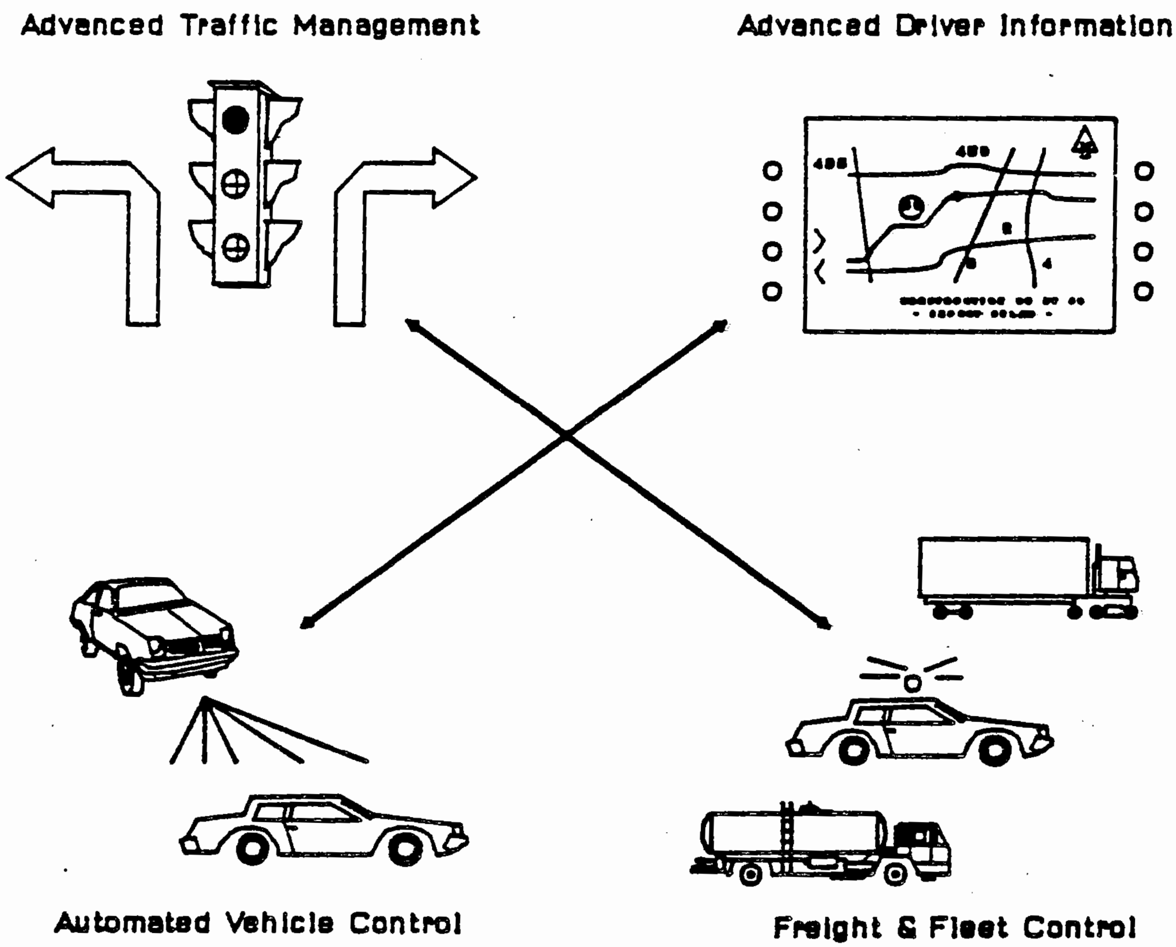
U.S. Department of Transportation
Office of the Secretary of Transportation

Discussion Paper on Intelligent Vehicle-Highway Systems

May 1989



U.S. Department of Transportation
Office of the Secretary of Transportation

400 Seventh St., S.W.
Washington, D.C. 20590

MAY 10 1989

Dear Sir/Madam:

Last year, Congress asked the Department of Transportation to prepare a report on the emerging field of Intelligent Vehicle-Highway Systems (IVHS) technology. I would appreciate your assistance in the development of this report and its recommendations. Specifically, the Conference Report on the FY 1989 Department of Transportation Appropriations Act directs the Secretary of Transportation to report to Congress. The purpose of the report is to: (1) assess ongoing European, Japanese, and U.S. IVHS research initiatives; (2) analyze the potential impacts of foreign IVHS programs on the introduction of advanced technology for the benefit of U.S. highway users and on U.S. vehicle manufacturers and related industries; and (3) make appropriate legislative and/or programmatic recommendations.

Enclosed is a discussion paper we have prepared to solicit views, comments, and recommendations on this subject. Copies of this paper are being sent to a broad range of groups, including state and local governments, universities, other transportation researchers, private sector transportation groups, electronics manufacturers, motor vehicle manufacturers, and the general public.

The material contained in this discussion paper is preliminary. The Department has not taken a position at this time on the merits of a commitment to a coordinated national IVHS research program nor in the approach that should be taken to fund IVHS research. Before making any recommendations on the magnitude, composition, organization and funding on an IVHS research and demonstration program, we want to consider the views of the transportation community and the public at large.

We would appreciate your comments on any aspect of this discussion paper and on the broader issues implied by the Congressional requirements. We have also enumerated some specific questions for comment in the last section of the paper. Four copies of any comments should be sent to:

Intelligent Vehicle-Highway System Discussion Paper
U.S. Department of Transportation
Docket Clerk, Room 4107
Docket No. 46284
Notice No. 89-4
400 Seventh Street, S.W.
Washington, D.C. 20590

Notice of the request for comments is being published in the Federal Register, and comments should be received by June 15, 1989. While the Department will accept comments received after that date, their consideration cannot be assured. All comments received will be included in an open docket and will be available for public inspection and copying.

If you have any further questions, you may contact Mr. Thomas E. Marchessault, Office of Economics, P-37, (202) 366-5412.

Sincerely,

Patrick V. Murphy
Deputy Assistant Secretary for
Policy and International Affairs

Enclosure

DEPARTMENT OF TRANSPORTATION

Office of the Secretary

[Docket No. 46284; Notice No. 89-4]

Intelligent Vehicle-Highway Systems (IVHS) Technology; Availability of Discussion Paper and Request for Comments

AGENCY: Department of Transportation, Office of the Secretary.

ACTION: Request for comments; notice of availability of discussion paper.

SUMMARY: The Conference Report on the FY 1989 Department of Transportation Appropriations Act directs the Secretary of Transportation to report to Congress by July 1, 1989, on Intelligent Vehicle-Highway Systems (IVHS) assessing European, Japanese, and U.S. advanced vehicle-highway technology research and development initiatives. The report will analyze potential impacts of foreign programs on U.S. highway users, vehicle manufacturers, and related industries and make appropriate legislative and/or programmatic recommendations. In conducting this study, the Department is directed to consult with state and local governments, private sector transportation groups, and vehicle and electronics manufacturers. To assist in the preparation of the Report to Congress, the Department has prepared a discussion paper to solicit views and recommendations.

DATE: Comments should be received by June 15, 1989. Late-filed comments will be considered to the extent possible.

ADDRESS: Requests for copies of the discussion paper should be sent to IVHS Discussion Paper, P-30, Office of the Assistant Secretary for Policy and International Affairs, U.S. Department of Transportation, 400 7th Street SW., Washington, DC 20590. Comments should be sent (four copies) to Docket Clerk, room 4107, Docket No. 46284, at the same address.

FOR FURTHER INFORMATION CONTACT: Thomas E. Marchessault, P-30, at the above address; telephone: 202/366-5412.

SUPPLEMENTARY INFORMATION: The Department has prepared a Discussion Paper on Intelligent Vehicle-Highway Systems (IVHS) to solicit views and recommendations.

The Discussion Paper considers the need for a national Intelligent Vehicle-Highway Systems (IVHS) program in view of the fact that serious urban traffic congestion has been creating the need for traffic operations techniques and systems that will substantially increase highway capacity and improve traffic flow efficiently and safely. The Discussion Paper describes types of Intelligent Vehicle-Highway Systems (IVHS) and their benefits; reviews existing European, Japanese and U.S. Programs; weighs possible impacts of foreign IVHS preeminence on U.S. industry and consumers; discusses goals and a possible research agenda for a potential national IVHS program; and suggests alternative organizations to develop and coordinate a national IVHS cooperative program.

Through the use of advanced computers, telecommunications, and control technology, IVHS can improve communication between drivers and traffic control centers, creating an integrated highway transportation system. Ultimately, with the assistance of IVHS, automobile travel has the potential to become safer, more time and space efficient, more energy efficient, and more environmentally benign.

Features of potential IVHS fall into four categories: (1) "Advanced traffic management systems" can be used to influence the pattern of route choice by redistributing traffic between geographic areas or between highway systems to reduce delays and accidents; (2) "Advanced driver information systems" are designed to provide additional information to the driver through navigational information and real-time traffic data allowing the driver to follow optimal routes from origin to destination; (3) "Freight and fleet control operations" would allow a central controller to communicate with its vehicles to issue instructions and keep track of route progress. Moreover, traffic signals could be controlled, giving priority to public transportation and emergency vehicles; (4) "Automated vehicle control systems" are designed to take over many driving functions, allowing more cars to travel on highways, at faster speeds, with less wasted time, and in safer condition. These "automated highways" would operate in heavily traveled intercity highways and in selected urban areas.

Comments are solicited on specific issues related to any aspect of IVHS technology and on the proposition of a national IVHS program.

Issued this 10th day of May, 1989, at Washington, DC.

Patrick V. Murphy, Jr.,

Deputy Assistant Secretary for Policy and International Affairs.

[FR Doc. 89-11624 Filed 5-15-89; 8:45 am]

BILLING CODE 4910-62-M

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FOREWORD

The Conference Report on the FY 1989 Department of Transportation Appropriations Act directs the Secretary of Transportation to report to Congress by July 1, 1989 on Intelligent Vehicle/Highway Systems (IVHS). Appendix A includes the text of this requirement. The purpose of the report will be to:

-- Assess ongoing European, Japanese, and U.S. IVHS research initiatives;

-- Analyze the potential impacts of foreign IVHS programs on the introduction of advanced technology for the benefit of U.S. highway users and on U.S. vehicle manufacturers and related industries;

-- Make appropriate legislative and/or programmatic recommendations.

The purpose of this discussion paper is to solicit comments on the subject of IVHS to be used in the preparation of the report to Congress. The Department is requesting comments on the merits of a commitment to a coordinated national IVHS research deployment program and the approach that should be taken to fund an IVHS program. This paper is intended to prompt comments from the transportation community and the public at large on a number of issues, including composition, magnitude, organization, and funding. After comments are received and evaluated, the Report to Congress will be prepared.

Comments

Comments are being solicited from a number of sources, including state and local governments, universities, transportation researchers, private sector transportation groups, electronics manufacturers, motor vehicle manufacturers, and the general public.

Comments are requested on any aspect of this discussion paper and on the broader issues implied by the Congressional requirements. Included are a series of specific issues related to a national IVHS program.

Four copies of any comments should be sent to:

Intelligent Vehicle/Highway System Discussion Paper
U.S. Department of Transportation
Docket Clerk, Room 4107
Docket No. 46284
Notice No. 89-4
400 Seventh Street, S.W.
Washington, D.C. 20590

Comments should be received by the Department by June 15, 1989. While the Department will accept comments after this date, their consideration cannot be assured. All comments received will be included in an open docket and will be available for public inspection and copying.

For further information, contact:

Thomas E. Marchessault
U.S. Department of Transportation
Office of Economics, P-37
Room 10223
Washington, D.C. 20590
(202) 366-5412

SECTION I

INTRODUCTION

Highway traffic volumes are forecast to double on America's highway network from 1.9 trillion vehicle miles of travel (VMT) in 1988 to 3.8 trillion VMT in 2020. Unless improvements to the system are made, the consequences of this growth in traffic will include:

- greater congestion and reduced urban and rural mobility;
- sharp increases in accidents and a forecast of 80,000 fatalities per year by the year 2000 given today's fatality rate;
- more serious air pollution problems in more American cities;
- greater economic loss due to highway delays and accidents.

It is believed that the use IVHS technology has the potential to help alleviate these problems.

Often referred to as "smart cars" and "smart highways", a program of IVHS technology represents the marriage of the vehicle, the driver, and the highway, similar to that of the airplane, the pilot, and the air traffic control system. IVHS incorporates advanced communications technology, computers, electronics, displays, and traffic control systems and allows two-way communications between those operating the highways and those operating the vehicles so that operational efficiencies can be realized on the highway network. Highway operators will be able to monitor traffic on the network and assign optimum routing schedules and adjust signalization patterns to more effectively use existing highway capacity. Drivers will receive information on recommended routing, events such as weather, accidents, and other incidents that may affect their travel and be provided greater assistance to operate their vehicle more safely.

IVHS represents an evolution of technological improvements in the automobile and the highway:

- Microelectronics are becoming pervasive in motor vehicles. The value of vehicle electronics is expected to increase from approximately six percent today to 20 percent by the year 2000. The computer chips in some modern cars have the same power as IBM's original PC. More and more mechanically based systems are being controlled by reliable electronic systems, including automatic transmissions, power steering, power brakes, anti-lock brakes, fuel injection, and cruise control.

- Similarly, advances in computers, electronics, and telecommunications have led to the evolution of freeway management systems in several metropolitan areas. For example, through electronic detection, closed circuit television, radio, variable message signing, and ramp metering, freeway operations and safety can be significantly improved. Freeway surveillance and control system technology provide the capability, for example, of early detection and removal of incidents which account for over half of vehicle delay in our major metropolitan areas today.

The IVHS technology applications described in Section II will require a more unified development of the vehicle and the road to create a more integrated vehicle/highway transportation system. Technological advances in the private sector will require parallel changes in the public sector, and these changes must be coordinated to allow efficient operation of an integrated system.

The ultimate goal of IVHS is to make automobile traffic safer, more efficient, more energy efficient, and more environmentally benign. Successful development and use of this technology will eliminate some of the more onerous, difficult, and dangerous driving tasks in much the same way that earlier innovations like automatic transmission, cruise control, and freeways have already improved driving.

A major benefit of IVHS will be to help reduce the road congestion already serious in many parts of the country and which is predicted to spread to other areas in the coming years. It is expected that IVHS can increase capacity of the existing road infrastructure without major additional lane mileage.

Another goal of IVHS will be to improve the safety of the highway system and reduce the number of deaths and injuries occurring on the nation's highways. Although most crashes occur in congested areas, most harm occurs in non-congested areas.

Preliminary data indicate that most crashes occur in urban environments (78 percent urban; 22 percent rural) on roads with low speed limits (90 percent of urban and 46 percent of rural crashes occur on roadways with speed limits below 50 mph). Only a small proportion of fatal crashes occur on interstates, freeways, and expressways (12 percent); half of all fatal crashes occur on roadways with a speed limit less than 55 mph, and almost one-third of all fatal crashes occur at intersections and other junctions.

Although the application of high technology to motor vehicles has the potential to improve safety by assisting drivers in avoiding crashes, we need a better understanding of the distributions of crashes, fatalities, and injury levels by location, time of day, etc., in order to maximize potential safety improvements.

While it may be assumed that some reduction of risk of crashes will accompany reduction in congestion, it is also recognized that care must be taken in the implementation of new systems to avoid degradation of safety, particularly through the creation of human factor problems. There is a high potential for degraded driver performance as a result of the proliferation of information channels and displays competing for driver attention.

What is needed, therefore, is the conduct of sufficient research to develop the data and understanding to enhance highway safety through exploitation of advanced technology in the development of vehicle safety countermeasures and to assure no loss of safety as new driver aids, control resources, and/or crash avoidance systems are implemented.

Even in those parts of the country where congestion is not a major problem, the increased speed of automobile travel and increased complexity of the highway system has left many drivers apprehensive. Under today's driving conditions, many drivers do not have sufficiently good reflexes to take appropriate actions in emergency situations in a timely manner. The safety implications of greater assistance to the driver are clearly significant. Even beyond that, however, traffic complexity greatly diminishes the utility and enjoyment of driving. It is believed that IVHS can play a major role in easing the navigational difficulties many drivers experience.

Of particular note is the assistance that IVHS could provide to older drivers. In 1984, approximately 12 percent of the population was 65 or older; by 2020, this group will represent almost 20 percent of the population, or 51.5 million persons. More than 40 percent of these older Americans will be over 75. This cohort of older Americans, unlike previous older cohorts, has become highly dependent on the automobile for mobility. Few have used public transit in the past as their primary mode of transportation. Moreover, most of the older persons live in low density suburbs and rural areas that are difficult to serve with public transportation. It is likely, therefore, that this group will continue to rely on the automobile for mobility, even in their older years. Increased driver automation and improved driver information systems could be particularly important to these drivers. (Human factor concerns are particularly important for this segment of the population.)

In the commercial sector of highway travel, direct operational benefits could come from the use of IVHS technology. The greater need for reliable on-time delivery systems places a higher premium on more efficient operations. Improvements in truck pick-up and delivery schedules and the ability to locate trucks accurately and quickly will pay immediate payoffs in increased profits to trucking companies and the businesses they serve. This could also lead to reductions in the urban congestion exacerbated by the presence of these trucks. In addition, commercial vehicle operations are subject to regulations pertaining to registration, permits, size and weight, operating hours, special taxation, and vehicle safety that require controls, inspections, and monitoring by government officials. While these controls are legitimate and necessary, they impose significant compliance costs on the trucking industry. It is believed that IVHS may provide a means of reducing the cost of compliance with these regulatory requirements.

There is also a need to alleviate truck-related congestion in urban areas. Especially serious are the traffic delays caused by truck accidents. In one city, for example, it is estimated that a major semitractor incident occurs every three days, and two-thirds of them cause a blockage of two or more lanes. This problem has given rise to the discussion of potential regulations on truck usage on urban freeways. Such regulations could have a profound effect on the productivity of trucks. Implementation of appropriate IVHS technology could be a viable alternative to these restraints on truck traffic.

The next section describes the major elements of IVHS technology. Section III is a description of the major European and Japanese IVHS research programs. Section IV outlines the major U.S. research programs in this area. Section V discusses some of the possible impacts of non-U.S. preeminence in IVHS technology. Section VI discusses specific program goals and a preliminary research agenda of a U.S. IVHS program. Section VII discusses several organizational options for consideration on IVHS programs. Section VIII contains questions for which comments are solicited.

SECTION II

TYPES OF INTELLIGENT VEHICLE/HIGHWAY SYSTEMS

Intelligent vehicle/highway systems (IVHS) are evolving from advancements in automotive and highway traffic systems which are, in turn, benefiting from rapid advances in electronics, communications, and information processing technologies. Current technology, which has been under development for some 30 years, is already capable of improving highway system efficiency and safety. Future prospects for more sophisticated technological developments promise even greater benefits.

Elements of potential future IVHS can generally be grouped into four categories:

- o Advanced traffic management systems;
- o Advanced driver information systems;
- o Freight and fleet control operations; and
- o Automated vehicle control systems.

A. <u>Advanced Traffic Management Systems (ATMS)</u>

Traffic management systems help achieve full utilization of highway network capacity and reduce trip times, congestion, and accidents. By reducing congestion and delays, traffic management systems also improve the productivity of commercial fleets, produce energy saving, improve safety, reduce traffic noise, and lessen air pollution. Traffic management systems in metropolitan areas are a baseline requirement for the majority of the advanced technologies discussed herein.

Traffic management systems influence the pattern of route choice by providing early traffic incident detection and management, redistributing traffic between geographic areas or throughout a freeway corridor and highway network, utilizing excess capacity in the remainder of a network to accommodate the traffic diverted because of an incident. Advisories from traffic management centers, via driver information systems, can help prevent secondary accidents and direct vehicles away from congested areas.

Traffic management systems have two separate components, a freeway management component and a traffic signal control component. Freeway management uses sensors and microprocessors to locate disturbances in the freeway traffic flow. These techniques working in concert with other techniques, including ramp metering and lane closures, variable speed controls, express lanes and reversible lanes, are used to control the flow along freeways and corridors. Twenty-nine state-of-the-art systems are under development or operational in the United States.
There are four principal types of traffic signal control:

- o Isolated intersection control;
- o Fixed time, coordinated control;
- o Computerized traffic signal control; and
- o Interactive traffic signal control.

Eighty percent of the existing 204,000 traffic signals at urban intersections are under isolated intersection control or fixed time coordinated control. Only about 20 percent (about 900) of the traffic signals in urban areas are under computerized control. These latter systems allow centralized control and facilitate the adjustment of signal timing when incidents occur on a freeway or on major arterials. These systems include the capability to implement pre-determined traffic signal timing changes in response to actual traffic patterns.

Adaptive traffic signal control is the most recent advancement and is still under development. Under these systems, new timing sequences are deployed as traffic conditions change, providing optimal timing for actual traffic conditions on a minute-by-minute basis.

Interactive traffic signal control, which will be the next generation of traffic signal control, is still in the conceptual stage. These systems will integrate freeway control and traffic signal control into an integrated traffic management system using computer based techniques. Interactive control will link real time traffic monitoring, short-term travel forecasting, and electronic route guidance. Using information on the actual destinations of vehicles, it will simultaneously optimize signal timing and give electronic route guidance within an urban highway network.

B. Advanced Driver Information Systems (ADIS)

Advanced driver information systems will provide drivers with information on congestion, navigation and location, traffic conditions, and alternative routes. The information could include accidents, other traffic incidents, weather conditions and delays, advisory information on alternative routes, recommended speeds, lane restrictions, and trip planning. The use of this information will allow drivers to be more efficient in the use of the highway network through better route choice. These systems could have a substantial safety benefit by providing the driver with relevant safety advisory and warning messages specific to his needs and current driving situation.

There are a number of available techniques for providing drivers with improved information. Some of these are external to the vehicle, although the trend is towards in-vehicle information presentation. These include:

- o Improved maps and signs;
- o Pre-trip electronic route planning;
- o Traffic information broadcasting systems;

- o Safety warning systems;
- o On-board navigation systems;
- o Electronic route guidance systems;
- o Automatic vehicle identification systems; and
- o Automatic vehicle monitoring systems.

The use of improved maps and more accurate and consistent signs can reduce trip distance and times and increase driver confidence in the information being provided. In many countries, including France, Great Britain, Germany, Belgium, Canada, Switzerland, and Australia, pre-trip electronic route planning systems are being developed. These are computer-based systems that determine minimum time, distance, or cost paths for planning trips.

Traffic information broadcasting systems update network traffic conditions, enabling drivers to replan their routes. These systems can warn drivers of recurring congestion problems, short-term holdups caused by a traffic incident, or construction/ maintenance activities. In some systems, transmissions are received through the car radio after the driver is alerted to turn the radio to a specific frequency. In other instances, special receivers must be installed in the car to receive and decode the message. Existing examples of these systems include Highway Advisory Radio in the United States and the ARI (Autofahrer Rundfunk Information) system in Europe.

On-board navigation and location systems are a more advanced means of providing information to drivers. The information is provided on video display terminals in the car or dashboard signals and can be used for route planning and on-route navigation. More sophisticated systems, termed electronic route guidance systems, provide real-time information on traffic and other conditions on the network. These video display terminals can show the highway network and the location of the traffic problems, allowing drivers to change routes and avoid the area with the problem. As these systems evolve, they may assist in decision-making for the driver.

Development is also underway on safety-related information needs which could be provided through an on-board driver information system. These could replicate warning or navigational roadside signs which may be obscured during inclement weather or when the message should be changed such as lower speed limits during ice, rain, or snow conditions.

Adequate driving performance is critically dependent on the availability of a steady flow of information to drivers and their capability for acquiring and responding to this information in an accurate and timely manner. To reduce crash risk, crash avoidance systems which provide early warning of potentially dangerous drivers, vehicles, road or environmental conditions are needed. Examples of such systems include proximity warning (to address sideswipe and backup accidents resulting from blind spot problems); rollover threshold warning (to address the problem of rollover with high center-of-gravity vehicles); driver inattention warning systems (to address "attention" related accidents); collision warning devices (to address rear-end accidents where the trailing driver misjudges the speed of the preceding vehicle); etc.

In addition to driver information systems, there are related technologies for the identification and monitoring of vehicles. These can assist in such tasks as collecting tolls and managing fleets of vehicles.

C. Freight and Fleet Control Operations

These systems are directed at improving the efficiency of operating a particular fleet of vehicles, including freight operations, bus transportation, and taxis. They are also intended to improve the efficiency of compliance with specific regulatory, inspection, and monitoring operations. These systems are actually in early operational use in some instances. Fleet management systems allow a central controller to know the location of all its vehicles and to monitor progress along their assigned routes and communicate with them, as needed.

Two aspects of vehicle fleets need to be recognized. First, these vehicle fleets often have very different physical and operating characteristics than regular passenger cars that must be taken into account when designing and implementing the various IVHS technologies. Second, these fleets are a readily identifiable group of vehicles that can be used to test certain IVHS technologies.

D. Automated Vehicle Control Systems (AVCS)

The AVC systems currently envisioned will help the driver perform certain vehicle control functions and actually perform some of these functions on specific highways. The use of these technologies will likely result in greater safety, more consistent driver behavior, and improve traffic flow, as well as allowing increased operating speeds, and thus reduce trip times.

Vehicle control is complex because of the large number of interactions which exist between the driver and the vehicle. A driver must constantly assess vehicle placement on the road, speed, distance to the vehicles ahead, and judge gaps for merging and passing. Additionally, the driver must anticipate the actions of other road users and make decisions on timing of lane changes, merges, intersection maneuvers, and the like.

At the most basic level, automated vehicle control systems can provide the driver with useful information and warnings based on data collected by on-board sensors. At the next level of sophistication, these techniques can automatically adjust the control system to account for current operating conditions and prevent situations which give rise to a loss of control. Under most circumstances, the driver would not even be aware of the operation of the automated system. More advanced systems would allow the control system to intervene and manage critical situations. At the most advanced level, the system would take over the driving tasks completely on dedicated highway facilities in such locations as high demand urban corridors or intercity routes.

A number of technologies are available or under development in this area. These include:

- o Antilock braking systems;
- o Speed control systems;
- o Variable speed control;
- o Radar braking;
- o Automatic headway control;
- o Automatic speeding control; and
- o Automatic highway system.

Antilock braking and speed control systems currently exist and are available on some American and foreign vehicles. Research and development is occurring on variable speed control, radar braking, automatic headway control, and automatic steering control. In the fully automated highway system, vehicles would be totally automated in most aspects of control using a combination of these technologies. The system has considerable potential for decreasing congestion by increasing throughput and improved trip predictability, as well as providing significant safety, energy, and environmental benefits.

E. Conclusion

There is an enormous range of technology in existence or in various stages of research and development which has the potential of contributing to a future intelligent vehicle/highway system. IVHS is evolving from current traffic management, driver information, fleet management systems, and vehicle control, which either are already in operational use or under development.

It is still uncertain as to which techniques and strategies will prove to be effective for the tasks they are designed to perform. Furthermore, extensive testing and demonstration will be needed to determine which approaches will be the most cost-effective alternatives. There is also the issue of legal liability if these systems do not perform as designed or if there is a component or system failure. However, early improvements in vehicle and highway technology have produced benefits in terms of reduced vehicle delay, increased capacity, and greater safety; more advanced systems offer even greater opportunity for a wide array of benefits.

Although these broad systems are described separately in this paper to facilitate an understanding of their functions and related program activities, they in fact have considerable interdependence. The success of an overall program to develop and deploy IVHS will be dependent on their continued parallel development and integration into a unified network system.

SECTION III

FOREIGN PROGRAMS

Congress requested this study largely as a result of concern that foreign countries have been making greater efforts in research, development, and demonstration in support of IVHS technology than has the United States. These non-U.S. research programs appear to be well funded and have strong central organization and guidance. In this section, we shall summarize the information we have on these foreign programs.

A. Europe

Most of the European IVHS programs are included in the broader EUREKA program. EUREKA is a $5 billion, 19 country program to stimulate cooperative research and development between industries and governments in Europe with the goal of improving European industrial competitiveness. PROMETHEUS is the major IVHS program under EUREKA, but there are also the following European research programs:

EUROPOLIS - a $150 million, seven year research project to design automated road systems for the next century and develop technologies to automate the driver functions;

CARMINAT - a four year research project to develop in-vehicle electronic navigation and communications systems;

ATIS - a $8.5 million, five year project with the objective of providing pre-trip information on road traffic conditions to tourists; and

ERTIS - a $2.7 million, three year project to develop a common road information and communications system for motor carriers across Europe.

Two IVHS programs not associated with EUREKA are ALI-SCOUT and AUTOGUIDE. ALI-SCOUT is a route guidance system developed in Germany by Bosch/Blaupunkt and Siemens. This system uses infra-red transmitters and receivers to transfer navigation information between roadside beacons and on-board displays in appropriately equipped vehicles. Earlier versions of the ALI system were tested along a 60-mile stretch of the German autobahn in the North Rhine-Westphalia region. The more advanced ALI-SCOUT system was tested in Munich, and, most recently, in Berlin. AUTOGUIDE is another route guidance system developed in England also using infra-red transmitters and receivers. Currently, a pilot test is under way in the Westminster section of London and in a corridor between London and Heathrow Airport; it is anticipated that roadside beacons will cover the entire London area and then the entire country by the early 1990s.

PROMETHEUS

The most important European IVHS program is PROMETHEUS, which stands for PROgraMme for European Traffic with Highest Efficiency and Unprecedented Safety. It is a large scale research project within the larger Eureka program. PROMETHEUS is principally a private sector initiative aimed at developing a uniform European traffic system incorporating IVHS technology. A consortium of European automobile companies, suppliers, electronic firms, and university research institutes has been formed to carry out the objectives of this program.

The goal of the PROMETHEUS research effort is to design "intelligent vehicles" and electronic traffic flow detectors that improve communications between drivers and provide automatic crash avoidance. The general objectives of the PROMETHEUS programs are to improve traffic safety, efficiency, and convenience, and to reduce environmental effects of automobile travel, such as air pollution. Safety is a key element of this project, and a specific goal has been targeted of reducing European traffic causalities by 50 percent by the year 2000.

A major economic objective of PROMETHEUS is to improve European competitiveness in the world automotive electronics industry. The goal has been established of achieving dominance in this industry by European firms within the next decade. For these competitive reasons, non-European firms have been strictly prohibited from participating in this program. (We understand that Opel, a European affiliate of GM, has sought to participate in PROMETHEUS. Even if their request is granted, it is not clear whether special restrictions will be imposed on their participation.)

PROMETHEUS began in 1986 and is a seven-year, $800 million program. Program objectives are formulated by an 11-member steering committee consisting, exclusively, of vehicle company representatives. The various European governments relate to the PROMETHEUS steering committee through the PROMETHEUS Council, consisting of government representatives. The steering committee defines a program of basic research and a program of industrial research. The various governments help coordinate the basic research activities along with the research community. PROMETHEUS will support the development work up to the point where the companies involved decide upon the appropriate technology. The various private companies are thus free to launch new products on the market in competition with each other.

PROMETHEUS is conceived as a European-wide traffic management and control system using three major levels of information transfer or communication.

1. Intelligent driver aids on board the vehicle, assisting the driver or providing backup control;

2. Communication networks between vehicles; and

3. Communication and information systems interlinking vehicles and roadside facilities.

The overall research project has been broken down into three areas of industrial research and four areas of basic research. The three industrial research categories are the following:

-- PRO-CAR: use of on-board, self contained technologies to monitor vehicle performance and provide the driver with information and assistance;

-- PRO-NET: communication between vehicles; and

-- PRO-ROAD: communication between the vehicles' on-board computer and the road.

The four basic research areas are:

-- PRO-ART: use of artificial intelligence in the vehicular system;

-- PRO-CHIP: use of microelectronic components for the various subsystems;

-- PRO-COM: communication between the vehicle and the driver, another vehicle, and the road; and

-- PRO-GEN: evaluation of the impact that changes in motor vehicles are expected to have on the general traffic environment.

The PROMETHEUS project is now at a critical stage. The "Definition Phase" has been completed, and a report, Topics of Research, defining hundreds of functions to be developed, has been published. The "Launch Phase" is now ending; it produced coordinated research plans for the automobile industry, suppliers, and the electronics industry. The final "Research Phase" is about to begin and is scheduled to continue until 1994. (Our understanding is that, at the present time, not all elements of the PROMETHEUS program have had equal success. Moreover, there has been active participation by only certain members of the industry.)

DRIVE

The DRIVE (Dedicated Road Infrastructure for Vehicle Safety in Europe) program is a European Community (EC) three-year program of collaborative research and development to alleviate some of the present problems in road transportation through the application of advanced technology for information and telecommunications. DRIVE's goal is to improve road safety, reduce poor transport efficiency, and reduce environmental pollution. In 1985, studies were conducted for the EC on road transport informatics. The results of these studies confirmed the EC's view on the priority need for a strategic program in this area, and DRIVE was formally adopted as an EC program in June 1988.

The DRIVE program is concerned with the transmission of information between vehicles and infrastructure-side control, or assistance centers. It encompasses collision avoidance systems and other safety systems that will prevent or reduce the severity of accidents. The program is also examining implementation issues, e.g., national policies on traffic signalling or the funding process may be different from country to country, yet a standardization must be met that may be used regardless of the country.

The DRIVE program structure includes a management team that acts as general manager and reviews the DRIVE program four to six times a year. Participants in the DRIVE program include members from the public sector, industry, and users.

DRIVE will support "pre-competitive" research and development and will determine how best to exploit the new information technologies within the context of road transport. DRIVE will bring industry and research institutes together to pursue new developments in road transport and create the framework needed to foster the use of new technologies. The program includes: research, development and assessment of a range of road transport informatics technologies; the evaluation of strategic choices of candidate systems; and standardization and common functional specifications relating to the development of advanced transport infrastructure and traffic management systems for a wide variety of European IVHS programs such as PROMETHEUS, EUROPOLIS, and CARMINAT.

The DRIVE workplan was drawn up by the EC in consultation with the member states, industry representatives, and representatives of road-user organizations with a funding level of about $132 million, half government and half industry. The workplan forms the basis for proposals for projects to be carried out under rules established by the EC's R&D Framework program. A call for proposals was issued last year, and DRIVE began awarding contracts for 60 projects in January 1989. There are four principle rules for proposals:

1. Proposals will normally be submitted in reply to an open solicitation ("tender") and involve the participation of at least two independent partners not all from the same country, and at least one of the partners will be an industrial concern.

2. Projects are to be carried out by means of shared-cost contracts, under which the group awarded the contract is expected to bear a substantial proportion of the costs. In the case of universities and research institutes, the EC may contribute up to 100 percent of the expenditure involved.

3. Organizations from European countries not members of the EC may participate in the program where agreements allow and

where there would be mutual advantage; in such cases the EC will expect the organizations concerned to make a full financial contribution.

4. Only in cases of projects indispensable for key requirements of the workplan will the Management Committee waive certain elements of these rules.

B. Japan

Japan has two major IVHS research programs: Advanced Mobile Traffic Information and Communication System (AMTICS) and Road-Automotive Communication System (RACS). Both of these programs emphasize communications and traffic control and are intended to contribute to improvements in Japanese traffic congestion. Traffic congestion in Japan is considerably more severe than in the United States, increasing the priority to the development of technologies that would lead to some alleviation of this problem. Also, Japan has given technological innovation in the automotive industry a high priority in order to maintain their major role in the world automobile industry. Unlike the European PROMETHEUS project, the Japanese have expressed interest in sharing information and having cooperative research. The United States has a specific technology exchange agreement with Japan, and it appears this area of technology will be included.

AMTICS

AMTICS is a relatively sophisticated traffic control system sponsored by the National Policy Agency, the Ministry of Posts and Telecommunications, the Japan Traffic Management and Technology Association, and 59 private companies. We do not currently have definitive information on either the budget or the time frame of this program.

AMTICS transmits traffic congestion information from a traffic control center to an in-vehicle navigation system. The information shown on a display within the vehicle uses the telecommunication terminal system planned by the Ministry of Posts and Telecommunication Services. The AMTICS system has static information and dynamic information. The static information component uses in-vehicle compact disc systems (CD-ROM) and in-vehicle video display terminals to display road maps, local traffic regulations, the location of parking lots, hospitals, gas stations, tourist information, etc. The dynamic component will use roadside beacons to provide real-time information on traffic conditions, temporary events that might affect traffic conditions, weather and accident warnings, parking space availability, and the like.

The basic design of this system was completed, and production of the pilot units began in October 1987. Pilot experiments were started in April 1988 in central Tokyo. Twelve companies developed pilot systems engineered to basic functional specifications. Each of these companies are carrying out production activities. The pilot experiments, which used 11 passenger cars and a bus, were completed in June 1988. During the experiment, various types of basic data were collected to develop design specifications for subsequent implementation. The conclusion reached was that the program should proceed toward a preliminary implementation phase.

At this time, the network for traffic data acquisition has been completed on a large scale. It is also possible to develop a system with expanded use, e.g., to include various business systems and communication between vehicles, thereby making full use of the teleterminal communication system. In addition, the CD-ROM used in the system has sufficient memory capacity to provide a variety of static information potentially useful to drivers, e.g., information on gas, food, lodging, parking, tourism, etc. Construction of the teleterminal system is making steady progress and began providing service for 23 wards of Tokyo. The construction of the next teleterminal system is under consideration for Osaka. A wider scale implementation of the AMTICS system is planned for 1990.

RACS

Another effort is the Road-Automotive Communication System (RACS). RACS is a parallel research underway using a different communication technology. This program is sponsored by the Public Works Institute of the Ministry of Construction, the Highway Industry Development Organization, and 25 private companies.

RACS is composed of roadside communication units (beacons), car units, and a system center. The system is designed for collection and provision of information through communication between the beacon and the car unit and is thus recognized as "mobile communication." The system functions (or services to be offered) are classified largely into the following three groups: navigation, roadside information, and message systems.

The navigation methodology uses autonomous dead reckoning by means of the car unit only. However, the dead reckoning navigation accumulates positional error. In this system, this positional error will be corrected with the positional data received from the roadside beacons.

The roadside information beacons are connected to an information center to update dynamic information such as correct road traffic information and current parking space information. The car unit receives this data and provides appropriate information to drivers. Further, in combination with the on-board navigation system, the receipt of this real-time traffic information makes dynamic navigation possible.

The roadside communication beacons allow the exchange of information between the systems center and the individual automobiles, making possible the monitoring of the location of particular cars, the collection of detailed road traffic data, and the distribution of messages, facsimile, and other types of radio communication services. Beacons form "spot radio zones" to allow high speed data communication between a car and a beacon during a very short period in which the car runs through each radio zone.

The first road test of this system was started in March 1987. The road test was carried out in an area of about 350 square kilometers extending over the southwestern part of Tokyo and the northern part of Yokohama City with 74 location beacons installed, each using a digital road map and eight cars having car navigation units (receiver, microcomputer, CRT, etc.). The effectiveness of the location beacons was confirmed by this test.

The second road test was started in March 1988, with the number of beacons increased to 91 and the use of improved digital road map and car units. Further, two information beacons were installed to provide real time data and road traffic information. In this phase of testing, inductive radio type location system beacons with a transmission speed of 9600 bps were used. The radio zone of communication of the inductive radio system is about five meters in length.

A digital road map shows the current location, various routes, and road traffic information. For the demonstration, the PWRI prepared a database of digital road maps of the road test area. The structure and contents of this data base were improved using the results of the 1988 road tests.

The 1987 and 1988 road tests led to the following observations regarding the digital road map data base for navigation:

-- The road system should be expressed as an aggregate of nodes and links to permit use for map matching.

-- The map has various modes of application such as displaying, route search, and map matching. Thus, for the road data, stratification in three layers of principal road, basic road (roads of two lanes or more), and whole road is desirable.

Road traffic information is compiled in digital format at the Tokyo Expressway Control Center and sent through the information beacons to equipped vehicles. Data furnished include information on congestion, construction work, accidents, traffic control, and travel time.

In the 1988 road test, the information beacons were installed at toll gates where the cars stop for a moment in order to avoid the difficulty of using induction radio beacons to provide a mass of information to a moving vehicle. Eventually, microwave technology will be used to transfer large amounts of data to moving vehicles. The third field test is scheduled for July 1989. The total concept of RACS will be tested, i.e., navigation, information, and individual communication. Eight microwave beacons for individual communication are planned to be installed along a 40 kilometer expressway section. The communication between each vehicle and the communication center will enable automatic vehicle identification, automatic vehicle monitoring, and message correspondence. The high transmission speed of 512 kilobits per second (Kbps) will also enable the transmission of FAX messages. This field test is the last test activity before moving to a practical stage. Installation of the microwave beacons is expected to begin in 1990 upon receipt of a license.

SECTION IV

EXAMPLES OF EXISTING U.S. PROGRAMS

This section provides a brief summary of some of the major IVHS research underway in the United States. One objective of this discussion paper is to solicit additional information on ongoing U.S. IVHS research for inclusion in our report. We have organized the discussion according to the four types of organizations conducting IVHS research: the federal government, state and local governments, colleges and universities, and the private sector.

A. Federal Government

At this time, two operating administrations of the Department of Transportation (DOT), the Federal Highway Administration (FHWA), and the National Highway Traffic Safety Administration (NHTSA) have research and development (R&D) responsibilities germane to IVHS. Each administration conducts IVHS research projects in selected areas, but neither has a formal overall IVHS R&D program. A third operating administration, Urban Mass Transit Administration (UMTA), has supported IVHS-type R&D in the past but is not conducting any at the present time.

The FHWA research program includes some activities involving advanced driver information systems. This research is investigating selected issues related to the possible deployment and operation of in-vehicle motorist information and navigation systems. As part of this research, FHWA is co-sponsoring, along with the California Department of Transportation (CALTRANS), and General Motors (GM) a field evaluation of an in-vehicle urban freeway navigation and information system. This field experiment, which is called PATHFINDER, will provide an initial United States assessment of this technology. The experiment will be performed in the Los Angeles, California area and will use 25 vehicles equipped with electronic navigation systems. The project began last September, and the one-year field test will begin in March of 1990. The NHTSA research program includes work involving the use of advanced technology to improve highway safety.

While not directly an IVHS program, there are other federal programs that are relevant to IVHS technology. For example, the U.S. Bureau of the Census has developed the TIGER (Topologically Integrated Geographic Encoding and Referencing) system as a digital map base that automates the mapping and related geographic activities required to support the census and their survey programs. TIGER provides coordinate-based digital catographic information for the entire United States. It includes roads, railroads, rivers, and other geographic features; addresses ranges within metropolitan areas; political boundaries; as well as latitude and longitude coordinates. TIGER files are now available for all counties and statistical areas.

B. State & Local Governments

Several state governments have become quite active in IVHS research, development, and demonstration. For example, the California Department of Transportation (CALTRANS) has a substantial program to determine whether advanced technology can be used to increase the capacity of the existing highway system. Most of California's efforts are being undertaken through the University of California, Berkeley (described below). CALTRANS has already committed $1.5 million to the university's programs and has budgeted another $3.0 million.

As another example, there is a multi-state consortium supporting the Heavy Vehicle License Plate (HELP) program.[1] These tests are to determine whether heavy trucks operating along a major truck corridor are able to use transponders to communicate "on the fly" with state regulatory and law enforcement officials and eliminate the delay caused by manual verification of regulatory compliance. The information transmitted replaces the manual verification of certain mandatory truck documents and weighs the truck as it crosses state borders. The project location is along I-10 from the New Mexico/Texas state lines, west through New Mexico, Arizona, and California to the Los Angeles area, then north from Los Angeles along I-5 through California, Oregon, and Washington, to the international border with Canada. Tolls will be collected at 28 locations.

Several large urban areas have also begun to explore the testing and implementation of various types of IVHS technologies. In the Los Angeles area, the Santa Monica Freeway Corridor has been designated as the Smart Corridor. Sensors on the freeways and arterial streets in this corridor will provide information on current traffic conditions that will be used to make control decisions and to provide up-to-date information to motorists through many different media. This is also the location of the cooperative PATHFINDER project discussed above under the FHWA research program.

In the New York City metropolitan area, an inter-governmental agency, TRANSCOM, is considering various means of providing real-time traffic conditions to motorists. Currently, they are testing a traffic alerting system with several regional trucking firms on

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[1] The 15 agencies supporting the HELP program are Alaska Department of Transportation (DOT), Arizona DOT, California DOT, Colorado DOT, Idaho DOT, Iowa DOT, Minnesota DOT, Nevada DOT, New Mexico DOT, Oregon DOT, Pennsylvania DOT, Texas Department of Highway and Public Transportation, Virginia DOT, Washington DOT, and the Port Authority of New York and New Jersey.

both scheduled (e.g., road work) and unscheduled (e.g., accidents and weather) highway incidents. In the discussion stage is a project to use transponders similar to those currently being used in the HELP project to measure delays at the numerous toll bridges and tunnels in the New York City area.

Also, GISs (Geographic Information Systems) for transportation purposes are under development in a number of areas. A GIS is a computerized data management system that is designed to capture, store, retrieve, analyze, and display spatially referenced data. They will allow the assimilation, integration, and presentation of data collected by different divisions within a particular agency, as well as other agencies. The American Association of State Highway and Transportation Officials (AASHTO) has created a working group to develop a charter for a permanent task force on GIS. The task force would promote the use of GIS through education, mapping standards, information exchange, and vendor requirements for the development of transportation applications. In addition, state highway departments through the National Cooperative Highway Research Program are sponsoring a $220,000 research project to design a framework for transportation GIS and implementation guide.

C. Universities

Several universities have supported either individual IVHS-related projects or IVHS-related programs. In some cases, these programs are in cooperation with state or local Departments of Transportation; in others, they are financed by other institutions.

California: The Institute of Transportation Studies (ITS) at the University of California, Berkeley has the most ambitious academic program in IVHS technology. This effort, Program on Advanced Technology for the Highway (PATH), was established in 1986 by ITS and the California Department of Transportation (CALTRANS). PATH is currently a six-year, $56 million program for the development of automation, electrification, and navigation technologies. The specific objectives of this program are to develop these technologies to progressively higher levels of capability (e.g., speed, functions performed, etc.) on University test facilities first, then in field demonstrations in a low-speed semi-automated application, and then in a controlled highway facility. Current funding sources for this program, which is approximately 18 percent funded, include FHWA, UMTA, and CALTRANS. Additional funding is being sought from the California utility industry, the automotive industry, the U.S. Department of Energy, and other private sector groups. ITS is the principal agency for CALTRAN's IVHS program.

Michigan: The University of Michigan Transportation Research Institute (UMTRI) and the College of Engineering are completing a one-year planning effort to develop an agenda for a Michigan-based

IVHS Research & Development program. As part of this planning study, they have conducted a formal Delphi study of the most feasible development and implementation schedules for IVHS technologies; have sponsored a display of relevant U.S. technologies; and have supported feasibility work on "smart chip" technology for roadway information. The University has drafted a formal IVHS program which would conduct research, train students and professionals, and provide coordination services to enable the delivery of intelligent systems technology for improving highway travel in North America.

Texas: The Texas Transportation Institute (TTI) at Texas A&M has initiated a program in advanced highway transportation technology in order to stay abreast of the best methodologies for the application of these new technologies to highway transportation. The first task it is undertaking is a review of the literature to determine those areas which hold the most promise for beneficial application to Texas. The second task will be to assess those aspects of urban congestion most amenable to mitigation; this analysis will be stratified by different types of urban areas and highway systems. The third task will be to determine how some separate vehicle and highway near-term technologies can have some impact on urban congestion and provide even greater impacts when the two types are integrated. Finally, they will determine how Texas should be involved in IVHS research in the future.

Massachusetts: The Massachusetts Institute of Technology has received modest support from the State of Massachusetts and the U.S. DOT to conduct a reconnaissance study to determine Massachusetts' role in a national program of cooperative research to develop and apply advanced technology consisting of communications, computers, and control to the vehicle/highway system to achieve significant improvements in urban traffic flow.

Other: Other universities have been exploring this area to determine whether they should establish formal IVHS programs at their universities, but no formal programs or program proposals have been put forward for consideration. Finally, the Transportation Research Board (TRB) plans to perform a policy study of IVHS.

D. Private Sector

Through the efforts of the Highway Users Federation (HUF) and the University of Michigan Transportation Research Institute (UMTRI), we have conducted a preliminary survey of the research and development being undertaken by the private sector. The results of this survey are summarized in Appendix B. In our report, we would like to include a more complete summary inventory of the research underway and the products being developed by the private sector. We would encourage other private-sector companies engaged in this type of research to submit information to us on the work they are conducting. Appendix C is a sample format for submitting information for this survey.

<u>Motor Vehicle Manufacturers</u>: Due to proprietary concerns, we have only limited information on the research & development being conducted by the major U.S. motor vehicle manufacturers. We understand that, with a few exceptions, these manufacturers' emphasis is more on near-term product development and less on research for long-term innovations.

A substantial amount of activity appears to be underway in the development of driver information systems. Research (and even some testing) is underway in evaluating various approaches to on-board navigation and location systems. Also testing and evaluation of various means of presenting that information to the driver is being conducted. At this time, we do not know the extent of existing research directed towards the longer term IVHS technologies. The study team would welcome information from the motor vehicle manufacturers in these longer-term research possibilities.

General Motors, as a leading U.S. vehicle manufacturer, has had long-standing programs for improved transportation system which go beyond vehicles themselves. Current work within General Motors includes efforts in automatic vehicle location and identification, navigational aids, motorist information and communication systems, trip planning and route guidance, advisory traffic messages, dashboard displays as driver aids, head-up displays, advanced vehicle control ("steer-by-wire," "brake-by-wire," "drive-by-wire"), adaptive cruise control, near obstacle detection systems, collision warning, collision avoidance, fleet management, vehicle communications, and a variety of efforts in supporting technology such as sensors and actuators.

Other areas of motor vehicle manufacturer research & development are related to IVHS technology. The introduction of computers into automobiles and trucks could prove useful to a wide variety of potential IVHS technologies. For example, computer systems used to monitor engine performance may be used to monitor and process navigation information. In addition, research underway in the safety area could use IVHS technologies or provide ancillary IVHS uses. For example, companies are conducting research into various types of collision detection, collision warning, and collision avoidance systems. This research may well make use of advanced automation technologies that could be useful for functions beyond those immediately being considered.

<u>Electronics Companies</u>: In many instances, automotive technologies are developed outside of motor vehicle manufacturing companies and subsequently adopted or adapted by them. It is not surprising, then, that a considerable amount of research and interest seems to be centered among electronics companies. Numerous companies are already offering vehicle location products, and development is underway to improve these systems and to develop vehicle navigation systems. Motorola, for example, has been working on a number of IVHS electronic-based products for the collection and

processing of data into meaningful data for highway officials and drivers. Included in the types of products in this area are design, installation and maintenance of advanced Radio Frequency (RF) communication networks, advanced Digital Signal Processing semiconductors, Global Positioning System (GPS) satellite receivers, microwave devices and automotive electronics design and packaging approaches.

E. National Coordination

At the present time, there is no formal national organization for coordinating or directing activities related to IVHS. Several groups have begun to discuss the need and desirability for the development and implementation of IVHS. These include Mobility 2000 and the Highway/Vehicle Technology Committee of the Highway Users Federation (HUF).

Mobility 2000 is an informal coalition of industry, university, and federal, state, and local government participants who are convinced that IVHS technology will make highways more productive and vehicles more efficient and safer. This organization has become very active in bringing attention to IVHS goals and developing an appropriate research, demonstration, and deployment agenda.

The Highway/Vehicle Technology Committee of the Highway Users Federation is composed of representatives from major U.S. companies involved in transportation. This Committee is identifying the value of IVHS and how the U.S. can move toward greater availability and use of such systems.

F. Conclusion

Many separate programs dealing with IVHS technology currently exist. However, no central, permanent organization is either coordinating the separate elements or is ensuring that research is conducted in the wide variety of disciplines needed before products can finally be developed by private sector companies for operational use in actual conditions. This is in sharp contrast to the programs in Europe and Japan which appear to have a unified, clear set of goals and objectives and carefully defined responsibilities.

SECTION V

IMPACT OF IVHS TECHNOLOGY ON THE UNITED STATES ECONOMY

One of the requirements of this study is to determine "....the potential impacts of foreign programs on the introduction of advanced technologies for the benefit of U.S. highway users and U.S. vehicle manufacturers and related industries...". There are at least two reasons for concern that the United States may lose the lead in IVHS technology to another country. The first reason is that by falling behind in the development of this technology, U.S. highway users will realize its benefits later than is desirable. The second concern is that if U.S. companies do not develop and produce the equipment using this technology, much of the manufacture of the products will go to companies in foreign countries, further exacerbating the nation's serious trade deficit.

A. Use of IVHS Technology

Absence of major United States involvement in IVHS development would not necessarily constrain the implementation and use of this technology in the United States. The United States is currently, and likely to remain for the foreseeable future, one of the larger consumer markets for motor vehicles and related equipment. Whether or not we produce the technology domestically, manufacturers of products using this technology are apt to be eager to offer it in the United States. Already, U.S.-based motor vehicle manufacturers and automotive electronic manufacturers have foreign subsidiaries and affiliate companies who provide components and equipment for U.S.-assembled automobiles. It is certainly conceivable that this strategy could be used for IVHS equipment. U.S. automakers could incorporate advanced electronic systems developed and manufactured by foreign component companies. This result, of course, would lead to the realization of the second concern, i.e., the industrial impact.

B. Industrial Impact

The second concern is that the U.S. will forfeit leadership in the manufacture of IVHS products to the countries that are aggressive in developing the technology. Some industry representatives have said that if the United States does not develop this technology, their companies would enter into licensing or joint venture arrangements with foreign companies to manufacture the IVHS products in the United States. This would suggest that technology development may not be absolutely necessary for domestic production of this technology.

The lack of U.S. technology development may not necessarily lead to a complete reliance on foreign sources. The United States could take a lower profile in the research and development phase and still hope to get a reasonable share of the manufacturing and implementation of this technology. Proponents of this strategy suggest that we should allow the Europeans and Japanese to find out which technologies work and then be aggressive in manufacturing the products incorporating the successful technologies. However, it is uncertain how successful such a strategy would be. It may be unreasonable to expect the U.S. to be able to get a meaningful share of any market that finally emerges. It may be unrealistic to believe that we can simply wait through the development phase and expect to be a major participant in manufacturing. The comparative advantage of U.S. industry has generally been as innovators of new, advanced products, rather than as manufacturers of products using existing technologies. It is questionable whether this "wait and see" approach has been a successful U.S. strategy in the past and whether the U.S. has been successful in adopting foreign technology (for example, how many U.S. manufacturers have been successful in adopting the technology of, say VCRs, and been able to achieve a significant market share in U.S. VCR sales?) Experience to date seems to suggest that foreign companies which have developed a technology have been able to maintain the preeminence in manufacturing and sales of products using those technologies.

C. Infrastructure Required

An additional consideration is the fact that maximum benefits are achieved when the "smart" vehicles are linked with "smart" highways. Key elements of the United States highway system must be equipped with appropriate technology to facilitate system management as well as communication between the highway and vehicle systems. Early development of United States standards for communication and other systems will be necessary to ensure compatibility among systems in the various states and metropolitan areas. Continuing the VCR comparison, unless the United States is directly involved in the early development phases, we may be faced with "VHS systems" in the United States and "Beta vehicles" from foreign manufacturers.

D. Size of the IVHS Market

An important consideration in deciding whether the U.S. should consider a national IVHS program is the likely size of the eventual IVHS product market. As noted above, current estimates are that electronics accounts for about six percent of the value of a current automobile; this implies an automotive electronic equipment market of about $8.5 billion per year out of total automobile sales of $140 billion per year. The forecast that this percentage will rise to 20 percent by the year 2000 would mean a market of $28 billion per year. This estimate does not even include any secular increase in U.S. motor vehicle sales or the capital and operations expenditures for the roadside equipment that may use IVHS technologies. At this point, we have not refined the total IVHS expenditure estimate to take into account any of these considerations. Commenters are invited to submit information that would help us make such an estimate.

SECTION VI

IVHS GOALS AND PRELIMINARY PROGRAM AGENDA

This section provides a preliminary overview of the intelligent vehicle highway systems (IVHS) goals and how the resulting program elements could be structured. The research agenda is based upon one developed at a recent Mobility 2000 workshop. (Mobility 2000 is an ad hoc group of transportation researchers concerned with advanced highway technologies.) Both the goals and supporting agenda presented here must be detailed and refined before they are used as the definitive statement of an IVHS program. We invite comments on the goals and program agenda to assist us in the preparation of the report to Congress.

A. Overall Program Goal

The broad goal of a program of IVHS technology is to put in place the necessary vehicle/highway management, information, and control systems to combat congestion and move the United States into the 21st century with enhanced levels of highway transportation efficiency, safety, mobility, and convenience. Achieving these goals will, in large part, require an aggressive, long term commitment to develop, demonstrate, and deploy successive generations of advanced highway and vehicle technology. These future systems will not generally require major technical breakthroughs; but, will rather mold existing state of the art communications technology, microcomputers, and control software to the special needs of vehicle/highway systems. Deployment of these systems will benefit both rural and urban areas in the United States, and benefits will accrue to all users and trip types, ranging from local commuters to long distance travellers and from business trips to tourism and recreational travel.

B. Specific Program Goals

Specific program goals have been formulated as a set of six goals which collectively frame the overall program of IVHS. These six goals include program activities which span a period of both short term (1-10 years) to long term (> 20 years). Each goal individually contributes to significant highway operational improvements and is also readily integratable and compatible with the other goals. The specific goals are:

I. Increase traffic movement efficiency of urban streets and highways using advanced traffic management systems including real-time, traffic responsive control strategies, and integration with advanced information systems.

II. Enhance individual motorist's information on route choice, current traffic incidents, and other pertinent information through advanced in-vehicle driver information systems.

III. Improve safety of highway operations through the use of in-vehicle safety advisory, warning systems, aids, and improve driver detection and response.

IV. Increase the efficiency, safety, and reliability of trucks and other highway based fleet operations using safety warning systems and driver control aids, communication, vehicle identification, and safety back-up systems.

V. Substantially improve highway operational performance including vehicle throughput and trip predictability in high demand urban corridors through the use of automated vehicle control (AVC) technology.

VI. Substantially increase future levels of highway service (higher speeds and increased safety) for intercity and rural highway travel using partial and eventually fully automated vehicle control.

Achieving these goals will require a program of research, development, demonstration, and deployment in each of the four system technologies: advanced traffic management systems, advanced in-vehicle driver information systems, freight/fleet operations systems, and automated vehicle control.

It is essential to realize these four areas are interdependent in many ways. As the systems mature, this interdependence will become even greater, and the elements of each of these systems will tend to converge in functions and subsystems.

C. <u>Advanced Traffic Management Systems (ATMS)</u>

The current state of the art technology in traffic management systems already has a modest level of "intelligence" and can provide reasonably effective metropolitan area traffic management. This technology will need to be deployed more widely to lay the foundation for future improvement. As noted above, traffic management systems are at the very core of the infrastructure for IVHS as their primary function is to monitor current network traffic conditions, evaluate alternative control options and implement actions to manage overall traffic operations.

The future program direction of advanced traffic management systems could be as follows:

1. Support the implementation of current state of the art traffic management systems in all major metropolitan areas.

2. Continue the development of the supporting subsystem technologies to make it more versatile, accurate, reliable, and economical. The subsystems include detectors and surveillance devices, communications equipment, and operating software including the use of artificial intelligence and "expert system" improvements.

3. Further develop computer-based traffic models to more accurately model and evaluate traffic network problems and develop accurate and effective control measures.

4. Develop ATMS control strategies which are fully responsive to real time (minute by minute) variations in traffic conditions and which implement control measures on an areawide basis. That is, freeways and surface streets operated as an integrated overall system and managed by a master control strategy throughout the metropolitan regional area.

5. Develop the capability for ATMS to communicate with later generations of advanced driver information systems so that individual driver destinations will be known and overall traffic control parameters (signals, ramp meters, reversible flow lanes, etc.) can be adjusted to optimize individual route choice and overall network traffic flow on a continuous real time basis.

Selected R&D Needs: Selected R&D topics appropriate for a national ATMS program would include:

-- Detection - Develop and demonstrate applications of advanced detection techniques and devices for use in the collection of reliable real-time traffic data.

-- Communication - Develop and demonstrate applications of advanced communication techniques and equipment in a traffic control environment including inter-vehicle system communications; develop and test systems which obtain information from the individual vehicles on such items as travel time and speed, and which communicates directly to the vehicles.

-- Adaptive Control Systems - Demonstrate traffic control systems (e.g., traffic lights and ramp meters) which adjust to actual traffic conditions.

-- Integrated Control Strategies - Develop traffic control strategies to integrate arterial street control and freeway control and integrate surface street systems across jurisdictional boundaries.

-- Real-time Assignment - Develop and test algorithms and models on optimal routing and diversion.

-- Expert System/Artificial Intelligence for Prediction - Develop and demonstrate algorithms using artificial intelligence to predict or anticipate traffic congestion.

D. **Advanced Driver Information Systems (ADIS)**

Accurate, up-to-date, and contiguous traffic information is essential for intelligent motorist route selection and diversion around accidents, construction, or other traffic disruptions. Effective motorist information systems can also significantly improve the quality of driving and reduce driver anxiety. Such systems can provide additional benefits to the tourist and other unfamiliar travellers in both urban and rural locations.

Major improvements in individual driver safety may well come from vehicle-based ADIS systems which advise and/or warn the driver of safety related situations. Examples of warning messages could include specific hazards such as hidden entrances or road construction and maintenance. Messages tailored to specific vehicle classes could provide recommended speeds on ramps and long grades, reduced speed on curves and ramps during inclement weather, etc. Such an advisory system could replicate existing roadside signing in poor visibility situations such as fog, rain, or snow. These in-vehicle messages could be very useful to older drivers and others with poorer vision.

The program direction of ADIS could be as follows:

1. Develop and field evaluate a route choice and traffic conditions driver information system. An evolutionary stage would include navigation capability, on-board information storage, and a communications link with a traffic information source. These systems would be demonstrated in operational settings, and deployed in selected major metropolitan locations with substantial traffic problems.

2. Develop and field test the safety advisory and warning capability of ADIS. As this function matures, it would be incorporated into the ADIS systems as they are operationally deployed.

3. Develop national standards and specifications so that these systems are compatible throughout the United States, are effective, and are human engineered for safe and efficient use. (These national specifications would be established jointly by industry, users, and government.)

4. Undertake a program to deploy ADIS systems nationally. The systems would include both the traffic operations and safety functions and would be deployed in both urban and selected rural locations.

5. Eventually, develop ADIS to the stage where it can provide specific route guidance to individual motorists. This stage will require two-way communication with vehicles to ascertain present location and desired destination and to provide route guidance. This individual vehicle route information could be the basis for a major enhancement to area traffic control as it will allow traffic signal, freeway control, and similar decisions to be made on a real-time basis of known traffic conditions, and expected traffic demands. (This objective parallels goal five of AMTS.)

Selected R&D Needs: Selected R&D topics appropriate for a national ADIS program might include:

-- Driver Information Requirements - Develop specific information and format most useful to drivers (i.e., how to display congestion and motorist services information).

-- Driver Performance - Determine driver capabilities and limitations in responding to multiple sources of information to assure that amount, type, and mode of information presentation does not result in impairment of driver performance.

-- Driver Aids - Determine driver needs for real time information supporting decision-making and conduct an assessment of "expert systems" and artificial intelligence to fill these needs.

-- Communications Techniques - Define and evaluate alternative communication designs.

-- Systems Architecture - Determine how to link in-vehicle systems, roadside devices, and voice/data broadcasts. Determine protocol and format for communication links.

-- Traffic Management - Integrate advanced ADIS systems with Traffic Management Systems.

E. Freight and Fleet Vehicles

There is a direct relationship between efficient commercial transportation and the nation's economic vitality. Advanced technology is already being demonstrated and placed in operation to enhance individual fleet and truck operations. These systems include automatic vehicle identification, automatic vehicle location, and vehicle satellite data communication links.

Safety and the need to facilitate a safer use of heavy vehicles require special emphasis for commercial users. This is a major public concern now and certainly will continue to be so. Both government and private industry are interested in making truck regulation compliance as efficient as possible. One way is to reduce administrative costs including the paperwork burden for both the public and the private sector. Finally, interest in these technologies is driven by the desire to increase productivity and improve customer service.

Given these emphasis areas, the future program direction could be as follows:

1. Evaluate the productivity and cost reduction benefits to carriers and regulators of IVHS technologies and additional national demonstrations of IVHS technologies similar to the HELP project being evaluated by the Southwest and Western States.

2. Establish standards for automatic vehicle identification (AVI) systems using nationally compatible technology. (The standardization issue is very important to the trucking industry and national fleet operators who do not want different transponders on their vehicles as they move from state to state.)

3. Develop truck-related collision warning, crash avoidance technology, and impaired driver detection technologies. These apply to both passenger cars and trucks, but are especially important in commercial vehicles. Trucks are on the road almost continually, and when they are involved in an accident the effects can be much more damaging. Technology should be developed to help prevent loss of driver control and to provide site-specific warnings to commercial vehicles as suited to the types of vehicles. Also, the ability to detect impaired drivers is needed.

4. In the future, develop systems to prevent collisions using devices that alert the driver to the presence of a hazard and then automatically intervene, if required, to avoid a collision.

5. Develop systems for real-time routing of commercial vehicles. With such a system, operators would specify where they wanted to go and the system would provide them with the best route. These types of systems will be developed under ATMS and ADIS but freight and fleet operations have specialized needs which must be reflected in the associated R&D activities.

<u>Selected R&D Needs</u>

Selected R&D projects appropriate for the program areas could be:

-- Conduct human factors research aimed at specific information and control assistance needs of heavy vehicle operators.

-- Develop and test systems for sensing truck position relative to other vehicles in "blind spots" and develop and test collision warning and avoidance systems for trucks.

-- Develop and test operator impairment detection and warning systems.

F. Automated Vehicle Control (AVC)

Future highway system needs require the development and eventual deployment of systems with substantially improved operational performance characteristics. Automated vehicle control appears as the natural direction of future vehicle/highway systems and is a means of establishing higher levels of performance. In the highway context, this means consistent high levels of traffic flow with reliable trip times even under degraded environmental conditions. It also means enhanced motorist safety and convenience. From the point of view of the highway "physical plant," automation should offer considerably higher vehicle throughput for a given amount of right-of-way. This is a major benefit in congested urban corridors where the addition of extra lanes is becoming less viable.

Also, there is a growing need for higher speed, safer, and more reliable travel in many rural intercity and interstate trips. Manually controlled vehicles with backup control systems have the potential to provide safe and reliable operations at much higher speeds than present legal speeds under manual-only operation. It is expected that these backup or partially automated systems would eventually evolve into fully automated systems. While it is not expected that automated systems will be deployed in the near future, because of systems development lead times R&D must be initiated now.

Program Direction

Given these needs, program directions could be as follows:

1. Develop the necessary subsystems required for both partial (and eventually) fully automated control.

2. Conduct full scale engineering tests on a test track facility to resolve engineering issues and to fully evaluate the expected operational performance of deployed systems. These engineering tests would include both urban and rural performance configurations.

3. Undertake selected, limited scope operational demonstrations to provide actual operational assessments to both enhance the system design and to develop public awareness of the benefits of this system.

4. Evaluate potential deployment scenarios and prospective initial locations including preliminary engineering to assess costs and related deployment issues.

Selected R&D Needs

Selected R&D project appropriations to these program areas include:

-- Develop and evaluate alternative sensor systems. Examples include sensors which accurately measure vehicle lane location both laterally and longitudinally, and headway measurement sensors.

-- Conduct analytical and experimental R&D to establish realistic headway spacing performance goals. This is perhaps the critical parameter which sets the operational effectiveness of urban automated systems.

-- Conduct human factors research related to transitions between manual and automatic control and to driver response capabilities in use of system failures. Also, determine driver acceptance of automated control, manual monitoring, and intervention.

-- Establish and develop traffic control strategies at the local, area, and regional level.

-- Conduct research on a range of institutional and "soft-side" operational problems which could critically affect an operational system. Examples include ownership of vehicles, inspection, liability, revenue needs, etc.

G. Highway Safety/Human Factors

There is a lack of solid data and understanding in all of the broad technology system concepts discussed above. To assure reasonable levels of system effectiveness, human factors principles must be observed in the application of advanced technology to vehicle and highways systems. The systems must be designed and implemented to meet driver needs with consideration of driver capabilities and limitations. Care must also be taken to assure that driver performance is not impaired and safety degraded with the introduction of new vehicle-highway technological systems.

Adequate driving performance is critically dependent on the availability of a steady flow of information to drivers, and their capability for acquiring and responding to this information in an accurate and timely manner. Thus the driving task includes many different component tasks, when examined closely, it appears to be largely a perceptual and cognitive one.

Program Direction

Crash avoidance systems must be developed that:

-- provide better information earlier to help the driver avoid unnecessary exposure to high risk situations;

-- reduce high risk behavior by providing early warning of dangerous driver, vehicle, road or environmental conditions;

-- facilitate earlier and better response by aiding the driver in obtaining information, making decisions, and executing actions; and

-- perhaps, ultimately, provide means of reducing driver command and control responsibilities under particular driving conditions.

Selected R&D Needs

Some of the R&D projects that would seem appropriate to these issues include:

-- Develop and apply evaluation protocols to assess the potential safety impact of new technology. This is especially critical for those systems which have the potential for degrading driver performance. Examples of these systems are electronic displays of maps, head-up displays, and in-cab computer and communication systems.

-- Determine the requirements for direct and indirect visibility for safe driving and to identify and evaluate means of providing this visibility. Applications of advanced technology are needed to improve visibility in inclement weather and to reduce blind spots to the sides, rear, and front of all classes of vehicles.

-- Develop practical on-board computerized systems which can be used to detect and warn drivers when their performance is dangerously impaired. Driver use of alcohol or drugs, fatigue, excessive mental workload, or other sources of impaired driver performance together are the major causes of highway crashes.

-- Develop driver aids/"co-pilot" systems to assist the driver in obtaining and evaluating critical crash avoidance information now unavailable. Examples include systems to provide truck drivers with cues of incipient rollover and systems to provide drivers with indications of visually undetectable vehicles on a collision course with their vehicle.

-- Define and measure critical driver visual, motor, and cognitive performance capabilities. The distributions of critically required driver capabilities and their limitations in the driving population must be delineated to provide the basis for evaluating new systems and countermeasures, the development of means of meeting the needs of mature drivers, and as a basis in the development of rational safety standards.

-- Update and develop research and analysis tools. Quantitative models and decision tools are needed to aid in the selection and assessment of alternative solutions to defined safety problems. New technology must be exploited to develop instrumentation for use in measuring and evaluating driver and vehicle real-time performance, and a moving base simulator must be developed to provide the capability for conducting precisely controlled, repeatable experiments which would be risky and dangerous in on-road, full scale vehicle tests.

-- Encourage collaborative research and demonstration projects with the purpose of integrating the vehicle technologies developed through those research activities into the vehicle fleet.

-- Demonstrate vehicles with enhanced crash avoidance capabilities resulting from the application of advanced technology with the purpose of improving highway safety. Application of advanced electronic, computer, information, and communication technology will provide: (1) early warning of potentially dangerous driver, vehicle, road, or environmental conditions, e.g., proximity warning (blindspot), collision warning, rollover threshold warning, driver inattention/driver impairment, etc.; (2) driver assistance/aids, e.g., antilock brakes, active suspensions, smart cruise control, enhanced night vision systems, etc.; (3) vehicle control, e.g., adaptive speed control, electronic steering, braking and throttle control, vehicle lateral position control, etc.; (4) optimized driver-vehicle-information interfaces to ensure amount, type, and mode of information presentation does not result in degraded driver performance.

Section VII

ORGANIZATIONAL OPTIONS

At this point in our analysis, we have not determined whether there needs to be a national program for the development and implementation of Intelligent Vehicle-Highway Systems. More consideration must be given to whether the United States should give a higher priority to the development of these systems, whether the existing scale of effort in the United States is sufficient, or whether we can generally rely upon the development work being conducted in Europe and Japan. Comments are specifically solicited on whether there should be a national program to support these technologies.

It does seem that if a national research, development and demonstration effort for advanced technology highway vehicle systems is warranted, there needs to be a strong organizational framework which pulls together both the public and private interests in this area. Such a public/private cooperative program would need to involve the private sector, and the Federal, State and local governments, as well as academic and other research organizations.

There are a number of organizational options to provide this cooperative framework. Two approaches are suggested below: one would build upon the resources within the U.S. Department of Transportation, and one would be designed as an independent public/private effort. Both of these approaches stress the need for this to be a cooperative partnership between all the interests involved.

The Department has not determined which approach is preferable and discusses them here to solicit comments on the advantages and disadvantages of each.

A. <u>U.S. Department of Transportation Focus</u>

The first approach is to have the U.S. Department of Transportation (including the Federal Highway Administration and the National Highway Traffic Safety Administration) as the focal point for a national program. This approach was suggested by the Mobility 2000 group. DOT has the primary Federal responsibility for the nation's highway system. This alternative is to build upon the Department's capabilities and expertise and apply them toward the advancement of these technologies. There would still be a need for private industry and State and local governments to be involved in the development and implementation of IVHS, and DOT would take the leadership role in the bringing these parties together. As part of this alternative, a number of suggestions are made for providing such a coordinative mechanism.

The U.S. Department of Transportation would begin immediately to take the necessary actions to accelerate IVHS research and development, which would be increased in scale and scope as progress is achieved. As the DOT program produced early products and demonstrated the practibility of these technologies, it would foster credibility for the technology. At the same time, DOT would begin to initiate public/private cooperation to make the program successful over the long term.

Development Activities - Under this alternative, the DOT could perform a number of functions directed at increasing the visibility of IVHS and, broadening the development effort:

-- Estimate the potential for IVHS to alleviate highway capacity and safety problems;

-- Strengthen IVHS activities in the Department;

-- Develop a research and development program and establish priorities, in conjunction with industry, universities, and State and local government;

-- Redirect the limited research and development funding currently available to IVHS;

-- Broaden Federal project funding eligibility criteria to encourage IVHS applications; and

-- Coordinate near term technical activities and demonstrations.

Core Program Activities - The DOT would also provide leadership in coordinating and carrying out a number of core program activities:

-- Planning and evaluation, including program definition, deployment, oversight, and evaluation;

-- Program management, including project definition, contract solicitation, and award, initial funding, staffing, and program delivery;

-- Development of an outreach program, including public information and education activities, publicizing successes, and technology transfer.

-- Coordination of the standards and protocols for radio frequencies, in-vehicle displays, maps, etc.;

-- Identification and assessment of legal issues including anti-trust, liability, and licensing;

Support Activities - The DOT would take the lead in assuring that a long term research and development strategy is developed, and take actions to assure that the overall program is well supported:

-- Seek increased federal funding for IVHS research activities.

-- Seek long-term funding for deployment of the IVHS infrastructure (highway-related systems).

-- Develop a long-range research, development, and demonstration program with the assistance of State and local governments, and private industry.

Coordination Mechanism: Although this alternative focuses on the activities of DOT to further IVHS, it is recognized that there would likely be a need to create some entity to establish long-range strategies for IVHS development and deployment and coordinate private/public efforts. Such an entity would best be formed as soon as possible to work with the Department from the beginning of the program. The specific functions of such an organization would include:

-- Highlight the nature of the problems and their size and extent;

-- Design a long-term research, development, and demonstration program, building on the earlier work by DOT and others;

-- Determine the appropriate roles of the Federal, State, and local governments and the private sector;

-- Recommend funding levels and potential sources of funds;

-- Address the issue of national industrial policy and the potential involvement of other countries in this program; and

Again, there are a number of options for creating such an organization.

Presidential Commission - One possibility would be the creation of a Presidential Commission on Intelligent Vehicle/Highway Systems. This alternative has been suggested by the Mobility 2000 group as well as the Motor Vehicle Manufacturers Association. The Commission would be authorized by the Congress, would have a relatively short life (say one year), and would be supported by a small staff. The Presidential Commission would build on the work and activities of the Department and other groups, and develop a long-term strategy on IVHS development and implementation. The Presidential Commission may also bring high visibility to the program.

Advisory Committee - An alternative would have the DOT continue its leadership role into the longer term, complemented by a technical advisory committee. Such an IVHS Technical Advisory Committee would be composed of representatives of State and local government, universities, and private industry. The Committee could be divided into a number substantive subcommittees in carrying out its functions, including:

-- The development of a long-range research, development, and demonstration program;

-- The selection of projects and the selection of contractors;

-- The determination of the categories of projects appropriate for a cooperative effort and the matching share;

-- Management of the progress of projects; and

-- Evaluation of the results of the projects.

Organizational Models - Some other models exist for a coordinative organization. These include the Health Effects Institute (a partnership addressing automotive issues), the Strategic Highway Research Program (an effort directed at improving pavement technology), and Sematech (a consortium addressing microchip technology). Also, of course, there are the organizational structures used by the European and Japanese programs. These examples illustrate the range of options available for coordinating a public/private partnership.

Conclusion - All these examples, the Commission, the Advisory Committee and the other models, have a common element in that they would depend on the DOT to provide the majority of developmental and program management support while assisting the Department in establishing the program priorities and long range objectives.

B. <u>Organization for Advanced Technology Highway Systems (OATHS)</u>

A new independent public/private agency is another approach for developing IVHS technology. An independent Organization for Advanced Technology Highway Systems (OATHS), authorized by Congress, would develop a time-phased research, development and demonstration plan including both short and longer range elements. It would be responsible for obtaining commitments to carry out various elements in the work program, but would not generally provide the funding nor carry out the work itself. For some tasks involving the overall direction of the program and for those tasks that do not have sponsors, the organization could contract directly for the research. OATHS would assure that the program is a cooperative effort of private industry, the public sector, and consumers.

DOT would still provide leadership in those areas of the program that relate to its current role and responsibilities for the nation's highway system, including the establishment of standards, the demonstration and deployment of new highway systems, and the development of program delivery mechanisms. Beyond these types of activities, DOT's responsibilities would not be much expanded.

<u>Functions</u> - OATHS would perform a number of functions in support of the cooperative nationwide research and development effort:

-- Develop and update a time phased research, development and demonstration work program;

-- Secure commitments for individual work elements;

-- Coordinate research, development, and demonstration activities;

-- Coordinate the development of standards;

-- Maintain data and information bases;

-- Organize information transfer activities; and

-- Issue periodic progress reports.

Organizational Structure - Although such an organization could be organized a number of different ways and evolve as the organization matures, one approach would be to divide the OATHS into two major units:

Policy and Planning Unit - The Policy and Planning Unit of OATHS would ensure that all of the efforts are directed towards developing and demonstrating an integrated and operational system. It would consist of a Board of Directors, Executive Director, and a small professional staff with support. The Board would include membership from the various organizations that are involved in the development program and concerned with the results including representative from automobile manufacturers, producers of communication and other equipment, governmental agencies, universities and other research centers.

Research, Development and Demonstration Units - The units actually carrying out the research, development and demonstration activities would be of several types depending upon the nature of the work to be accomplished. These units would be selected by the Board of Directors and their research plans would be approved by the Board. Each of these could be guided by a Steering Committee consisting primarily of knowledgeable professionals, but also consisting of persons directed to assist in coordinating the activity with other activities in the overall program.

Research Units could be established at a university or research center, or consortium, with the cooperation of interested private companies and governmental representation. Development Units could also be established at universities and research centers. There is also an opportunity for private corporate research centers to serve as developmental centers, but the issue of the extent to which the results would be proprietary would have to be addressed. Demonstration Units would most likely be established at the public agencies that would implement these systems. They would coordinate a team drawn from those that develop the system, manufacturers of the system, and potential users of the system.

Funding - Sources of funding would vary depending on the particular activity. As an example, funding of the organization itself could be on a membership basis with the participating organizations. These would included private companies, governmental bodies, and other organizations that are involved in the program. On the other hand, research could be funded through a partnership or shared cost arrangement, such as 50 percent governmental and 50 percent private sector, or on an ad hoc basis for each project. Similar options could be established for developmental and demonstration activities.

Launching the Program - In order to launch this program with the wide array of individuals, organizations, and resources needed to carry it out, it would be useful to have a Congressional mandate. Without such a mandate, no organization would have the power to take decisive action. The Congressional mandate would need to specify a Program Goal, and the nature of the organizational structure and its functions.

Program Goal - The overall program would be designed to be accomplished within a ten year time period. That is, the program would seek to develop and demonstrate an advanced highway vehicle system by the year 2000, assuming that work began by 1990.

Start-Up Process - The Congressional mandate would specify that initial steps to create the organization be taken cooperatively by the DOT and such organizations as the National Academy of Science (NAS) and the American Association of State Highway and Transportation Officials (AASHTO). This start-up process would begin with the convening of a "blue-ribbon" committee who would select the first Board of Directors, and would take the initial steps to establish operating procedures and charter the organization. The "blue-ribbon" committee would have a limited life, perhaps three months in length.

SECTION VIII

SPECIFIC ISSUES FOR COMMENT

1. Is there a need for a national research, development, and demonstration program that would form the basis for implementation of IVHS technology on a reasonable time-table?

2. What should be the principal goals of a national IVHS program?

3. Is the preliminary research agenda appropriate to achieving the goals we have set forth? What changes/deletions would you suggest? Which elements should be undertaken by the government? Which elements should be undertaken by the private sector? Which elements could most efficiently be undertaken by a cooperative public/private effort?

4. What are the appropriate roles and responsibilities of the federal government, the state and local governments, and the private sector in a national IVHS program that encompasses research, product development, implementation, and operation of the various elements of IVHS?

5. What is the most appropriate organizational structure to manage and direct an IVHS program?

6. What funding level, funding sources, and time-table is appropriate to achieving the goals set forth for a national IVHS program?

7. Should the participation of foreign governments and companies be allowed in a U.S. national program? Should their participation be encouraged? Should any distinction be made between Canada and Mexico versus other non-American countries?

8. What other issues are important in considering a national IVHS program?

Appendix B

COMPANIES SUBMITTING IVHS PRODUCT INFORMATION

Allen Bradley	- RF-Responder for Highway Advisory Sign Posts
M. T. Aronow	- Route Guidance Navigation System
Chrysler	- Laser Atlas Satellite System - Radio Data System
Delco Electronics Corporation	- NAVICAR - Near-Obstacle Detection System (NODS)
ERIM	- Imaging Laser Radar
ETAK, Inc.	- On-board Vehicle Location Device
Farradyne Systems, Inc.	- Pathfinder
Ford Motor Company	- Collision Avoidance - Fault Detection Filters for On-Board Detection of Faults and Degradation of Automotive Control System - Communication/Navigation
General Motors	- Mobile Information System Vehicle - Heads-up Display
JHK & Associates	- Traffic Network Displays
Martin Marietta	- Autonomous Land Vehicle
Motorola, Inc.	- RF-Based Data Communications Infrastructure - Global Positioning Satellite (GPS) Sensor for Navigation Systems - System Interface for FM based Driver Information Systems

Nissan Motor Co., Ltd.	- Development of a High Speed Image Processor - Automotive Heads-up Display System - Rear-end Collision Warning System Using Laser Radar
Radar Control Systems Corp.	- Vehicle Radar Collision Avoidance and Driver Support Systems
Rockwell International	- Land Mobile Satellite Communications - Vehicle Stability System - Vehicle Information/ Communications Systems - Vehicular Navigation System
Wilbur Smith Associates	- Columbia Area Signal System (CASS) - Weigh-in-Motion Systems - Automatic Vehicle Identification Systems for Road Pricing Applications
3M Corporation	- Radio Frequency Vehicle Identification System - RIA License Plate Reader - Automated Vehicle Surveillance System - Opticom^{tm} Priority Control System for Emergency Response Management - Canoga^{tm} Microloop Vehicle Detection System
II-Morrow	Automatic Vehicle Location System
Lewis J. Valentine	- Anti-Lock Braking System

Appendix C

IVHS PRODUCT INFORMATION

TITLE OF PRODUCTS:

COMPANY AND DIVISION NAME:

PRODUCT DESCRIPTION:

TYPE OF PRODUCT OR PROJECT

___TRAFFIC MANAGEMENT SYSTEM

___DRIVER INFORMATION SYSTEM

___VEHICLE CONTROL SYSTEM

___FREIGHT/ FLEET APPLICATION

STATUS AND TIMETABLE:

RESEARCH UNDERWAY OR PLANNED PRIOR TO IMPLEMENTATION:

DESCRIPTION OR EXTERNAL DEVICE OR SYSTEM