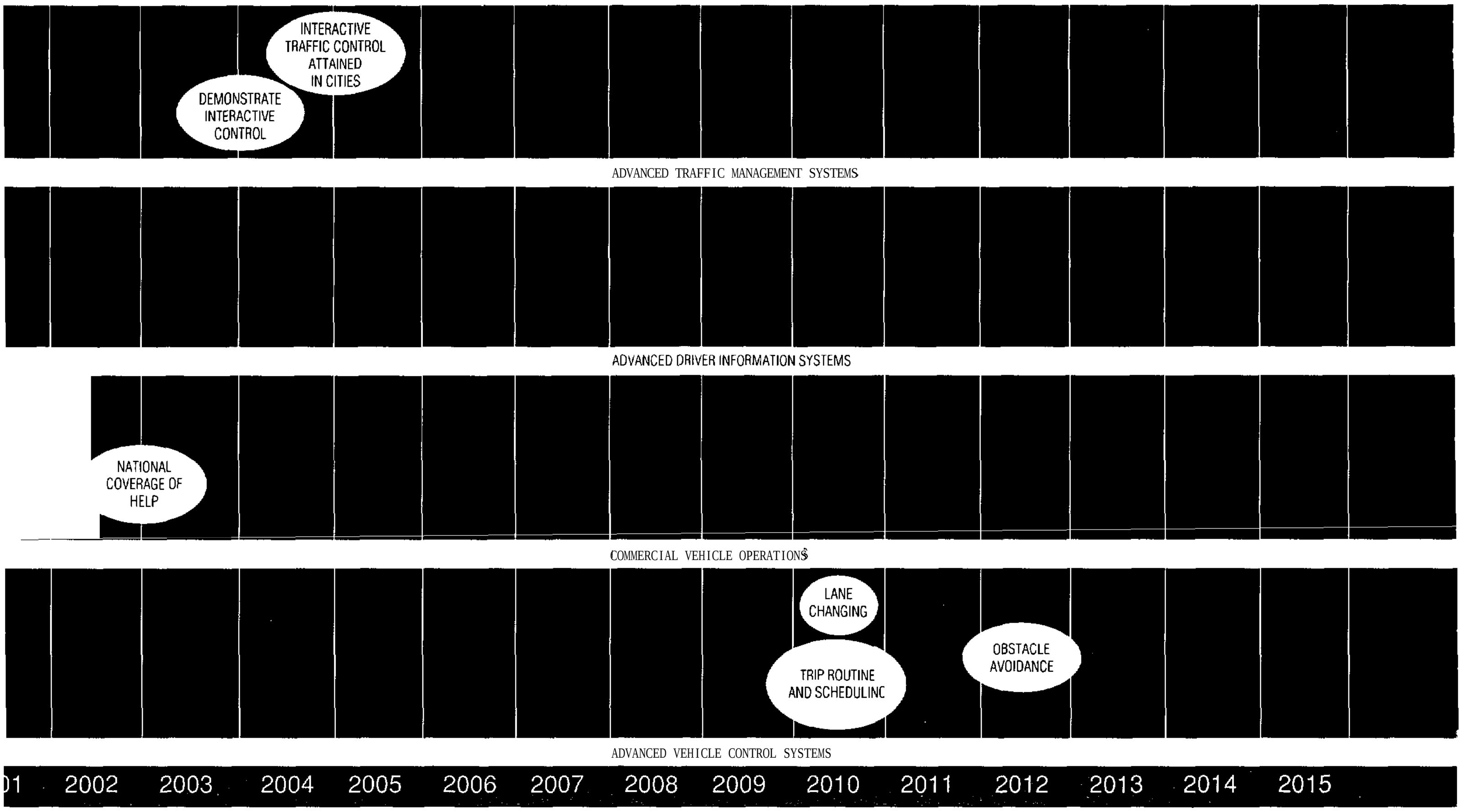


MOBILITY 2000 PRESENTS

INTELLIGENT VEHICLES AND HIGHWAY SYSTEMS

1990 SUMMARY

CONTENTS

The national IVHS Workshop in Dallas March 19-21, 1990 was sponsored by government, university, and industry members involved in Mobility 2000, and hosted by the Texas Transportation Institute, The Texas A&M University System. The Workshop was a forum for the exchange of ideas, plans, and definitions. An *Executive Summary* was published by TTI to brief executives at the May 3-5 IVHS National Leadership Conference on the progress of the Workshop. One very important purpose of the Workshop was to open a dialogue between all involved parties—in government, industry, and research. A dynamic dialogue took place in Dallas, and continued through the publication of the *Executive Summary* in April of 1990. This publication is an update and reprinting of the April *Executive Summary*.

VISION OF INTELLIGENT VEHICLE/HIGHWAY SYSTEMS

The United States is now moving from the enormously successful Interstate Highway construction program to programs that will set the course of highway transportation well into the 21st century. These present program decisions will determine the mobility, safety, and viability of highway operations for present and future generations-just as the Interstate program did 35 years ago.

A significant part of the post-Interstate highway program is expected to be a national cooperative program of Intelligent Vehicle Highway Systems (IVHS). This program will involve public-private partners in joint ventures. It will develop, test, and deploy advanced electronics technology and systems to meet the increasingly critical operational needs of the highway transportation system. IVHS will be a major complement to other highway improvement programs such as preservation and new construction. These programs are essential to maintain the viability of the highway system.

IVHS include a range of technologies and ideas that can improve mobility and transportation productivity, enhance safety, maximize existing transportation facilities and energy resources, and protect the environment. IVHS are based on modern communications, computer and control technologies. The program contains four broad, interrelated areas: *advanced traffic management systems, advanced driver information systems, commercial vehicle operations, and advanced vehicle control systems.*

The program will involve significant cooperation among government at all levels, universities, and industries such as those producing motor vehicles, electronics, communications, computers, and transportation services.

The results of this national undertaking will continue over many years. Many near-term benefits will come from applying existing, state-of-the-art technology. Long-term benefits will accrue well into the next century. These long-term benefits will, in some cases, require extensive research and development. Profits from short- and medium-term benefits will justify the longer-term research and development needs,

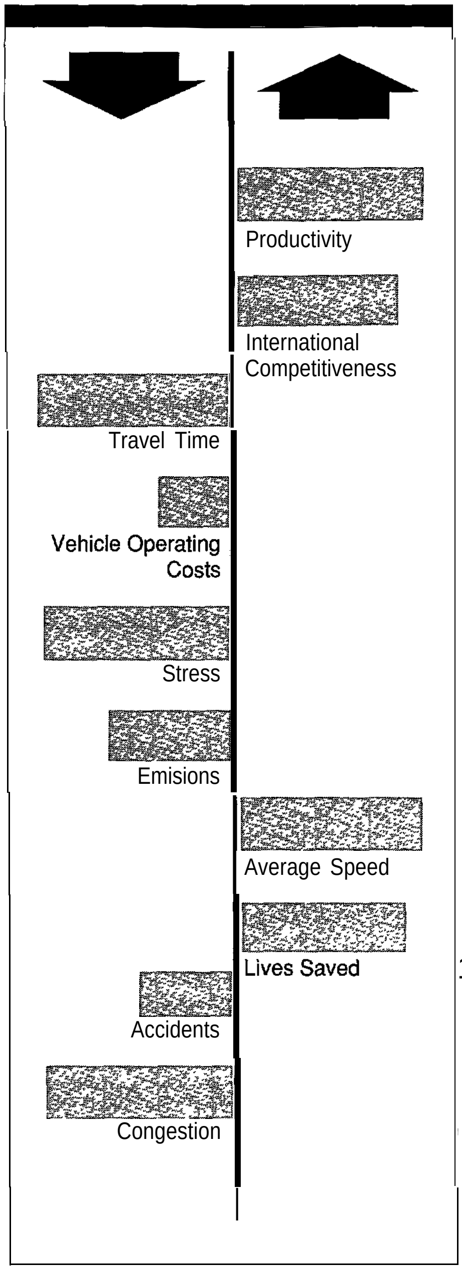
NATIONAL MOBILITY

IVHS will significantly improve mobility in the United States. Urban areas will more efficiently manage their existing streets and freeways through improved traveler information and traffic control systems. Rural and urban area travelers will benefit from improved security, comfort, and convenience. Experience gained from better management of existing facilities will further improve the design and use of new facilities. With the time and energy saved through enhanced travel efficiency, the cost of producing goods and services will decrease, resulting in improved industrial profitability and international competitiveness

Intelligent Vehicle/Highway Systems include a range of technologies and ideas that can improve mobility and transportation productivity, enhance safety, maximize existing transportation facilities and energy resources, and protect the environment.

All vehicle operators will benefit from more efficient and less stressful travel. Through IVHS, drivers may access routing information that allows them to select a route based on speed, fuel efficiency, scenic views, interesting places, or many other variables. Older drivers will have more mobility because advanced technologies can augment vision and judgment, for instance at night or during bad weather. Significant improvements in service levels and transportation information systems will increase the attractiveness of transit, car pooling, van pooling, and other multiple-occupancy vehicle systems.

Measured, quantified improvements to mobility include: reduced congestion, accommodation of increased travel and higher trip speeds, reduced motorist confusion and aggravation, augmented and enhanced driver capabilities, reduced cost in the transportation element of producing goods and services, and reduced driver fatigue and frustration.



SAFETY

IVHS will significantly improve safety on highways and streets in the United States. In fact, many believe that IVHS technologies, such as driver information systems providing in-vehicle advisory and warning messages, plus future control assist systems, will usher in a new, substantially increased level of motoring safety. Future IVHS systems will include obstacle detection, collision warning, and collision avoidance features to help drivers avoid serious accidents. Such systems will be especially useful in rural driving situations, where the fatality and serious injury accident rate is significantly higher than the national average.

Safety benefits will be substantial. They include reduced fatalities, injuries and property damage. Further, reducing accidents will keep lanes open and minimize the frustration that can contribute to further accidents. The economic byproducts of reduced accidents will benefit all society, not just transportation system users.

ENERGY AND ENVIRONMENT

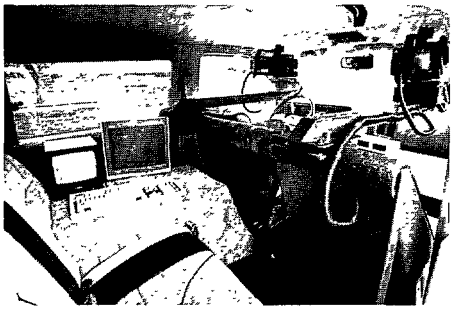
1 IVHS improve energy efficiency by reducing congestion, and improving travel planning and routing. Drivers may obtain information on recommended routes, based on traff ic conditions, time of day, weather, construction, or other variables. Rural and urban drivers will find travel time decreases in a smoother traffic stream.

IVHS has environmental benefits through fuel savings, reduced vehicle emissions, and reduced noise levels. These improvements are especially helpful in metropolitan areas with particularly severe needs.

Direct benefits that have been measured include: reduced vehicle emissions, enhanced use of HOV and transit, and more efficient use of existing facilities.

ORGANIZATIONS AND INSTITUTIONS

These IVHS-based improvements will be accomplished through a partnership of public and private organizations carried out through a thoughtfully planned, coordinated National Cooperative Program. Partners in this program include federal, state and local government, universities, and private sector industries including those producing motor vehicles, electronics, communications, computers, and transportation services.



BART (Binocular *Autonomous Research Team) is being developed at Texas A&M University. The autonomous vehicle can* fol*low* a lead *car, execute turns, and stop itself, using only video* imput.

This cooperative program is essential to the successful implementation of IVHS technologies. It must recognize the complex matrix of government, industry, society, and individuals who are responsible for and users of the transportation system. The vision of IVHS will become a reality through coordinated efforts among these many partners. This reality, in concert with other highway programs, will continue the mobility that helped the United States develop preeminence in the world. Mobility enabled the U. S. to excel in the world marketplace, for we could move people and products more efficiently and safely than other countries. IVHS will also strengthen our position as a major supplier to world markets of transportation products, services, and systems. Our quality of life will improve, and our transportation infrastructure will continue to be the standard of the world.

WHAT ARE INTELLIGENT VEHICLE/HIGHWAY SYSTEMS?

OBJECTIVES

- Streamline traffic operations
- Enable informed route selection
- Enhance individual and system performance
- Help avoid accidents
- Improve mobility
- Automatically control vehicles
- Safer traffic flow

Many modern communication, computer, control, and electronic technologies have been incorporated into stand-alone traffic management applications. Traffic signal timing is a good example. IVHS combine component technologies to provide a more productive highway system. IVHS is, therefore, not a single, static technology, but a continually evolving group of technologies. Each advancement will build upon previous advancements, and provide increased benefits to highway operators and users. For example, existing technologies streamline operation of urban traffic systems and commercial vehicle operations. Soon, improved driver information and navigation systems will enable informed route selection. Other technologies will enhance individual and system performance. Further along, systems will help drivers avoid accidents, and improve the mobility of physically impaired drivers Eventually, streams of vehicles may be fully automatically controlled to permit substantially improved and safer traffic flow.

Mobility 2000 grouped IVHS technologies into four functional areas The functional areas depend on similar technologies. For example, increased communication capacity depends on increased channel capacity. The total vision must always be considered so that initial installations are suitable to become permanent installations. A system engineering prospective is key to the successful evolution of IVHS.

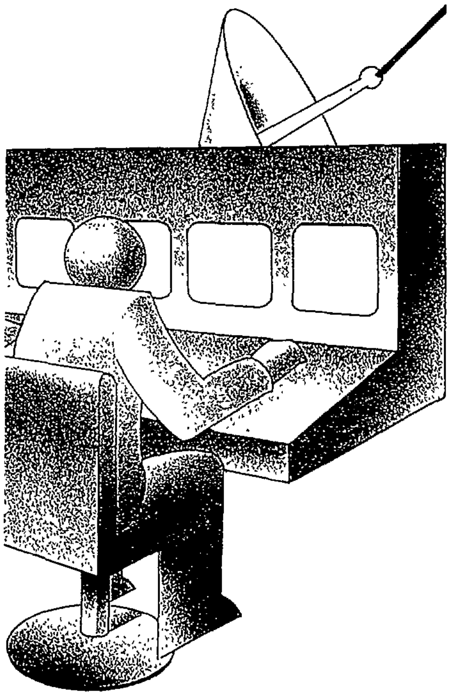
- Advanced Traffic Management Systems (ATMS) permit real-time adjustment of traffic control systems and variable signing for driver advice. Their application in selected corridors has reduced delay, travel time, and accidents.

- Advanced Driver Information Systems (ADIS) let drivers know their location and how to find desired services ADIS permit communication between driver and ATMS for continuous advice regarding traffic conditions, alternate routes, and safety issues.

- Commercial Vehicle Operations (CVO) select from ADIS those features critical to commercial and emergency vehicles. They expedite deliveries, improve operational efficiency, and increase safety. CVO will be designed to interact with ATMS when ATMS is fully developed.

- Advanced Vehicle Control Systems (AVCS) apply additional technology to vehicles to identify obstacles and adjacent vehicles, thus assisting in the prevention of collisions in safer operation at high speeds. AVCS will interact with the fully developed ATMS to provide automatic vehicle operations.

ADVANCED TRANSPORTATION MANAGEMENT SYSTEMS (ATMS)



ATMS involve detection, communication, and control. A surveillance system detects traffic conditions in a metropolitan area and transmits the information to a traffic management center. The traffic management center processes the information and combines it with information obtained from other sources, including from other vehicles acting as probes in the traffic stream. The processed information is used to:

- advise people about current and expected traffic conditions
- inform people of the location, severity, and expected duration of incidents
- recommend the best routes for people to take to reach their destination.

The information is also used to develop ramp metering rates and traffic signal timing to meet current and anticipated conditions. To implement the best control strategies, adjacent jurisdictions must cooperate, for example, when diverting traffic from a freeway to an arterial. Competent operating staff and maintenance crews will also be required to keep traffic moving.

ATMS are being introduced with current technology, and will benefit from advanced technology. Where installed, they are reducing congestion by improving traffic flow, and reducing accidents and emissions.

- In Minneapolis/St. Paul freeway speeds increased 35%, and accidents declined 27%.

- In Seattle, ramp metering reduced travel time from 22 to 11.5 minutes while volume rose and accidents decreased.

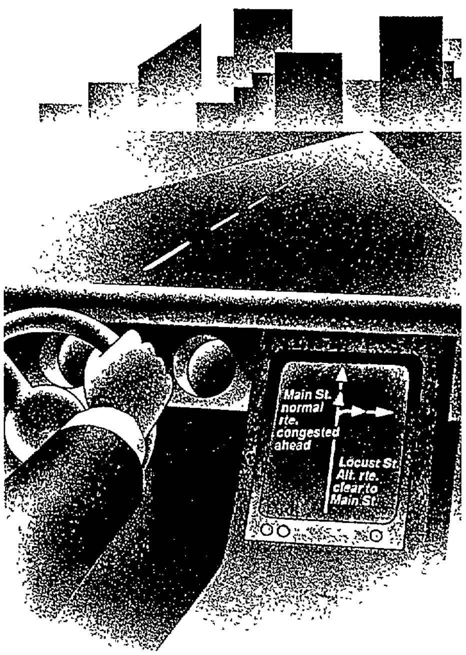
- On Long Island, travel time decreased 13 to 20%, fuel consumption fell 6.7%, hydrocarbon emissions fell 13.1%, and carbon monoxide emissions fell 17.4%.

Traffic management during incidents may reap the largest benefits.

- An accident blocking one of three lanes reduces capacity by 50%.

- A 20-minute blockage wastes 2100 vehicle-hours, makes a queue almost 2 miles long, and takes 2 1/2 hours to clear. During peak periods, waste and delay may be fifty times worse.

ADVANCED DRIVER INFORMATION SYSTEMS (ADIS)

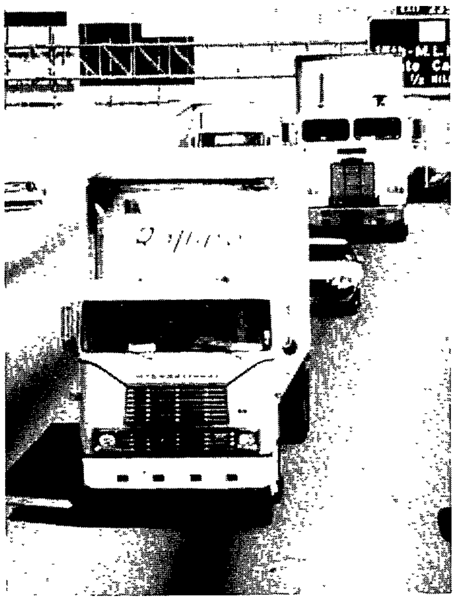


ADIS equipment in the vehicle will use visual or auditory systems to inform the motorist of current traffic conditions, and provide real-time guidance on route decisions. ADIS will provide safety advisory and warning messages to the motorist, which will be especially beneficial in decreased visibility situations involving weather or sight distance. ADIS will also provide an on-board "Yellow Pages" type directory of motoring information.

Specific ADIS features include:

- vehicle location, map-matching navigation system
- traffic information receiver
- route-planning for minimum distance of travel
- color video display for maps, traffic information, **and** route guidance
- an on-board database with detailed maps, business directory, specific locations of services, hospitals, and tourist-related information
- information from traffic management centers on congestion, incidents, and other traffic problems
- electronic vehicle identification for toll debiting
- safety advisory systems
- assistance for aged drivers
- "mayday" signaling and response capabilities.

COMMERCIAL VEHICLE OPERATIONS (CVO)



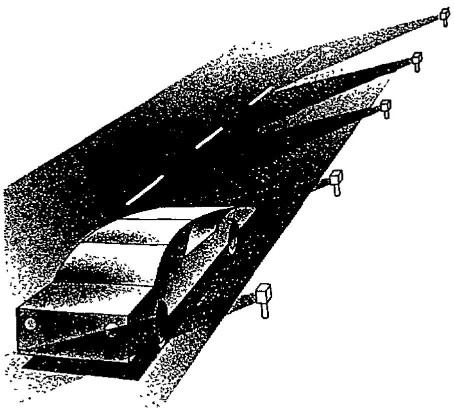
Global competition is forcing U. S. companies to change the way they do business. Carriers are being asked to provide faster, more reliable, and more cost-effective services. IVHS technologies are emerging as the key tools that carriers need to reduce costs and improve productivity. These productivity improvements have a direct impact on the quality and competitiveness of U. S. businesses and industries at both the national and international levels.

IVHS technologies, such as weigh-in-motion sensors, automated vehicle identification transponders, and automated vehicle classification devices-some already deployed-will reduce the time spent in weigh stations, reduce labor costs to states, and minimize red tape for commercial operators.

Commercial vehicles are leading the way in the applications of IVHS technologies. Already they are using automatic vehicle location, tracking, and two-way communications; routing algorithms for dispatch; and in-vehicle text and map displays. IVHS technologies of use to commercial vehicles include:

- automatic vehicle identification
- weigh-in-motion
- automatic vehicle classification
- electronic placarding/bill of lading
- on-board computer
- two-way real time communication
- automatic clearance sensing.

ADVANCED VEHICLE CONTROL SYSTEMS (AVCS)



AVCS enhance vehicle control by facilitating and augmenting driver performance. Ultimately, they could relieve the driver of most driving tasks in high-demand traffic corridors, or long-distance, high-speed trips. Three levels of enhancement are foreseen.

Early AVCS technologies should include vehicle-based systems that detect the presence of obstacles or other vehicles. Studies have shown that one-half of all rear-end collisions, and up to one-third of intersection accidents could have been prevented if the driver had an additional I/2 second warning. Basic AVCS will use a radar-type technology and other on-board systems to:

- provide additional warning time
- observe presence of vehicles or obstacles in blind spots
- warn drivers of loss of alertness.

Intermediate AVCS technologies will initially implement lateral and longitudinal vehicle control functions in specific applications such as high occupancy vehicle (HOV) lanes. Vehicles would enter the lanes voluntarily under manual control, but once in the lane, would be under full or partial control. Advantages include:

- increased speed
- increased safety and reduced collisions
- platooning (the linking of a cadre of vehicles)
- for private vehicles, vehicle-to-vehicle communication of travel paths.

The most comprehensive AVCS applications will build on early and intermediate technologies to completely automate driving functions for vehicles operating on specially-equipped freeway facilities. These systems will be especially effective in:

- "automatic chauffeuring" of vehicles from on-ramp arrival to off-ramp departure.
- increasing the throughput of traffic in both urban and intercity, high-demand traffic corridors
- realizing a new level of safety and mobility through high-speed operation in Interstate travel.

BENEFITS FROM IMPROVED MOBILITY

The *benefit most often* visualized *of* IVHS is *the role it will play in reducing traffic congestion. The* daily *commuter knows well the routefrom home to work, but may not always know of impending congestion on the route,* accident *locations, road maintenance, or other factors.* IVHS *technologies enable the daily* commuter *to choose routes that minimize congestion. Commercial delivery businesses and travelers can derive even larger benefits from more advice and direction on optimum routes.*

Benefits from IVHS will occur only when the systems are deployed. Present information suggests that the greater the deployment, the greater the benefits. The target is large. ATTI study including 39 major cities estimates that $41 billion per year is lost in the U. S. because of congestion. Losses exceeding $1 billion/per year have been estimated in each of the twelve largest metropolitan areas.

- Advanced Traffic Management Systems have been shown to reduce stop-and-go traffic by up to 30%, and to reduce travel time from 13% to 45%.
- Advanced Driver Information Systems are expected to contribute another 10% to 15% in travel time reduction.
- CVO systems will contribute significantly to the efficient utilization of trucks. Experience in airline, railroad, and trucking industries indicate these systems contribute significantly to fleet efficiency. More efficient truck operations will increase national productivity.
- As a consequence of sensors and controls, AVCS will reduce accidents and increase traffic flow. They are predicted to double traffic flow on current freeways
- Reducing congestion will improve air quality. Experiments completed in 1989 yielded a 15% reduction in carbon monoxide, and an 8% reduction in hydrocarbon emissions.
- Exposure to hours of congestion is known to increase personal stress, and affect health and job performance. Thus, additional benefits can be expected in terms of worker attitude and productivity.
- AVCS-controlled HOV facilities may double or triple through-put in the HOV lane.
- Intercity and vacation routes will benefit from reduced congestion.
- Theintroduction of IVHS can be expected to yield unexpected benefits just as the introduction of the Interstate System made changes in transportation that were not predicted.

BENEFITS FROM IMPROVED SAFETY

Although the IVHS program will explore many aspects of transportation improvement, a primary concern is safety to motorists. The technology developed for safety measures will greatly benefit the highway travelers of tomorrow.

Accidents can be grouped into collision types, each of which poses certain requirements for effective prevention through technology. The following selected accident types are those seen as most amenable to prevention by IVHS technology.

- Off-road accidents: IVHS technology can sense the location of lane boundaries, using an electronic imaging system, and cooperative lane-edge markings.
- Angle Collisions: Technology which automatically senses oncoming vehicles, and otherwise knows the right-of-way status, can directly advise the driver that it is unsafe to proceed.
- Head-on Collisions: A lane-edge detection and path-prediction technology warns the driver when the vehicle crosses the center line.
- Rear-end Collisions: Reduction of rear-end accidents is seen as another prime candidate for relatively early benefits through IVHS technology with the security provided by anti-lock technology. Future radar-controlled braking technology should be even more effective.
- Side-swipeCollisions: The "blind spot" problem is currently the subject of developments using ultrasonics, infrared, and radar-type sensing technologies.
- Aggravating Environments: Major improvements in nighttime acuity have been achieved through infrared enhancement of the forward field of view.

Baseline Estimates of IVHS Safety Benefits

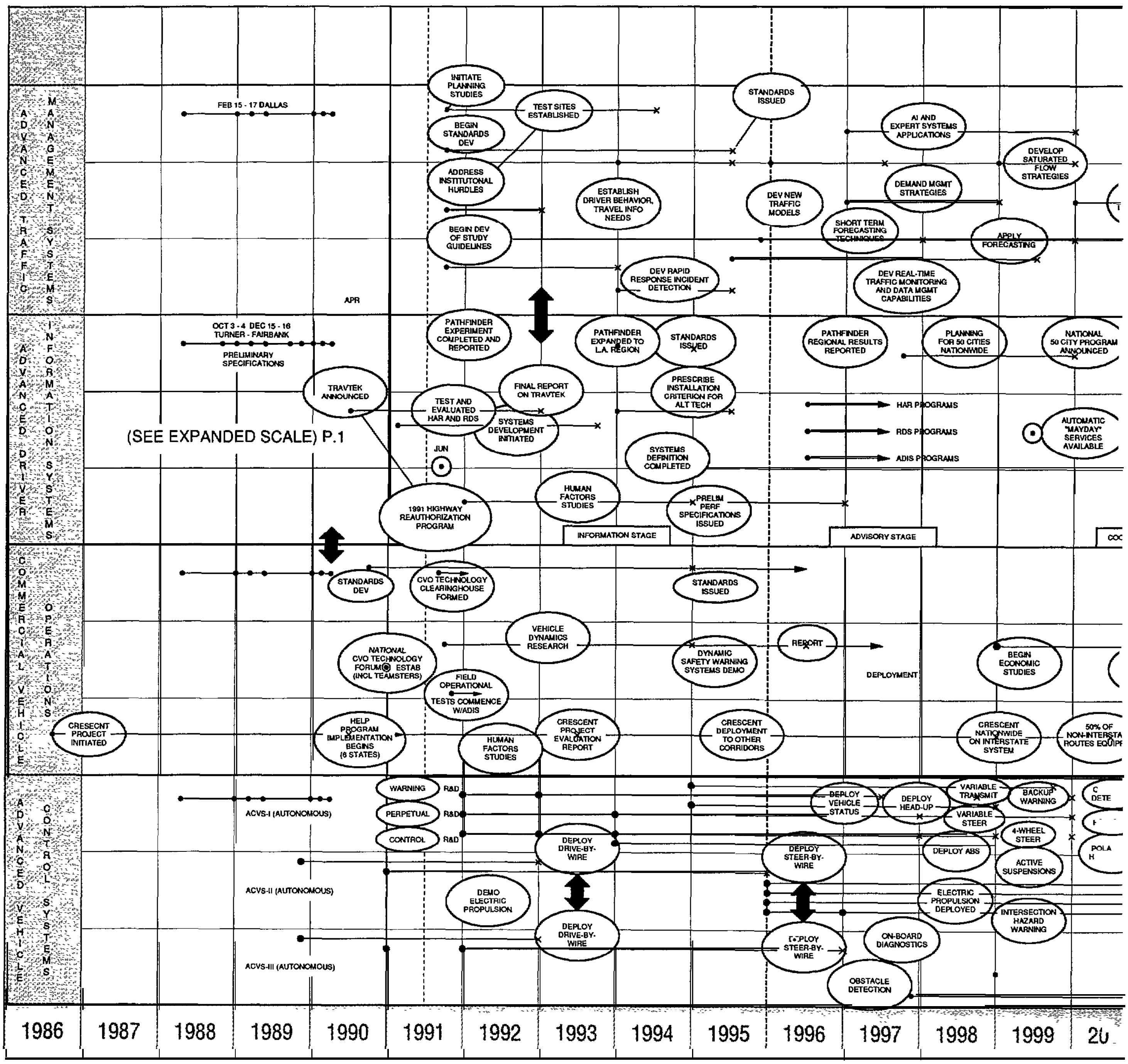
Lives Saved
11,529 by 2010
927 by 2000
88 by 1995

Injuries Saved
442,000 by 2010
~~35,500~~ [redacted]
3,060 by1995

Dollars Saved
22.2B by2010
1.8B by 2000
167M. by 1995

MILESTONES

Program milestones were addressed during the Mobility 2000 National Workshop. The question addressed was straightforward: "Given the present state of development of IVHS in North America, what are the major program milestones that can be identified and promoted?" The Workshop identified policy, legislation, funding, organization, programs, projects, and technologies as major subject areas. The time line on these pages shows development of IVHS technologies over the next 25 years. The milestones below summarize optimal developments for the next ten years,



By1995

ATMS
- major field tests underway
- real-time, adaptive signal control

ADIS
- in-vehicle, real-time traffic information and routing systems tested
- vehicle-highway communication developed
- safety advisory and warning capability developed and being tested

CVO
- demonstration of Crescent technologies (WIM, AVI, etc.) completed
- operational deployment on 2-3 national interstate routes
- major research complete on commercial driver safety advisory and warning systems

AVCS
- many autonomous control assists developed and demonstrated
- research and development for vehicle control complete and testing underway

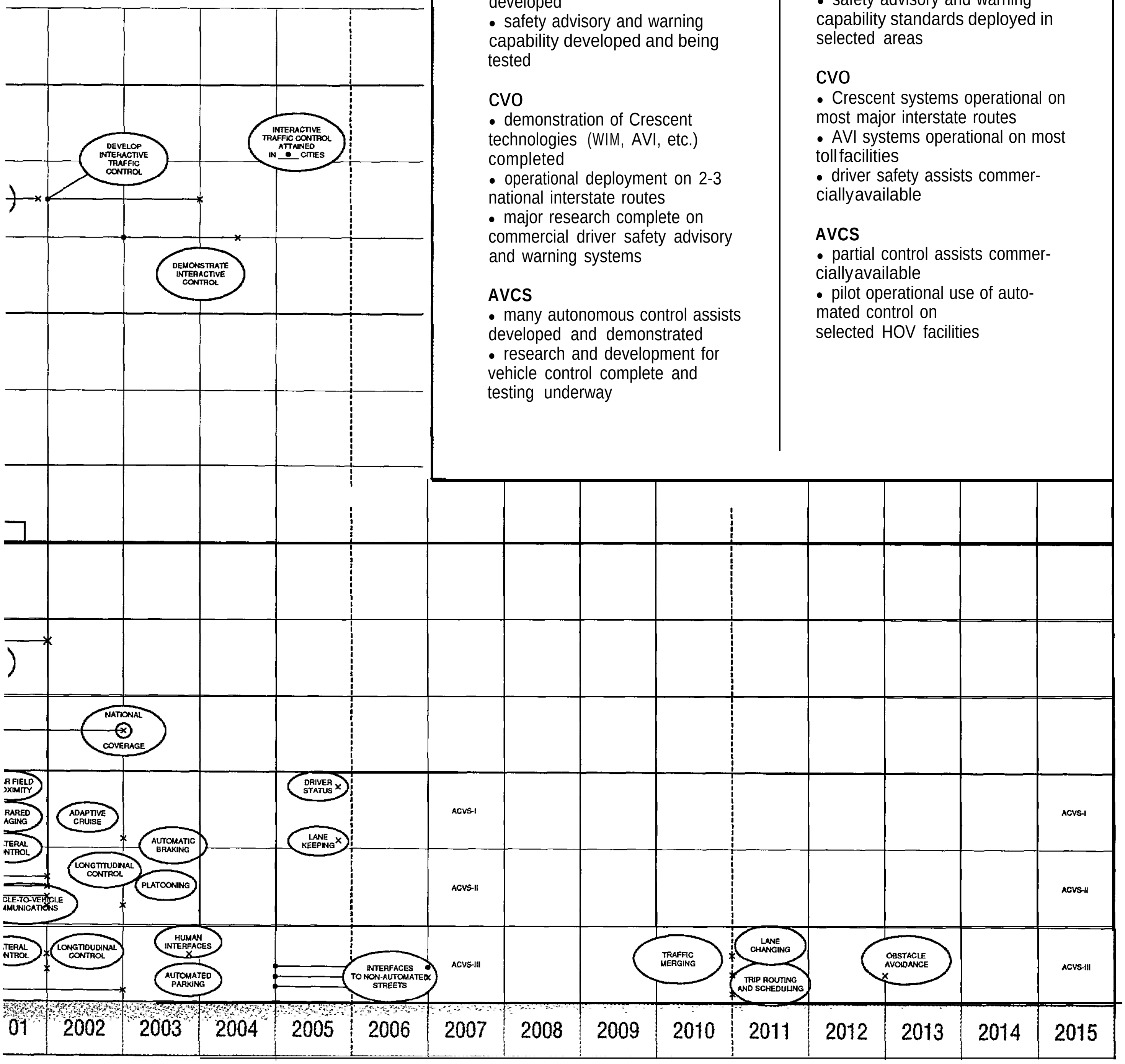
By2000

ATMS
- major urban areas equipped
- several cities communicating real-time traffic information to ADIS-equipped vehicles

ADIS
- operational ADIS systems in use in major congested areas
- safety advisory and warning capability standards deployed in selected areas

CVO
- Crescent systems operational on most major interstate routes
- AVI systems operational on most toll facilities
- driver safety assists commercially available

AVCS
- partial control assists commercially available
- pilot operational use of automated control on selected HOV facilities



RESEARCH AND DEVELOPMENT NEEDS

IVHS represent immediate opportunities for reducing congestion, improving safety, and contributing in other ways to the more effective use of the highway system. While ATMS, ADIS, and CVO systems are now being deployed, each will benefit from additional research. AVCS will require substantial research before it can become operational.

- Research on ATMS will include development of sensors, improved software for management of traffic signals, and development of expert systems to assist in incident management. Further work will advance the development of optimum communication and data processing systems. Much study is necessary to determine the response of drivers to ATMS, and operator effectiveness in managing ATMS. In addition, studies are needed to identify means of assuring systems integration across jurisdictional boundaries.

- Research on ADIS will address improvement of vehicle navigation systems, and the development of communication systems to link vehicle navigation systems with traffic information provided by ATMS. Much needs to be learned about driver response to ADIS from human factors research. In addition, there are many issues of liability and standardization that must be resolved before ADIS can become fully operational.

- Research on CVO will include transponder development to assure vehicle-to-roadside communication of essential information. Research on route guidance and communication technology will lead to improved systems. Human factors research to assure compatibility of the driver within these systems is essential. Research on vehicle dynamics and sensors will improve control and reduce accidents. In addition, many legal and institutional issues must be resolved to assure driver acceptance. CVO may be perceived as intrusive when it manages lane entry, controls driving in platoons, or monitors unsafe driving.

- AVCS cannot be deployed without more research. Much more must be learned about the availability and reliability of devices that detect the spatial relationship of a vehicle to obstacles or other vehicles, and to use this information for automatic control. The automatic control system of the vehicle must change speed at a rate compatible with equipment and human limitations. Extensive full-scale testing facilities will ultimately be required in order to evaluate promising concepts. Introduction of these systems will require special traffic lanes for the AVCS-equipped vehicles. Automatic inspection procedures must be developed to check for functional AVCS before a vehicle enters the lane.

ATMS
monitoring traffic conditions
communications
controlling and managing traffic
program execution issues
system planning
systems analysis
optimal visual and auditory characteristics
sensory channel tradeoffs
expert systems for incident detection and management
use-prediction model
preference and attitude attributes

ADIS
traffic data fusion
link-time database and statistics
origin-destination statistics
congestion leveling strategies
communications
productivity and time savings
transmitting and receiving information
artificial intelligence to prioritize messages
rerouting algorithms
models for coordinated routing and traffic control
multimodal urban systems
communications architecture
vehicle-to-vehicle communication
format and wording of traffic information
format and symbology for navigation
intelligibility-cognitive spatial mapping
cognitive time scaling
driver performance

CVO
human factors
vehicle performance
bridge height sensor
transmitting and receiving information
vehicle identifiers

AVCS
sensors: distance, velocity, acceleration, torque, rotation
computation
image processing and pattern recognition
reliability/safety/fault tolerance
communication
nonlinear and adaptive control
electric propulsion

AGGREGATE FUNDING: RESEARCH AND DEVELOPMENT

(millions)

	1991-95	1996-00	2001-10	TOTAL
Applications	70	60	—	130
Systems	135	20	15	170
Dynamics and Control	300	335	160	795
Human Factors	122	108	70	300
TOTAL	**$627**	**$523**	**$245**	**$1,395**

FIELD OPERATIONAL TESTS

Field tests analyze technology performance and cost-effectiveness. They will also assay market support. Conducting these tests is essential to show the public that the IVHS program works.

Effective tests require a substantial commitment of resources. Because the field tests are so important to market support, test locations should be carefully evaluated. Urban and rural sites hosting tests should either have or be willing to install the necessary infrastructure. They should have demonstrated a willingness to form partnerships. If the tests are successful, host test sites must be prepared to support operations and maintenance of the test infrastructure. They should have in place institutional arrangements needed to operate the system.

An operational field test is conducted in a "real world" environment under "live" traffic conditions (both large and small scale). The field test will not only evaluate the readiness of the technology, but will also try new institutional and financial relationships. Partnerships between federal, state, local, private, and other institutions will be essential to the success of the program.

1990-1995

- Real-time travel information
- Route guidance
- Corridor systems that integrate freeways and arterials
- Automatic vehicle identification and classification, weigh-in-motion, and on-board computers
- Roadway hazard warning

1996-2000

- Real-time two-way communications
- Modeling techniques manage congestion
- Vehicle-to-vehicle hazard warning
- In-car enhanced images of roadway signs and hazards
- Adaptive cruise control, automatic braking, automatic lane keeping
- Platooning
- Roadway powered electric vehicles
- Automated parking facilities

2001-2010

- Network of fully automated freeways, traffic information and management systems, and arterials
- High-speed intercity and rural travel
- Electric vehicles for commercial delivery and public transit fleets

AGGREGATE FUNDING: FIELD OPERATIONAL TESTS
(millions)

	1991-95	1996-00	2001-10	TOTAL
ATMS	158	315	—	483
TRANSIT	15	20	25	60
ADIS	160	237	511	908
CVO	96	48	24	168
AVCS	75	670	765	1,510
TOTAL	$504	**$1,290**	**$1,325**	**$3,119**

DEPLOYMENT

To achieve its potential, the IVHS program must culminate in the extensive deployment of technologies throughout urban and rural America. Implementation is most important, but depends on research, development, and field testing. Portions of the program, such as advanced traffic management, commercial vehicle operations, rural safety elements, and initial driver information systems, are proceeding into deployment. Other segments, such as automated highways, require significant research and development before extensive implementation may begin. Work must begin immediately on these elements if they are to become available within the time frame needed to achieve the greatest benefits of IVHS.

Major deployment issues include:

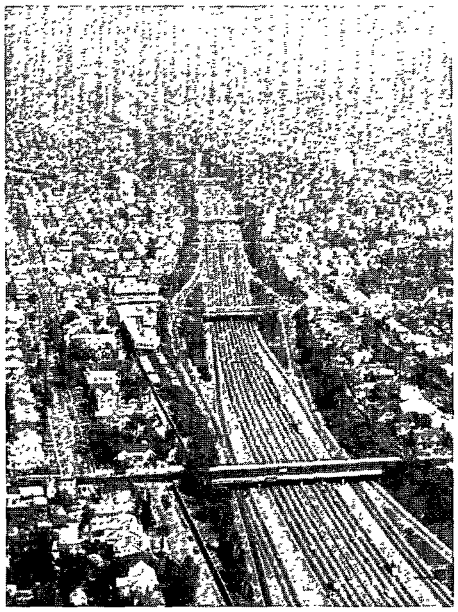
- IVHS embraces many specific systems and technologies which are at different stages of availability. Many of these systems have proven elements which should be aggressively deployed now. Others will require additional research and field tests, which should be pursued simultaneously to have them when we need them.

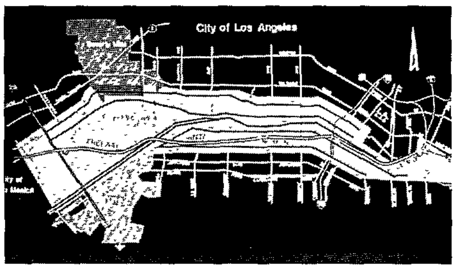
- The various IVHS elements must be integrated into an overall system having a common framework and standardized interfaces. This is essential both for effective performance, and to assure national coverage and uniformity.

- Deployment must also recognize a commitment to the annual operating and maintenance costs necessary to keep these systems functioning effectively.

- IVHS is a partnership between private motorists and public roads. Therefore, successful IVHS deployment will require the close cooperation between private and public sectors.

- Successful deployment and operation may require new innovative contracting, leasing or entrepreneurial approaches for the portion of the systems that have historically been the responsibility of local or state government.





The freeways and arterial *streets shown are managed by several "traffic control centers." The Santa Monica Freeway* "Smart" *Corridorproject will coordinate the* traffic *control centers to give drivers the most efficient route, based on freeway and arterial conditions.*

PROGRAM INVESTMENT REQUIREMENTS

Recommended IVHS Investment Levels
(in millions, using constant 1990 dollars)

Elements	1991-95	1996-2000	2001-10.
R & D	$627	$523	$245
Field Tests	504	1,290	1,325
Deployment	3,105	10,880	15,950

Linking IVHS funding requirements to realistic but visionary milestones, and concomitantly showing sensitivity to the institutional issues that a comprehensive IVHS program must address, is a major challenge. The Mobility 2000 conferees at Dallas/Ft. Worth believe that the recommended investment levels shown in the table above meet that challenge. Note, operation and maintenance costs, which may amount to 15% of capital costs. were not included in the table.

Deployment of ATMS, ADIS, and CVO have already begun. Major commitments have been made in Texas, Florida, California, Oregon, Arizona, Michigan, New York, Washington and several other states.

A $35 billion investment in IVHS R&D, field testing, engineering, and deployment over 20 years will buy the following:

- Instrumentation of 18,000 miles of freeways integrated with approximately 200,000 signalized intersections in 250 of the largest metropolitan areas for greatly improved traffic management.
- Communications systems to interact with ADIS in the 250 largest metropolitan areas, and in rural areas in every state as well as a statewide traffic control center to monitor incidents on the intercity network of roads.
- Instrumentation to interact with the CVO systems on the 42,500 mile Interstate System, and the remainder of the roads in the National Network for Trucks.
- Systems to interact with AVCS in 16 platooning highway systems to achieve headway, speed, and merge control.
- Forty-four electric-propulsion highway systems in 25-mile increments in the most congested metropolitan areas with a population over 1 million.

The investment for ADIS is viewed as a consumer investment in equipped vehicles. Full performance systems will cost $800 to $1200 per vehicle (est.).

Public research and development investment will improve ATMS, assure effective interaction of ATMS and ADIS, and provide the basis for AVCS. Private investment will develop ADIS. Without the research investment, ATMS can proceed with current technology, ADIS will be limited to in-vehicle systems with incomplete capability to interact with ATMS, and AVCS will not be developed.

Field tests will discover system errors, and correct them before full deployment. Field tests help define what research is needed. Finally, they will yield comprehensive data on benefits that will justify the entire program.

ACTION ITEMS

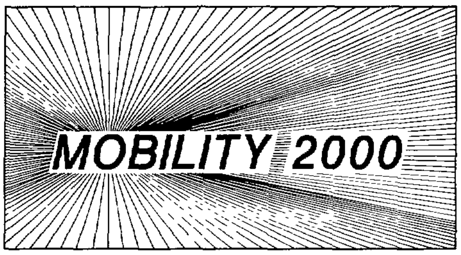
Actions are essential to an IVHS national cooperative effort. Immediate action is needed to consider, revise, and act upon these steps.

The federal government, state and local agencies, universities, and private industry need to organize a cooperative IVHS national effort to accomplish the following:

- Develop and coordinate national goals, and establish a strategic plan to achieve these goals. The plan will need flexibility to accommodate changes in assumptions, predictions, and expectations.
- A national IVHS policy should be formed using input from federal, state, and local levels. From that policy, legislation and funding programs should be developed to guide needed research, conduct operational testing and evaluations and deploy systems on a meaningful scale.
- Operate and maintain systems on a continuous basis as integral part of IVHS programs.
- Identify and propose solutions to public/private institutional issues. These issues include merging public/private research support, finding opportunities and partners for joint ventures, resolving state/local jurisdictional conflicts, protecting personal and organizational privacy, and identifying antitrust, insurance and liability issues.
- Create a national organizational structure to provide the public/private coordination necessary to address the institutional issues of IVHS.
- Determine appropriate IVHS system architectures, and corresponding divisions of responsibility between public and private sectors.
- Provide mechanisms for international cooperation and compatibility.
- Promote technical standards that assure hardware and software compatibility between large computers and small ones.
- Identify current and long-range educational and manpower needs, and take steps to meet those needs.
- Identify and take steps to accommodate special needs segments of society.
- Provide for a continuing exchange of information within the transportation community, and assure reliable flows of information to the public, media, and elected officials.

These actions are essential to a national cooperative IVHS effort. Immediate action is needed to consider, revise, and act upon these steps.

MOBILITY 2000



Work on advanced transportation technology has been underway for several decades. Early work was supported by the Federal Highway Administration. During the middle 1980's, the California Department of Transportation (Caltrans) focused renewed emphasis on advanced technology as a critical part of dealing with growing urban traffic congestion. Other government organizations, universities, and industries have since become active in this field.

Mobility 2000, a self-appointed informal assembly of interested individuals from the public and private sectors, has evolved from a series of meetings and activities resulting from these initiatives. In its meetings, it sought to define a national cooperative program to advance the development of technology that would address highway problems. Mobility 2000 sponsored major meetings in San Antonio in February 1989 and in Dallas in March 1990, which served to focus attention on issues and opportunities for the several elements that constitute Intelligent Vehicle Highway Systems (IVHS).

The work of Mobility 2000 is also stimulated by the awareness that both Europe and Japan have major projects. In Europe, the projects are coordinated throughout the European Community. DRIVE is largely sponsored by the governmental units with the primary objective of defining “road transport informatics” for the communities. A high priority of the European Community is to integrate DRIVE with the industry-sponsored projects of EUREKA, of which PROMETHEUS is the best known in United States. Japan has three major projects designated as AMTICS, RACS, and IVS. AMTICS and RACS combine vehicle navigation with real-time traffic information. Unless the United States establishes an active IVHS program, it will be entirely dependent on foreign developments.

IVHS technologies are applicable to urban mass transit systems as well as private automobiles, They may, in fact, find their earliest application in commercial vehicles. When and where these systems are fully deployed, IVHS are expected to contribute as significantly to U. S. mobility, safety and international competitiveness as did the Interstate Highway program, which is now essentially completed. IVHS are the present and future of transportation.

Robert J. Betsold
Federal Highway Administration

Richard P. Braun
University of Minnesota

G. Sadler Bridges
Texas Transportation Institute

Robert D. (Bob) Ervin
University of Michigan

William J. Harris, Jr.
Texas Transportation Institute

Bob G. Hodge
Texas State Department of Highways and Public Transportation

Dennis C. Judycki
Federal Highway Administration

William A. Leasure, Jr.
National Highway Traffic Safety Administration

Douglas J. McKelvey
Federal Highway Administration

Donald E. Orne
Michigan Department of Transportation

Robert E. Parsons
University of California at Berkeley

James H. Rillings
General Motors Research Laboratories

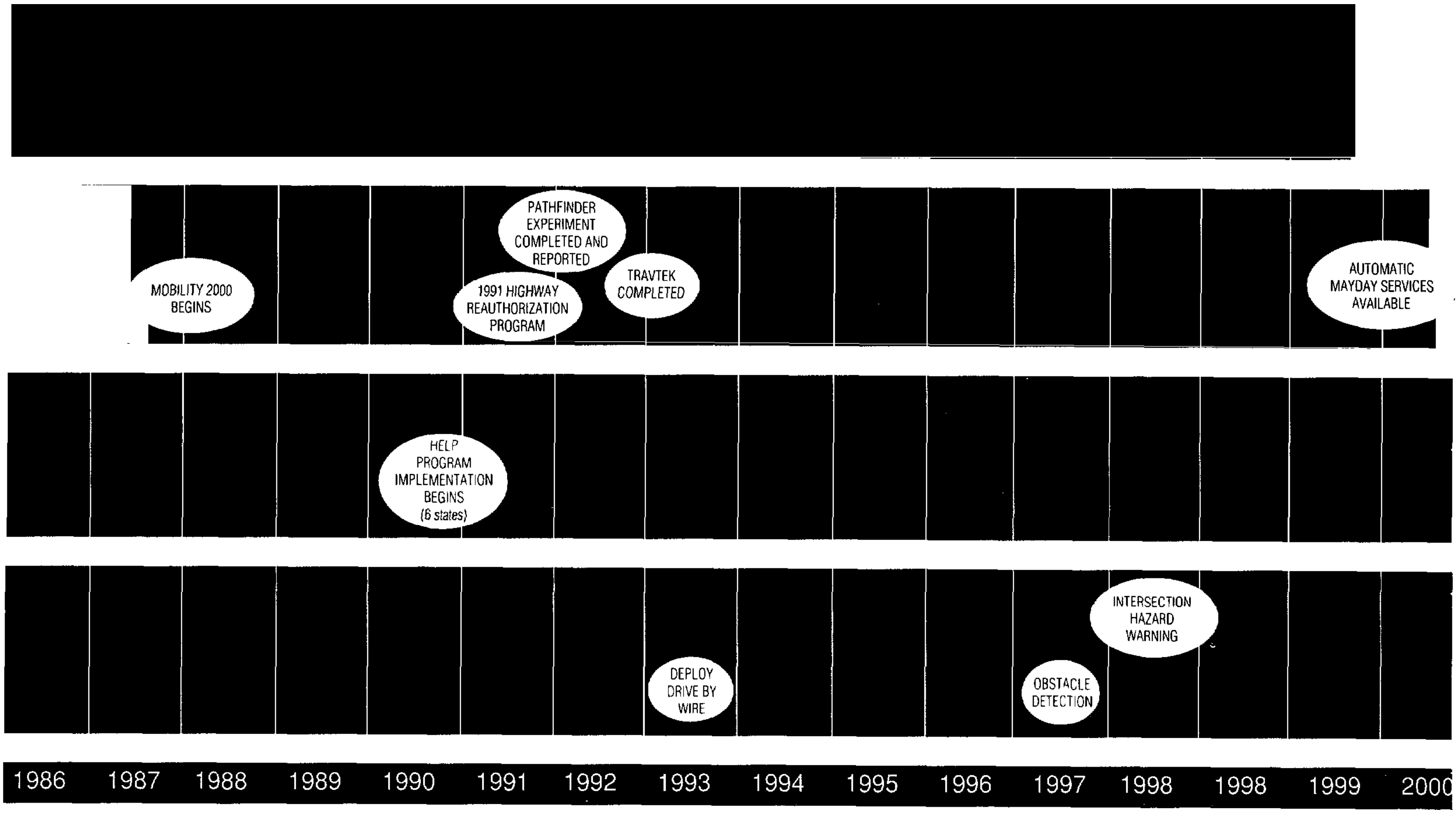
Carlton C. Robinson
Highway Users Federation

Lyle Saxton
Federal Highway Administration

William M. Spreitzer
GM Corporation

Joseph M. Sussman
Massachusetts Institute of Technology

David K. Willis
The ATA Foundation, Inc.



Produced by TTI Communications/July 1990/2000