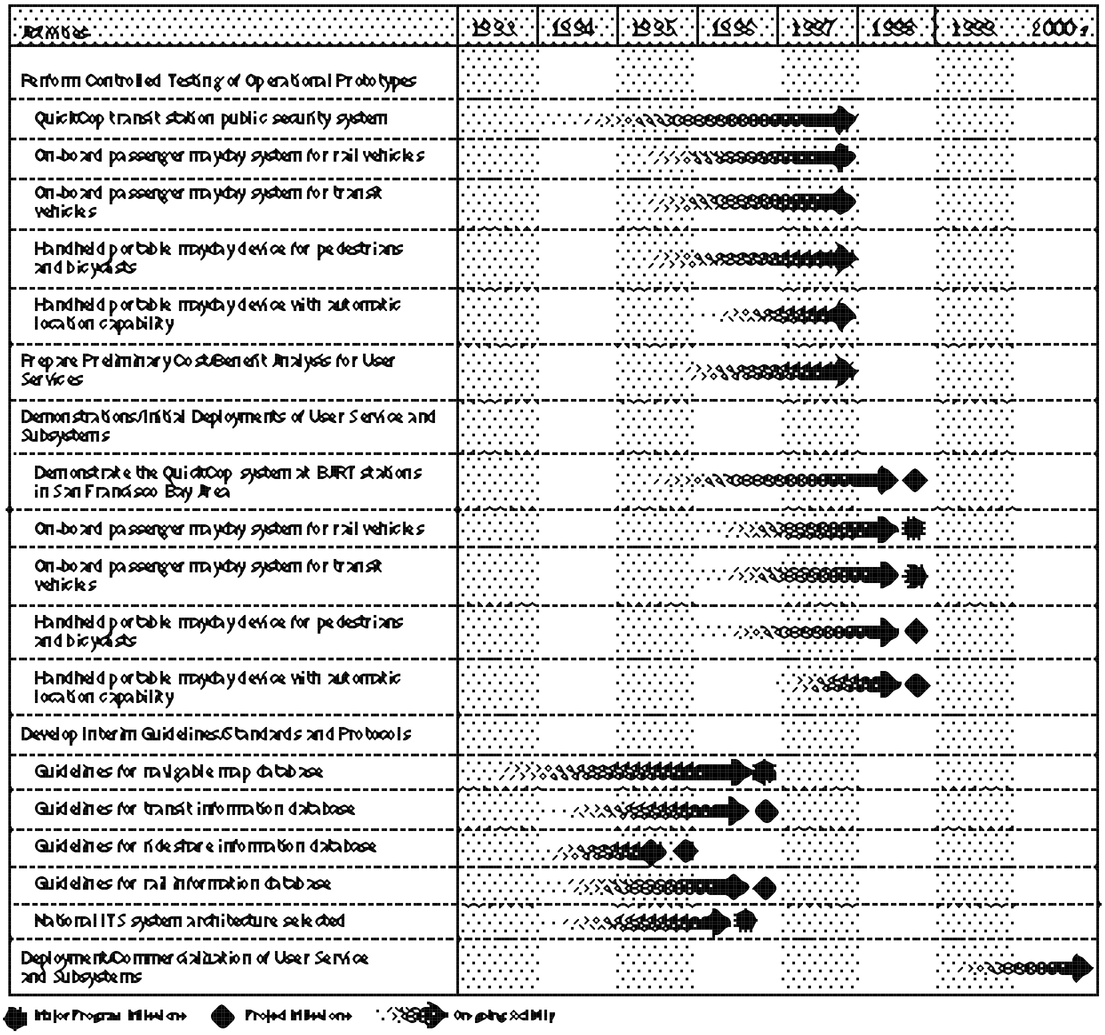
### Multimodal Traffic Management — Activity Charts



## Transportation Management Systems

### Multimodal Traffic Management — Activity Charts

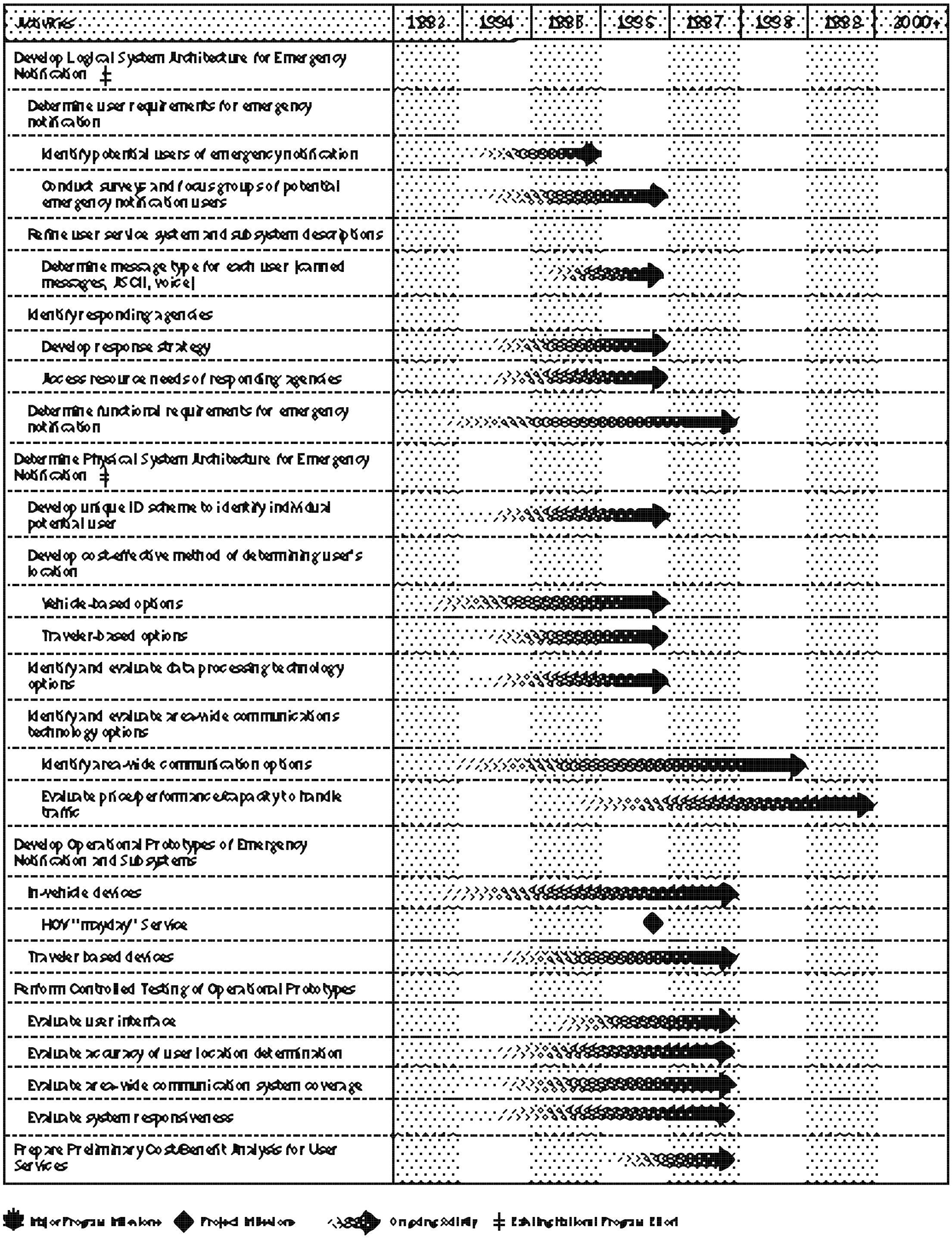
Public Travel Security contd



## Transportation Management Systems

### Multimodal Traffic Management — Activity Charts

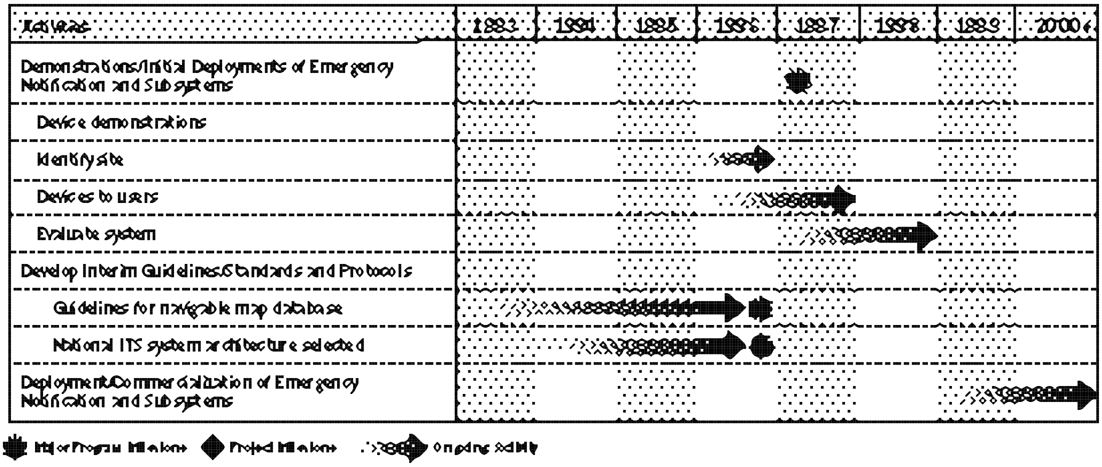
Emergency Notification and Personal Security



## Transportation Management Systems

### Multimodal Traffic Management — Activity Charts

Emergency Notification and Personal Security contd



## Transportation Management Systems

**Multimodal Traffic Management — Project Highlights**

### Transportation Management Systems/Centers

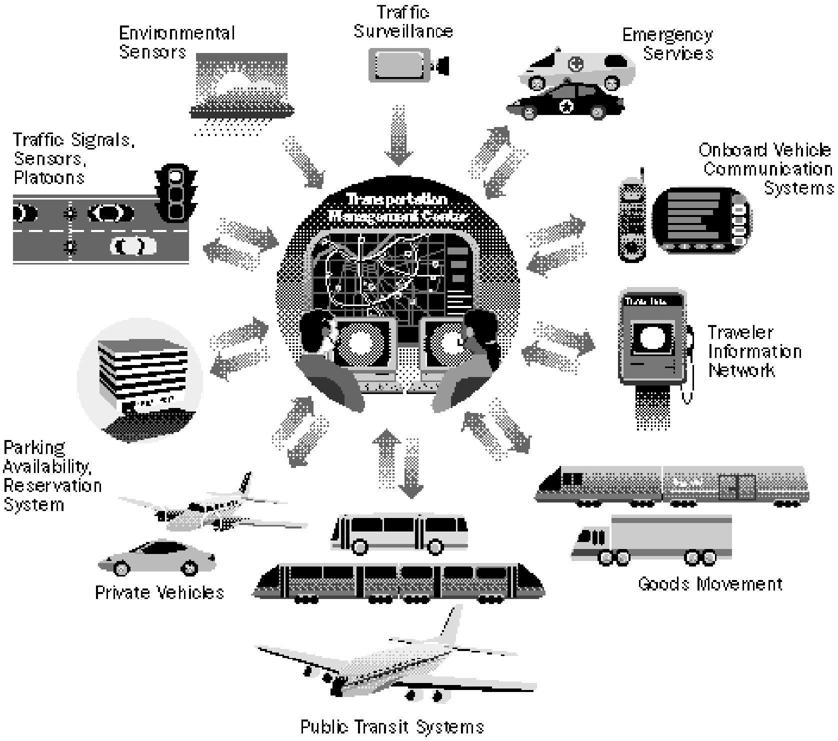
A Transportation Management Center (TMC) simulator is in place at California Polytechnic State University, in San Luis Obispo

For the past 20 years, Caltrans has been utilizing state-of-the-art technology to manage over 750 miles of southern California freeways. Ramp metering, now commonplace in many areas of the state, was first implemented in southern California in 1970. Plans, which included a Traffic Operations Center (TOC), for traffic mitigation for the 1984 Olympics, were developed starting in 1976 and made history in the field of traffic management. The importance of traffic surveillance in managing traffic was clearly demonstrated during this monumental undertaking.

The Los Angeles TOC, the first in the state, is still its most advanced and has become a blueprint for those being developed in major metropolitan areas throughout California. Formerly TOCs, they are now called Transportation Management Centers (TMCs) because they encompass so much more than just traffic operations. TMCs are jointly developed and staffed by the California Highway Patrol and Caltrans—the first partnership of its kind in the country.

The next logical step in this progression is the development of an Intermodal Transportation Management and Information System (ITMIS) (see page 192). An ITMIS is a building block for the transportation system. There are two major approaches for its design. In Orange County (Caltrans District 12), efforts are focused on developing a distributed system of centers linked by communications and data. The new TMC in San Diego (opened in July 1995) includes the California Highway Patrol and Caltrans Maintenance and Operations Communications Center all in one location. In the future, the center will include transit and commercial fleet operators and other local transportation providers.

Caltrans has already established a TMC simulator at California Polytechnic State University in San Luis Obispo to help train traffic managers and TMC operators in optimal TMS strategies. Computer-based expert systems will also help TMC operators handle accidents, hazardous material spills and other incidents and emergencies, and would enable automation of routing management functions now performed by humans. Fiber optics and satellite communications can provide the broad bandwidth necessary for video image and high volume data transmission from field to control center, and among control centers (state and local).



Advanced Fleet Management applications can be defined in the following user services terms:

- ### Automated Roadside Safety Inspection

**Focuses on improving safety in all commercial vehicle operations.**

Automated roadside safety inspections include roadside access to records of carriers, vehicles, and driver safety. Such convenient and thorough access will be helpful in determining what should be checked and how to maximize resources spent on safety. Advanced diagnostics will efficiently check critical vehicle systems and driver fitness for duty.

These capabilities will provide safer, more efficient, and more accurate inspection of commercial vehicles. Enforcement personnel will have access to important safety information and records for all commercial vehicles. Automated inspections could provide pass/fail assessments of critical systems, as well as expected life projections. Carriers could also apply rapid automated safety checks in their preventive maintenance programs.

- ### Public Transportation Management

**Automates operations, planning, and management functions.**

Computer analysis of real-time vehicle and facility status will improve operations and maintenance. The analysis identifies deviations from schedule and provides potential solutions to dispatchers and drivers. Integrating this capability with traffic control services can help maintain transportation schedules and assure transfer connections in intermodal transportation. Automated planning and scheduling capabilities will use archived data for analyzing trends. Information regarding passenger loading, bus running times, and mileage accumulated can be applied to route and service improvement. Automatically recording and verifying performed tasks will help with personnel management.

- ### Commercial Fleet Management

**Provides the same capabilities and performs the same functions in the commercial goods movement area as in public transportation management.**

Technological advances in public transportation management are directly applicable to commercial vehicles providing goods movement. Caltrans is heavily involved in promoting advanced technologies that facilitate improved fleet operations. Currently, there is a research project to determine the most appropriate role for government in furthering fleet management services and their applications for improving intermodal transfers.

**Caltrans and the CHP will continue development efforts in these areas and will collaborate with companies that transport goods in developing new transportation systems.**

## Transportation Management Systems

### Advanced Fleet Management — Scope

- **Commercial Vehicle Preclearance**

  **Facilitates domestic and international border preclearance, minimizing stops.**

This user service provides for point to point non-stop operation while satisfying regulatory requirements such as the issuance of licenses and permits, record keeping, tax collections, and inspection and weighing across multiple jurisdictions, including domestic and international borders.

- **Commercial Vehicle Administrative Processes**

  **Provides electronic purchasing of credentials and automated mileage and fuel reporting.**

Electronically purchasing credentials gives carriers the option to select and purchase annual and temporary credentials via computer link with the appropriate jurisdictions. Automatic deductions from the carrier's account with a jurisdiction will also streamline processing. There is a potential for synergy with commercial vehicle preclearance services.

For registration and auditing purposes, carriers maintain accurate mileage and vehicle information for every trip. Automating this procedure with the commercial vehicle administrative processes service enables participating interstate carriers to electronically capture mileage, fuel purchase, trip, and vehicle data by state. Electronic logs eliminate the need to manually prepare quarterly reports for fuel taxes and annual reports for registration.

- **Emergency Vehicle Management**

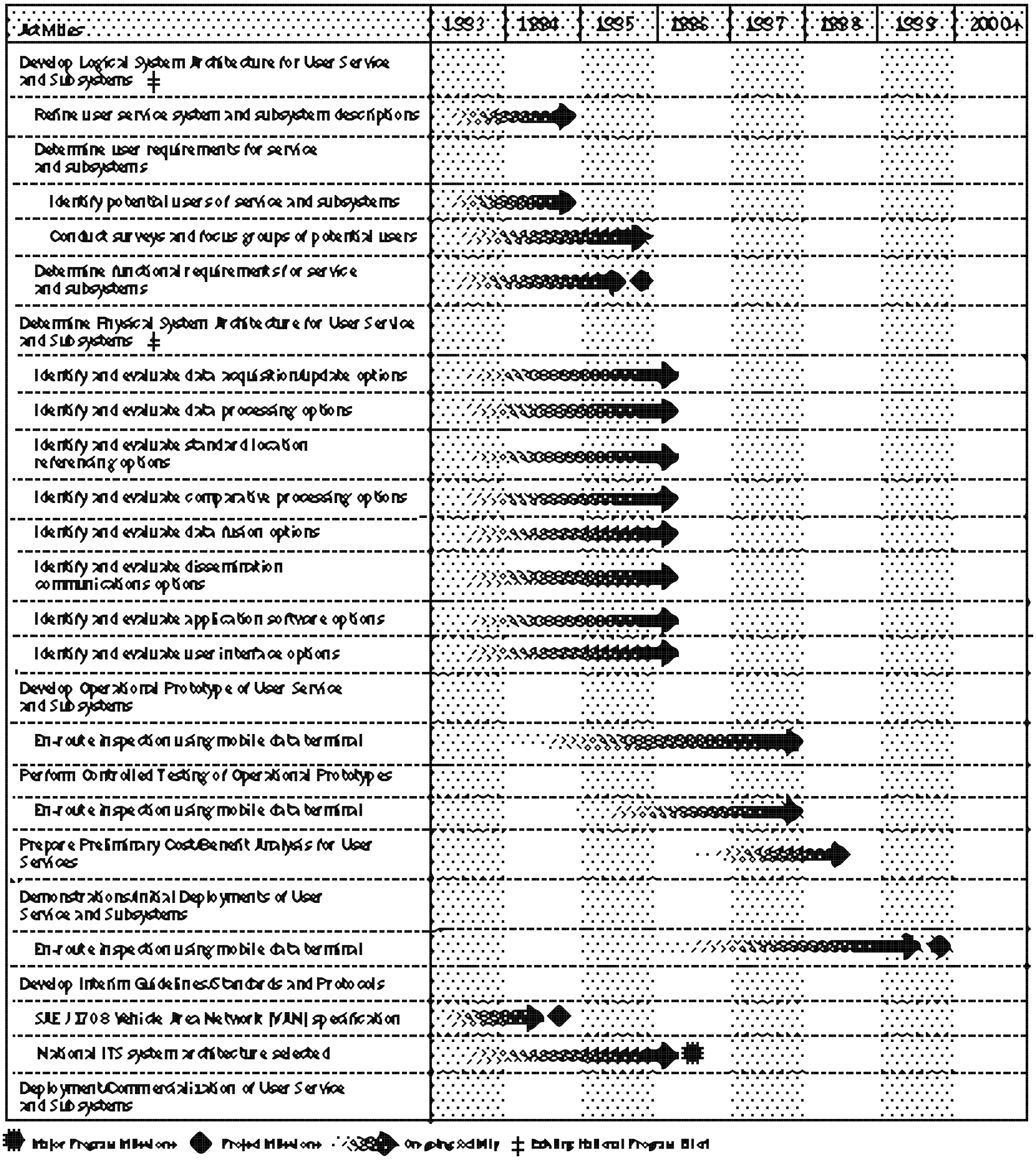
  **Reduces the time it takes to respond to incident notification and arrive on the scene.**

This user service is closely related to the hazardous material incident management user service, within the commercial vehicle operations category. Primary users include police, fire and medical units. The service comprises three capabilities: fleet management, route guidance, and signal priority. Fleet management will improve the display of emergency vehicle locations and help dispatchers efficiently send the unit that can most quickly reach an incident site. Route guidance directs emergency vehicles; signal priority clears traffic signals on an emergency vehicle's route.

## Transportation Management Systems

### Advanced Fleet Management — Activity Charts

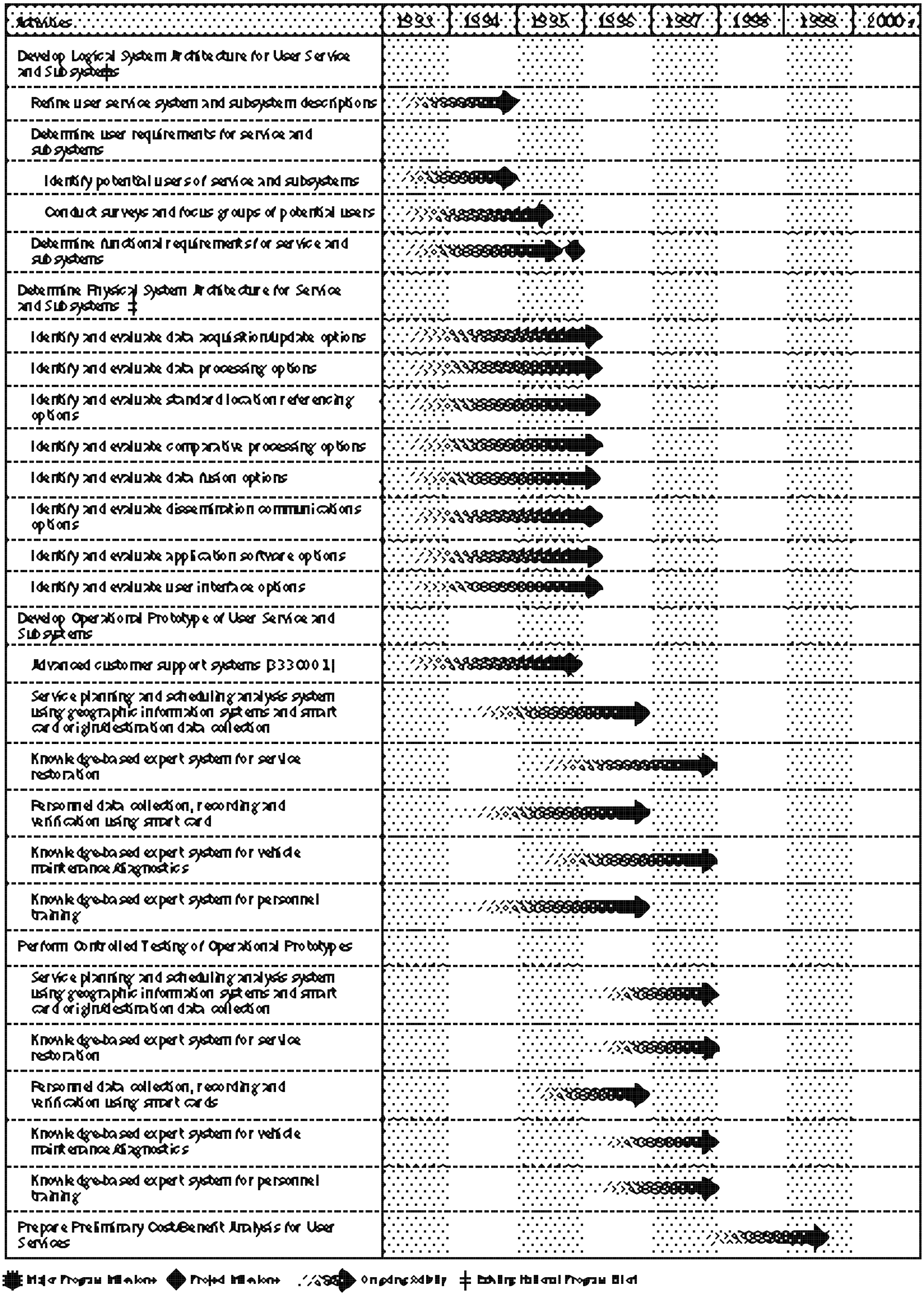
Automated Roadside Safety Inspection



## Transportation Management Systems

### Advanced Fleet Management — Activity Charts

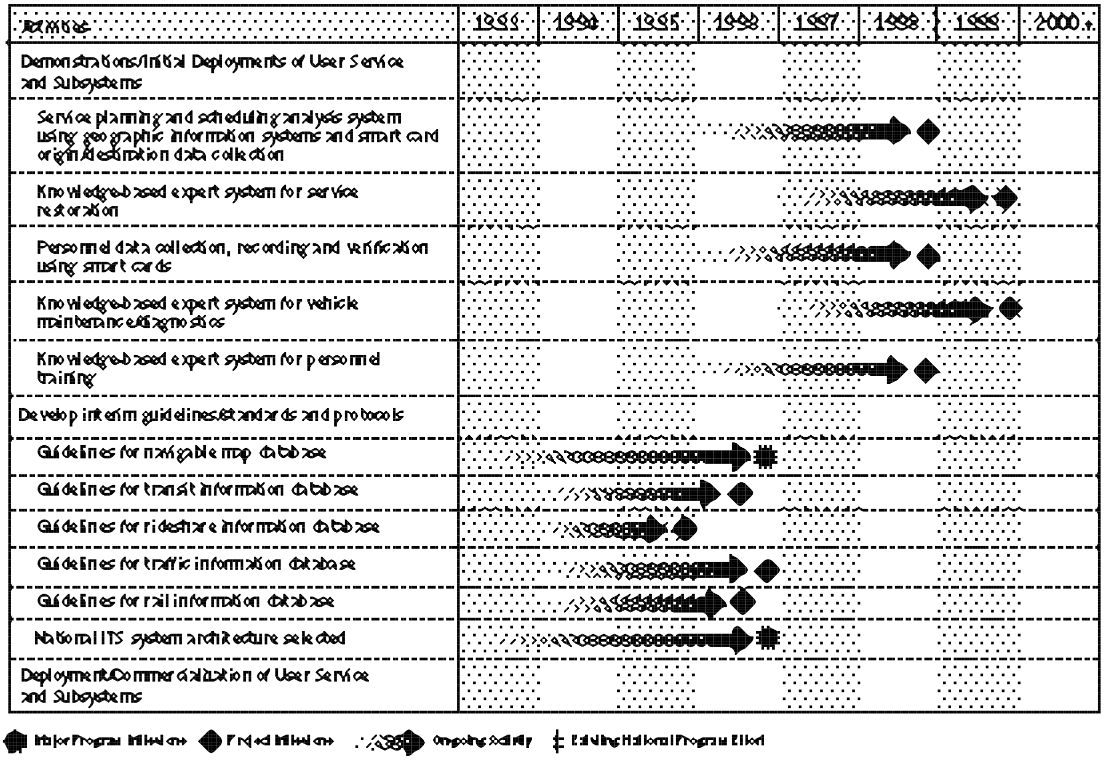
Public Transportation Management



## Transportation Management Systems

### Advanced Fleet Management — Activity Charts

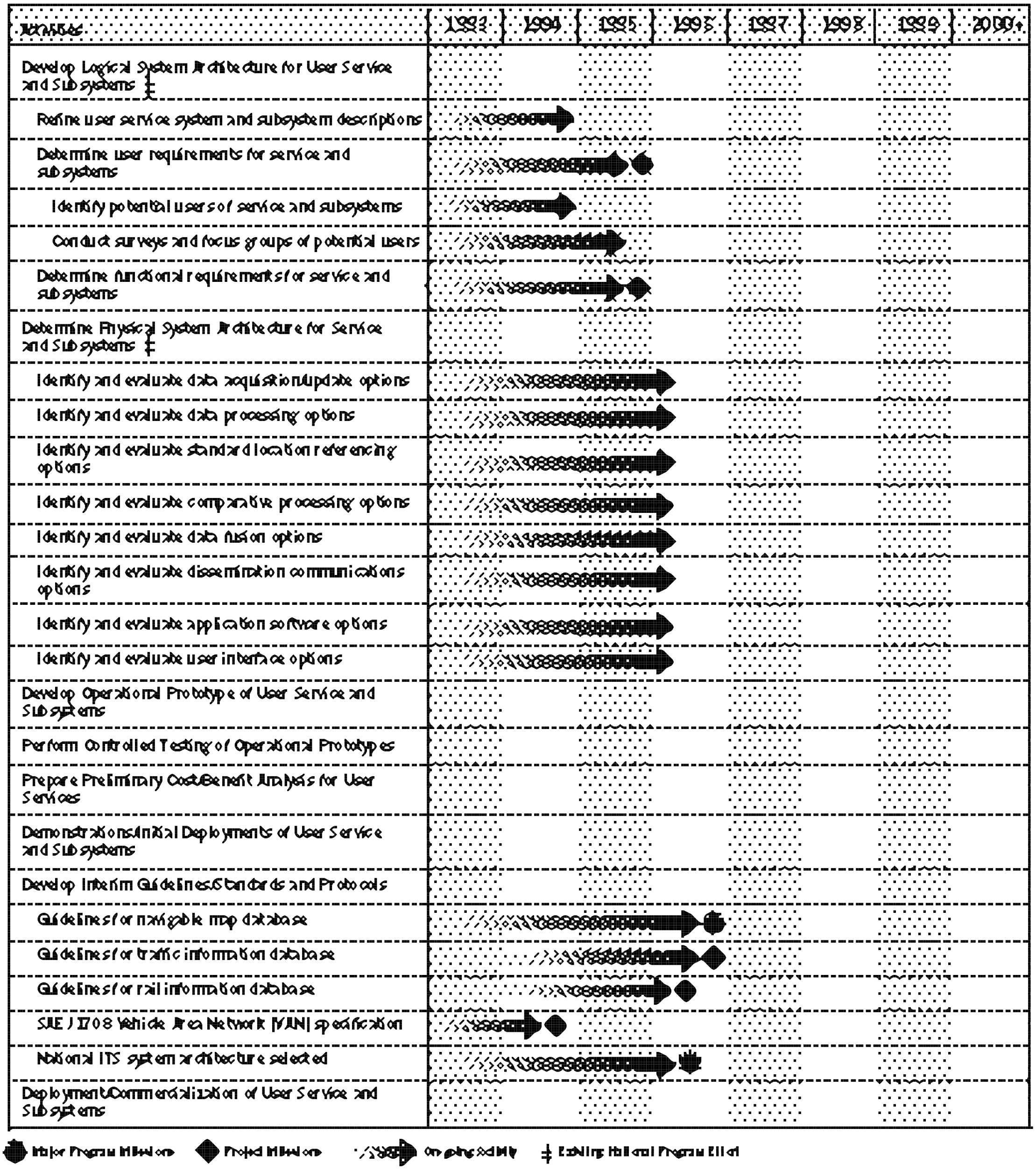
Public Transportation Management cont'd



## Transportation Management Systems

### Advanced Fleet Management — Activity Charts

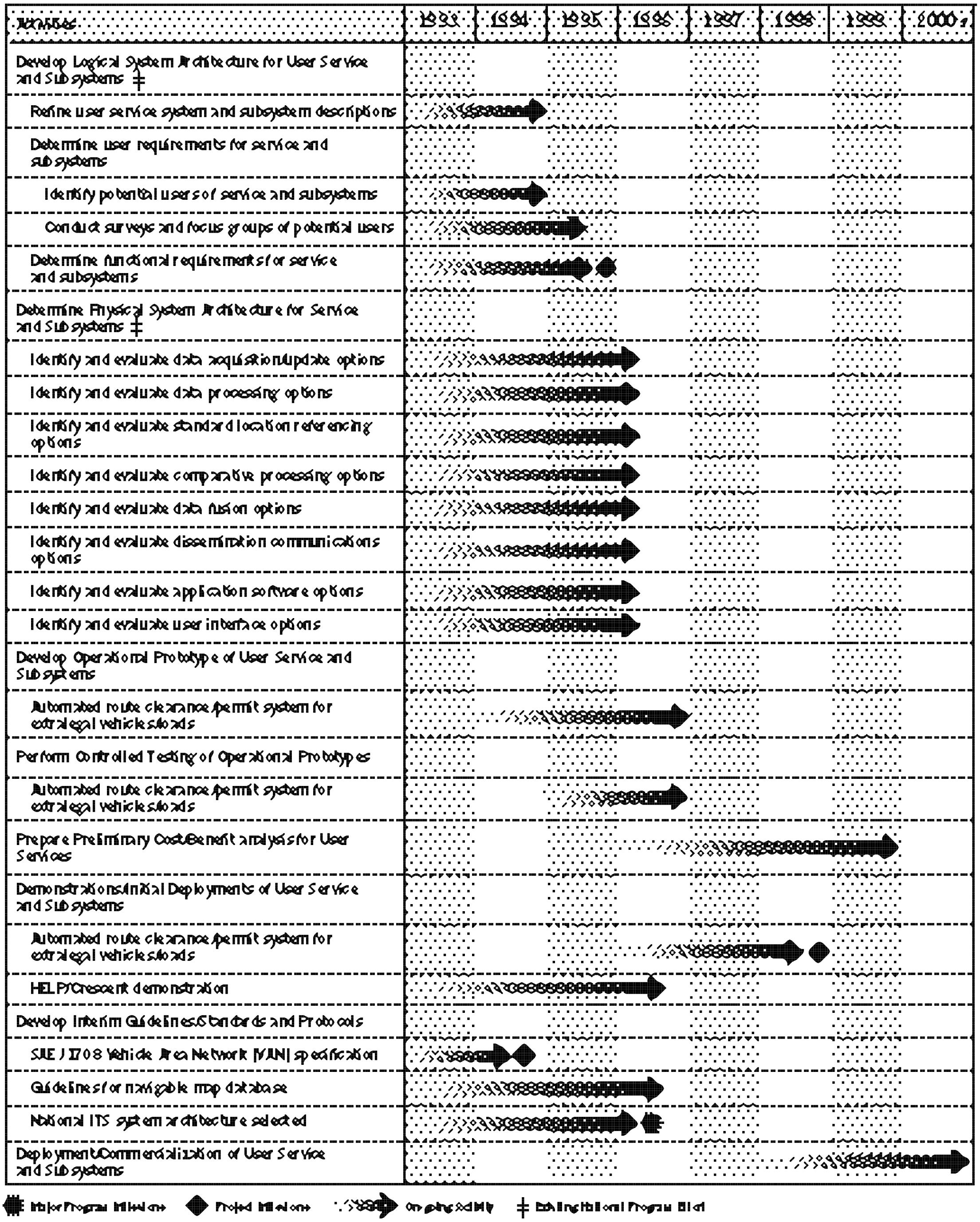
Commercial Fleet Management



## Transportation Management Systems

### Advanced Fleet Management — Activity Charts

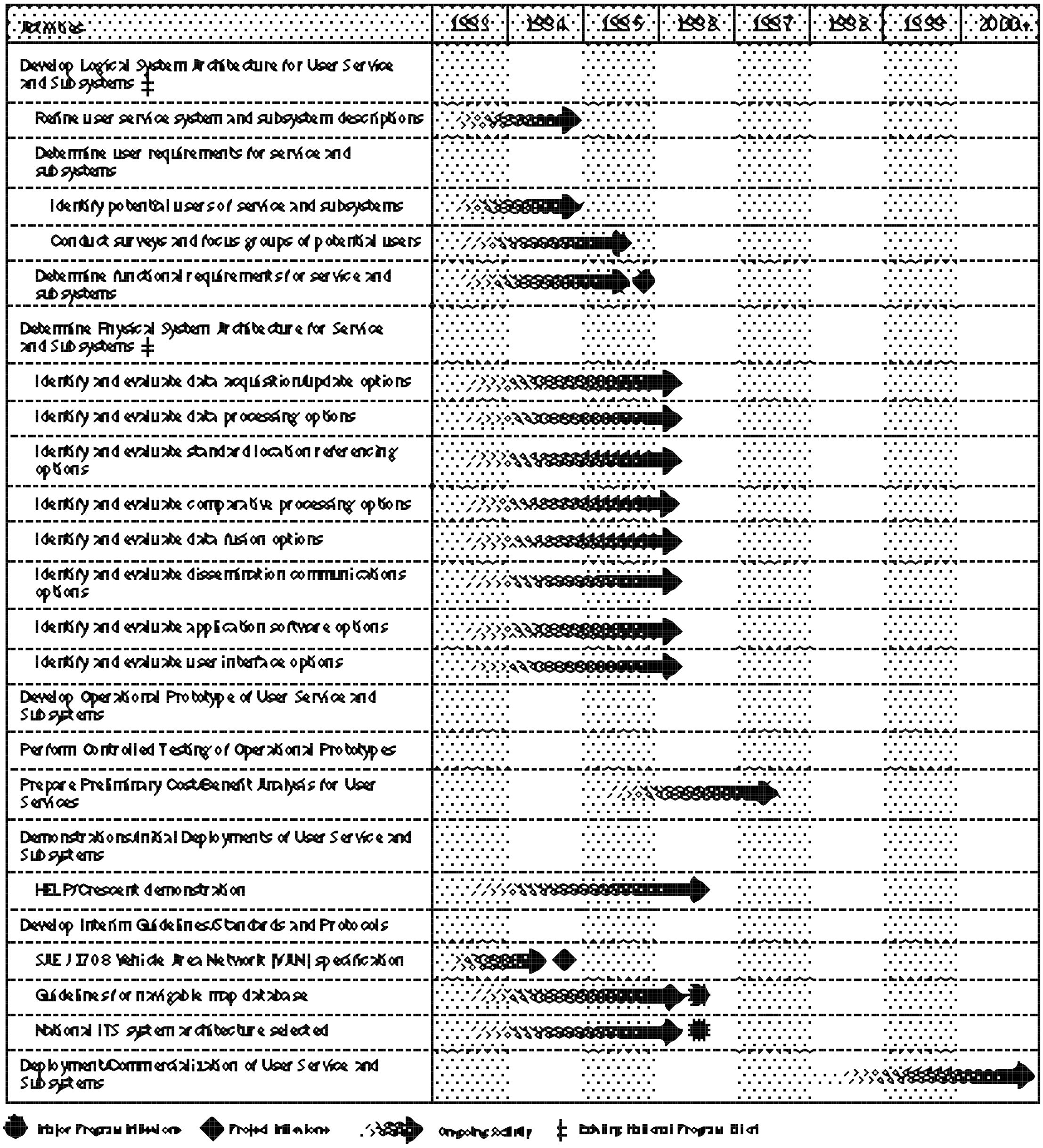
Commercial Vehicle Preclearance



## Transportation Management Systems

### Advanced Fleet Management — Activity Charts

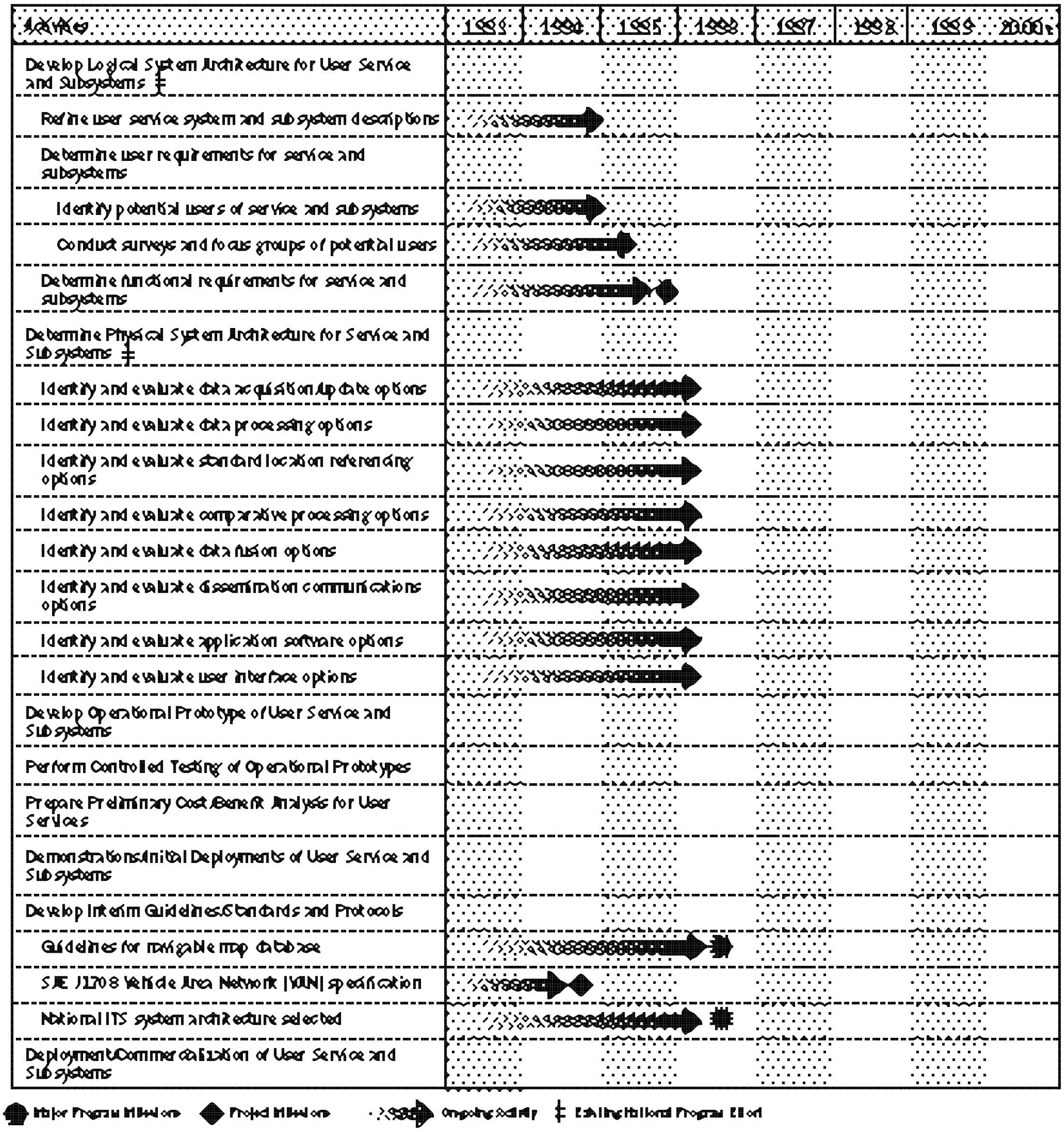
Commercial Vehicle Administration Processes



## Transportation Management Systems

### Advanced Fleet Management — Activity Charts

Emergency Vehicle Management

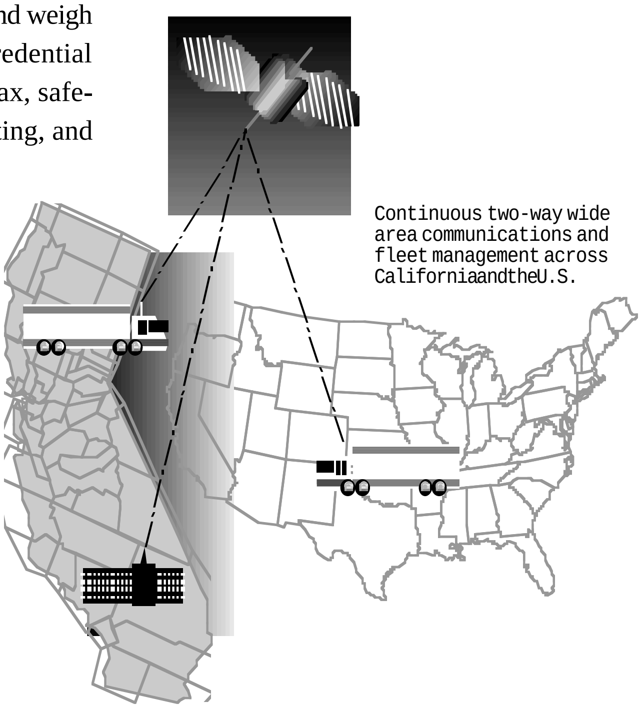


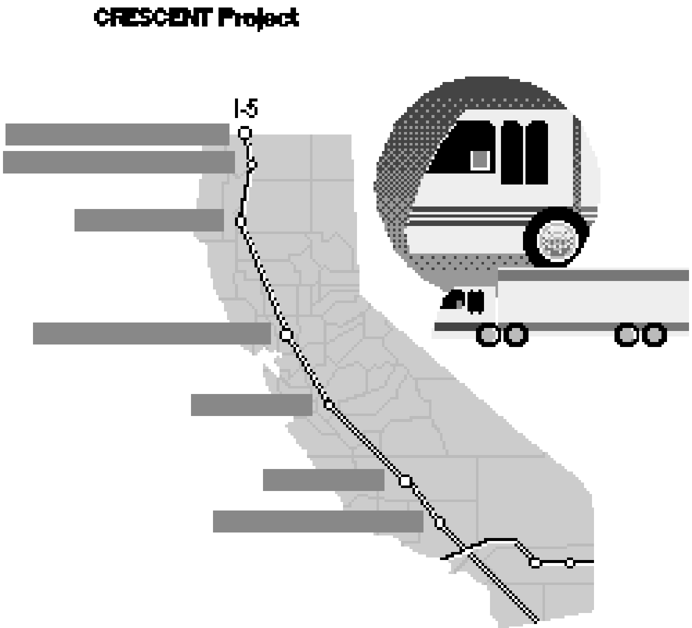
## Transportation Management Systems

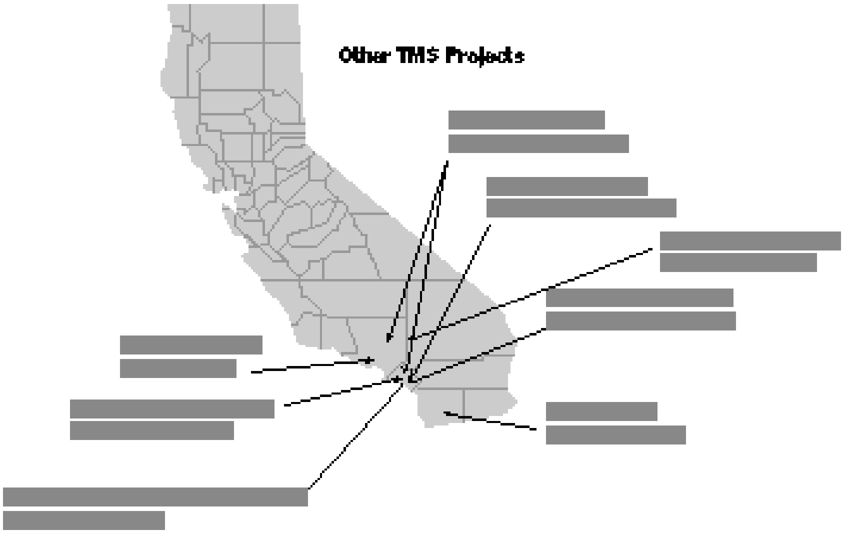
**Advanced Fleet Management — Project Highlights**

### H.E.L.P. Project

The Heavy Vehicle Electronic License Plate Program (H.E.L.P.) is a multistate, multinational research effort to design and test an integrated heavy vehicle monitoring system. Using Automatic Vehicle Identification (AVI), Automatic Vehicle Classification (AVC) and Weigh-In-Motion (WIM) technology, the H.E.L.P. project permits trucks to bypass ports of entry and weigh stations by providing automated credential verifications of registrations, fuel tax, safety, oversize and overweight permitting, and a central data base for fleet information and management. It is expected to be completed in 1996, when it will include preclearance sites in ten states. H.E.L.P. facilities are being installed in California on I-5 and I-10, and are proposed in several other areas, including I-880 in the San Francisco Bay Area.



Connectivity of the various modes for people and goods movement can be enhanced through terminal facilities where travelers can transfer from one mode to the other with a minimum of discomfort or where goods can be efficiently moved from one mode to another.

Approaches that will assist with intermodal connectivity are:

- Bringing bus stops, with easily understood signage, close to the disembarkation areas of planes and trains;
- Bringing trains into air terminals to facilitate transfers of passengers and baggage from one mode to the other;
- Establishing safe bicycle storage facilities at transfer points for cyclists to transfer to buses, trains or planes;
- Designating routes on the National Highway System to be “Freight Corridors” to establish design, construction, and maintenance priorities; and, to reduce congestion; and,
- Working at the national level, with public and private organizations, to design programs and secure funding for the advancement of intermodalism as an equal partner in the transportation fabric of California and the United States.

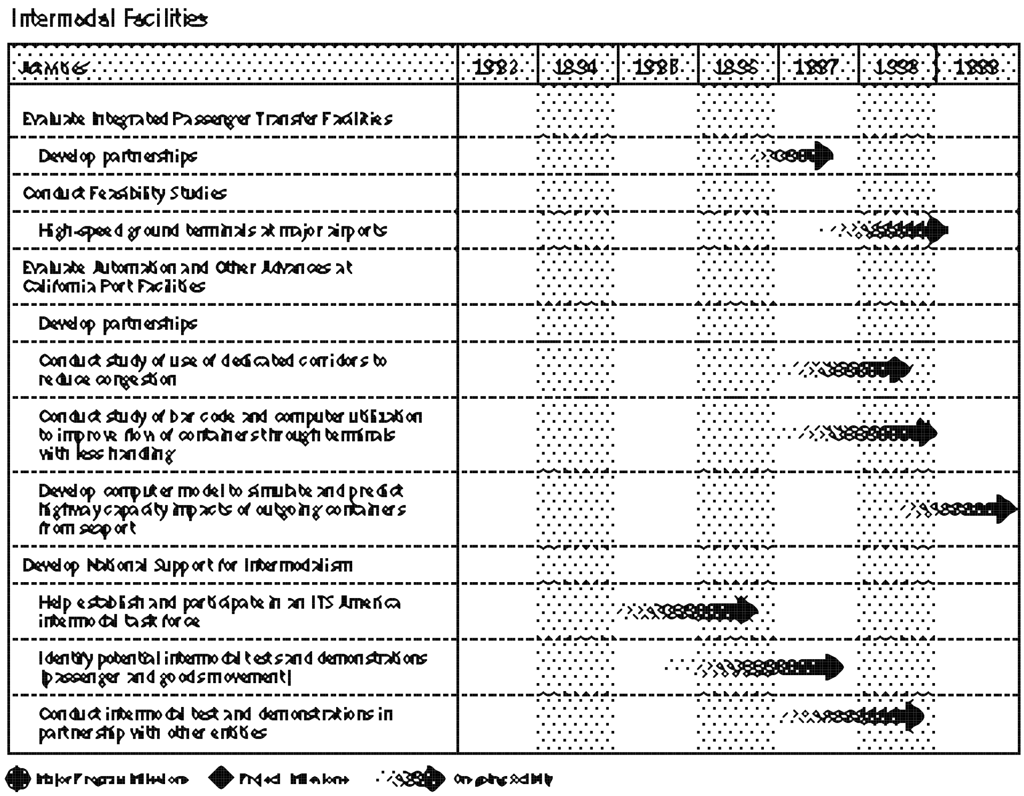
Work to redesign, improve the technology and automate California ports and terminals will be required to realize the full benefits of the ATS highway, rail, waterway and airway infrastructure. Application of ATS at the transfer point (“interfaces”) will increase the efficiency and effectiveness of intermodalism for both passengers and goods.

California’s extensive port (air/waterway) and waterway system could benefit greatly from the same ATS technologies and coordination being applied to other ground systems. Among the benefits would be improved ground access and maximized efficiency of the “landbridge” across the state and the North American continent (movement of goods inland from seaports and across the continental United States). Examples of applicable technologies are:

- Ship collision avoidance, such as in low visibility areas using digital maps, global positioning systems, computers and wireless communications;
- Vessel routing, tracking and scheduling;
- Vessel fitness monitoring;
- Automated cargo monitoring; and,
- Next-generation port/intermodal transfer facilities.

## Transportation Management Systems

### Intermodal Facilities — Activity Charts



## Transportation Management Systems

### Intermodal Facilities — Project Highlights

In March 1994, ITS America's Coordinating Council established a new task force to investigate including other modes of transportation (rail, air, sea) into an integrated, effective, intermodal transportation system. Caltrans was involved in an Intermodalism Conference late in 1994, to discuss research, development, and demonstration agendas; new initiatives; and, the future direction of "Intermodalism."

Application of information and communication technologies to the interfaces (e.g., terminals) of modal exchange will increase efficiencies, resulting in lower costs and improved safety. This scenario would be especially true in the goods movement area when coupled with management system and logistics planning. With respect to passenger systems, improvement at the interfaces will also increase the attractiveness of using public transportation.

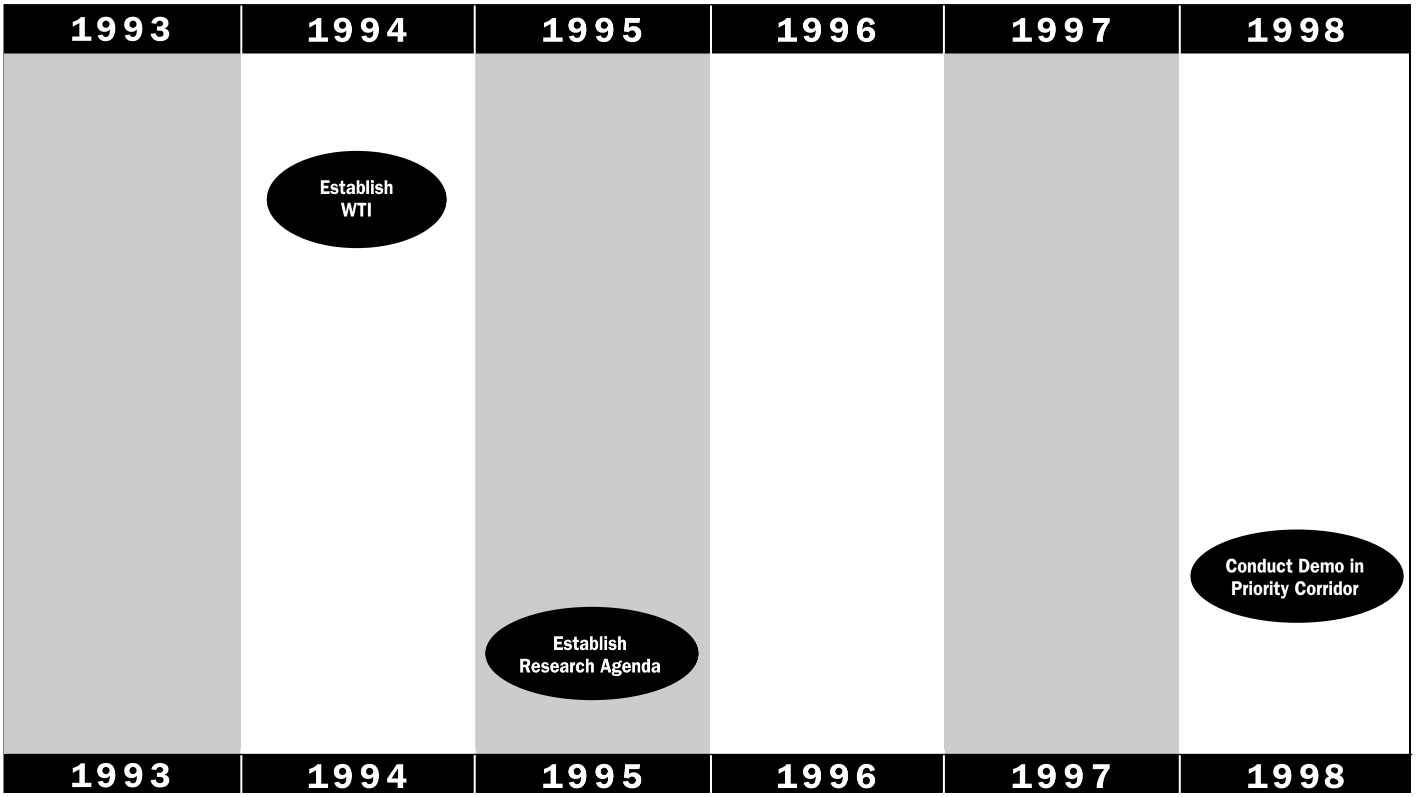
Projects being sponsored to encourage intermodal transportation usage by the public will include "off-airport terminals" construction, operation and evaluation to provide congestion relief at airports; studies and recommendations to extend rail facilities into or closer to air terminals to encourage use of alternate modes of transportation; and, studies to determine ways to lessen the impact of port side operations that affect truck usage of adjacent roads and highways.

# RURAL

**The rural transportation program focuses on the transportation concerns of rural California to assure the appropriate application of advanced transportation technologies to rural transportation problems.**

**The milestones, scope of services, activities and project highlights for Rural Transportation are discussed on the following pages.**

# Rural Transportation



## Rural Transportation

### Scope

Increased interest in rural transportation issues in the new technology/intelligent transportation systems arena is a fairly recent development. Because federal, state and local officials have been overwhelmed by the problems plaguing urban transportation, such as traffic congestion, and related air quality, noise and energy issues, little time, or resources have been devoted to rural transportation issues.

Two-lane rural highways are the backbone of the rural transportation network. These roads carry local traffic, as well as commercial vehicles, transit vehicles, school buses, and recreation and commuter traffic. Additionally, there is a system of multi-lane divided highways that serve metropolitan centers and traverse rural areas. Like urban transportation, rural transportation is also concerned with air quality control and energy conservation. While the primary focus of urban transportation may be traffic congestion, the primary focus of rural transportation technology is safety.

In 1992, the Caltrans New Technology and Research Program embarked on a research study, the "Program for Advancing Rural Transportation Technology" (PARTT). The purpose of PARTT is to focus proper attention on the transportation concerns of rural California and to assure the appropriate application of advanced transportation technology to rural transportation problems.

Directly attributed to this research study are the following successful results:

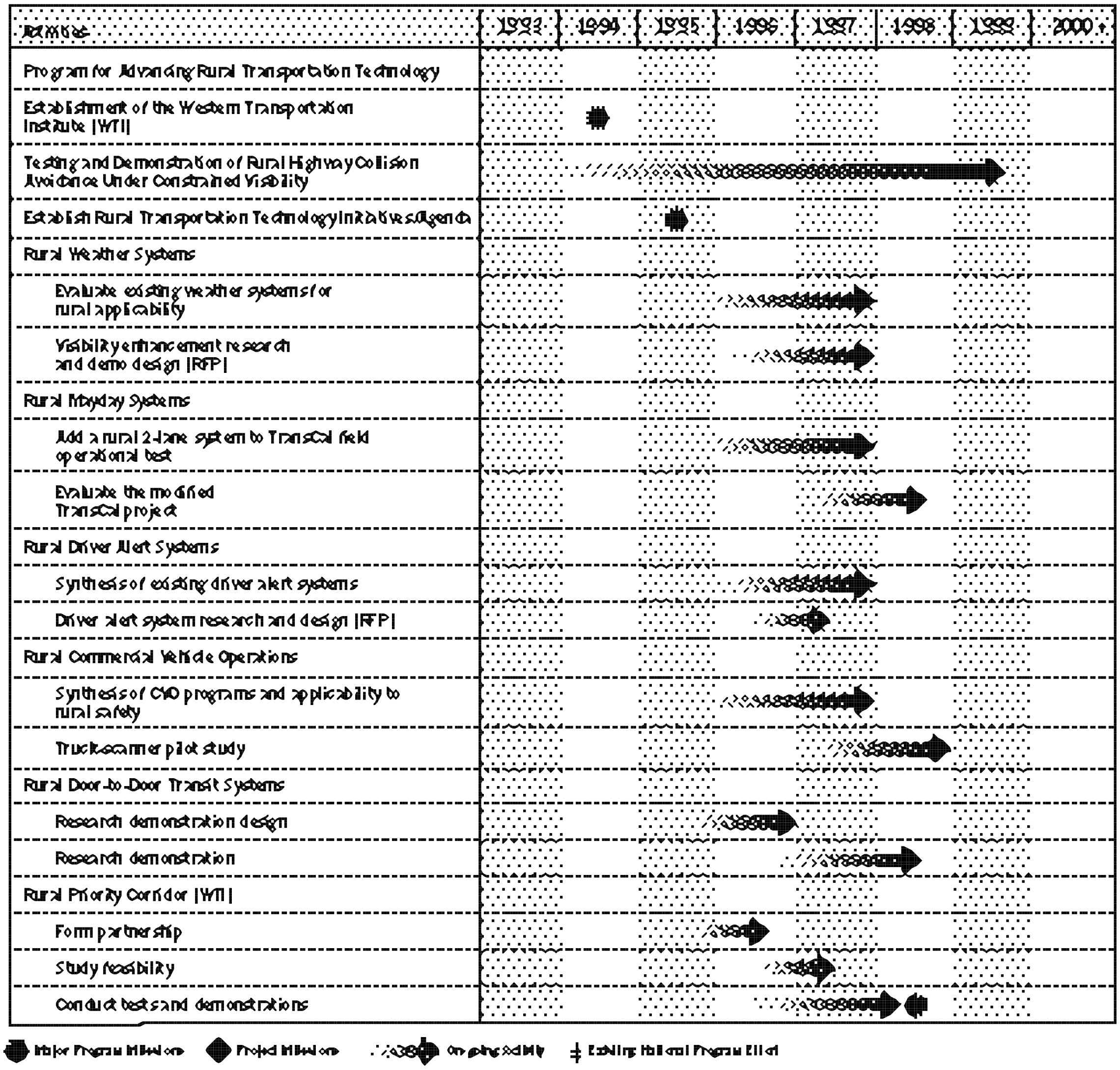
- The first national discussion on advanced rural transportation technology in the second draft of the "ITS America Strategic Plan" (January 1992);
- Establishment of an ITS America Committee to deal specifically with rural transportation technology concerns (ITS America Advanced Rural Transportation Committee, April 1992);
- The first rural transportation technology conference sponsored by Caltrans (Redding, California, September 1992); and,
- The Western Transportation Institute (WTI) established in 1994.

In addition, with ITS America, the WTI and other partners, Caltrans will help establish a formal rural technology research agenda.

## Rural Transportation

### Activity Charts

Rural Transportation



**Rural Transportation**

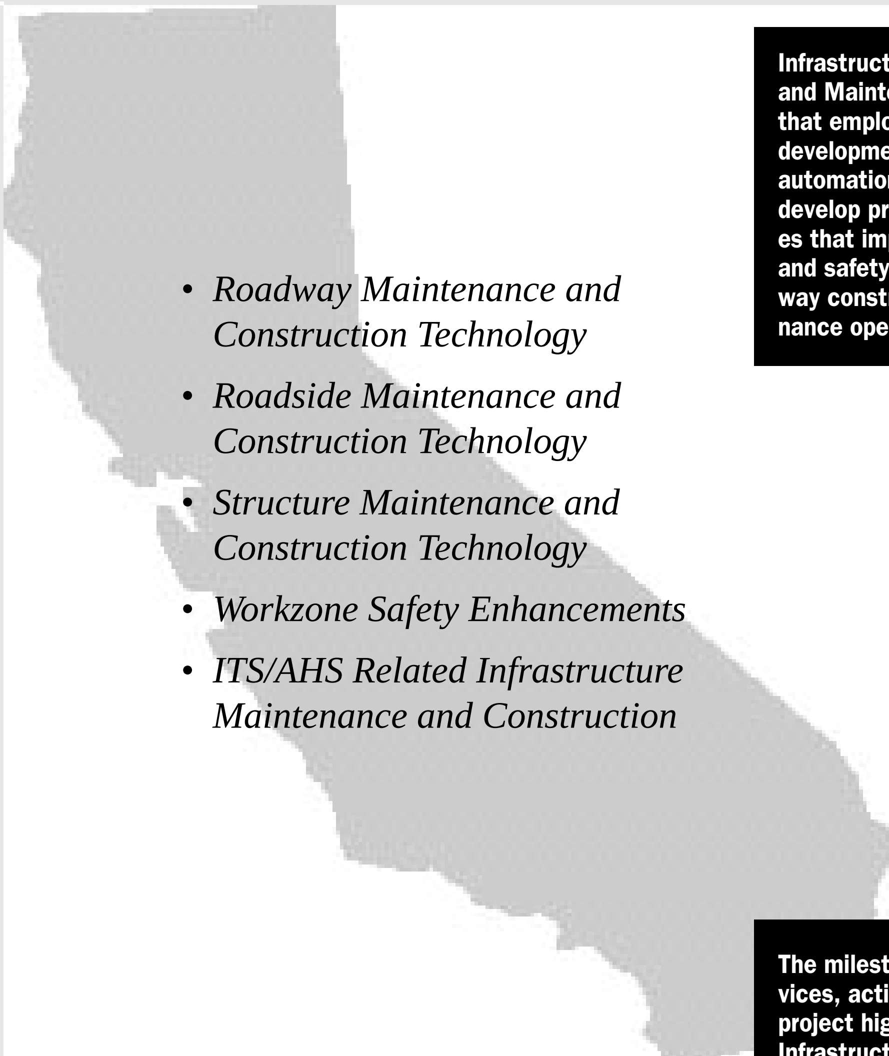
**Project Highlights**

## The Western Transportation Institute — A Western Center for Rural Transportation Excellence

The Western Transportation Institute (WTI) was established in 1994, to pursue research and education in Intelligent Transportation Systems (ITS) and other rural transportation matters. WTI maintains close ties with other ITS programs nationally, including PATH.

WTI is also affiliated with many national ITS programs and organizations including the NAHSC, the National ITS System Architecture Program and ITS America. WTI, with participation from government, industry and academia, is currently working to establish a national ITS rural priority corridor for demonstration and deployment of promising rural transportation technology.

# INFRASTRUCTURE CONSTRUCTION AND MAINTENANCE



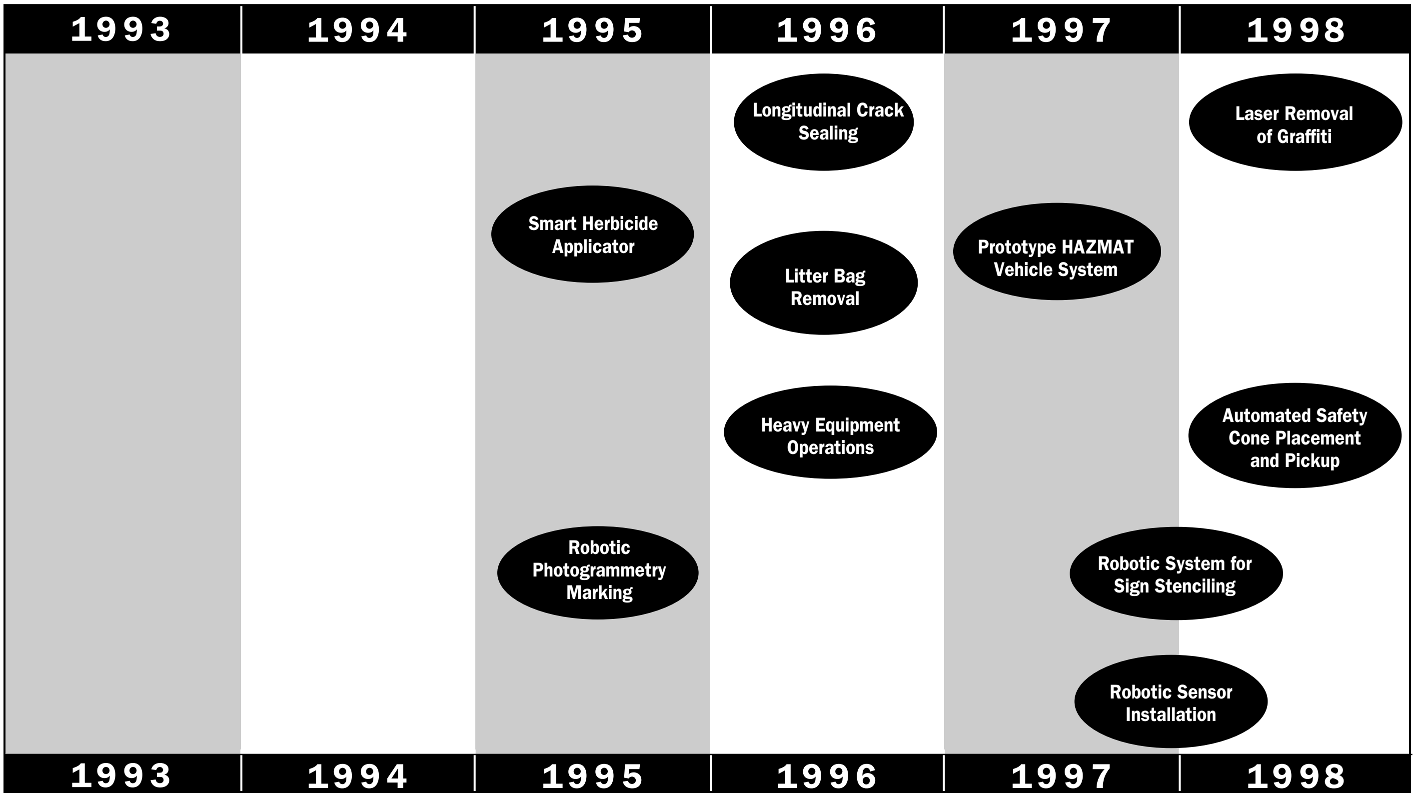
- *Roadway Maintenance and Construction Technology*
- *Roadside Maintenance and Construction Technology*
- *Structure Maintenance and Construction Technology*
- *Workzone Safety Enhancements*
- *ITS/AHS Related Infrastructure Maintenance and Construction*

**Infrastructure Construction and Maintenance is a program that employs technological developments, such as automation and robotics, to develop products and processes that improve the efficiency and safety of traditional highway construction and maintenance operations.**

**The milestones, scope of services, activities and specific project highlights for Infrastructure Construction and Maintenance are discussed on the following pages.**

**MAJOR PROGRAM MILESTONES**

## Infrastructure Construction/Maintenance



## Infrastructure Construction & Maintenance

### Scope

Current efforts by the Advanced Highway Maintenance and Construction Technology (AHMCT) Center include the development of technologies such as external sensing systems, manipulation systems, control and coordination systems, communication systems, material storage and retrieval systems, mobility systems, and human-machine interfaces. These technologies are critical to the development of automated or robotic equipment intended for transportation maintenance and construction.

The jointly staffed University of California, Davis/Caltrans AHMCT Center has developed expertise in these areas; has an understanding of current and emerging robotic and automation technology and has specifically researched future trends in technology applicable to automation of construction and maintenance tasks.

- **Roadway Maintenance and Construction Technology**

Of prime importance to Caltrans is the effective maintenance of road surfaces and pavement delineations in the form of lane striping, pavement markers and pavement and roadside signage. Efforts are underway to introduce automation and robotic technology to conventionally slow, labor intensive and potentially unsafe operations. Examples of activities under investigation include: sealing pavement cracks; painting pavement markings, including survey premarks; and, placing raised pavement markers on the pavement at prevailing speeds. These technological advances will eliminate the exposure of maintenance personnel to moving vehicles and have the potential to transform a static lane closure into a moving operation.

- **Roadside Maintenance and Construction Technology**

Caltrans is responsible for maintaining the roadside right-of-way, including landscape management, refuse and graffiti cleanup, and removal of hazardous materials. Landscape maintenance efforts are designed to limit employee exposure to the dangers of moving vehicles while performing landscape maintenance operations. Research is also aimed at substantially reducing water and herbicide usage and developing landscape vegetation suited to reduced maintenance and watering. Innovations in the areas of litter pickup equipment, remote landscape management systems, graffiti removal and prevention, and rapid and remote hazardous material spill identification and remediation are being researched. These developments will ultimately reduce employee exposure to highly toxic materials and reduce the time necessary for lane closures occurring during landscape maintenance operations.

- **Structure Maintenance and Construction Technology**

The development of methods and equipment for rapid and remote inspection of bridge components and other structures is critical to maintaining the safe condition of a deteriorating transportation infrastructure. The nation's large inventory of aging elevated structures mandates frequent and detailed inspections using equipment of increasing sophistication. Efforts in this area focus on the development of products that will allow remote inspection of structural facilities, while reducing human risk and improving efficiency.

- **Workzone Safety Enhancement**

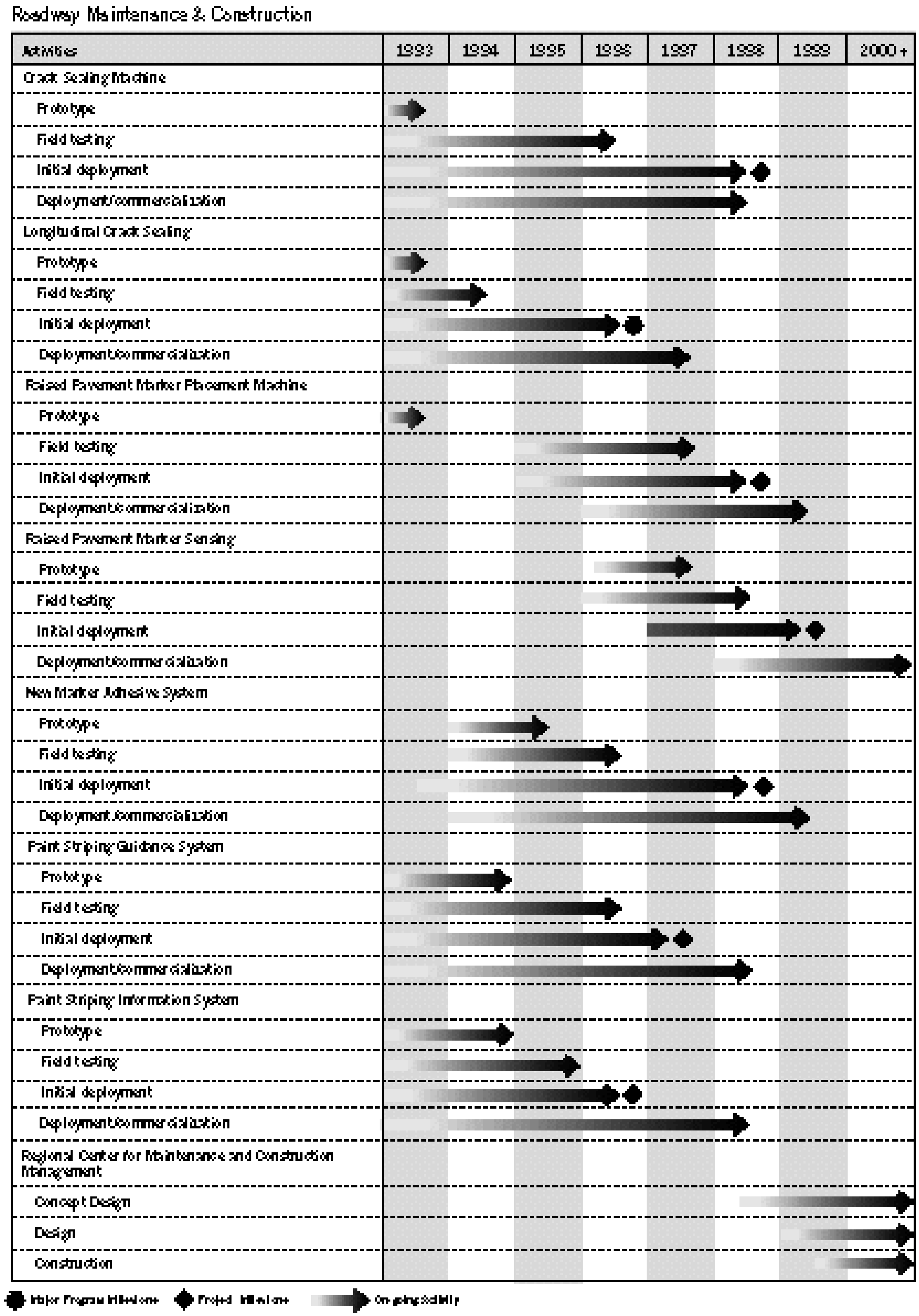
A wide variety of devices and processes has been developed to enhance the safety of field workers, including such products as hard hats, highly visible garments, safety cones, equipment backup signaling, and lane closure procedures. These and many other products and procedures have been adopted by the construction industry with life-saving success. Products continue to be developed at a rapid pace, as the desire to improve workzone safety continues. Recently, many products, such as workzone intrusion warning systems, vehicle sensors to prevent equipment or equipment/human collisions, and garment sensors used to alert workers of the approach of heavy equipment, have become sophisticated through the advent of the computer and sensor revolution. While research in other areas is directed towards eliminating the necessity for workers to be exposed on the roadway, the mission of workzone safety research at the AHMCT Center is to substantially increase the safety of workers both on and off the roadway.

- **ITS/AHS Related Infrastructure Maintenance and Construction**

As more technologically advanced transportation systems are implemented, construction and maintenance operations will become more complex. ITS construction and maintenance will require accurate equipment positioning, frequent testing, and rapid repair of control and communication instrumentation. Such achievements will be critical to automated transportation systems. Recent advances in design for automated assembly, manufacturability, and life cycle, have sanctioned the evaluation and development of new concepts for automated construction and maintenance of a demanding ITS infrastructure.

## Infrastructure Construction & Maintenance

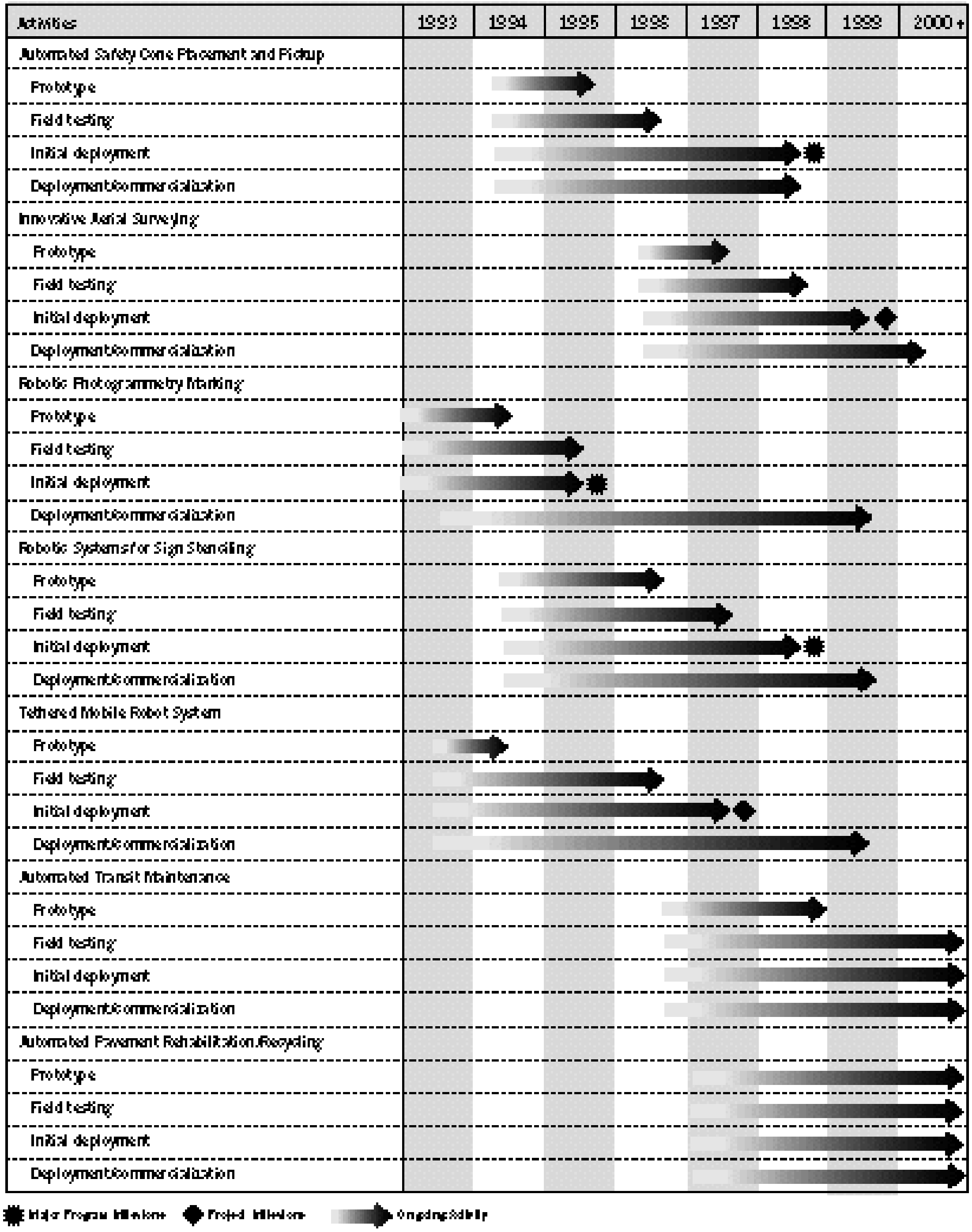
**Activity Charts**



## Infrastructure Construction & Maintenance

### Activity Charts

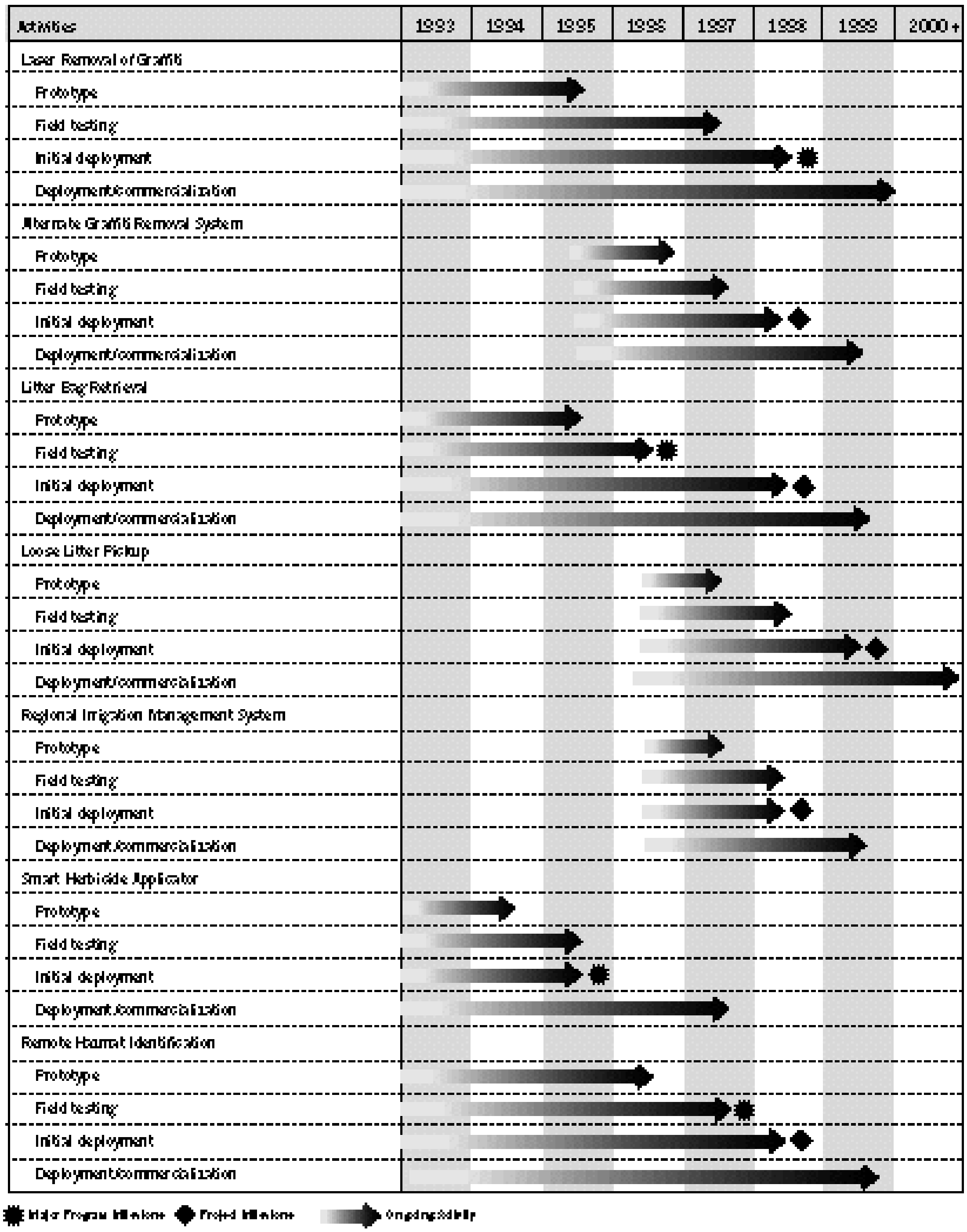
Roadway Maintenance & Construction cont'd



## Infrastructure Construction & Maintenance

**Activity Charts**

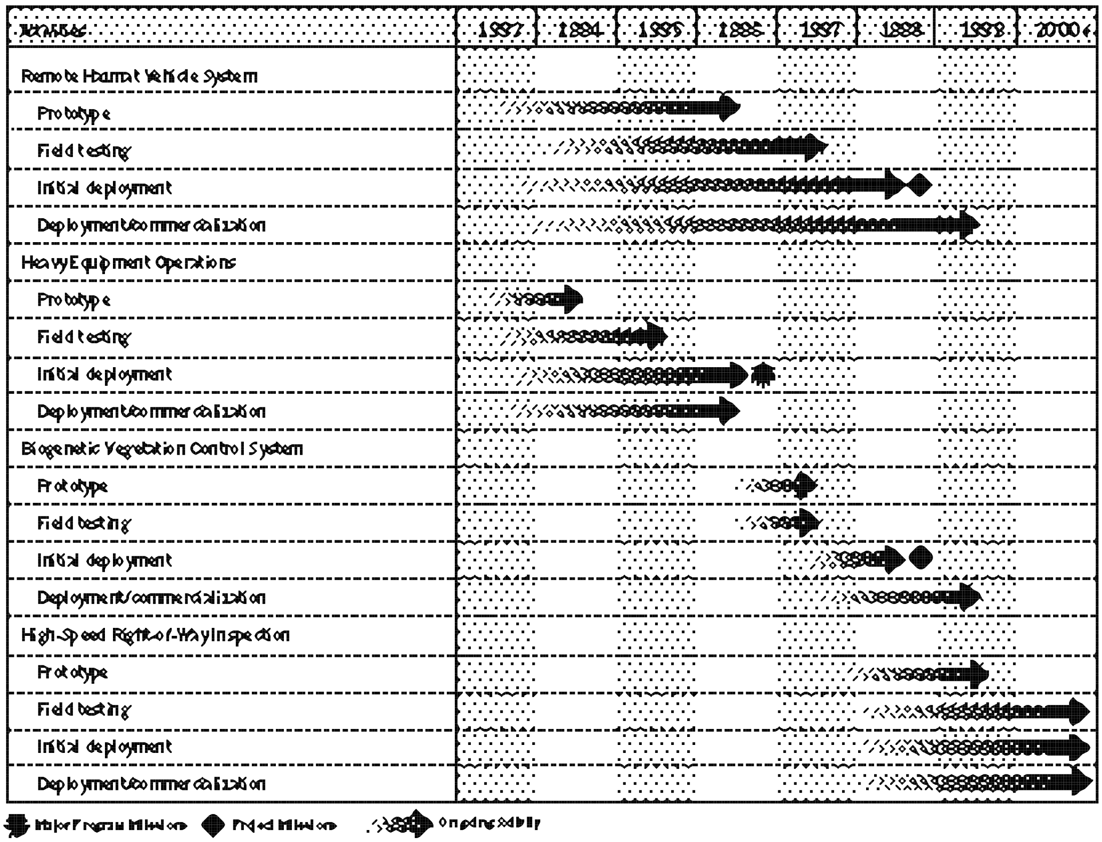
Roadside Maintenance & Construction



## Infrastructure Construction & Maintenance

**Activity Charts**

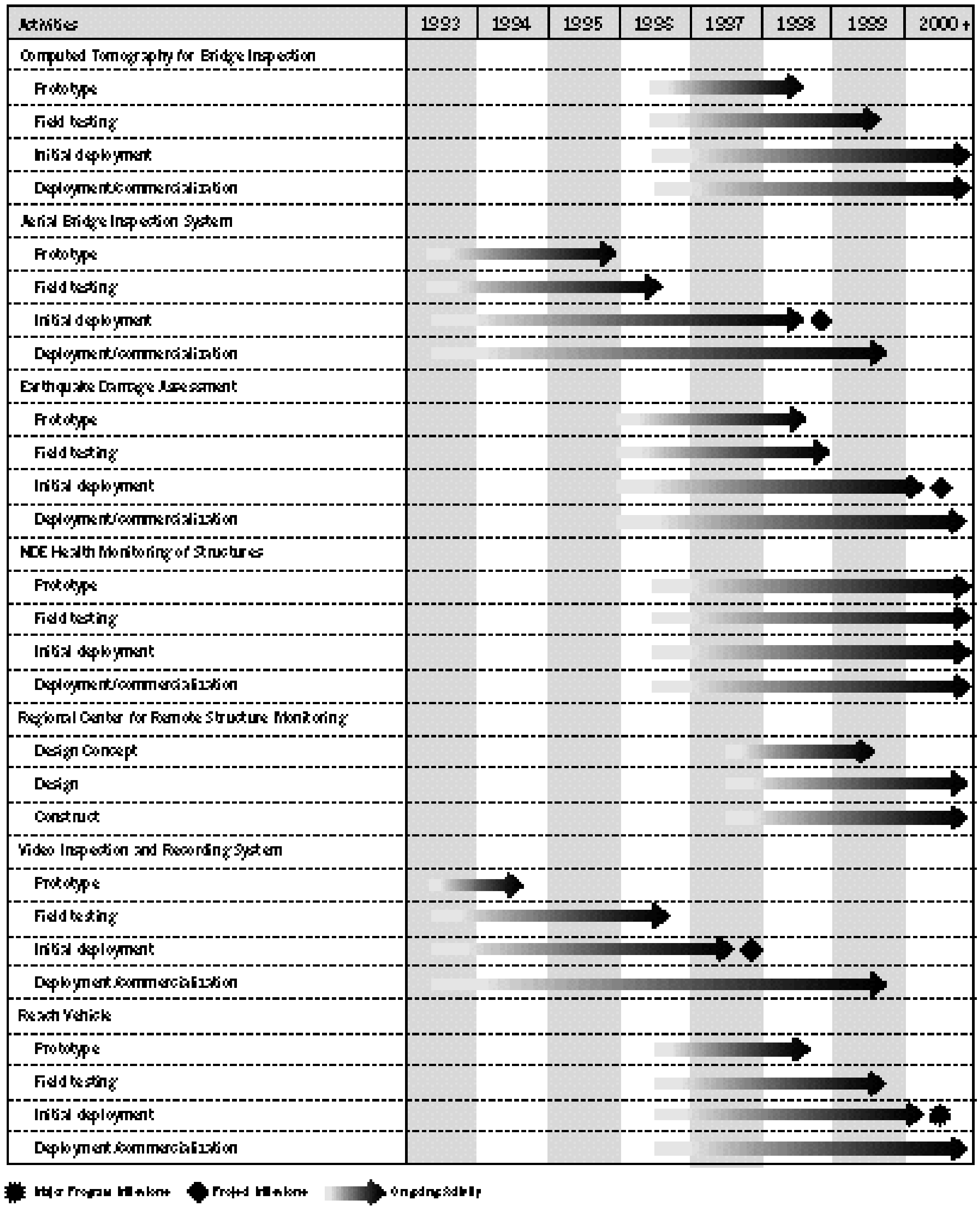
Roadside Maintenance & Construction contd



## Infrastructure Construction & Maintenance

**Activity Charts**

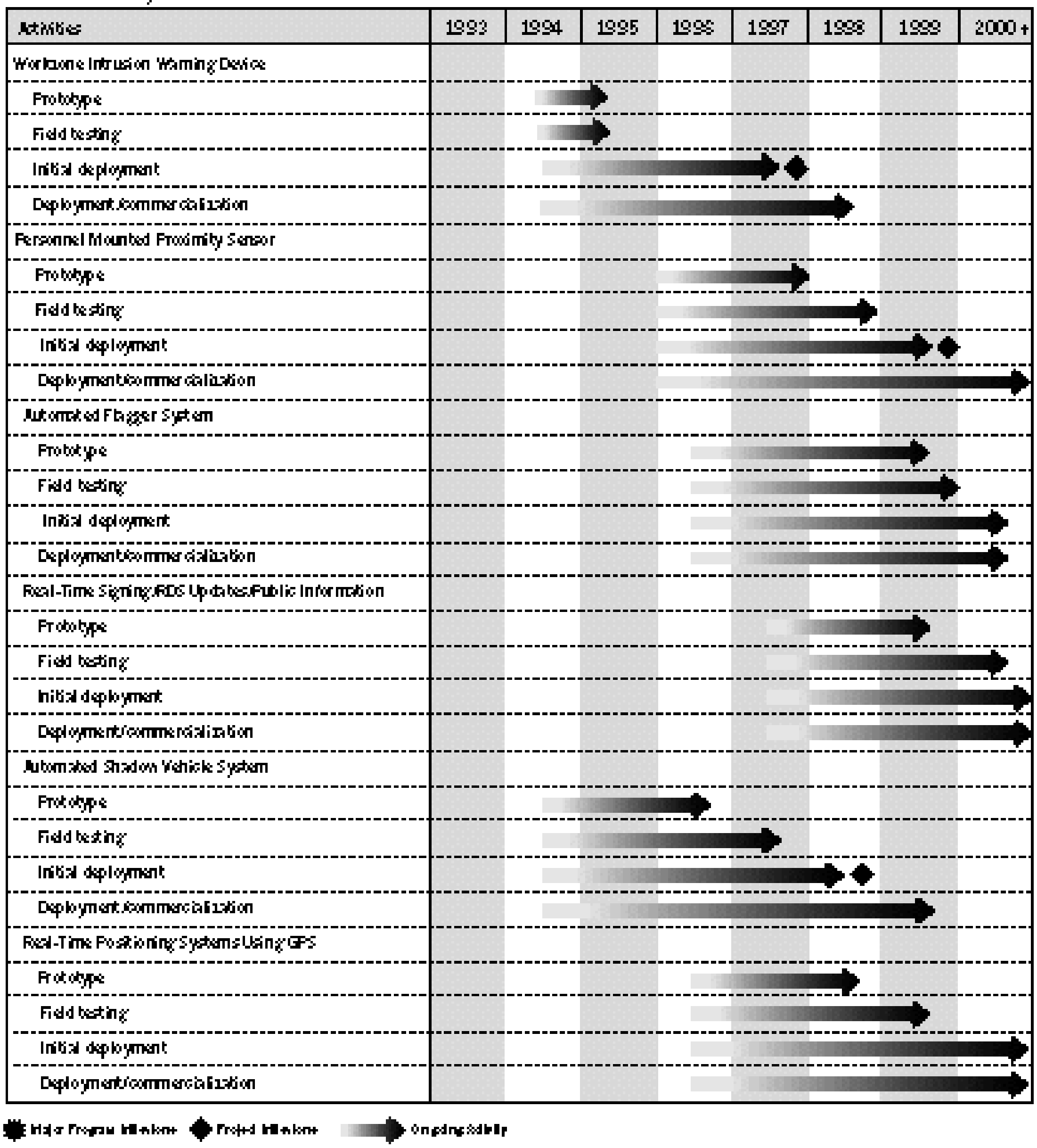
Structure Maintenance & Construction



## Infrastructure Construction & Maintenance

### Activity Charts

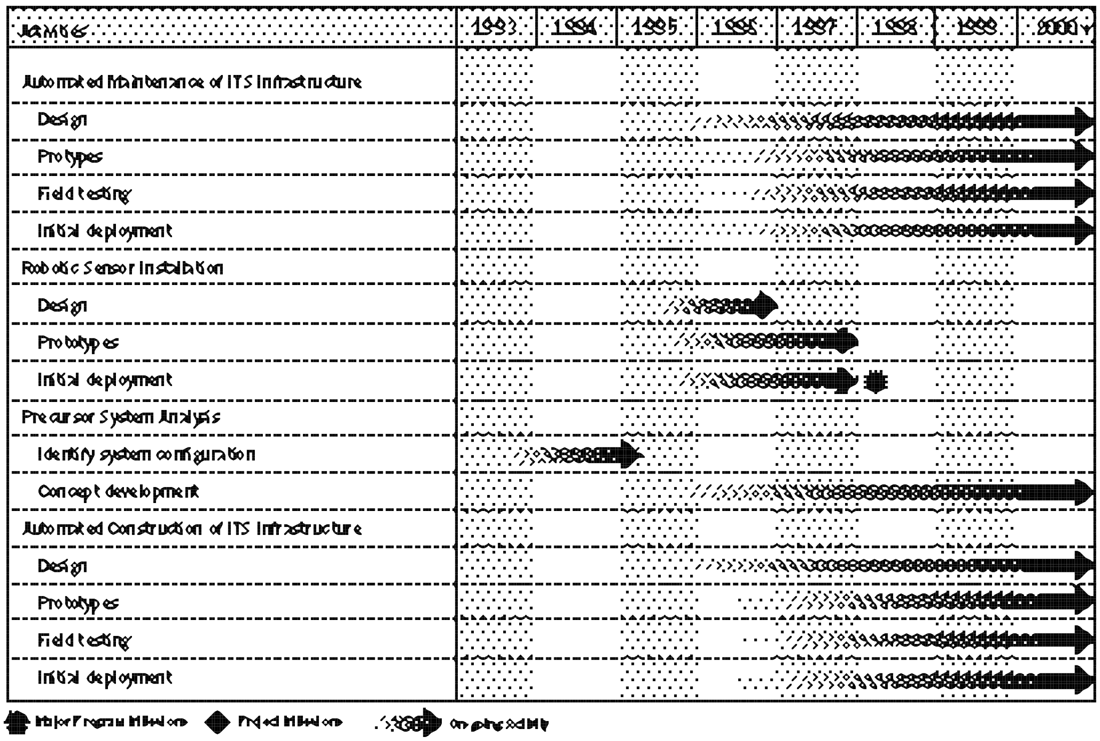
Workzone Safety Enhancements



## Infrastructure Construction & Maintenance

### Activity Charts

ITS/AHS Infrastructure Maintenance and Construction



**The following AHMCT projects show the most immediate potential for commercialization or extensive field prototype operation:**

### Crack Sealing Machine

The Automated Crack Sealing Machine (ACSM) is a self-contained prototype vehicle for automatic identification, preparation, and sealing of roadway cracks—a conventionally dangerous, slow, and labor-intensive operation. This vehicle will increase the efficiency of crack sealing and enhance the safety of maintenance workers and the traveling public, as well as reduce the time necessary for lane closures.

The vehicle is equipped with a vision system, a robot positioning system, and computer and mechanical support systems. During automated operation, the vision sensing system detects the position of cracks, including their orientation, while the relative position of the vehicle is continuously monitored by a dead-reckoning system. The crack data is buffered and processed by modules which determine the order of cracks to be sealed as they become accessible in the sealing workspace and positions the robotic arm with a custom sealant head along the calculated crack positions. The sealant head, custom designed to fill and seal any size crack according to standard specifications, is so innovative that interest from maintenance and industry personnel has encouraged accelerated efforts to commercialize it as an independent material delivery module.

A longitudinal crack sealing vehicle has been developed to seal only the continuous pavement joints along lanes. The quick-moving vehicle uses the same custom sealant head as the general crack sealing machine, and has been tested in Caltrans District 2 (Redding), District 3 (Marysville) and District 11 (San Diego).

### Robotic System for Sign Stenciling

The traditional method of stenciling is a very slow, labor-intensive operation that requires manual placement of a stencil and paint, exposing maintenance workers and the traveling public to hazards. The goal of the new stenciling system is to improve the safety, reliability and efficiency of the roadway sign stenciling operation through the application of automation and robotic technologies. The first prototype resulting from this project focuses on the stenciling of survey premarks for photogrammetry. Using the automated stenciling system, a single operator can accurately complete the painting operation from within the cab of the maintenance vehicle in a fraction of the half-day-per-mile required by the traditional four-person survey crew. By eliminating or reducing the exposure of workers to traffic, the safety, speed, and efficiency of the stenciling operation is significantly improved.

**Crack sealing machine prototype testing, District 3 (Marysville)**

**Infrastructure Construction & Maintenance**

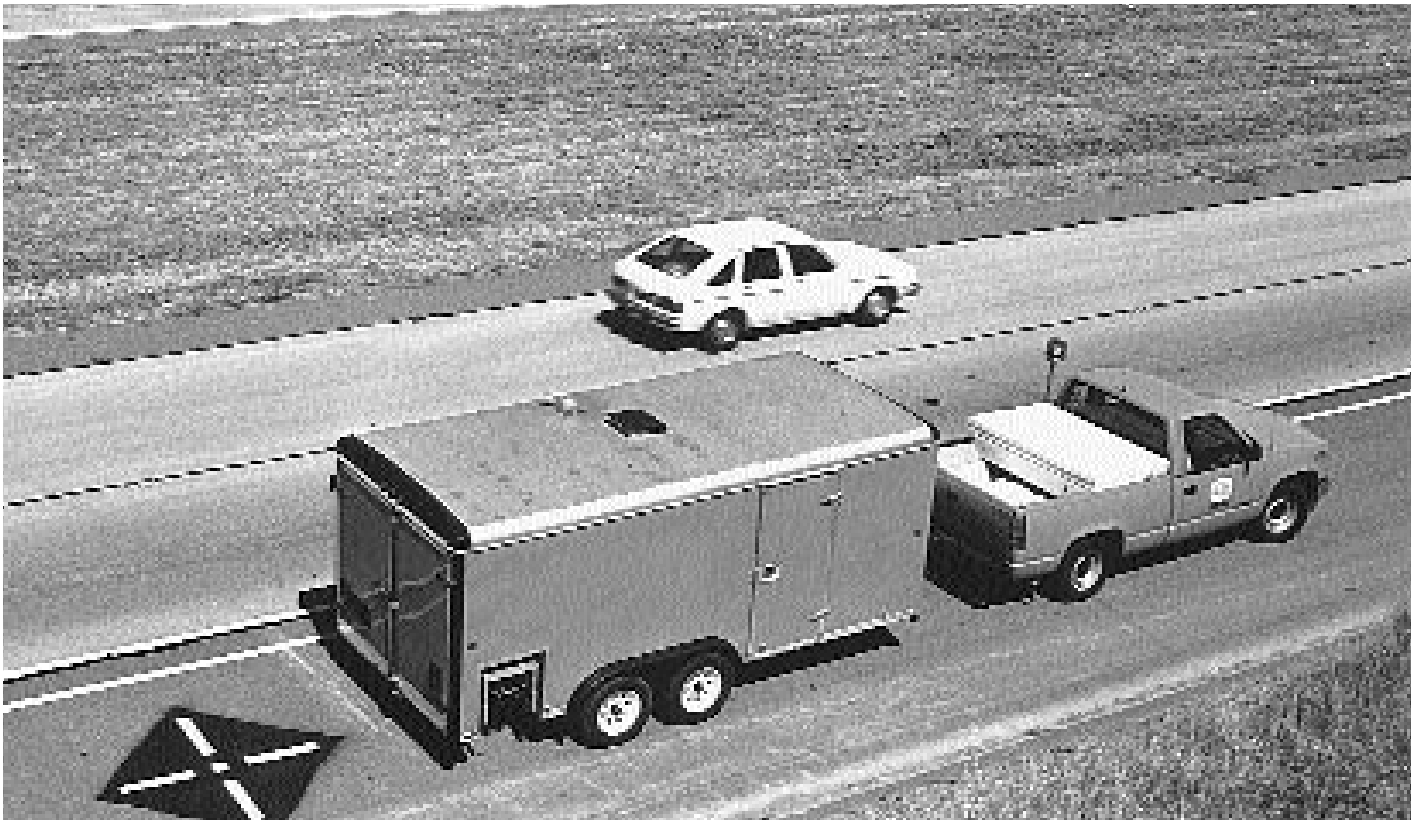
**Project Highlights**

**TAMER equipment in operation. Both of the methods shown, the backpack unit and stationary console, are available for remote operation.**

### Remote-Control Heavy Equipment

Heavy equipment such as crawler tractors, dozers, and loaders, are often used in hazardous situations such as clearing avalanches, landslides, and snow, as well as cleaning up hazardous materials. The respective equipment operators are by necessity exposed to this high-risk, unstable environment. Remote controlled capability permits the operator to control the equipment from a safe distance when the conventional operation is deemed dangerous. The remote distance for reliable operation is 488 meters (1600 ft).

Teleoperated and Automated Equipment Robotics (TAMER) technology has most recently been applied to a Caltrans front-end loader. It is anticipated that such a remote-control system could also be adapted to other existing maintenance and construction equipment.



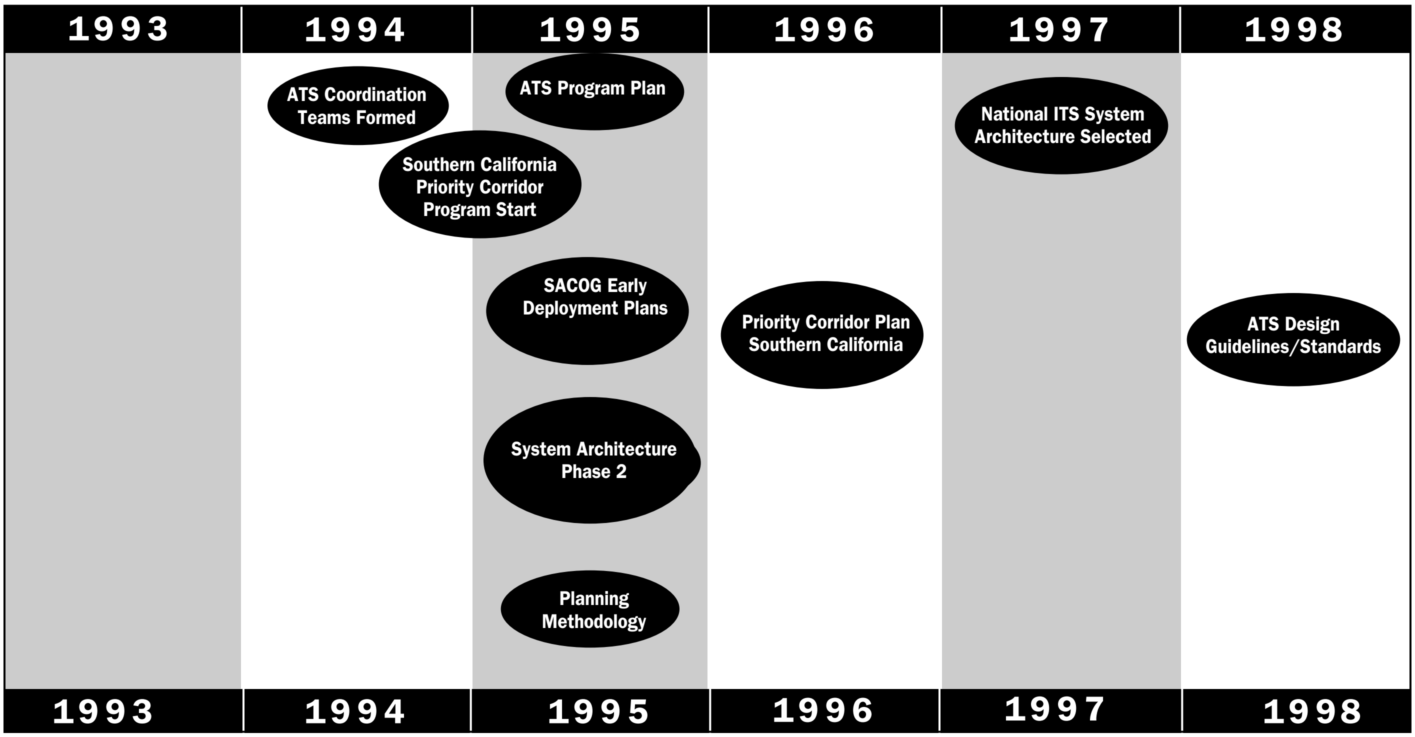
**Robotic System for Sign Stenciling in operation.**

# SYSTEMS DEVELOPMENT, INTEGRATION AND IMPLEMENTATION

**Systems Development, Integration and Implementation includes Caltrans involvement in integrated systems design and operation framework; planning, programming and environmental aspects, as well as legal and institutional issues associated with the deployment of advanced transportation technologies in California.**

**The milestones, scope of services, activities and specific project highlights for Systems Development, Integration and Implementation are discussed on the following pages.**

# System Development, Integration and Implementation



## Systems Development, Integration and Implementation

**System Architecture-Scope**

### ITS Architecture Definition

An ITS architecture is a framework that defines the system elements, determines their functions, and describes how the elements interact with each other. It describes the system operation by what data is collected, what information is distributed, and the means by which that is accomplished. The framework is presented via charts and diagrams, along with narratives. The architecture framework is *not* a system hardware or software design and it is not a policy decision or directive.

System architecture presents the total perspective to aid in the analysis and design of the individual ITS parts while taking into consideration the needs and constraints of the transportation system as a whole. Within this context, the objectives for the ATS Program are to:

- Define an integrated system design and operational framework. The best approach to designing such a framework is to develop an overall system architecture that will determine not only the functions of individual components, but more importantly, their connectivities (design) and interrelationships (operation);
- Analyze the system-level aspects that could create problems or have impacts on the system as a whole, and not necessarily on its individual parts. Such problems would apply to system modeling of interconnection/communications, design, human factors, reliability, optimization, openness, and full automation;
- Synthesize and integrate the various components and subsystems as they are being developed, produced, and deployed to insure their connection, the correction of deficiencies, and elimination of duplication and unwanted redundancies; and,
- Synchronize research and development, as well as deployment work across all programs to ensure efficient use of time and resources, as well as satisfactory progress and timely completion of tasks.

The degree to which these objectives are accomplished determines how timely and complete the intermodal advanced transportation system can be, as well as how efficiently and harmoniously it will operate.

### Significance of the ITS Architecture

The significance of the ITS architecture stems from its ability to allow nationwide deployment of compatible transportation systems and synergistic transportation services. The architecture's significance is manifested by its stated objectives which are:

- Promote national compatibility via determining and implementing national standards and protocols for vehicle-to-vehicle and vehicle-to-infrastructure communications;
- Facilitate ITS user service integration via a framework for integrating data collection, data transmission, information processing, information dissemination, traffic control, and intermodal transportation system functions;
- Accommodate new and evolving user services via a structural framework of basic building blocks for incorporating new systems and functions; and,
- Provide regional, institutional, and consumer decision-making flexibility in implementing ITS systems without weakening the above three objective benefits.

### Caltrans' Involvement in the National System Architecture Program

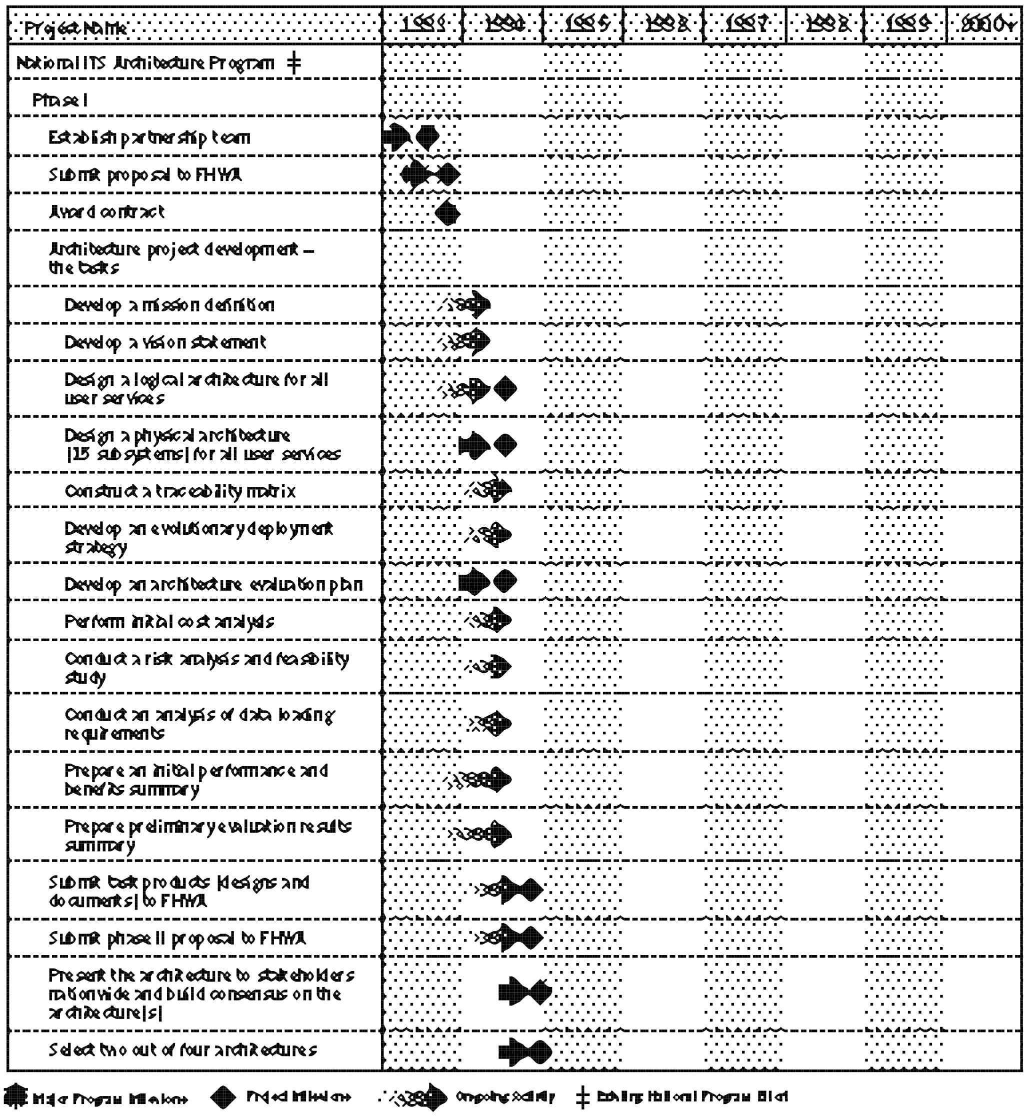
Caltrans is an active participant in the Architecture development process to:

- Insure that California traffic congestion problems and transportation system needs are well addressed;
- Influence the design of the national architecture so it leverages and maximizes the utilization of California's existing transportation infrastructure, as well as California's future plans and investments in the transportation systems;
- Insure that future transportation systems in California are designed/deployed to fit well within the emerging national ITS architectural framework; and
- Share Caltrans' experiences with, and provide expertise to, the FHWA, as well as to the rest of the states' DOTs.

## Systems Development, Integration and Implementation

### System Architecture-Activity Charts

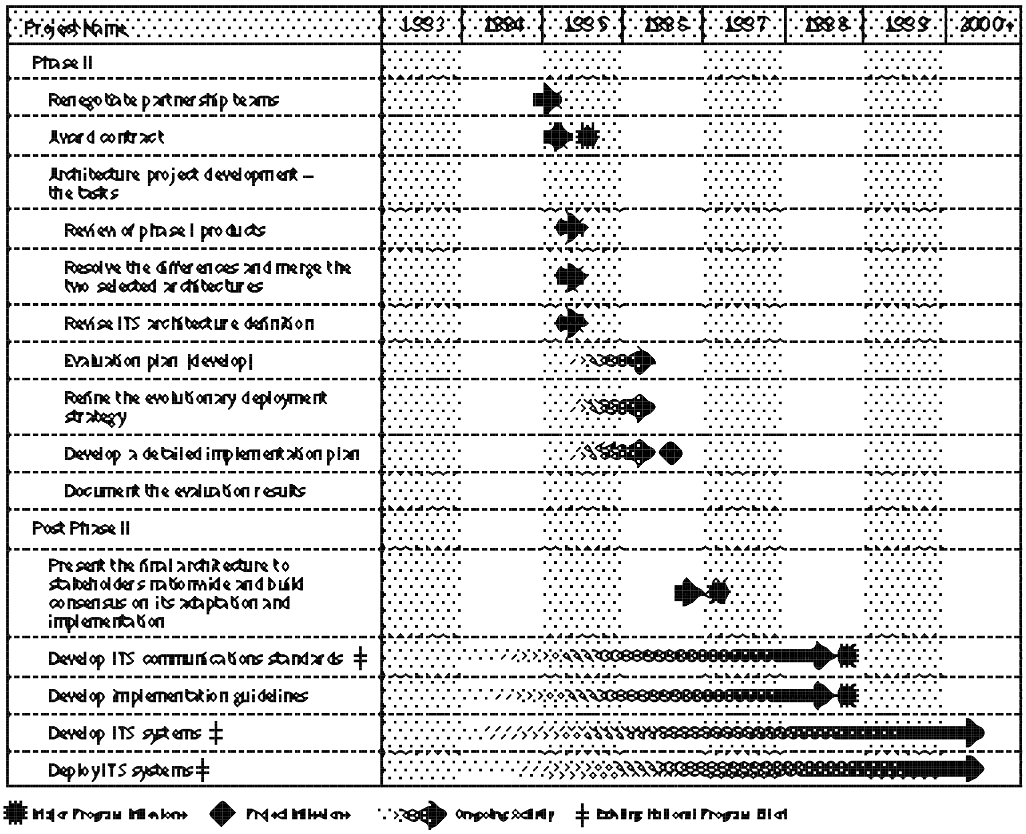
System Architecture



## Systems Development, Integration and Implementation

### System Architecture-Activity Charts

System Architecture contd



## Systems Development, Integration and Implementation

### Institutional and Legal Issues - Scope

For Caltrans, the scope of institutional and legal issues covers planning, programming and environmental needs, as well as legal and institutional barriers. Caltrans, in cooperation with all levels of government, the private sector, academia, and various interest groups, is working on several fronts to help assure timely and responsible deployment of advanced transportation systems in California. Examples include:

- Caltrans is working with its partners to establish regional teams throughout the state to coordinate ATS programs and activities and help facilitate ATS deployment;
- Caltrans, in cooperation with local and regional agencies, is preparing the Southern California Priority Corridor Plan as provided for in ISTEA to showcase ITS technologies in Southern California (see Project Highlights); and,
- Caltrans, in cooperation with ITS America and the Federal Highway Administration, co-sponsored a policy conference on air quality in June 1994. This was the third conference in a series addressing the relationship of ITS to air quality.

Caltrans is considering state policy and legislative initiatives that will support ATS and related economic endeavors such as:

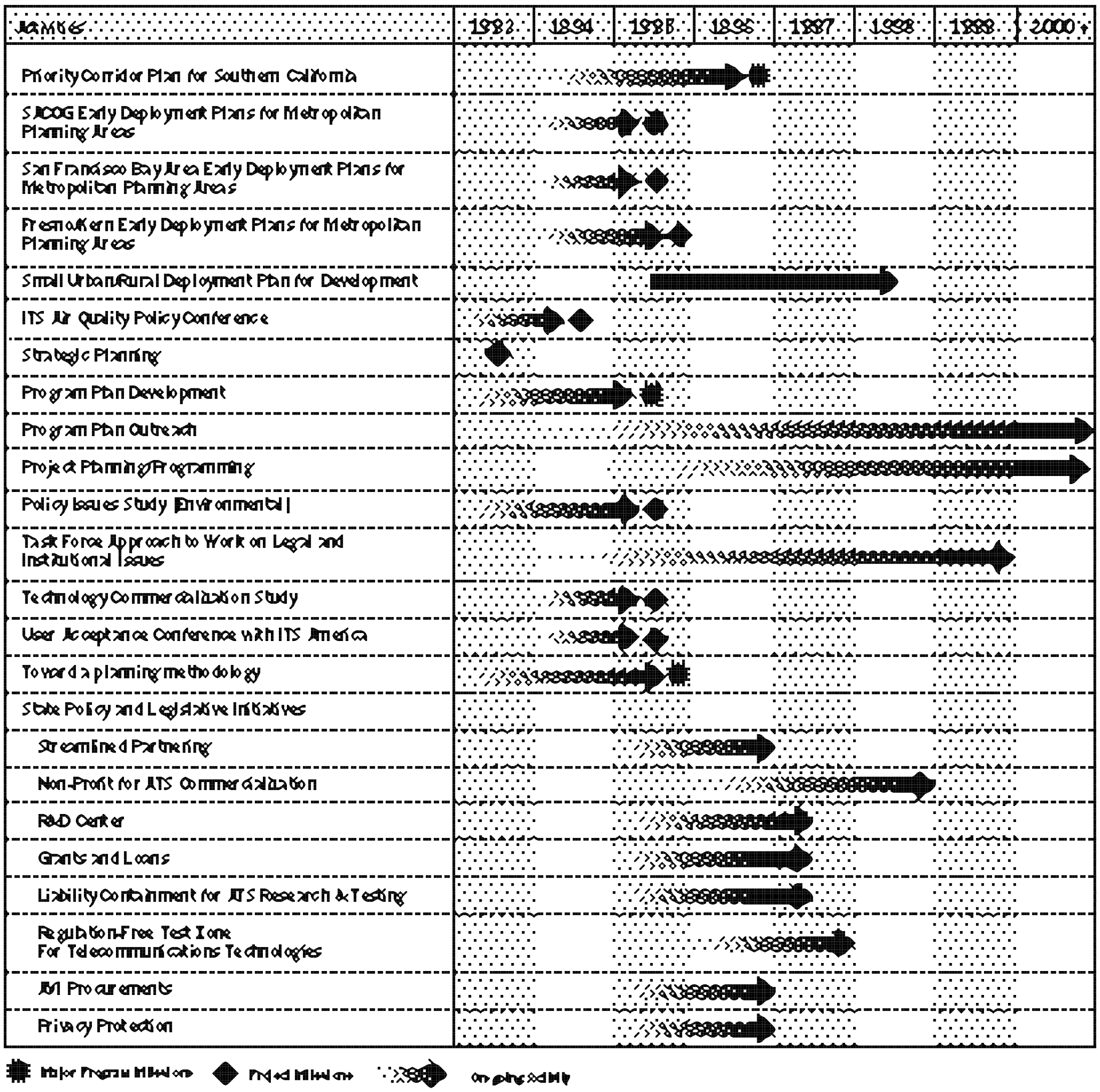
- Streamlined partnering arrangements for the program
- Non-profit corporation for ATS commercialization
- Grants and loans for ATS innovations by small businesses
- Liability containment for ATS research and testing in California
- Regulation-free test zone for telecommunication technologies
- AVI procurements for public fleet vehicles
- Privacy protection in ATS deployment

The five-year activity charts for these and other activities provide the institutional base for ultimate deployment of advanced transportation systems, products, policies and services.

## Systems Development, Integration and Implementation

### Institutional and Legal Issues - Activity Charts

Institutional Issues



**Systems Development, Integration and Implementation**

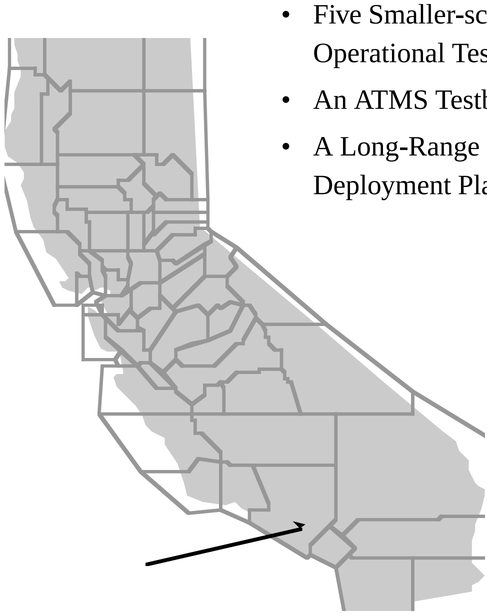
**Systems Architecture and Institutional Issues - Project Highlights**

### A Showcase of ITS Technologies and Stakeholder Cooperation

The Southern California Priority Corridor, one of four corridors identified in the nation, is to be a showcase for the deployment of intelligent transportation systems (ITS). Southern California is a major destination for international travel and goods movement. Travelers and goods flow to and through the corridor from Asia, Mexico, Central America, South America and Europe to destinations in Southern California and the rest of the nation. It is critical, therefore, that the transportation system supports the smooth flow of people and goods through the most populated area in the state.

The four major efforts occurring in the corridor are:

- An Intermodal Transportation Management and Information System (ITMIS) Showcase Project;
- Five Smaller-scale Field Operational Tests;
- An ATMS Testbed; and,
- A Long-Range ITS Strategic Deployment Plan.



An important component of the showcase of ITS is the institutional cooperation that is necessary to accomplish these objectives. The Southern California Priority Corridor partners have begun to lay a solid foundation by establishing cooperative agreements, regional teams, and a steering committee to assure the effective execution of the four initiatives. Local participation and leadership will be emphasized in the management of this effort.

### ITMIS Showcase Project

The showcase is a major effort to integrate intelligent transportation system technologies into a model intermodal transportation management system. The project will design, implement, operate and evaluate ITS user services which provide linking and optimization of multimodal transportation systems within the region. The showcase project will demonstrate an areawide interactive/integrated transportation management and information system based on real-time, computer-assisted transportation management and communications. User service will include:

- Real-time information to travelers and operators;
- Decision/management support to transportation management centers, traffic engineering/public safety departments and vehicle fleet operators (public and commercial); and,
- Information/communications network, linking transportation systems and modes which are presently uncoupled, including marine and air.

### Field Operational Tests

Five Field Operations Tests have been funded by FHWA in the corridor.

- In the city of Irvine, an integrated ramp metering/adaptive signal control project will evaluate the operational effects of balancing traffic flow between I-5/I-405 and the parallel arterial streets. The project will also demonstrate the effectiveness of collaborative action on the part of transportation management agencies to optimize their strategies to improve traffic flow.
- The city of Anaheim is testing Split, Cycle, Offset Optimization Technique (SCOOT) as an adaptive signal timing control package. SCOOT automates the data collection process and then automatically optimizes traffic signal timing based on real-time traffic conditions. Video Traffic Detection System cameras will be installed and evaluated in conjunction with the SCOOT system.
- At locations throughout Orange County, a Mobile Surveillance Field Operations Test will evaluate the use of a portable detection and surveillance system for highway construction, special events, and incident locations. Specially-equipped trailers will be placed at temporary traffic congestion locations. Trailer-mounted video image detectors will use spread spectrum radio for transmission of real-time information to state and local control centers.
- State, regional and local agencies in San Diego will take advantage of the extensive call box system to increase their functionality by adding an interface to traffic management devices. These “smart” call boxes will collect traffic census data; obtain traffic counts, flows and speeds for accident detection; detect and report hazardous weather conditions; control changeable message signs, and operate roadside closed-circuit television cameras.
- The city of Los Angeles is conducting a spread spectrum radio traffic interconnect project to evaluate wireless traffic signal communications. The radios will be tested in a network of signals to determine their ability to reliably re-route communications links, their ability to work in a variety of geographies, their ability to provide for large-scale once-per-second communications, and to determine the cost-effectiveness of using this technology.

**Systems Development, Integration and Implementation**

**Systems Architecture and Institutional Issues - Project Highlights**

### Testbed

The Advanced Transportation Management Systems (ATMS) Testbed is a cooperative program sponsored by Caltrans, PATH and local agencies in Orange County to enable ongoing research, testing and evaluation activities for development and operation of integrated multijurisdictional and multimodal transportation management systems. The testbed utilizes existing real-time, computer-assisted traffic and transportation management systems and PATH labs at the University of California, Irvine and California Polytechnic State University, San Luis Obispo.

The ATMS testbed is intended to:

- Provide an instrumented, multijurisdictional, multiagency transportation operations environment linked to university laboratories for real-time technologies and applications. It will enable off-line testing of products and further development of research prototypes prior to installation in the field;
- Provide a meeting ground for practitioners and researchers to try new approaches to transportation system management;
- Enable private industry to demonstrate and evaluate their prototyped technologies under real-world traffic conditions; and,
- Make available a continual testing ground for California and national ITS efforts.

### Strategic Deployment Plan

Early deployment planning for intelligent transportation systems in the Priority Corridor will occur over an 18-month period. A Strategic Deployment Plan, estimated to be completed in the summer of 1997, will address the 29 user services defined by ITS America as they would apply to the needs of Southern California. The plan will identify “early starts,” as well as a 20-year plan/ schedule and funding estimates for deployment of ITS elements. Public participation is an important element of the plan. To define the needs of the users of all transportation systems and modes, input will be solicited from commercial freight operators, transit operators and travelers.

Start-up activities in the corridor have already provided an exceptional opportunity to develop partnerships with stakeholders. These include MPOs, state agencies, air quality management districts, cities, counties, and transit districts. The opportunity to participate will continue to expand to include various modal operators, private industry, and others.

## ATS Program Resource Needs

Stability in state funding that parallels ISTEA is essential if California is to realize the vision set before it. Currently $12.9 million in state funds is annually budgeted to leverage, in conformance with AB3096, $20 million in federal funds and $10 million in cost sharing from Caltrans' partners.

This baseline budget provides Caltrans with the minimum state funding necessary to ensure viable California economic partnerships to continue current major program initiatives in the areas of the Automated Highway Systems (AHS) Prototype; Priority Corridor Showcase; Smart Traveler Deployments (urban); Deployment Planning (urban and rural); Transportation Management Systems Testing; and, Automated Highway Construction and Maintenance.

However, a more aggressive ATS market approach could have far reaching economic benefits for California in key market areas, such as: nearer-term vehicle safety products; multimodal traffic management; advanced fleet management; and, premium traveler services packaged for new multimedia and telecommunications markets.

This market approach requires aggressive institutional issues resolution to assure integrated public/private efforts, cooperative research, development, and testing, supporting technology deployments in the public infrastructure, and standards development to accelerate commercialization. Accordingly, adoption of state policy and legislative initiatives may be required.

The resource estimates for aggressive research, development and testing of technologies on an annual basis are:

- State - $30 million;
- Federal - $20 million; and,
- Partners - $30 million.

Public infrastructure improvements/deployments are estimated at $300 to $500 million from all sources.

A strong commitment to the ATS Program will further mobility and economic opportunities for California. The program's vision will be realized primarily through strategic deployment of technologies to the public transportation infrastructure. Private sector investment and commercialization will be necessary. This holds great potential for establishing new California businesses in international markets and the creation of jobs for Californians into the 21st century.

# CONCLUSION

The Advanced Transportation Systems (ATS) Program provides the foundation for ATS efforts in California. The ATS Program Plan has been developed to give Caltrans' partners and other interested parties a broad overview of the program and partner roles. It outlines program goals and objectives in light of Caltrans' mission, and its vision of a balanced, reliable, safe, environmentally efficient, and integrated intermodal transportation system, and the steps Caltrans will take to develop the program technologically and institutionally. This program relies on both governmental action and market forces and will require extensive cooperation on the part of the state, its political subdivisions and private industry to realize Caltrans' 15-year ATS deployment vision.

Achieving the ATS vision will lead to societal benefits including:

- Improved mobility through better use of the transportation infrastructure;
- Enhanced public transportation and commercial vehicle fleet operations;
- Access to reliable, real-time transportation information and to traveler services;
- Higher levels of safety for both urban and rural areas;
- More attention, and, therefore, more products and services designed to address the specific and unique needs of the elderly, and physically and developmentally challenged;
- Better environmental energy efficiency of transportation systems;
- Improved economic productivity; and,
- Defense conversion leading to an increased job market.

Major public and private sector investments have already been made in ATS and will increase in the coming years. An effective way of managing and leveraging these investments is crucial to the success of the program. This document is designed to be used as a tool to manage research, development, testing and deployment of the products and services outlined in the preceding chapters. The ATS Program Plan is essential if we are to spend resources wisely, speed the achievement of ATS benefits, and assure acceptable standards and uniformity across regional, state and even national boundaries.

The proposed program is based on required activities, increases in state support for the program, the availability of federal ISTEA funding and a reasonable degree of public/private cost-sharing by California's ATS partners. It is designed to move California's ATS program forward in an orderly and cost-effective manner. It is consistent with the goals and objectives outlined in the draft National Program Plan released by USDOT in June 1994.

Caltrans has identified an ambitious set of milestones to be attained over the next five years. It is critical that the momentum for ATS progress be maintained.

In summary, the Caltrans ATS Program calls for:

- Funding to allow for an aggressive market approach to ATS;
- Forging strong public and private partnerships;
- Cooperative ATS multiyear research, development and operational test projects leading to the 15-year deployment;
- Continuing evaluation of ATS projects to determine if any program/project revisions are necessary to meet user needs;
- Systems modeling and compatibility planning;
- Developing cooperative systems architecture;
- Using building block deployment strategies;
- Standards setting;
- Resolution of legal and institutional issues; and,
- Support for private sector commercialization.

Unprecedented levels of cooperation and partnerships are being accomplished to promote the continued development and growth of ATS technologies. Partnerships are being formed between many governmental organizations and between the public and private sectors. Caltrans will continue to work closely with its partners in both the private and public sectors to advance a balanced and effective program.