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A COMPARISON OF IVHS PROGRESS IN THE UNITED STATES, EUROPE, AND JAPAN

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FOREWORD

IVHS is an international phenomenon that continues to change the face of surface transportation all over the world. Unique to IVHS among international high-tech fields is the amount of international cooperation that has occurred and the fact that the United States is providing substantial leadership in these cooperative endeavors.

These efforts include the ATT/IVHS World Congress, international standards-making, and stimulating the establishment of IVHS AMERICA-like organizations around the world, even in Japan, a nation with an edge in the development and deployment of IVHS technologies but that for years lacked a central coordinating organization. Another IVHS AMERICA effort of international significance is the comparative analysis of IVHS progress in the United States, Europe, and Japan reported herein.

The United States was the first nation to fully act on the need for an institutional embodiment of the public/private partnerships that make IVHS deployment feasible. Congress recognized the need for a coordinating organization early in the IVHS program, stating in the FY91 House Transportation Appropriations report:

> "The Committee is . ..concerned about the apparent lack of a nationwide public/private coordinating mechanism to guide the complex research and development activities anticipated in the IVHS area."

IVHS AMERICA was formed to remedy this need. It is a partnership of the public, private and academic sectors involved in IVHS. Its mission is to coordinate and accelerate the development and deployment of advanced IVHS technology. It fulfills part of this mission through its role as a utilized Federal Advisory Committee to the U.S. Department of Transportation. In this capacity, IVHS AMERICA gives advice on federal IVHS activities and helps establish program priorities.

IVHS AMERICA's growth in only three years of operation has established its leadership in the IVHS community both in the United States and around the world. Its success has stimulated other countries and regions to form organizations similar to IVHS AMERICA to facilitate coordination of their IVHS activities. These organizations include ERTICO in Europe, VERTIS in Japan, IVHS Australia, and IVHS Canada. All of these organizations have their own unique structures, but they all share similar goals and missions to coordinate the development and deployment of IVHS around the world.

Over the past several years, it has become abundantly clear that the developed countries of the world, led by Japan, Europe, and the United States, are moving quickly toward deploying advanced technology on the highways. Numerous demonstrations are in progress or are planned to test the navigation, communication, and control systems technologies necessary for full-scale deployment. It is also clear, however, that each region is leading in certain technologies and that some are further ahead than others in deployment or in institutional arrangements that serve as the framework for IVHS implementation.

As a result, the Transportation Appropriations Subcommittee of the House Appropriations Committee raised questions about the relative positions of the acknowledged three leaders in IVHS development: Europe, Japan, and the United States. This comparative analysis of IVHS progress is in response to those inquiries.

Robert L. French, the designated study leader, assembled an international team of specialists to plan and execute the required analysis. In addition to their own research, their study incorporates the excellent piecemeal assessments that had already been done by others so as to minimize duplication and repetition.

The major thrust of the comparative analysis lies in the selection and compilation of the measures to be used. Notwithstanding the comparisons of progress, however, is the amount of work remaining to be done to deploy IVHS. One key to wide-scale deployment, for example, is the development of international standards. Fortunately, considerable forward movement has been made in this and other areas in recent months, but considerable work remains.

Although no single country at this point leads the world in all areas of IVHS, the United States certainly has an edge in the institutional leadership it brings to the international IVHS community. The United States has gained international respect for this leadership as it continues to forge and strengthen ties with international sister organizations through work on the ATT/IVHS World Congress, standards development, and other areas. IVHS AMERICA believes that this work and the information exchange it provides will assist in the development of a strong U.S. IVHS industry.

James Costantino

PREFACE

The scope of the task of identifying and systematically comparing relevant measures of IVHS progress in Europe, Japan, and the United States makes it inevitable that the selection of information presented and the observations made in this report at least partially reflect subjective views of the authors. Although the authors made special efforts to confirm their views on IVHS progress with knowledgeable and objective colleagues in arriving at consensus interpretations for this report, it seems appropriate to explain the frames of reference for the individual perspectives on IVHS.

Robert L. French, MS (physics), an independent IVHS consultant, is a pioneer in automobile navigation, having invented map matching in the early 1970s. Since then, he has closely followed IVHS developments in Europe and Japan and has encouraged adoption of IVHS concepts in the United States through proposals, publications, professional society activities, and educational seminars. He helped lead Transportation Research Board (TRB) IVHS initiatives in the mid-1980s and was an invited speaker at the 1986 Caltrans Conference. Along with co-author Christopher Queree. he originated *The Intelligent Highway,* the first IVHS newsletter, in 1990. A Founding Member of IVHS AMERICA, his international consulting practice specializes in assisting established clients as well as newcomers to IVHS with information services, technology and market assessments, and planning activities.

E. Ryerson Case, MS (control systems), is a Professional Engineer who had senior management and research responsibilities at the Ontario Ministry of Transportation (MTO) from 1973 to 1991. While with MTO, he played a leading role in the development and operation of the first computerized freeway traffic management system (FTMS) in Canada. He later pioneered the use of fiber optics for FTMS communications and served as the Canadian delegate in the OECD Expert Groups on "Dynamic Traffic Management in Urban and Suburban Road Systems" and "Evaluative Research of Road-Vehicle Communications Systems." Case was a leader of TRB IVHS initiatives in the mid-1980s, participated in the 1986 Caltrans conference, was a member of Mobility 2000, is a Founding Member of IVHS AMERICA, and is a Charter Member of the Canadian IVHS Roundtable. He originated the VNIS (Vehicular Navigation and Information Systems) international conference series of the IEEE in 1989. He currently maintains an independent consulting practice in IVHS in the Province of Ontario.

Yoshikazu Noguchi, BS (mechanical engineering), has been with Toyota Motor Corporation since 1973. He held various engineering and management positions in engine systems design and development until being assigned in 1987 as a manager at Toyota's European office in Brussels, Belgium, with responsibility for homologation and regulation. Upon returning to Japan in 1990, he joined Toyota's Corporate R&D Planning Division where he became Project Manager for IVHS. In 1992, he was assigned as Visiting Fellow to JSK (Association of Electronic Technology for Automobile Traffic and Driving), which operates under auspices of the Ministry of International Trade and Industry (MITI). In 1993, he was named IVHS AMERICA Distinguished International Fellow.

Christopher Queree, PhD (transport planning), is a Director with MVA Systematica, a specialist management consultancy and system house, where he is responsible for the team working in transport information systems. He is Chairman of the UK's Royal Institute of Navigation's Land Navigation Group and co-founder of the RTI/IVHS newsletter, *The* Intelligent Highway." He managed the original DRIVE Planning Exercise for the European Commission and leads MVA Systematica's participation in several DRIVE projects. These cover digital road map development, driver navigation systems, hazardous goods monitoring and control, traffic data interchange, and RTI systems engineering. He also manages MVA's assistance to the European Commission for the transport, tourism and GIS elements of the IMPACT Programme, and is providing specialist private sector consultancy advice to European information services in road transport and tourism.

Kentaro Sakamoto, MS (applied mathematics and engineering physics), has been since 1973 with Sumitomo Electric Industries Ltd., where he became involved with IVHS as a participant in Japan's pioneering CACS (Comprehensive Automobile Communications System) Program during the 1970s. He was subsequently project leader of Sumitomo Electric's digital design group for advanced traffic management systems. While assigned from 1983 to 1989 as R&D Vice President at Sumitomo Electric's New York City offices, he became involved in the exchange of IVHS information through the TRB. His assignments upon returning to Japan included management of fiber optic communication systems market development and management of the Systems Development Office of Sumitomo Electric's Systems and Electronics Group. He was assigned in 1993 as IVHS AMERICA's first Distinguished International Fellow.

Ove Sviden, PhD (economics), a futurist with roots in the aerospace and automotive industries, pioneered advanced driver information concepts including head-up displays through Sweden's ARISE (Automobile Road Information Systems Evolution) study which preceded PROMETHEUS and DRIVE in the mid-1980s. He was an invited speaker at the 1986 Caltrans conference and conducted the International Institute of Applied Systems Analysis 1987 Delphi study of future IVHS scenarios. His work as Lead Researcher with the PRO-GEN work area of PROMETHEUS during 1987-1988 included formulation of 35 IVHS functions based upon driver needs rather than technical solutions. During 1989-1991 he was a member of the DRIVE SECFO (Systems Engineering and Consensus Formation Office) team with responsibility for synthesizing IVHS system architecture scenarios that cut across all DRIVE projects. He is currently Managing Director of ARISEeeig. a non-profit research service European Economic Interest Grouping with offices in Brussels as well as in Sweden.

EXECUTIVE SUMMARY

Background

From 1970 until the mid-1980s, the United States essentially shelved many of its IVHS initiatives that were underway in the late 1960s because they failed to gain necessary policy and funding support. During this dormant period, Europe and Japan conducted field tests and continued other developments that enabled them to surge ahead of the United States with major IVHS research programs that began to form around the mid-1980s.

The European and Japanese programs enjoyed substantial government support and lent impetus to similar U.S. interests that were beginning to coalesce in 1986 as the Interstate Highway Program, which had preoccupied the United States since 1956, approached completion. As documented in many publications, including the U.S. Department of Transportation's 1990 statement of national transportation policy and the U.S. Congress' Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, there was concern about loss of competitive advantage unless the United States took action to catch up in this rapidly developing new field.

Objective and Approach

Now that the U.S. IVHS program has undergone several years of definition; planning, research, and field testing accelerated by rapid growth in funding, it is inevitable that questions arise about how the United States presently compares with Europe and Japan in developing and deploying IVHS. IVHS AMERICA commissioned the study reported herein with the objective of answering such questions. Although it is recognized that other countries are also making progress in IVHS, the scope of the study is limited to Europe, Japan, and the United States.

The study was begun with a comprehensive comparison of overall IVHS progress in terms of key initiatives and accomplishments from the 1960s through 1993. Top-down comparisons were then made from selected points of view: funding levels and sources, organization for development and implementation, research and testing, systems architecture and standards, deployment and marketing, institutional and legal issues, and planning for the future.

Europe

Since starting with DRIVE planning exercise in the mid-1980s, the European countries have made remarkable progress in infrastructure-oriented IVHS research coordinated through the

European Community (EC) and are presently focusing on pilot projects and demonstrations. Public sector funding of 200 million ECU (approximately $230 million based on current exchange rates) cover up to 50 percent of the cost of various DRIVE I and II projects from 1988 through 1994. There is speculation that the DRIVE III (1994-1998) budget may be approximately 160 million ECU ($180 million).

The public-sector programs have been complemented by vehicle-oriented industry initiatives coordinated through EUREKA that have no parallel in the United States or Japan. EUREKA projects are funded largely by industry but include some contributions by national governments. The largest and most widely-known EUREKA IVHS project is PROMETHEUS (PROgraMme for a European Traffic system with Highest Efficiency and Unprecedented Safety), which evolved from an internal Daimler-Benz initiative to include the entire European automotive industry in joint pre-competitive research. PROMETHEUS' original planning called for expenditure of $770 million for 1986 through 1993.

DRIVE, PROMETHEUS, and related European programs have yielded promising technologies, some of which are commercially available or could quickly become available. In addition, although not strongly coupled with the EC and EUREKA programs, Europe has made great progress in the application of IVHS technologies to buses and mass transit.

However, the not-invented-here syndrome remains a major constraint to deployment; each country typically identifies its own priorities and implementation approaches, thus hindering progress towards an IVHS environment that is seamless across national boundaries. This "NIH" element also means that the anticipated common market for European IVHS products may not be quickly realized.

These obstacles could, in principle at least, be resolved through ERTICO, an organization chartered to promote and assist with the coordination of IVHS implementation in Europe. However, ERTICO's limited membership and powers leave the follow-through on IVHS deployment largely up to individual countries, which have widely varying ideas about IVHS architecture and the division of public and private roles. Thus one of ERTICO's main strategies is to promote standardization and the early inter-operability of different systems available or about to become available.

Japan

Japan is only one institutional breakthrough away from quickly reaching full-scale deployment of integrated traffic management and in-vehicle information systems. Japan's lead is not so much the result of its substantial government funding as it is of Japan's profound needs for IVHS benefits and of government policies that have articulated IVHS goals since the 1970s. The consistent policy support was particularly important in attracting unsubsidized industry participation.

The Japanese government has systematically invested in advanced traffic management over the past two decades through a series of five-year programs, and has a widely deployed infrastructure for centralized traffic monitoring and information that needs little more than mobile communication links to service smart in-vehicle systems. Although IVHS funding is not always clearly delineated from other capital spending, it is estimated that approximately $1.85 billion was expended for deployment of advanced traffic management systems between 1985 and 1992. A total of $690 billion has been appropriated for the 1993-1997 road improvement program.

On the vehicle side, industry had already sold 300,000 autonomous navigation systems (mostly as factory-installed) at prices typically in the $2,000-$6,000 range by the end of 1992 and is positioned to rapidly address the large market expected once administrative decisions are made on the communication links. During 1993, keen competition developed among the numerous suppliers of aftermarket versions as prices started to drop below $2,000. At the end of 1993, 20,000 systems were being sold each month and sales of 350,000 systems were projected for 1994.

Many of the navigation systems evolved from test versions developed by approximately 18 companies in order to participate in a series of ongoing field trials (e.g., RACS, AMTICS, and VICS) sponsored by government agencies since 1986 primarily to test various means of communicating traffic information to in-vehicle units. It is estimated that, in addition to research labor, the larger companies have invested $4 to $20 million per year in order to participate.

In spite of this progress, "turf struggles" among the concerned Japanese government agencies have been an obstacle to the consolidation of traffic data and the system-wide deployment of communication links between the infrastructure and in-vehicle equipment. However, once these agencies resolve their parochial interests, Japan is poised for rapid deployment and operation of integrated IVHS.

Recent developments suggest that the necessary institutional breakthrough may be at hand. The five agencies that share IVHS interests and jurisdiction (Ministry of International Trade and Industry, Ministry of Construction, National Police Agency, Ministry of Posts and Telecommunications, and Ministry of Transport) formed an inter-ministry committee in July 1993 to facilitate greater cooperation within the Japanese government. In addition, VERTIS (VEhicle, Road and Traffic Intelligence Society), an associated IVHS AMERICA-like organization, was set to be established early in 1994 with representatives from private industry and academia as well as the five government agencies.

Moreover, following the Liberal Democratic Party's recent loss of a 38-year hold on power in Japan, there is also talk of streamlining the number of government agencies. Mentioned possibilities include a single ministry with responsibility over IVHS.

United States

Although the United States originated IVHS research in the 1960s and developed many of the key technologies now used worldwide, the United States seriously lagged Japan and Europe in coherent IVHS efforts until a national vision emerged from the work of Mobility 2000 in the late 1980s. Mobility 2000 was an ad hoc group of volunteers from public sector transportation agencies, industry, and academia that coordinated IVHS planning prior to the formation of IVHS AMERICA in 1990. The subsequent emphasis on IVHS promoted by IVHS AMERICA and the mandates and funding provisions of the landmark ISTEA quickly led to establishment of long-term goals and application of a top-down planning approach while simultaneously carrying out large-scale trials of prospective alternatives.

The rapid buildup of the United States IVHS program was enabled by increases in IVHS funding for research, development, and testing from only $2 million in 1989 to budgets of well over $200 million per year at present. Another major factor is the proactive role played by IVHS AMERICA as a forum for consolidating the interests of all levels of government, the private sector, academia, and surface transportation users, as well as serving the U.S. Department of Transportation as a utilized Federal Advisory Committee on IVHS matters.

As a result of these developments, the United States IVHS program already rivals foreign programs in some aspects and leads in others (e.g., organization, strategic planning, and certain technical areas such as electronic toll collection and commercial vehicle fleet management). Also of particular significance in the United States is the early consideration given to the necessity of recognizing and addressing institutional and deployment issues.

Nonetheless, the United States transportation infrastructure is largely owned and operated by state and local entities, which has resulted in fragmented efforts, including slow growth in key enabling standards (e.g., AVI). The national IVHS system architecture now under development along with special outreach efforts should help, but inconsistent involvement by state and local governments remains a concern.

Progress in IVHS development has also been impeded by limited flexibility to optimize the allocation of the substantial government funding now available for IVHS development and field trials in the United States as a result of extensive Congressional earmarking during the period of rapid build up. However, a detailed National Program Plan for IVHS now in preparation should provide a more coherent basis for future earmarking,

Conclusions

The comparative study of IVHS progress in the United States, Europe, and Japan indicates that have all made great progress in IVHS development, although the focus varies widely from region to region.

In Japan, the main focus has been on deployment of advanced traffic management systems for arterial streets and the development and marketing of automobile navigation systems as a platform for in-vehicle information. The European focus has been on exploration and evaluation of numerous alternatives for a wide variety of IVHS services with the view that a common architecture would evolve in due course. The United States started late and has focused on evaluation and planning, organization, and a top-down systems engineering approach to developing a national IVHS architecture while simultaneously carrying out extensive research and field trials.

IVHS now enjoys strong public sector support in all three regions, but it comes in different forms. In Japan, the installation of advanced traffic management systems has been addressed through a series of five-year government programs for traffic safety facilities. The development of automobile navigation systems by industry has been encouraged for over a decade by the promise of government-provided IVHS traffic data communications infrastructure and more recently by government-coordinated road map database efforts.

Public-sector support of IVHS research and development, but not deployment, in Europe has been in the form of centralized planning and coordination as well as by partial funding of research projects by the European Community. In addition, national governments have helped fund individual industry projects under EUREKA. Although specific comparisons are elusive, government funding for IVHS development in the United States has quickly grown to the point that it compares favorably with directly identifiable government funding in Europe and Japan.

Institutional issues, albeit of different types, are a universal impediment to IVHS deployment. In Japan, they are in the form of jurisdictional issues among high-level government agencies with IVHS interests. In Europe, they are mainly in the form of national sovereignty issues that hinder the evolution and deployment of a common system architecture. The main public sector issues in the United States are similar in that state and local governments involvement in IVHS must be fostered rather than mandated by the federal government.

In all, it must be concluded that the United States has recognized the problems that must be solved, has planned effectively, and is enjoying government support and making overall IVHS progress that compares quite favorably with Europe and Japan. Although Europe and Japan are still ahead by certain measures, the momentum already gained by the United States should enable it to draw even or even pull ahead by the end of this decade, provided present funding trends continue and flexibility is permitted to respond to operational field test findings and to directions set by the National IVHS System Architecture Program.

It will also be necessary for state and local governments to more fully embrace IVHS concepts in order for the United States to achieve and maintain the lead. Although top-down outreach efforts to this end are underway by the USDOT and IVHS AMERICA, it is concluded that these efforts should be supplemented by a bottom-up study of IVHS perceptions, needs, and concerns as seen by state and local agencies.

Comprehensive comparisons of the core technological competencies of Europe, Japan, and the United States could not be undertaken within the scope of this study. However, they are of fundamental importance in high-tech pursuits such as IVHS. Successful transfer of these capabilities to IVHS development is critical because of the multiplicity of technologies involved. Thus we also conclude that core technological competencies and the prospects for successfully transferring them to IVHS applications should also be compared to gain a better understanding of future expectations regarding international competitiveness in IVHS.

1.0 INTRODUCTION

The purpose of this study is to compare the relative progress in Intelligent Vehicle Highway Systems (IVHS) made by Japan, Western Europe, and the United States through 1993. IVHS progress is vital to each region's economy for two reasons:

1. National Benefits from Deployment IVHS has potential for ameliorating traffic congestion, improving traveler mobility and safety, improving air quality, and improving transportation productivity, among other social and economic benefits. Although not all benefits are yet fully understood, it is well established that benefits will accrue from improvements on both the demand side (e-g-, from electronic tolls and road pricing as well as from encouraging and facilitating transit use) and on the supply side (e.g., from traffic management, route guidance, and traveler information).

2. Emerging High-Tech Industry with International Markets The markets for IVHS-based products and services will become significant and fast growing for building and operating national infrastructures and for mobile products. Mobile IVHS products (e.g., route guidance systems, data communications equipment, and intelligent cruise control) may be especially important to international competitiveness in the electronics and automobile markets.

Our goals are to broadly assess past progress and current status, to provide a balanced and realistic comparison of IVHS progress in Europe, Japan, and the United States, and to identify the major factors that will influence IVHS progress in each region over the next several years.

1.1 Background

IVHS has received significant international attention for several decades, albeit under various other names. Interest intensified in the mid-1980s when major initiatives began to take shape in Europe and Japan for systematically researching and applying advanced technologies, including information processing, communications, positioning, and control, to help alleviate congestion, improve safety, and reduce the environmental consequences of road traffic.

The European and Japanese initiatives lent considerable impetus to similar U.S. interests that were beginning to coalesce in 1986. Arguments subsequently advanced by various U.S. groups for responding to the European and Japanese initiatives are summarized in Chapter 2, "Competitive Concerns."

The foreign initiatives enjoyed government as well as industry support and blossomed into full-blown programs, which underwent several stages of evolution by 1990, the year that the embryonic IVHS program was institutionalized with the formation of IVHS AMERICA (Intelligent Vehicle Highway Society of AMERICA). The need for such an organization was recognized by the U.S. Congress, the U.S. Department of Transportation (USDOT), the Highway Users Federation for Safety and Mobility (HUFSAM), American Association of State Highway and Transportation Officials (AASHTO), Mobility 2000, automobile and electronics companies, and other organizations.

IVHS AMERICA, which has become a leader in promoting international cooperation as well as principal architect of the U.S. program, is briefly described in Appendix A.

Now that the U.S. IVHS program has undergone several years of definition, planning, research, and field tests enabled by rapid growth in funding, it is inevitable that questions arise about how IVHS progress in the United States presently compares with Europe and Japan. For example, in conjunction with a hearing on IVHS conducted by the Transportation Subcommittee of the House of Representatives Committee on Appropriation during the IVHS AMERICA 1993 Annual Meeting, Congressman Frank R. Wolf (Virginia) asked questions (see Appendix B) such as:

> "How far behind foreign countries are we in the race to develop IVHS technology?
>
> "HOW does the U.S. compare to Japan in government support for IVHS?"

In response, IVHS AMERICA commissioned an international team of specialists to perform this study to answer these and similar questions asked by transportation professionals as well as by public administrators and politicians.

1.2 Approach

IVHS is an umbrella term for a still-growing collection of diverse but generally interdependent technologies and applications relating to the roadway transportation infrastructure and its operators, to individual vehicles and their operators, and (especially in the United States with its intermodal focus) to surface travelers in general whether they are planning a trip or are enroute. These categories, in turn, consist of numerous subcategories, not all of which are being pursued with equal interest or priority in Europe, Japan, and the United States.

As a result, when the question of who is ahead in particular categories or subcategories of IVHS is asked, the answer is

Europe and/or Japan in some cases and the United States in others. Developing comprehensive answers to such piecemeal questions would require considerable research beyond the scope of the present study, and the answers would not necessarily be additive to obtain a meaningful overall answer. Therefore we planned the following alternative approach:

1. Develop a comprehensive set of broad measures for comparing IVHS progress in the United States, Europe, and Japan.

2. Prioritize the measures and perform top-down comparisons.

3. Synthesize the results into mosaic-like portrayals of IVHS accomplishments, strengths, and weaknesses.

4. Based on the above steps, assess how vigorously and successfully IVHS is being pursued and exploited in each region.

We next compiled key information on each of the selected measures. The compilations are based on review of published information such as program documents, conference proceedings, the National IVHS Information Clearinghouse operated by IVHS AMERICA, and direct consultation between team members and IVHS leaders worldwide.

Other important resources included the reports of IVHS tours and missions by various groups of experts to Europe, Japan, and the United States. Highlights of reported findings are given in Chapter 3, "Earlier Assessments." These examples illustrate the evolution of international perceptions and show patterns of observation that are generally consistent, both with one another and with the findings of this study.

The project team members also drew heavily upon personal knowledge and information files resulting from their extensive but disparate backgrounds, which collectively touch upon many IVHS technologies, applications, and major programs activities (see Preface). The process of rounding out and melding their interpretations of IVHS progress in Europe, Japan, and the United States started with several exchanges of suggestions and planning ideas on the scope and approach for the comparisons.

The primary author then prepared and circulated partial drafts as "straw men" for various report topics. All team members reviewed and critiqued the partial drafts, supplied missing or corrected information, and suggested alternative or additional materials for the next version. As part of this process, the authors made special efforts to confirm their views of IVHS progress with knowledgeable and objective colleagues.

The drafting and reviewing process was carried through several iterations to build consensus and flesh out the final version of this report. As a final step, the report was reviewed and approved by the Executive Committee and the International Liaison Committee of the IVHS AMERICA Board of Directors.

1.3 Scope

The following broad measures were selected for assessment and comparison of IVHS progress through 1993:

* Early initiatives
* Contemporary developments
* Funding levels and sources
* Organization and roles
* Research and testing
* Systems architecture and standards
* Marketing and deployment
* Institutional and legal issues
* Planning

However, even with the extensive information resources available to the project team, the comparisons for the above measures are not uniform and complete in all aspects. For example, consistent comparisons of all relevant government funding are precluded by differences in national jurisdictional responsibilities, institutional practices, and the extent to which IVHS expenditures are delineated from other expenditures. At the same time, proprietary considerations prevent full access to information on IVHS expenditures by industry.

Thus, as explained by IVHS AMERICA Chairman of the Board Frederick T. Tucker in a preliminary response to Congressman Wolf's questions,

> "In our study, we will attempt to benchmark current and projected products in lieu of an investment analysis."

Although the scope of the study is limited to the United States, Europe, and Japan, we recognize that other countries and regions are also making progress in IVHS. For example, one of the earliest pilot tests of computer-operated traffic signals was performed in Canada in the mid-1960s, the well-known SCATS (Sydney Coordinated Adaptive Traffic System) for real-time traffic signal control was developed in Australia in the 1970s, and both Hong Kong and Singapore have made pioneering efforts towards road pricing.

We use the term "Europe" in its broadest sense. It refers to the European Free Trade Association (EFTA) with its member countries (Austria, Finland, Iceland, Liechtenstein, Norway, Sweden, and Switzerland) as well as the European Community (EC) with its 12 constituent countries (Belgium, Denmark, France, Greece, Germany, Ireland, Italy, Luxembourg, the* Netherlands, Portugal, Spain, and the United Kingdom). It also refers to EUREKA, the industrial research coordination initiative of 19 European countries including all of the above countries plus Turkey and the EC itself.

1.4 Nomenclature

The sudden emergence of IVHS as a major field of endeavor creates the illusion that IVHS is a new development, although some elements of IVHS have been well entrenched for decades. What is actually new is the use of new nomenclature and broad programmatic umbrellas for promoting the improvement of road transportation efficiency and safety through the use of computer, communication, positioning, and automation technologies.

What has been known as IVHS since 1988 in the United States and certain other countries (e.g., Canada and Australia) is known in other parts of the world by an expanding number of alternative terms with closely related meanings. The newest alternative term for IVHS is Transport Information and Control Systems (TICS), the name selected for ISO/TC-204, an International Standards Organization Technical Committee that was recently established to address IVHS standards at the international level (see Section 6.4). Table 1.1 lists the principal names now in use.

The confusion brought by the still evolving variety of names for IVHS is exacerbated by the use of different sets of inconsistent categories defined within each. We use generic descriptions for categories where applicable in this report. Otherwise, the category names reflected by the committee structure of IVHS AMERICA are used. Table 1.2 lists the IVHS AMERICA categories and gives examples. Appendix C further describes and discusses each category.

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* The entry into force of the Maastricht Treaty on European Union on November 1, 1993 has introduced changes in the terminology regarding the European Community and some of its institutions. Although the EC continues to exist as a legal entity within the broader framework of the European Union (EU), the term EU is rapidly supplanting EC in common usage.

Table 1.1 Alternative Terms for IVHS

Region	Acronym	Full Name
United States	IVHS	Intelligent Vehicle Highway Systems
Europe	RTI ATT	Road Transport Informatics Advanced Transport Telematics
Japan	VERTIS VICS SSVS UTMS ARTS ASV	Vehicle, Road & Traffic Intelligence Systems Vehicle Information & Communication System Super Smart Vehicle System Universal Traffic Management System Advanced Road Traffic Systems Advanced Safety Vehicle
ISO	TICS	Transport Information and Control Systems

Table 1.2 IVHS Categories and Typical Examples

Categories	Examples
Advanced Traffic Management Systems (ATMS)	• Adaptive Traffic Signal Control • Electronic Road Pricing & Toll Collection
Advanced Traveler Information Systems (ATIS)	• Vehicle Navigation & Route Guidance • Geocoded Directory & Intermodal Info
Advanced Vehicle Control Systems (AVCS)	• Intelligent Cruise Control • Lane Following & Collision Avoidance
Commercial Vehicle Operations (CVO)	• Fleet Dispatch & Management • Dynamic Weight & Classification Sensing
Advanced Public Transportation Systems (APTS)	• Automatic Location & Schedule Monitoring • Real-Time Transit, Ride Share, HOV Info
Advanced Rural Transportation Systems (ARTS)	• Weather & Road Surface Condition Info • Automated "Mayday" Systems

Table 1.3 IVHS User Services

No.	Service	IVHS Categories					
		ATIS	ATMS	CVO	APTS	ARTS	AVCS
1.0	Pre-Trip Travel Information	x					
2.0	En Route Driver Information	x					
3.0	En Route Transit Information	x					
4.0	Traveler Services information	x					
5.0	Route Guidance	x					
6.0	Ride Matching and Reservation	x					
7.0	Incident Management		x				
8.0	Travel Demand Management		x				
9.0	Traffic Control		x				
10.0	Electronic Payment Services		x	x		x	
11.0	Commercial Vehicle Preclearance			x			
12.0	Automated Roadside Safety Inspections			x			
13.0	Commercial Vehicle Administrative Processes			x			
14.0	On-Board Safety Monitoring	x		x			
15.0	Commercial Fleet Management			x			
16.0	Public Transportation Management				x		
17.0	Personalized Public Transit				x		
18.0	Emergency Notification and Personal Security	x		x	x	x	
19.0	Public Travel Security	x			x	x	
20.0	Emergency Vehicle Management			x		x	
21.0	Longitudinal Collision Avoidance						x
22.0	Lateral Collision Avoidance						x
23.0	Intersection Collision Avoidance	x	x				x
24.0	Vision Enhancement for Crash Avoidance						x
25.0	Safety Readiness	x					x
26.0	Pre-Crash Restraint Deployment						x
27.0	Automated Highway System						x

Although the ATMS, ATIS, AVCS, CVO, APTS, and ARTS terminology is well-entrenched in the United States, a new IVHS taxonomy based on the 27 specific user services listed in Table 1.3 is being used by the U.S. Department of Transportation for the National IVHS Program Plan currently under development (USDOT 1993). As indicated in Table 1.3, some of the user services involve two or more of the IVHS categories.

1.5 Report Organization

Chapter 2, "Competitive Concerns," recounts concerns about international competition that were expressed by various organizations during the early stages of the present U.S. IVHS program. Chapter 3, "Assessments by Others," contains additional background in the form of highlights from expert reports on international visits of IVHS activities in Europe, Japan, and the United States from 1988 through 1993.

Chapter 4, "Early Initiatives: 1960-1985," describes selected developments relating to IVHS that occurred in the United States, Europe, and Japan during this formative period when solid-state electronics and, ultimately, microelectronics, began to find applications in virtually all aspects of road vehicle transportation operations. The institutional and technological foundations are thus set for understanding the subsequent IVHS boom described in Chapter 5, "Contemporary Developments: 1985-1993."

Chapters 4 and 5 also establish an important contextual framework for Chapter 6, which broadly reexamines earlier initiatives and contemporary developments in terms of funding, organization, research and testing, systems architecture and standards, marketing and deployment, institutional and legal issues, and planning. The overall results of the study are summarized and conclusions are drawn in Chapter 7, "Findings and Conclusions."

A glossary of acronyms and terms is included. Several resource documents and key references are incorporated as appendices.

2.0 COMPETITIVE CONCERNS

There is a general perception that Europe, Japan, and the United States are racing to prepare for the international markets envisioned for IVHS products once their internal IVHS issues are resolved. In fact, the United State's IVHS program was mandated by Congress in 1991 partly in response to arguments that it would be entirely dependent on foreign developments unless such a program was established.

This section gives excerpts of some of the observations and concerns that were expressed about international competitiveness by various organizations during the formative stages of the United States' National IVHS Program.

2.1 Mobility 2000

The genesis of the IVHS program in the United States may be attributed largely to Mobility 2000, the ad *hoc* predecessor of IVHS AMERICA that started meeting in 1988 to define and suggest a national cooperative program to advance the development and application of advanced technologies to road transportation (Saxton 1993, included as Appendix D). The influence of the head start in Europe and Japan on Mobility 2000 is clearly stated in the proceedings of a workshop held in 1989 (TTI 1989):

> "The work of Mobility 2000 is also stimulated by the awareness that both Europe and Japan have major projects.
>
> "While the European and Japanese programs address local problems, they also are intended to achieve superiority in international competition for supplying the components required for IVHS. Unless the United States establishes an active IVHS program, it will be entirely dependent on foreign developments."

2.2 U.S. Office of Technology Assessment

Similar sentiments were expressed in a 1989 report entitled *Advanced Vehicle/Highway Systems and* Urban Traffic Problems which was issued by the U.S. Office of Technology Assessment following an in-depth study of IVHS (OTA 1989):

> "The size of this potential market and the strong priority given [IVHS] abroad raise concern that the United States will lose out in developing and producing transportation electronics products unless steps are taken soon...
>
> [IVHS] activity in many other countries is better organized and coordinated and has greater government and private sector support than in the United States, in

large part because of severe urban traffic congestion problems caused by increased automobile ownership and old urban road systems built to handle far fewer cars."

2.3 U.S. Department of Transportation

Moving America, the 1990 Statement of National Transportation Policy by the U.S. Department of Transportation, continued the refrain (USDOT 1990):

> "In Europe and Japan, government agencies and private companies are working together to develop IVHS technologies. To match those initiatives and realize the safety and efficiency benefits of IVHS in the United States will take substantial investment in both vehicles and the roadways they use, as well as major operational and institutional change."

2.4 U.S. General Accounting Office

In a 1991 study of "Smart Highways: An Assessment of Their Potential to Improve Travel," the General Accounting Office reported that (GAO 1991):

> "Interest and support for IVHS has been increasing dramatically in the last few years. For example, a current European effort called PROMETHEUS plans to devote $750 million to IVHS over an 8-year period. Japan has also initiated major IVHS efforts. In the United States, IVHS has only begun to emerge as an area for federal policy action...
>
> "While ATIS systems are very recent in the United States, these systems have been studied more extensively in Europe and Japan."

2.5 Transportation Research Board

Advanced Vehicle and Highway Technologies, the 1991 report on a two-year policy-oriented IVHS study by the Transportation Research Board, observed that (TRB 1991):

> "Well-funded and -organized public-private European and Japanese IVHS programs compared with the heretofore diffuse U.S. efforts have inevitably attracted the attention of policymakers to IVHS. Active foreign research and development programs have raised concern that the United States may be left behind in an international race to devise standards and technical guidelines, which could affect the competitive position of U.S. firms."

2.6 U.S. Congress

Section 6052 (b) (1) of the Intelligent Vehicle-Highway Systems Act incorporated in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) passed by the U.S. Congress included as one of its goals:

> "The enhancement of United States industrial and economic competitiveness and productivity by improving the free flow of people and commerce and by establishing a significant United States presence in an emerging field of technology."

2.7 Library of Congress

Finally, a study of IVHS challenges, constraints, and federal programs by the Congressional Research Service of the Library of Congress (CRS 1992) commented on the international competitiveness implications of the rapid buildup of IVHS funding from only a few million in 1989 to well over $200 million for FY 1992:

> "These funds will provide a strong initial push for exploring the vision of IVHS, and also allow the United States to be a major player in the international IVHS arena. Various European nations as well as Japan have been heavily investing in IVHS technologies since at least the mid-1980s.
>
> "Investment in IVHS contributes to a strong technology base for this Nation and enhances our ability to compete in the international IVHS arena and cooperate with foreign IVHS initiatives, which have been more aggressively funded than U.S. efforts. The domestic deployment of IVHS would also contribute to market growth and a U.S. position in IVHS Technology."

3.0 PREVIOUS ASSESSMENTS

The following are highlights of assessments and observations of IVHS progress reported by a number of professional study missions among Europe, Japan, and the United States during the last five years. Although some of the prior assessments may be partially out of date, they are included to show the evolution of perceptions of international competitiveness. Overall, the prior assessments are generally consistent with with one another and with the findings of the present study.

3.1 JSK Association

In the report on an "International Survey of Automobile Information and Communication System" (sic) performed in 1988 by a mission of experts to Europe and the United States sponsored by JSK (a Japanese foundation associated with the Ministry of International Trade and Industry), it was observed that (JSK 1989):

> "Among overseas manufacturers, in particular, auto manufacturers in Europe, there are no outstanding manufacturers in scale. Therefore, basic research of future-oriented vehicle technology needs to be jointly made. This will require much money and many researchers. Under these circumstances, it is natural that the PROMETHEUS program, which is a multilateral joint research program...has been generated.
>
> Parallel to the PROMETHEUS program, the DRIVE program, which is a multilateral joint research program led mainly by governments in Europe, has also begun to be executed. It should be noted that the public and private sectors are trying to approach the basic research with the PROMETHEUS project from the vehicle side and the DRIVE project from the ground infrastructure, keeping in contact with each other, in order to accomplish the same object of improving the safety and efficiency of vehicle transport.
>
> "As for the development/penetration of vehicle information systems including a navigation system; the philosophies of the U.K. and West Germany contrast with each other. That is, the U.K. has a philosophy that the public sector mainly promotes research and development, but the private sector makes most of the system arrangement and operation in the stage of putting it [to] practical use... On the other hand West Germany has a philosophy that the public sector mainly promotes research and development/putting to practical use and penetration, based on IDSKIV concept which is a basic concept of traffic control, and also makes ground system arrangement and operation."

Recently, in support of the present comparison study of IVHS progress, JSK officials informally surveyed five Japanese IVHS experts to obtain their opinions on whether Japan or the United States is ahead on R&D and deployment in 28 selected IVHS technology and application areas. In consolidating the results, JSK placed extra weight placed on the opinions of those experts who are most knowledgeable in the individual areas.

Table 3.1 lists the consolidated results. For the 28 selected areas compared, the JSK survey indicates that Japan is ahead in R&D in 14 areas and ahead in deployment in 19 areas whereas the United States is ahead in 12 R&D areas and in 8 deployment areas. Japan and the United States are even in 12 R&D areas and in 11 deployment areas according to the JSK expert opinion survey.

3.2 DRIVE SECFO

In 1991, the SECFO (Systems Engineering and Consensus Formation Office) project of DRIVE sponsored a fact-gathering tour to Japan and the United States. The observations reported by SECFO leader Tage Karlsson regarding Japan included (Karlsson 1991):

> "Today the objective of the Traffic Control Centers has been expanded from Signal Control to Total Traffic Management, with the purpose to better utilize the substantial information gathered by the Control Centers.
>
> "To deserve to be called Total Traffic Management, it should also include some degree of Driver Information. There are already a number of Driver Information in Japan like Parking Guidance showing the occupancy on roadside displays, Expressway Congestion Displays at the entrances and on the Metropolitan expressways and Roadside Radio from a coaxial cable along road sections.
>
> "There are some 5000 - 6000 top level vehicles per month, i.e., about 1% of the total sales, sold in Japan, which have map matching navigation devices installed on the assembly line... The explanation of this early massive acceptance of navigation devices by the car makers, without knowledge of the customers attitudes, may be, that a high degree of these top class cars are for company Presidents and other high executives with drivers and frequent needs to go to various places by car in these economically extremely dense metropolitan areas. Another reason is probably the confidence given to the automotive manufacturers, because of the agreed upon Introduction Strategy for Navigation Systems."

Table 3.1 JSK Comparison of IVHS Technology Status in Japan and the United States

Category/Technology	Ahead in R&D	Ahead in Deployment
<u>Vehicle Detectors</u>		
-Ultrasonic	Japan	Japan
-TV Camera	United States	Japan
-Optical	*	Japan
-Loop	Japan	Japan
-Satellite	*	*
-Software	Japan	Japan
<u>ATMS Communication</u>		
-Wire Cable	*	*
-Wireless	United States	United States
-Optical Fiber	United States	Japan
<u>Traffic Management Center Display</u>	Japan	Japan
<u>Traffic Control</u>		
-Signal Control	Japan	Japan
-Ramp Control	United States	United States
-Booth Control	*	*
-Lane Control	United States	United States
<u>ATIS Communication</u>		
-Telephone	United States	United States
-Optical	United States	*
-Microwave	Japan	Japan
-Software	*	Japan
<u>Terminal</u>		
-Variable Signs	Japan	Japan
-PC Terminal	United States	*
-Phone Terminal	United States	United States
<u>Database</u>		
-Digital Maps	*	Japan
-Motorist Info.	United States	United States
<u>Route Guidance</u>		
-Static Software	Japan	Japan
-Dynamic Software	Japan	*
<u>In-Vehicle Equip.</u>		
-Speed and Direction Sensor	*	Japan
-Gyro, GPS	Japan	Japan
-Display	Japan	Japan

Table 3.1 JSK Comparison of IVHS Technology Status in Japan and the United States (cont'd)

Category/Technology	Ahead in R&D	Ahead in Deployment
Automatic Vehicle Control		
-Collision Protection	*	*
-Adaptive Cruising	Japan	*
-Platooning	United States	United States
-Vision Assistance	United States	United States
-Driving Assistance	*	*
-Distance Warning	*	Japan
Commercial Vehicle Operations (Control & Managment)		
-Bus Fleets	Japan	Japan
-Truck Fleets	*	*
-Taxi Fleets	Japan	Japan
-Emergency Vehicle Fleets	*	*

* Japan and the United States are approximately even.

3.3 Technology Transfer Institute

An IVHS study mission to Japan was organized in 1991 by the Technology Transfer Institute, a private organization established in Japan to facilitate technical interchange. Observations reported by Robert E. Ervin, University of Michigan, who directed the study team included (Ervin 1991):

> "The state of traffic congestion in Japan provides the most obvious reason for the accelerated pace of IVHS development... Accordingly, IVHS in Japan springs very much from a 'demand-pull' phenomenon following upon an enormous commitment to traffic management since 1970. Indeed a Japanese infrastructure for automated driver information systems can be readily deployed precisely because so much of the traffic surveillance and control system has already been built to deal with congestion.
>
> "Especially in the imminent deployment of a system for communicating traffic data in real time, Japan appears to be well ahead of other regions of the world. In its near implementation of active safety technology within the vehicle, Japan is at least in line with the European timetable and far ahead of any expected market in the U.S.
>
> "IVHS development has been carried forward as an unbroken process since 1972... The continuity sustained over twenty years reveals one widely-held conviction; namely, that the IVHS paradigm is both basically sound and highly significant to the future of automotive transportation."

3.4 Institute of Transportation Engineers

The report of a professional tour of European IVHS activities conducted in 1991 by the Institute of Transportation Engineers noted (ITE 1991):

> "Review of the more conventional traffic management systems in place in the greater London area, as well as in the other countries visited, reveals that the techniques employed and the hardware used are similar to those typically found in the United States.
>
> "The private industrial cooperation regarding IVHS certainly has a considerable head start on the United States, due to the PROMETHEUS program. The government-sponsored DRIVE program also provided for the government sector to maintain a leadership role in the IVHS program. In both areas, estimates still vary as to the time leadership in IVHS compared to the United States. Perhaps a three years lead is a better estimate at this time, although the United States appears to be closing fast with the leadership of IVHS AMERICA. There seems to

be a tremendous spirit for advancing research on new technology regarding transportation solutions in Europe, perhaps because the congestion problems are so severe in so many areas. In addition there seems to be an urgency in promoting common traffic control mechanisms across the continent, especially with the realization of the European Community."

A similar ITE study tour to Japan in 1992 yielded the following key observations (ITE 1992):

"IVHS coordination in Japan is achieved on a project-by-project basis, in the absence of any apparent, national, long-range strategic planning effort. There are many different national agencies involved in IVHS... Although there are several major efforts that are being jointly coordinated by combinations of these agencies, there is no formal, institutional association among them (such as IVHS AMERICA in the United States).

"Notwithstanding the lack of a specific plan, Japan is moving inexorably toward the Automated Highway System. The Japanese approach of incremental advancement of technical accomplishments results in a steady convergence of vehicle and roadway technology into an overall automated highway. Though there is no 'strategic plan' per se, there is very definitely a strong sense of the inevitability of this convergence.

"Electronic toll collection and automated ramp metering do not appear to be of significant interest in Japan... However, it appears that congestion is so pervasive on the expressways that the existing manual toll collection system itself acts as a ramp metering system. There also appear to be labor implications which the Japanese are not inclined to take on at the current time."

3.5 IVHS AMERICA

William M. Spreitzer of General Motors participated in an IVHS AMERICA study mission to Europe in 1991 and reported (Spreitzer 1991):

"Our general observations are that efforts in Europe and North America are more alike than they are different... Significant questions remain as to...the relative responsibilities of the many partners - both public and private... Europe has had greater initiative from industry and appears further along in studies of standards and institutional issues... Consultants appear to have a greater influence in European activities than in North America, while academic-based interests have played larger roles in North America programs."

The report of an IVHS AMERICA mission to Japan in 1992 observed (IVHSA 1993):

> "The principal reason that Japan has made the impressive progress it has in IVHS is that the Japanese decided in the 1950s that, primarily because of the lack of space, highway congestion, pollution and safety problems could not be solved solely by building more roads. Instead, they chose to 'marry' information and communications technologies to the infrastructure.
>
> "The delegation learned that coordination and liaison between the many Japanese IVHS-related programs and the associated ministries, industries and other entities is often a complex process... Japanese officials expressed the opinion that there isn't any umbrella organization or body that could view IVHS from an overall perspective. The fragmentation of responsibility is the reason that a cohesive vision of IVHS hasn't emerged...
>
> "Although a national IVHS organization - such as IVHS AMERICA - does not exist in Japan, public-private coordination is nevertheless accomplished through several associations created to provide an industry-government interface for coordination and to carry out joint research."

3.6 UK Transport and Road Research Laboratory (TRRL)

A 1991 TRRL report on a professional visit to Japan by W. J. Gillan included the following observations (Gillan 1991):

> "On the economic front Japan is interesting because it appears not to conform to economic orthodoxy. Japanese Ministries compete between themselves and have access to a variety of funds, some of which do not come via the Ministry of Finance, and some which are hypothecated and outwith its control. There is also expenditure which would count as public expenditure in the UK but does not appear in Government Accounts.
>
> "The rapid growth in the number of vehicles has produced road congestion on a scale and severity which is much worse than anything seen so far in the UK... Traffic management equipment technology is impressive, and there are some major systems, such as the UTC system which controls 6,000 signals in Tokyo. The management strategies are complex and well thought out...
>
> There is considerable interest and activity in driver information systems, largely based on navigation..."

3.7 England Department of Transport

In 1992, following a three-month sabbatical spent visiting IVHS activities in the United States and Japan, John C. Miles, Director of the London Traffic Management Division reported the following observations (Miles 1993):

> "The British traffic control software, SCOOT, is more advanced than comparable systems currently running in Japan and USA... However, SCOOT is not as user-friendly as some other traffic control systems. In particular SCOOT is facing tough competition in North America from the Australian system, SCATS. SCOOT would benefit from an interface with a good graphics package such as that developed for ATSAC in Los Angeles. Both Japan and USA have started to develop systems which will rival SCOOT and further competition in export markets can be expected in a few years time.
>
> "The latest in-car navigation units from Toyota and Honda are very good indeed... One can expect the Japanese to market these products in Europe as soon as digital road-maps become available... In Japan, the Ministry of Construction took the lead in co-ordinating the exercise to develop a digital road-map database for the entire country. This was a major undertaking which is now self-financing through a specially constituted consortium of public and private organizations.
>
> "Europe is at risk of losing to North America the lead it once held in the development of dynamic route guidance systems. US Federal agencies are providing 50 percent (or better) of the funding for three projects (TravTek, Fast-Trac, and ADVANCE) that use concepts that were central to the London Autoguide project which was aborted.
>
> "In IVHS AMERICA the USA has a very effective means of coordinating a national programme of research and development work into Advanced Transport Telematics. IVHS AMERICA acts as a champion for Intelligent Highway-Vehicle Systems, at arms length from government, but with the full participation of State and National Agencies."

4.0 EARLY INITIATIVES: 1960-1985

Meaningful comparisons and interpretations of the present status and directions of the IVHS movements in the United States, Europe, and Japan require consideration of the paths taken along the way. Thus we start with a comparison of early IVHS initiatives leading up to the year 1985, arguably the threshold of the present era of IVHS progress.

Prior to 1985, IVHS already had an extensive background in Europe, Japan, and the United States, some of which dates back to the 1960s (Saxon 1993) and even earlier. In the United States, for example, numerous automatic in-vehicle route guidance devices based on mechanical principals were patented and a few were actually put on the market around 1910 before reliable road signs and paper maps were widely available (French 1986). Automated highway and vehicle control concepts were featured by the General Motors pavilion at the 1939 World's Fair, long before concerted research studies got underway in the 1960s.

Figure 4.1 shows selected activities that are broadly indicative of developments relating to IVHS that occurred in the United States, Europe, and Japan during the 25-year period that immediately preceded the boom which started around 1985. It was during this formative period that solid-state electronics, and ultimately microelectronics, began to find applications in virtually all aspects of road vehicle transportation operations. The conceptual and technological foundations were thus set for the present worldwide IVHS efforts.

4.1 United States

Freeway Surveillance and Control Systems (FSCS) were one of the earliest widespread applications of IVHS in the United States. A pioneering example is the FSCS installed in 1961 for Chicago-area expressways (IH 1991). It has since grown to cover 118 miles of freeway with 1800 vehicle detector locations, 95 ramp controls, and 12 changeable message signs, all supervised from a Traffic Systems Center (TSC). One of the earliest examples of controlling signal lights in a central business district by a single computer was the IBM 1800 Data Acquisition and Control System (DACS) installed in Wichita Falls, Texas, in 1966 (Wilshire 1990).

In the late 1960s and early 1970'S the UTCS (Urban Traffic Control System) project of the FHWA researched and demonstrated computer-based traffic control based on selection from a family of precomputed signal timing plans (Saxton 1993). The Los Angeles Automated Traffic Surveillance and Control System (ATSAC) installed in 1984 was the first to integrate vehicle detectors, closed-circuit TV

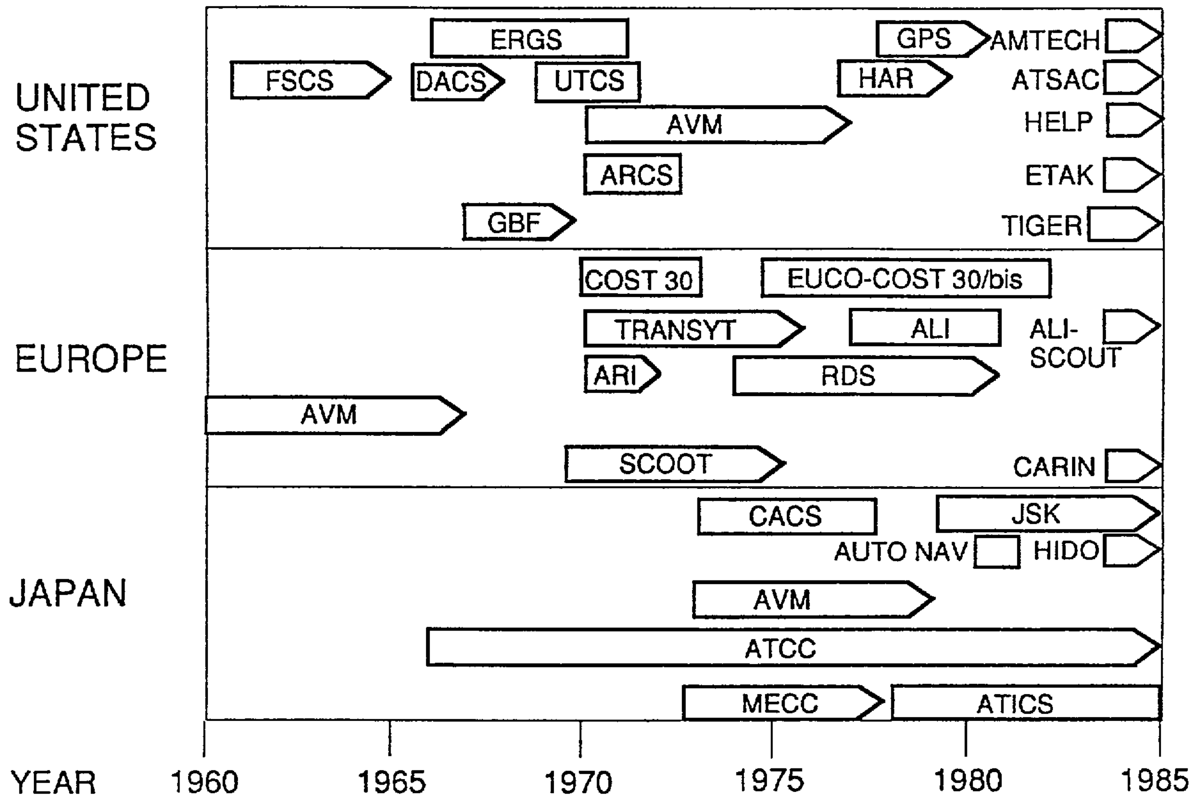


Figure 4.1 Early IVHS Initiatives

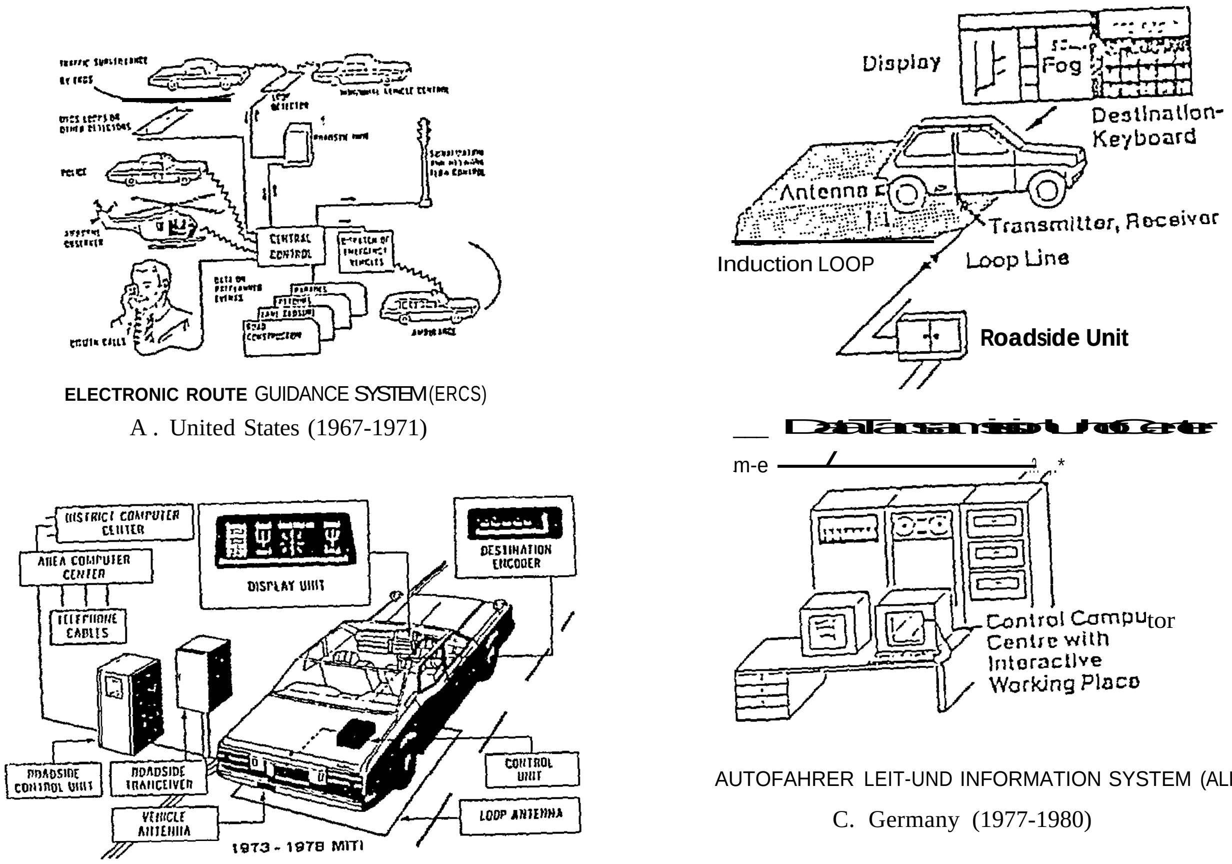
surveillance, automated generation of new traffic signal timing plans, and computer-controlled signals in a single, large-scale system (Rowe 1987). ATSAC was found to reduce stops by 35%, intersection delay by 208, travel time by 13%, fuel consumption by 12.5% and air emissions by 10%.

One of the most widely known early IVHS efforts was the Electronic Route Guidance System (ERGS) researched by the FHWA's predecessor, the Bureau of Public Roads, in the late 1960s (Rosen et al 1970). The ERGS concept included in-vehicle display of route guidance instructions based on two-way data communications with roadside units when passing strategically located intersections as illustrated in Figure 4.2.A. The roadside unit, in turn, communicated with a central computer to obtain routing instructions that reflect real-time traffic conditions.

Other early IVHS-related projects of the FHWA included a system to signal a driver whether it was safe to pass a vehicle, a system for reporting disabled vehicles, and research toward developing a fully automated highway system. Few of these projects proceeded beyond conceptual evaluation, and most, including ERGS, failed to gain government policy and funding support for continued development during the 1970s (Saxton 1993). Changes in the administration in the early 1980s brought further opposition to advanced research activities such as IVHS. Thus, with exception of modest research activities and low-budget developments (e.g., Highway Advisory Radio CHAR]) the FHWA's IVHS pursuits were essentially dormant from 1971 until the late 1980s.

In the meantime, the Urban Mass Transit Administration (UMTA, now Federal Transit Administration) started a series of automatic vehicle monitoring (AVM) experiments and trials in 1970 that continued into the early 1980s (UMTA 1991). The major objective was to evaluate a number of alternative positioning technologies (e.g., dead reckoning, proximity beacons or "electronic signposts," pulse trilateration, Loran-C, etc.) for tracking transit bus location from a central dispatch office. However, there was relatively little follow-up during the 198O's a particularly difficult period for transit.

Also in the fleet management area of IVHS is the HELP (Heavy Vehicle Electronic License Plate) project originated in 1984 by a consortium of states stretching from Texas to British Columbia to explore the effectiveness of an integrated monitoring and communication network to facilitate the institutional and regulatory as well as commercial aspects of heavy vehicle management (Walton 1992). HELP is the longest-running IVHS project in the United States and is now in its "Crescent" demonstration phase along a corridor through the western coastal states and the southwestern border states.



ELECTRONIC ROUTE GUIDANCE SYSTEM (ERCS)

A. United States (1967-1971)

Comprehensive Automobile Control System (CACS)

B. Japan (1973-1978)

AUTOFAHRER LEIT-UND INFORMATION SYSTEM (ALI)

C. Germany (1977-1980)

Figure 4.2 Early Route Guidance Research and Test Projects

Sources: A (Rosen et al. 1970)
B (Yumoto et al. 1979)
C (Braegas 1980)

Although the Global Positioning System (GPS) was not originally associated with IVHS, GPS development was initiated by the U.S. Department of Defense (DOD) in the mid-197Os, and the first test satellite was launched in 1978. However, now that GPS is operational and receivers are affordable for civil applications, GPS is seen as having numerous IVHS applications including vehicle navigation and location monitoring, perhaps the largest of all presently identifiable potential markets for GPS receivers.

Another early U.S. development that, in retrospect, helped pave the way for IVHS was the GBF/DIME (Geographic Base File/Dual Independent Map Encoding) project of the U.S. Bureau of the Census (Silver 1977). The first digital street maps were created in the late 1960s for processing census data.

Although the accuracy and completeness of GBF\DIME were not adequate for automobile navigation, the resulting map encoding concepts are now widely used for road map databases in automobile navigation and route guidance systems as well as in traffic management centers and fleet dispatch offices. GBF/DIME was replaced in the late 1980s by a new version called TIGER that, although upgraded and extended, was still unsuitable for automobile navigation. Thus unlike Europe and Japan, both of which have some form of digital map consortia, the development of digital road maps for automobile navigation in the United States is left to individual companies.

Map matching, an artificial-intelligence-like software technology used to detect position errors and to reconcile vehicle position with digital road maps, originated in the early 1970s (French 1989). It was originally developed for ARCS (Automatic Route Control System), an autonomous route guidance system that directed a vehicle over newspaper routes and signaled for a newspaper to be tossed when passing each subscriber house (French and Lang 1973).

In 1984, Etak, Inc. announced the NavigatorTM the first commercially available autonomous navigation system based on dead reckoning with map matching. Etak's Navigator, which later figured in the PATHFINDER operational field test, was the basis for "Travelpilot," an enhanced version introduced in Europe in 1989 and in the United States in 1991 by Bosch/Blaupunkt of Germany (Buxton et al 1991).

Automatic Vehicle Identification (AVI), an enabling technology for electronic toll collection systems, also dates back more than 20 years to developments at Los Alamos Scientific Laboratory.

4.2 Europe

The idea of technological cooperation among European countries on electronic aids for traffic first appeared in a 1969 European Community report (EC 1981). Specific technological cooperation was suggested with the objectives of improving road network operation and making the most effective use of European industrial resources in the field of traffic control.

A follow-on study, started in 1970 as Project 30 under COST (European Cooperation in the Field of Scientific and Technical Research), concentrated on means for communicating information to drivers. It was concluded that full-scale public demonstrations were needed to compare effectiveness of in-vehicle visual displays, in-vehicle spoken messages, and variable external message signs for communicating information to drivers. However, concern with the funding that such demonstrations would require led to further studies to define in more detail what could be expected of electronic aids.

The final report concluded that a demonstration project on variable external message signs should be pursued and recommended further cooperative research on the use of microelectronics in road/vehicle communication. Additional phases of COST 30 carried out 1980-84 as EUCO-COST 30/bis included both the recommended demonstration project and road/vehicle electronic communication research (EC 1985).

A one-year demonstration of electronic traffic aids was conducted on 10 kilometers of national highway in the Netherlands. It included traffic detection loops, overhead variable message signs, meteorological stations, and TV cameras along with terminals and a central computer and monitoring station. The demonstration showed that timely information on accidents, congestion, weather, road conditions, etc. presented to motorists on the variable message signs reduced accident rates by 23.6 percent, reduced journey times significantly, and improved traffic flow.

The final COST 30/bis research project on road/vehicle electronic communication recognized worldwide trends and progress toward intelligent in-vehicle navigational aids and recommended digital radio transmission to provide traffic updates to in-vehicle route guidance equipment. This recommendation led to the original interest in what has since evolved as RDS-TMC. Further cooperative work was recommended to ensure that the considerable amount of research and development already underway on vehicular route guidance and information systems did not lead to incompatible systems.

Early IVHS activities also occurred at the national level in Europe. These include the UK's development of TRANSYT, an off-line traffic signal timing optimization program

(Robertson 1968). The UK also developed SCOOT, a vehicle-responsive traffic signal control system that was found to reduce traffic delays by 12 percent compared to fixed-time signal controls (Hunt et al. 1981).

A German example is the AL1 (Autofahrer Leit-und Informationsystem) route guidance system that was tested on the autobahn in the late 1970s (Braegas 1980). ALI, which was developed jointly by Bosch/Blaupunkt and Volkswagen, used inductive loops to both detect and communicate with in-vehicle equipment in a system approach similar to that of the ERGS project in the United States (see Figure 4.2.C). AL1 was subsequently merged with the AUTO-SCOUT project of Siemens in ALI-SCOUT, a route guidance system subsequently used in the LISB field test in Berlin in the late 1980s and in the current FAST-TRAC project in Oakland County, Michigan.

Autonomous navigation and route guidance systems were also under development in Europe as the mid-1980s arrived. For example, Philips was developing CARIN (Car Information and Navigation System), the first autonomous route guidance system to use digital maps stored on CD-ROM. Later versions of CARIN were to figure in IVHS operational field tests in Europe (e.g., SOCRATES).

Early European developments relating to IVHS communications include ARI (Autofahrer Rundfunk Information), an analogue traffic information broadcasting system that uses FM sideband, and RDS (Radio Data System), which transmits a variety of digitized information on FM sideband.

4.3 Japan

Following pilot studies in 1968, the National Police Agency (NPA) of Japan embarked on the development of Area Traffic Control Centers (ATCC in Figure 4.1) which, starting with Tokyo in 1970, have since been installed in 74 major cities under a series of 5-year programs. The capabilities of the centers were enhanced as the result of the 8-year ATICS (Automobile Traffic Information and Control System) R&D project started in 1978 by the Japan Traffic Management Technology Association under NPA auspices. In addition to enabling signal optimization and the operation of variable message signs, the real-time traffic information maintained by these centers provides a resource for communicating traffic data to automobile navigation and information systems.

As indicated in Figure 4.1, the Metropolitan Expressway Control Center (MECC) was installed in 1973. It was followed by the Keiyo Expressway Control Center in 1977. In the meantime, AVM (Automatic Vehicle Monitoring) as well as AVCS (Automatic Vehicle Control Systems) projects were being pursued in Japan.

Starting in 1973, the Ministry of International Trade and Industry (MITI) sponsored CACS (Comprehensive Automobile Traffic Control System), a 6-year route guidance research project (Yumoto 1979). CACS used inductive loops for digital communications between equipped vehicles and the roadside somewhat like the earlier ERGS project in the United States (see Figure 4.2.B). However, unlike ERGS (which was tested at only two intersections), CACS infrastructure was established throughout a 28-square kilometer area that was used for trials involving 330 test vehicles and 1,000 probe cars.

The CACS operational trial, along with related computer modeling, confirmed the efficacy of dynamic route guidance and led to MITI's establishment of the JSK Association (Association of Electronic Technology for Automobile Traffic and Driving) in 1979 to promote the introduction of in-vehicle route guidance information systems. Since then JSK has continued as a major player in researching both technical and sociological aspects of IVHS.

Japan Highway Public Corporation started research work in 1977 on travel time estimation based on AVI technology established by CACS and vehicle detectors along the highway between Tokyo and Chiba. Based on this research, the current system displays the travel time over alternative routes between Tokyo and Chiba on changeable message signs.

In 1981, shortly after CACS and JSK's initial promotion of IVHS, Honda, Toyota, and Nissan introduced the first automobile navigation systems available as factory options (see AUTO NAV in Figure 4.1). Although these pioneering systems could only give the approximate direction and distance to a destination, they served to establish sensing techniques that are still used in some of the sophisticated models now on the market in Japan (see Appendix L).

The Highway Industry Development Organization (HIDO) was established under the auspices of the Ministry of Construction in 1984 to research, investigate, and develop new industrial fields related to highways. One of HIDO's early actions was to form a Car Communications Committee which coordinated plans for the Road/Automobile Communication System (RACS) program which led to field trials of navigation and alternative mobile communications systems starting in 1986.

5.0 CONTEMPORARY DEVELOPMENTS: 1985-1993

This chapter compares representative highlights and major accomplishments that occurred in the United States, Europe, and Japan from 1985 through 1993. In addition to characterizing and comparing overall progress, this chronological overview of contemporary developments also establishes context for the individual measures discussed in the following chapter.

Figure 5.1 shows selected highlights that are broadly indicative of IVHS developments that occurred in the United States, Europe, and Japan from 1985 through 1993. The following paragraph discuss developments during three sub-intervals: 1985-1987, 1988-1990, and 1991-1993.

5.1 New Foundations: 1985-1987

Many of the present IVHS programs, particularly in Europe and Japan, began to take shape during this three-year period. It was also the period during which the United States began serious, albeit informal, steps towards establishing an IVHS program. Table 5.1 lists selected highlights of developments in Europe, Japan, and the United States for 1985-1987. These and others are discussed in the following paragraphs.

5.1.1 Europe

In 1985, a top-down IVHS feasibility study with roots in aerospace systems engineering was sponsored by the Swedish National Road Administration in conjunction with other public and private Swedish organizations. Called ARISE (Automobile Road Information System Evolution), the study was the first to comprehensively address IVHS from the vehicular point of view (see Appendix D). The ARISE project was the basis for a subsequent Delphi study conducted by the International Institute for Applied System Analysis (IIASA) in Austria. The IIASA Delphi study forecast market penetration of future IVHS functions and stimulated similar Delphi studies performed later by the FHWA and the University of Michigan in the United States.

EUREKA, established in 1985 for European technological cooperation to increase productivity and strengthen global competitiveness, has had a major role in European IVHS projects. EUREKA projects are originated in a bottom-up approach that requires the involvement of at least two organizations from different countries. They are funded primarily by industry but typically include contributions by national governments.

The largest and most widely known EUREKA IVHS project is PROMETHEUS (PROgraMme for a European Traffic system with

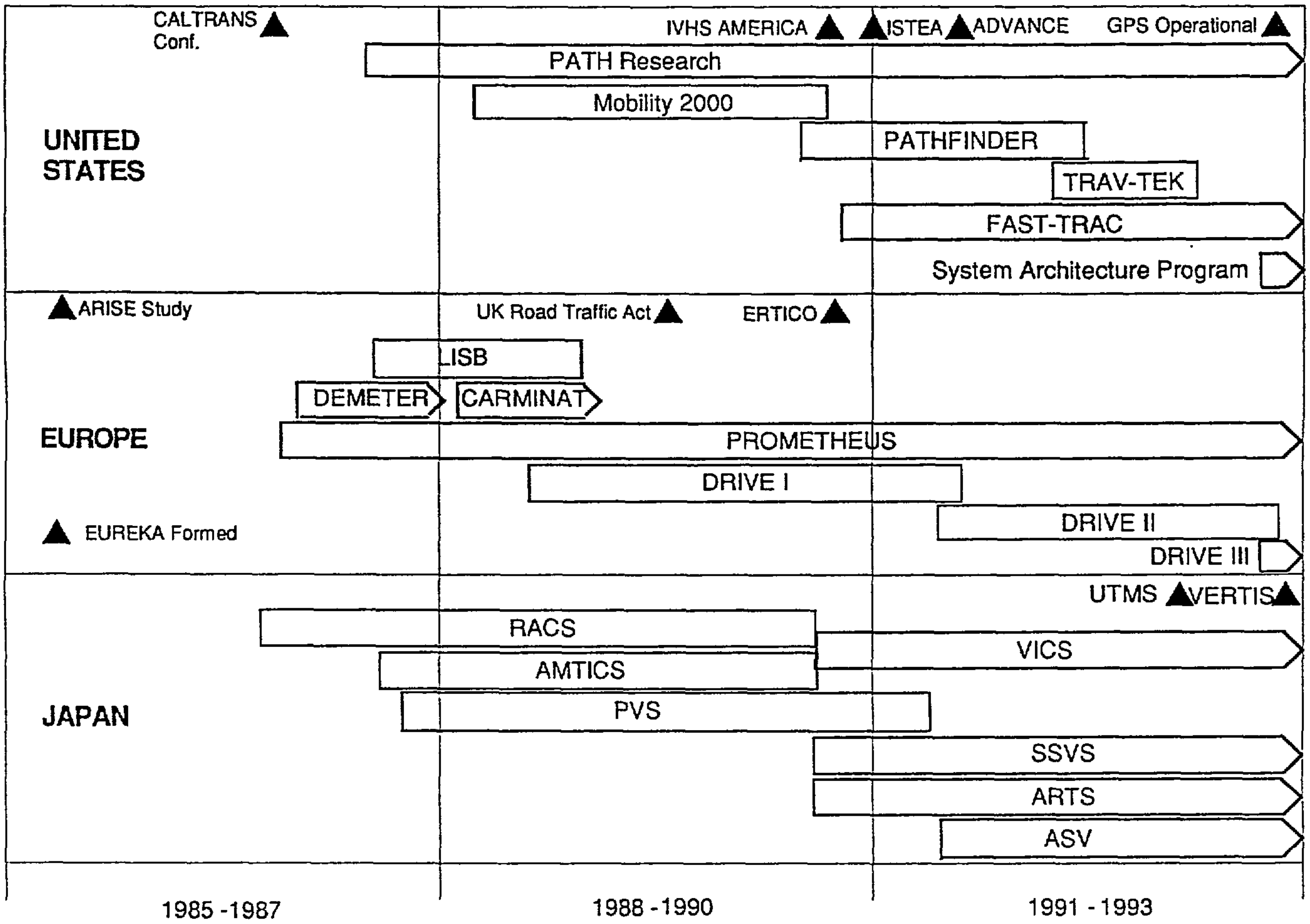


Figure 5.1 Selected Highlights of IVHS Progress for 1985-1993

Table 5.1 Selected IVHS Highlights for 1985-87

EUROPE	UNITED STATES	JAPAN
• ARISE feasibility study maps RTI evolution ('85) • EUREKA created ('85) • LISB field trial planning underway for Berlin ('86) • Autoguide Planning under-way in UK ('86) • IIASA Delphi forecasts RTI scenarios ('87) • $700M PROMETHEUS plan completed ('87) • $140M DRIVE I program proposed to EC ('87) • Other EUREkA RTI projects initiated: DEMETER ('86) CARMINAT ('87)	• Coronado Bridge electronic toll test underway ('85) • SAE navigation standards initiated ('86) • Project PATHFINDER conceived at CALTRANS • Caltrans PATH program underway ('86) • Geostar RDSS service under development ('86) • FHWA "futures" study initiated ('87)	• RACS nav & comm field trials ('86) • Police car AVM with Map Matching ('86) • AMTICS announced ('87) • JDRMA proposed ('87) • Toyota introduces Eletromultivision with CD-ROM maps ('87) • PVS project started ('87)

Highest Efficiency and Unprecedented Safety) which evolved from an internal Daimler-Benz initiative started in 1985. Other European automobile companies joined in when PROMETHEUS became a project under EUREKA in 1986. Several years later, General Motors and Ford were admitted into PROMETHEUS through their European subsidiaries.

Following a one-year planning study completed in 1987, PROMETHEUS set out on a seven-year joint research effort on cooperative driving by means of electronics, telematics, and presentation technology. Member companies share the research effort and results for areas considered to be pre-competitive. Recent PROMETHEUS accomplishments and current directions are summarized in Appendix F.

DEMETER, a EUREKA project started in 1986 by Bosch and Philips, was concerned primarily with the standardization and development of digital road maps. It led to the GBF (Geographic Data File) exchange format, and related work continued under PROMETHEUS and DRIVE. CARMINAT was a joint project of Philips, Renault, and SAGEM to integrate external information (RDS) with stored information (CD-ROM) and information from.various vehicle transducers to achieve safety, convenience, and cost-effectiveness of traffic by means of an electronic car monitoring and navigation system.

The original DRIVE (Dedicated Road Infrastructure for Vehicle Safety in Europe) planning exercise of the European Community was performed in 1986 parallel with, but independently of, PROMETHEUS planning. European experts collaborated on a plan of work and laid groundwork for EC funding, which was not to become a reality until 1988. DRIVE was almost dropped because of PROMETHEUS, but the EC was convinced to retain it, as it could focus on highway authority problems rather than those of automobile manufacturers.

Also underway during the 1985-1987 period were preparations for LISB, a large-scale operational field trial performed 1988-1991 in Berlin using an infrared beacon communications infrastructure and some 700 vehicles equipped with Ali-Scout. The Ali-Scout concept is shown in Figure 5.2.

5.1.2 Japan

In 1986, the Public Works Research Institute (PWRI) of the Ministry of Construction (MOC) started a 3-year cooperative study and experiment with 23 private enterprises in order to bring RACS into practical use. Preliminary transmission experiments, using both inductive radio and microwave type beacons, were conducted in late 1986 and early 1987.

RACS experiments involving nine different privately developed in-vehicle navigation systems in conjunction with radio beacons began in 1987. These early navigation systems used a

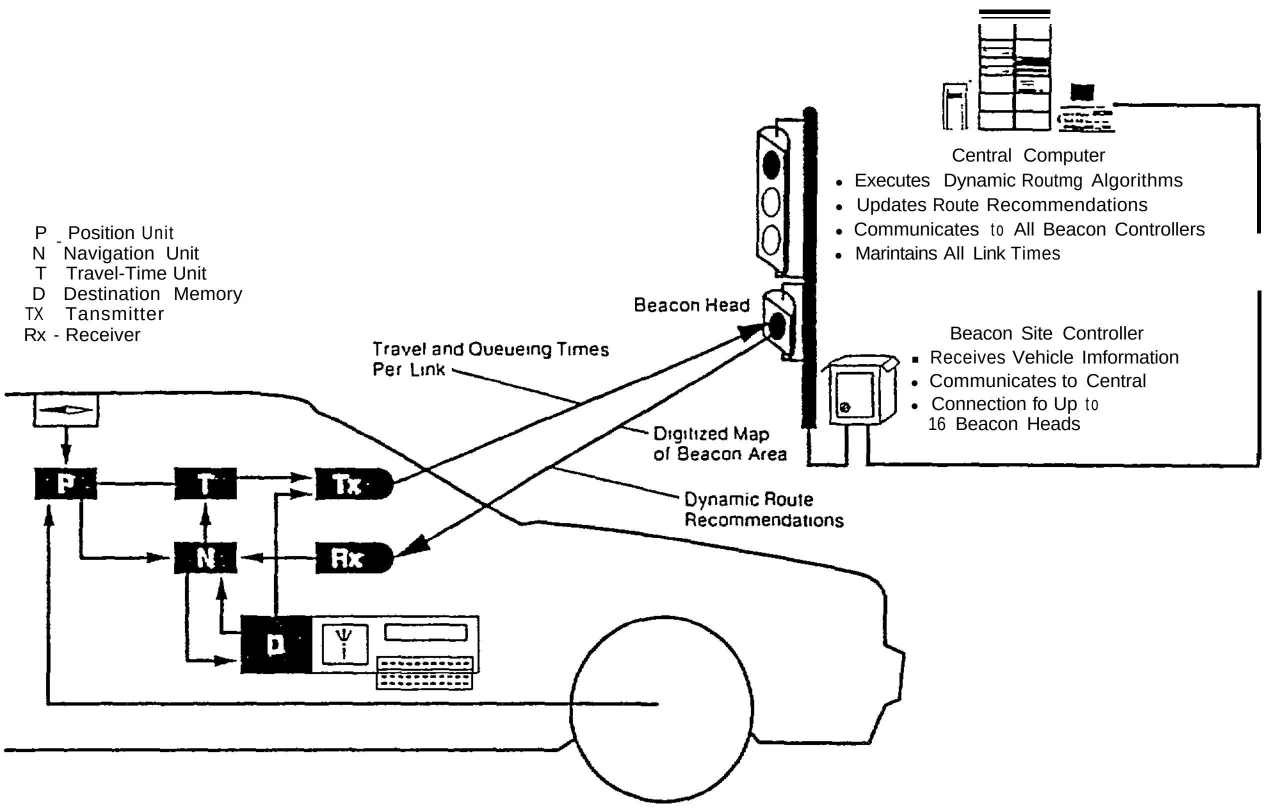


Figure 5.2 Ali-Scout System Architecture

digital road map prepared by PWRI for an area of 350 square kilometers including parts of the Tokyo and Yokohama. The results confirmed the usefulness of map matching but indicated a need for better digital map accuracy. Further experiments were planned for 1988 to transmit expressway traffic data from the MOC traffic management operations.

The first practical application of map matching in Japan started in 1986 when a Nagoya police car fleet was equipped with a vehicle location monitoring system based on dead reckoning with map matching. The importance of digital maps in IVHS was recognized by a proposal in 1987 to establish the Japan Digital Road Map Association (JDMRA) under MOC auspices to standardize map formats and share the efforts and costs in quickly digitizing the major roads and highways of Japan.

Also in 1987, the Advanced Mobile Traffic Information & Communications System (AMTICS) project was established by the National Police Agency (NPA) through the Japan Traffic Management and Technology Association. Much like RACS, AMTICS had the objective of communicating traffic data to in-vehicle navigation systems, but with cellular-like teleterminals rather than beacons. However, the AMTICS traffic data was limited to surface streets for which the NPA had traffic management responsibility.

Other 1987 IVHS highlights in Japan included Toyota's introduction of the Electromultivision navigation system, the first production system to use digital maps stored on CD-ROM.

Although the vast majority of IVHS projects in Japan during this period were focusing on linkage of in-vehicle navigation and information systems with advanced traffic management systems, the PVS (Personal Vehicle System) project was launched in 1987 under the auspices of the Ministry of International Trade and Industry (MITI) to research autonomous vehicle control systems.

5.1.3 United States

The first stirrings of what later became the National IVHS program were taking place in California in 1985 when Caltrans' interest in advanced technology was increased by the realization that it could not build its way out of traffic congestion. This led to the establishment in 1986 of the Caltrans Office of New Technology to organize and develop a research program for what eventually became known as IVHS. In August 1986, Caltrans started PATH (Program on Advanced Technologies for the Highway), a comprehensive IVHS research initiative that continues today under a new name: Partners for Advanced Transit and Highways.

However, the most influential early thrust of the Caltrans initiative was to sponsor the "Technology Options for Highway

Transportation Operations" conference in October 1986, a workshop and outreach event that is widely recognized as having sparked the present IVHS movement in the United States. A few months later, following a session devoted to the Caltrans Conference at the 1987 TRB Annual Meeting, the principal author, a participant in the Caltrans Conference, reported the following observation to a client:

> "The lack of a defined and coordinated program to establish means for collecting and communicating real-time traffic data and updated digital map data for use in dynamic routing is an obstacle to deriving full benefits from advanced car navigations systems in the United States. The Caltrans Conference...seemed to be the catalyst for starting. ..movement of industry, state departments of transportation, and the FHWA to seek new types of coalitions for applying advanced technology to help solve traffic problems. ..The evolving thrust from the need to relieve traffic congestion is consistent with the forces behind international programs which are, overall, a bit ahead of the U.S."

Indeed, PATHFINDER, the United States' first operational test of integrated in-vehicle navigation and traffic information systems, was conceived at the Caltrans Conference. Without doubt, excitement generated by the Caltrans event also influenced a task force of senior FHWA managers to consider IVHS as part of the framework for a "Future National Highway Program" for 1991 and beyond when they started preparing underlying working papers in 1987.

A number of independent activities that were to become identified with the IVHS movement were also underway in the 1985-1987 period. These included the first test of an electronic toll collection system at Coronado Bridge in San Diego, the Society of Automotive Engineers' formation of an Automotive Navigational Aids Standards Subcommittee, and Geostar Corporation's work towards a satellite positioning and communication service for the trucking industry.

5.2 Passages: 1988-1990

This three-year period saw major European and Japanese programs through their first phases and the beginning of new directions in Europe and Japan. A coherent vision for a national IVHS program in the United States emerged from the work of Mobility 2000 and led to establishment of IVHS AMERICA. Table 5.2 lists selected highlights of developments in Europe, Japan, and the United States for 1985-1987.

5.2.1 Europe

The PROMETHEUS program continued to be dominated by research, systems development, and demonstrations of components and

Table 5.2 Selected IVHS Highlights for 1988-1990

EUROPE	UNITED STATES	JAPAN
• 3-year DRIVE program launched ('88) • UK 1989 Road Traffic Act ('89) • PROMETHEUS enters CED phase ('90) • Trafficmaster begins pilot operation ('90) • 3-year DRIVE II program launched ('90)	• Mobility 2000 forms ('88) • SMART Corridor in planning ('88) • Dallas North Tollway electronic toll system in operation ('89) • PATHFINDER project in operation ('90) • DOT National Transportation Policy promotes IVHS ('90) • TravTek announced ('90) • DOT/HUFSAM "Leadership" conference spawns IVHS-AMERICA "('90) • FAST-TRAC started with $2M Oakland County funds ('90)	• 74 ATMS centers in operation ('88) • JSK worldwide survey on nav & comm ('88) • JDRMA established ('88) • Nissan Multi AV with map matching ('89) • VICS established ('90) • SSVS project starts ('90) • ARTS projects starts ('90) • Mazda introduces GPSS satellite car navigation ('90) • 117,100 car nav systems sold ('88-'90)

subsystems for cooperative driving. A major accomplishment in 1989 was the identification and definition of 23 functions as a common platform of understanding among participants working towards goals related to improved driver information, active driver support, cooperative driving, and traffic/fleet management. In 1990, emphasis was shifted to planning and developing "Common European Demonstrators" for features such as vision enhancement, collision avoidance, and dual-mode route guidance.

The DRIVE program was launched by calls for proposals in 1988. A total of 72 projects were to start in early 1989. Broad project groupings included development and modeling and evaluation tools, safety and human behavior, traffic control, telecommunications and databases, trip planning, development of multipurpose roadside processor, communications standards, and the economical and financial aspects of implementation. PROMETHEUS research teams were successful in obtaining EC funding to pursue some of their research ideas as DRIVE projects, thus establishing linkage between the two programs. All DRIVE projects involved multiple partners and most were limited to 50 percent funding by the EC. Appendix G gives further details on DRIVE.

DRIVE established a special SECFO (Systems Engineering and Consensus Formation Office) project with responsibilities for consolidating results from all DRIVE projects and synthesize a system architecture approach. SECFO was staffed by personnel from the major information technology and automobile industries to help assure that a single integrated road transport environment for Europe would result from the joint PROMETHEUS and DRIVE efforts.

RTI became recognized as an issue for pan-European standardization by the CEN/CENELEC organization in Brussels. This led to the establishment in 1991 of TC 278, a CEN Technical Committee, which eventually set up working groups covering most aspects of IVHS.

In 1989, the UK passed the Road Traffic Act to permit the licensing of private firms to install and operate traffic data acquisition and communication services. The first licensee, Trafficmaster, began operation in the London area in 1990 and has since spread to cover much of England. Ironically, Autoguide, the UK's high-profile in-vehicle route guidance venture which seemed destined to be the first licensee under the Road Traffic Act, has since foundered.

5.2.2 Japan

In 1988, the JSK Association attached to MITI carried out a survey of automobile and communications systems in Europe, Japan, and the United States. In addition to comprehensive descriptions and comparisons of these systems (see Section

3.1), the survey report promoted the development of an "internationally interdependent vehicle information and communication system," standardization, information exchange, and international joint research.

Another JSK activity was the organization of a 1989 international symposium on IVHS. A keynote speaker from the Japanese automobile industry noted that, while international cooperation is indispensable, a main issue is how to cooperate while competing.

Seventy-four major advanced traffic management centers along with 87 sub-centers were in operation by 1988-1990. Several additional production automobile navigation systems, including the first with map matching features (Nissan) and the first with a GPS receiver (Mazda), were introduced on the market and contributed to total sales of 117,000 units during this three-year period. Many of the navigation systems were derived from versions prepared for participation in RACS and AMTICS trials.

The development and marketing of navigation systems was facilitated by the quick development of basic digital maps for major roads by the JDRMA (see Appendix L). These were often supplemented by privately prepared digital maps for local streets. However, traffic attributes (i.e., one-way, turn restrictions) are not included in either the JDRMA database or the private enhancements.

RACS and AMTICS were continued as separate competitive programs for communicating traffic data to in-vehicle systems until 1990. At that time, steps were taken toward consolidation of expressway and surface street traffic data for communication via alternative links to in-vehicle systems under VICS (Vehicle Information and Communications System), a joint undertaking of the MOC, NPA, and MPT (Ministry of Posts and Telecommunications).

New Japanese IVHS programs starting during the 1988-1990 period included SSVS (Super Smart Vehicle System), a 3-year probing study promoted by MIT1 for intelligent driving systems and automatic vehicle control for 20 to 30 years in the future. ARTS (Advanced Road Traffic System), another new project, was aimed at intelligent coordination between vehicles and road infrastructure in the 2000-2010 time frame. As an MOC initiative, ARTS' main emphasis is on intelligent road facilities.

5.2.3 United States

IVHS in the United States underwent a transition from a collection of tentative thrusts and independent activities at the beginning of the 1988-1990 period to a coherent program that began to take on much of its present shape by the end of the period. A key event was the evolution in 1988 of Mobility 2000 (see Appendix E) from a core group of IVHS advocates that had been meeting informally since the 1986 Caltrans conference to discuss a structure for planning and coordinating IVHS activities and interests. Although an ad hoc committee of volunteers, Mobility 2000 was highly successful in organizing major workshops in 1989 and 1990 that shaped a consensus vision leading to IVHS AMERICA and the present program.

In the meantime, the profile of IVHS was being elevated by a number of individual activities. These included initiation of the SMART Corridor project in Los Angeles which, in addition to PATHFINDER, served as an operational test bed for a variety of other advanced traffic management technologies. The TravTek operational test project in Orlando, Florida was announced, Minnesota's Guidestar initiative got underway, and the Oakland County, Michigan, FAST-TRAC project was started. These projects, along with PATHFINDER, set the present pattern in which operational tests are carried out by partnerships including federal, state, and local government agencies as well as industry and academia.

IVHS was boosted in 1989 by a positive report issued by the U.S. Congress Office of Technology Assessment and by an AASHTO (American Association of State Highway and Transportation Officials) policy resolution favoring IVHS. IVHS was also promoted in Moving America, the 1990 Statement of National Transportation Policy by the U.S. Department of Transportation.

Thus the stage was set for coalescence of IVHS interests under a formal structure when the participants of the May 1990 National Leadership Conference on Implementing IVHS encouraged the Highway Users Federation for Safety and Mobility (HUFSAM), in cooperation with AASHTO and other groups to establish such an organization. As a result, IVHS AMERICA was incorporated in July 1990 as a nonprofit, educational association to coordinate and foster a public/private partnership to accelerate the development and deployment of IVHS to make the U.S. surface transportation safer and more efficient (see Appendix A).

5.3 Current Directions: 1991-1993

During this period, the European programs matured with a shift in focus towards deployment issues, the Japanese programs multiplied and made progress towards resolving jurisdictional conflicts, and annual funding for IVHS research and field trials in the United States escalated to over $200 million per year. Table 5.3 lists selected highlights for 1991-1993.

Table 5.3 Selected IVHS Highlights for 1991-1993

EUROPE	UNITED STATES	JAPAN
• CEN establishes TC-278 for RTI standards ('91)	• SAE forms IVHS standards division ('91)	• JSAE established VeRI committee for standards and cooperation ('91)
• ERTICO established ('91)	• GAO report praises IVHS ('91)	• PVS project completed
• SOCRATES demonstration ('91)	• ADVANCE project announced ('91)	• ASV project started
• 12 RTI standards working groups set up by CEN/TC-278 ('92)	• DOT names IVHS AMERICA as Utilized Advisory Committee (''91)	• Nissan introduces nav system with microwave beacon receiver ('92)
• Columbus portable route planner hits UK market ('93)	• ISTEA provides $660M for FY 1992-1997	• 165,000 car nav systems sold ('91-'92)
• DRIVE II concludes ('93)	• IVHS AMERICA launches Information Clearinghouse ('91)	• ATISS launched in Tokyo ('93)
• $180M budgeted for DRIVE III ('93)	• TRB Policy Study endorses IVHS ('92)	• UTMS Japan formed ('93)
• PROMETHEUS cooperation enters final phase ('93)	• IVHS AMERICA 20-year Strategic Plan completed ('92)	• VICS demonstration conducted ('93)
• ERTICO begins coordination of field trials ('93)	• 16 operational tests selected ('92)	• VERTIS inter-ministry committee formed for IVHS cooperation ('93)
	• TravTek completed ('93)	
	• Systems Architecture development program initiated ('93)	
	• 5-year IVHS Program Plan underway ('93)	
	• GPS reaches operational status ('93)	
	• 2nd round of operational tests selected ('93)	

5.3.1 Europe

The EC's ATT (Advanced Road Transport Telematics) Program (see Appendix G), known informally as DRIVE II, was launched with a call for proposals in 1991. The objectives are (1) to prepare for IVHS implementation by establishing a framework that will validate and improve the results from DRIVE I and by establishing common functional specifications and (2) to promote standards. In addition, DRIVE II expects to encourage the development of administrative and financial procedures and transfer the results to all regions of Europe.

A total of 56 DRIVE II projects were selected for cost-shared funding. Of these, 30 are urban and inter-urban pilot projects and the remainder are supporting R&D projects. The selections were made to assure a balance of among seven areas of major operational interest: demand management, traffic and travel information, integrated urban traffic management, integrated inter-urban traffic management, driver assistance and cooperative driving, freight and fleet management, and public transport management.

In 1992, following a period of contention among standards organizations with overlapping interests, responsibility for European IVHS standards was given the European Committee for Standardisation (CEN) under Technical Committee TC-278, "Road Transport and Traffic Telematics." The standards topics were then allocated among approximately 12 service-, database-, and interface-oriented working groups. A high degree of cooperation with other standards organizations, including ISO/TC-204, has since emerged.

As PROMETHEUS approaches the end of its seven-year life, the involved industries have become more reluctant to start new cooperative research, development, and demonstrations. This was expected, as it is assumed that once the industries had developed common specifications they would want to pursue their own product versions in competition and thus diminish their joint activities. Another reason for the cautious views about a follow-on PROMETHEUS initiative is the economic difficulty being experienced by the European automobile industry.

A major example of a PROMETHEUS accomplishment that will lead to early products is the Autonomous Intelligent Cruise Control (AICC) which controls vehicle speed and distance in relation to the preceding vehicle (see Appendix F). It is viewed as an effective IVHS component for stabilizing traffic flow and enhancing traffic safety. AICC has the further advantage of not requiring infrastructure support, which means it could appear on export as well as domestic automobiles.

ERTICO (European Road Telematics Implementation Coordination Organization) was formed as a coordinating link between R&D and national planning of IVHS deployment in different European countries. It is responsible for the CORD project of DRIVE II, which has a synthesis function similar to the SECFO project of DRIVE I. ERTICO's 25 members include major information technology industries, automobile manufacturers, road operators, telecom operators, national road administrations, and transport ministries. Current views of ERTICO's role and strategy are given in Appendix H.

5.3.2 Japan

New IVHS activities starting during the period 1991-1993 include the five-year Advanced Safety Vehicle (ASV) project of the Ministry of Transport (MOT). Initial ASV objectives are to improve safety through autonomous functions such as driver monitoring, obstacle detection, and headway keeping.

Following a year of slow progress in negotiating and planning for the amalgamation of AMTICS and RACS under VICS, the VICS Promotion Council was formed in October 1991 to promote surveys, research, development, and various preparatory activities related to the commercialization of VICS. The VICS concept calls for consolidation of traffic data for communication by separate communication links operated by the MOC and the NPA.

However, the MPT ruled that the MOC's microwave beacon approach for RACS would be limited to one-way transmissions to vehicles. At the same time, the NPA decided to evaluate an FM subcarrier approach in a continuation of AMTICS field trials in Osaka as an alternative to the more expensive teleterminal approach. Consequently, three communications media (microwave beacon, optical beacon, and FM subcarrier) were selected for VICS evaluation.

Also in 1991, a Liaison Council for IVHS/RTI Japan was formed to carry out liaison and IVHS/RTI information interchange both inside and outside Japan. Liaison Council members are IVHS AMERICA members and include representatives of the JTMTA connected with the NPA, HID0 under the auspices of the MOC, and JSK affiliated with MITI. Other developments included establishment of the VeRI (Vehicle/Road Intelligence) committee in 1991 by the Society of Automotive Engineers of Japan (JSAE) to interpret the directions of existing and coming technologies from the perspective of automobile engineers, to prepare technical papers on standardization, and to encourage cooperation with other IVHS/RTI-related engineering groups worldwide.

Pilot installations of microwave beacons were underway in 1992 by the MOC, but the transmissions were limited to static data such as location and connecting roads. Experiments with

FM sideband communications of interest to the NPA confirmed data transmission rates of 16,000 bits/second, of an order of magnitude greater than the European RDS. However, VICS progress was limited by lack of agreement on a responsible body for managing the consolidation of MOC and NPA traffic data for transmission to in-vehicle units. Instead of moving more directly towards operations, a VICS demonstration experiment was conducted in 1993 to promote public understanding. Figure 5.3 shows the latest VICS concept.

In the meantime, the Tokyo Metropolitan Police Department moved to establish a pilot ATISS (Advanced Traffic Information Supply Service) that would accomplish some of the original AMTICS objectives. In addition, NPA developed a new type of infrared vehicle detector that also serves as a high-bandwidth two-way communications beacon for supplying traffic information to and receiving link travel times from equipped vehicles.

In another move in April 1993, the NPA founded the Universal Traffic Management Society of Japan (UTMS Japan) to coordinate among all relevant sectors for planning and deploying a new Universal Traffic Management System incorporating integrated traffic control and several related areas that collectively cover most aspects of IVHS.

Finally, in July 1993 an inter-ministry committee for Vehicle, Road and Traffic Intelligence Systems (VERTIS) was formed that, for the first time, provides a mechanism for greater cooperation among the five government ministries (MOC, MITI, MOT, MPT, and NPA) with IVHS interests. In addition, a VERTIS promotion committee was proposed to coordinate among the private sector, academic sector, and the various IVHS-related associations such as JSK, HIDO, VICS, JTMA, etc., as well as interface with external organizations such as IVHS AMERICA and the ATT/IVHS World Congress. A meeting was scheduled for January 21, 1994, to establish the committee under the name "Vehicle, Road and Traffic Intelligence Society."

5.3.3 United States

The IVHS movement came of age in the United States during this eventful 3-year period. Further boosts came from study reports by the United States General Accounting Office and the Transportation Research Board. However, the biggest boost of all came with passage of the Intelligent Vehicle Highway Systems Act of 1991 incorporated in the ISTEA (Intermodal Surface Transportation Efficiency Act of 1991).

The ISTEA mandated establishment of a national IVHS program in cooperation with state and local governments, the academic community, and private industry. Other mandates included strategic planning, an IVHS information clearinghouse,

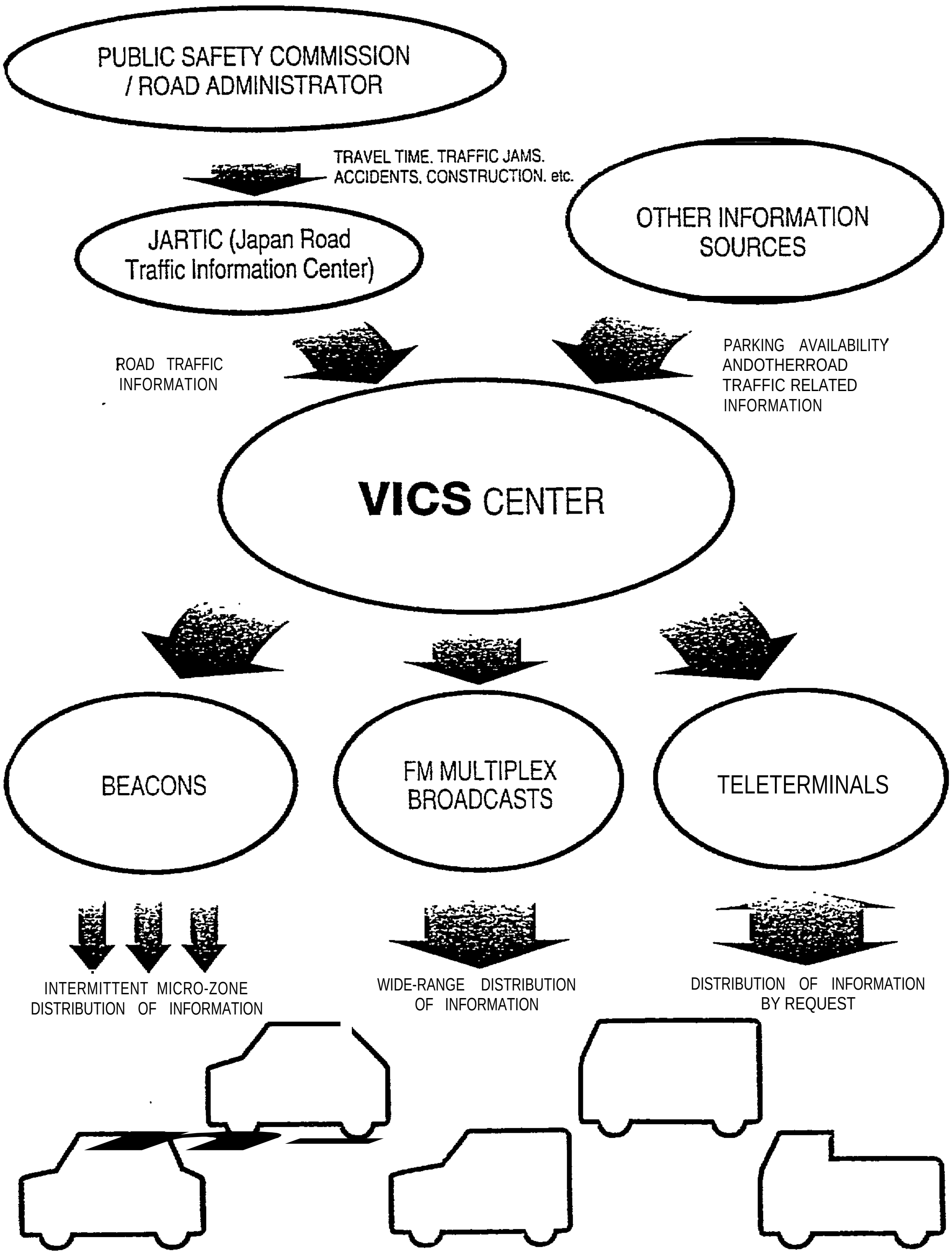


Figure 5.3 VICS Information Flow and Concept of the System

development of standards, an IVHS Corridors program, and a fully automated highway prototype or test track operation by 1997. The ISTEA also authorized baseline IVHS funding of $660 million for FY 1992 through 1997, which provided the assurances needed for undertaking long-term research and operational test projects.

Including other appropriations, the federal budget grew to $218 million in 1993 and is expected to average $231 million per year from 1994 through 1997. However, the vast majority of the federal funds are earmarked for specific projects, thus limiting flexibility for optimum application of available funds.

In 1991 IVHS AMERICA was named Utilized Advisory Committee to the U.S. Department of Transportation on IVHS matters and quickly took the lead in a major strategic planning exercise that established a blueprint for IVHS through the year 2011. Other IVHS AMERICA advice to the USDOT was the recommendation of a national systems architecture development program that was kicked off in 1993.

In the meantime, IVHS projects and operational field tests proliferated to the point that some 40 were in various stages of planning or operation by 1992. The selection of 16 additional field tests was announced at the end of 1992 and proposals were solicited for additional field tests in the fall of 1993. The highly successful TravTek operational field test in Orlando, Florida (see Figure 5.4), was concluded in 1993 and ADVANCE, the largest field test announced to date, was well along in preparation for starting up in 1994.

As 1993 drew to a close, the USDOT and IVHS AMERICA were working on a comprehensive national IVHS program plan that defines how all the disparate aspects of IVHS fit together in a unified program (USDOT 1993). A "demand-pull" approach is being taken in a plan to develop and deploy 27 specific user services to realize the goals and benefits of IVHS (see Table 1.3).

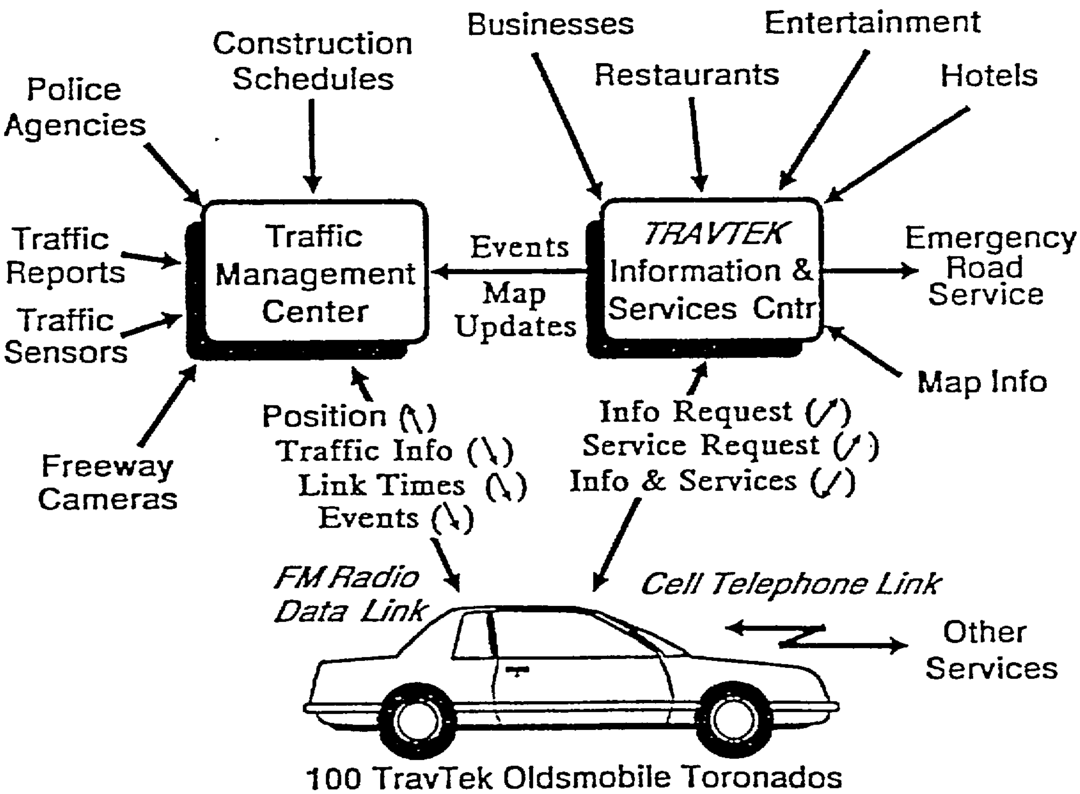


Figure 5.4 TravTek System Architecture

6.0 INDIVIDUAL MEASURES

In this chapter we briefly reexamine and discuss selected IVHS initiatives and developments described in Chapters 4 and 5 from the viewpoint of funding, organization, research projects and field trials, systems architecture and standards, marketing and deployment, institutional and legal issues, and planning.

Of necessity, there is substantial overlap between the information given here for individual measures and that presented in earlier chapters. In addition, there is overlap among information for some of the individual measures that are influenced by the same factors. However, the information on individual measures in this chapter is generally more detailed than that given earlier.

6.1 Funding

With the principal exception of certain vehicular systems that operate independently of infrastructure support, little IVHS development can be carried out without some degree of government involvement. Although government policies that facilitate private IVHS infrastructure (e.g., Trafficmaster under the United Kingdom's 1989 Road Traffic Act) are important, the levels of government funding made available for IVHS research, development, and deployment are perhaps the most fundamental measure of IVHS support.

Major components of IVHS funding in the United States, Europe, and Japan are listed in Table 6.1 and are discussed under separate headings below. Except as noted, these are funds are for research and field tests rather than IVHS deployment. Based on Table 6.1 and making allowances for unquantified local government and industry funding, we estimate that a total of $1 to 1.5 billion per year is currently being invested worldwide in IVHS.

6.1.1 United States

With exception of privately funded industry activities, IVHS funding levels in the United States are relatively well identified compared to Europe and Japan. The federal budget for IVHS research, development, and testing grew from almost nil in FY 1989 to $218M in 1993. Over $lOOM/year through FY 1997 is assured by the ISTEA, and total appropriations are projected to average $231M per year from 1994 through 1997.

For example, the FHWA's FY 1994 IVHS funding includes $113 million authorized by ISTEA for R&D and operational tests plus an additional $90 million under the FHWA's general operating expenses (Inside IVHS 10/25/93). Additional FY 1994 IVHS funding includes $7.5 million for NHTSA and a

Table 6.1 Major Components of IVHS Funding

EUROPE*	UNITED STATES**	JAPAN
▪ PROMETHEUS spending planned for 1987-93: $770M ▪ DRIVE (EC DG XIII) budget for 1988-91: $70M ▪ DRIVE II budget for 1991-94: $160M ▪ DRIVE III budget (estimate) for 1995-98: $180M ▪ EC DG VII (Transport Directorate) RTI/IVHS under Framework IV: $25M	Federal Government R&D: • 1989-$2M • 1999 - $13M • 1991 - $24M • 1992 - $234M • 1993 - $143M • 1994 - $203M • 1995 through 1997 - $231 M/yr (estimate)	1973 - 1979: ▪ Government funds of $180M for CACS R&D*** 1985 - 1992: • Government funds for R&D - $1.9M - NPA - $5.0M - MOC - $0.5M - MOT - $5.4M - MITI • Government funds for Deployment - $1.8758 - NPA - $519.5M -MOC - $17.9M - MOT

* Excludes national and local government investments, which collectively may exceed the DRIVE funding..

** Excludes state and local government investments.

*** Actually 7.3 billion yen, which amounts to $180M in today's dollars after adjusting for inflation and applying current exchange rates.

portion of the $24.25 million received by the FTA for its National Planning and Research Program.

However, there is limited flexibility in the types of IVHS activity the federal funds may be applied to. Only $33 million of the FHWA's FY 1994 ISTEA funds is available for discretionary IVHS research and operational tests because $79.5 million is earmarked for specific operational test projects. All of the FY 1993 ISTEA funds were so earmarked.

Although operational testing is presently the cornerstone of IVHS activities in the United States, the selection of tests and locations may not be optimal because of inflexible earmarks. An important trade-off is the risk of diminished Congressional support for IVHS unless the geographical distribution of IVHS funding beneficiaries is seen as equitable.

Most of the federal funds are primarily for research and operational testing. However, approximately $7 million is granted annually under an Early Deployment Program to state and local governments and Metropolitan Planning Organizations (MPOs) to assist with feasibility studies and development of multi-year deployment plans for IVHS services. Such grants, which must be matched by at least 20 percent funding from nonfederal sources, were made to 36 metropolitan areas through FY 1993.

The federal government funds up to 80 percent of the cost of individual operational tests but sets a target of 50 percent. Federal funds thus represent only the tip of an iceberg that, in addition to state matching funds for many projects, includes unfathomable investments by industry for IVHS product R&D that is motivated by estimated IVHS deployment expenditures of $210B (including $170B by consumers) by the year 2011.

Including investments at the state level and those of private companies and academia, we estimate that at least a billion dollars has already been invested in IVHS by the United States in the last few years. As early as 1990, the United States had 760 full-time people working on IVHS according to conservative estimates based on a survey of organizations of all types (Spreitzer 1990). We estimate that this represents a total investment of at least $100M per year, which is an order of magnitude greater than the federal funding for IVHS at that time.

6.1.2 Europe

The central source of public sector funding for IVHS research in Europe is the Commission of the European Communities, which manages and finances DRIVE (see Appendix G) as part of its broader Framework Program. Rather than the EC's

Transport Directorate (DG VII), DRIVE is organized under DG XIII, the Directorate General for Telecommunications, Information Technologies and Innovation.

The EC provided 60 MECU (=$70M) for the original DRIVE program (1988-1991) to cover administration and approximately 50 percent of the costs of some 72 research projects. The remainder of the project expenses was shared by various combinations of private and public organizations that participated in the projects.

The EC funding of 140 MECU (=$16OM) for DRIVE II (1991-1994) covers less than 50 percent of the costs and less than 20 percent for some large-scale pilots. Although funding for DRIVE III was still unsettled as this report was completed, indications are that 160 MECU (=$180 million) may be available for IVHS under the broader EC Framework IV program expected to start in 1995.

The EC idea of cost-sharing is that the industries involved should be motivated to pursue the ideas quickly into products on their own budget. However, there are strong feelings in Europe that shared-cost contracts slow progress. Some expect difficulty with the complex financial arrangements that will be required for equitable multi-country large-scale demonstration projects under DRIVE III.

Although the EC can finance transportation infrastructure investment in member countries, there is no mandate to do so. In the past, the amounts have been modest and gone mostly to rail. In the case of IVHS, the high cost of local infrastructure for field trials or demonstrations means that EC support is typically a marginal 10 to 20 percent of overall project cost. Recently, with a new realism and economic recession, a common view of the EC research programs such as DRIVE is that they give less, require more, and are becoming less attractive. Nonetheless, DRIVE status still gives a "seal of approval" to a project and helps assure funding support at the national level.

Private industry is the main source of funding for IVHS research carried out under PROMETHEUS, which is consistent with EUREKA's expectation that project participants find the required funds internally, by seeking private financial sources, or using any public funds made available by their respective governments (EUREKA 1987). For example, all of the involved national governments contributed to PROMETHEUS through support of research done in their own countries. In addition, PROMETHEUS research teams received EC funding to pursue some of their ideas in the form of DRIVE projects. Although the actual expenditures have not been publicly announced, the original PROMETHEUS planning called for $770M through 1993.

6.1.3 Japan

Research and development funds invested effectively by MITI in CACS (see Chapter 4.3) during the 1970s had a major influence on subsequent IVHS development in Japan. Although the CACS funding amounted to only 7.3 billion yen ($180M in today's dollars after adjusting for inflation and applying current exchange rates), the project confirmed the efficacy of dynamic route guidance and led to MITI's establishment of JSK in 1979 to popularize CACS results and expedite the introduction of in-vehicle route guidance and information systems. The resulting promotion stimulated private sector R&D, thus leading to technical achievements underlying some of the many automobile navigation systems now on the market in Japan.

Compared with Europe and the United States, Japanese funds for R&D and deployment are often combined in ways that are hard to delineate because of differences in jurisdictions and in the definition and classifications of funding. The IVHS R&D and deployment funding listed in Table 6.1 for 1985-1992 was estimated by JSK based on information compiled in cooperation with other associations and individuals knowledgeable in Japanese IVHS programs (JSK 1993).

Government funds for IVHS R&D are granted largely to foundations associated with the responsible ministries. Recent government funding for IVHS R&D, especially for public/private joint projects, has been quite modest. For example, the NPA's $1.9M for R&D listed in Table 6.1 went to the Japan Traffic Management Technology Association (JTMTA), and most of MITI's $4.5M went to JSK and the Machine System Promotion Association. Membership fees and donated labor from industry members are also important sources of support for the various associations.

Another reason for the relatively modest government investment in R&D is the stimulation of private sector R&D by a succession of Five-Year Programs for road and traffic safety facilities improvement started in the 196Os, which result in a steady flow of new technology developments. The 11th Five-Year Program (1993-1997), which is now underway with an appropriation totaling $690B, directs most of its activities at measures to improve the convenience, safety, and comfort of Japanese roads.

As in Europe and the United States, private sector investment in IVHS research and project development is hard to quantize. However, JSK estimates that the R&D investment of a typical large company participating in the RACS and AMTICS projects in 1987 amounted to approximately $4.5M excluding research labor costs (JSK 1993). The corresponding investment for participating in VICS in 1992 was estimated at $22.7M.

6.2 Organization

Most forms of IVHS could not be realized without unprecedented cooperation among government, private industry, and academia. Although the organizational structures differ substantially among Europe, Japan, and the United States, jurisdictional considerations require cooperation among government agencies at all levels in each region. Also affecting all three regions is the multi-disciplinary nature of IVHS and the strong interactions of IVHS subsystems, which, in addition to requiring cooperation between industry and government, often require joint development ventures between companies in different business enterprises such as transportation, motor vehicles, electronics, and communications.

Academia plays education and other important roles in IVHS that differ by geographic region, tending more strongly towards research in Europe, towards planning in Japan, and a combination of research and planning in the United States. Similarly, the roles of consulting firms also differ among the three regions. Compared to the United States, consultants are more involved in IVHS program planning and management in Europe and less involved in Japan.

Table 6.2 summarizes key information on organizational roles relative to IVHS in the United States, Europe, and Japan, and the following paragraphs discuss organizational approaches that have evolved to facilitate 'the necessary coordination.

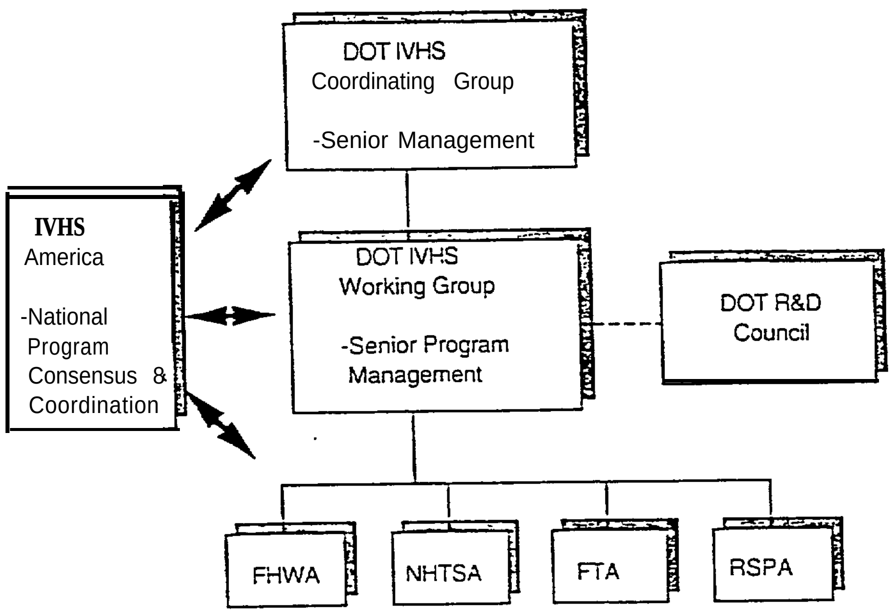
6.2.1 United States

Other than through the informal work of Mobility 2000 in the late 1980s (see Appendix E), there was no overall mechanism for organizing and coordinating IVHS interests and activities in the United States prior to the formation of IVHS AMERICA in 1990. IVHS AMERICA has since played a central role in IVHS planning and coordination as a utilized Federal Advisory Committee on IVHS matters for the U.S. Department of Transportation and as the principal interface among government, industry, and academia for planning and coordinating the national IVHS program.

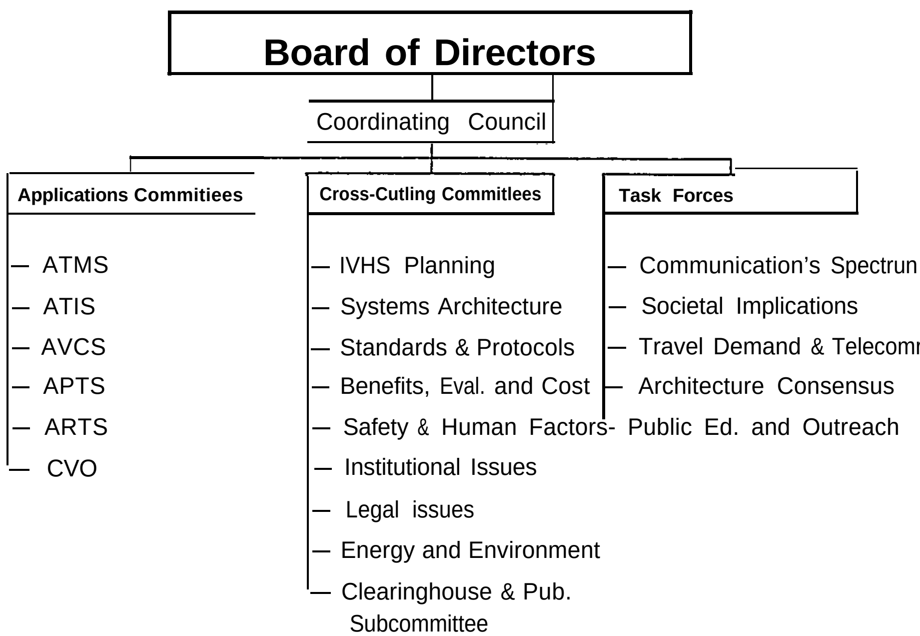
As shown in Figure 6.1.A, IVHS AMERICA interfaces with the USDOT through its IVHS Coordinating Group, IVHS Working Group, and the modal administrations (FHWA, NHTSA, FTA, and RSPA). The USDOT IVHS Coordinating Group is responsible for overall program direction and policy guidance. The FHWA, which is particularly concerned with improving the operational efficiency and safety of highway transportation, has been designated the lead agency for coordinating the federal IVHS program. The Federal Railroad Administration (FRA) is also becoming more involved in IVHS.

Table 6.2 Organizational Roles Relative to IVHS

EUROPE	UNITED STATES	JAPAN
"Central Government": • European Commission - Guidelines for transport planning for 12 member nations - DRIVE Program • ECMT - Joint recommendations for 28 nations - Coordinates planning • EUREKA - Promotes cooperation of high-tech projects between EC members - PROMETHEUS industrial programs • ERTICO - Europwide implementation strategies - Coordinates IVHS R&D with national deployment planning Individual Nations: • Transport Planning • Infrastructure development • Investment decesions • Taxation Private industry: • Participate in PROMETHEUS • Fund joint R & D projects • Independent product development	Central Government: • Department of Transportation - Evaluate cost and benefits - Centralized planning for nationally compatible IVHS - Fund high-risk research - Stimulate private sector, state, and local government efforts - Cooperate with public/private organizations to demonstrate & evaluate technology - Provide Federal-aid funding for IVHS implementation • Federal Communications Commission (FCC) - Allocate frequencies - Regulate communications • Department of Defense - Retarget defense industry Capabilities in IVHS - Technology Reinvestment program (TRP) State & Local Government: • Coordinate local IVHS planning through MPOs • Install, operate, and maintain IVHS infrastructure Private Industry: • Technology development • Product development • Services development Academic Institutions: • Basic and applied R & D • Technology assessments • IVHS educational programs Professional Societies: • Standards and Protocals • Information dissemination IVHS AMERICA: • Coordinate & foster public/private partnerships for IVHS • Advise Department of Transportation on IVHS programs and planning • Facilitate the exchange of information among interested parties	Central Government: • Ministry of construction (MOC) - Traffic control for expressways, non urban & some urban roads - Roadway equipment • National Police Agency (NPA) - Traffic control for urban roads - Safety regulations for vehicles • Ministry of Transport (MOT) - Safety regulations for vehicles • Ministry of Posts & Telecommunications (MPT) - Allocate frequencies - Regulate telecommunications • Ministry of International Trade & Industry (MITI) - Basic R&D, and promotion of advanced technology Public/Private Associations: • Coordinate public and private sector activities • One or more sponsored by each ministry • Funded largely by private sector membership fees • Examples; JSK, HIDO, JTMTA, JDRMA, UTMS, RCR, VERTIS Industry: • Participation in cooperative projects through associations • Independent R &D and product development harmonized with national thrusts



A. U.S. Department of Transportation IVHS Program Coordination (Source: _________)



B. IVHS AMERICA Organization (Source: ________)

Figure 6.1 IVHS Organization in the United States

NHTSA is addressing the safety aspects of IVHS, especially as related to warning and vehicle control systems and to driver interaction with IVHS technologies. The FTA is pursuing IVHS applications to encourage high-occupancy vehicle travel, including transit buses, car pools, and highway-related transit operations. RSPA is interested in transportation system approaches and technologies with intermodal impacts, including the development and implementation of telecommunications and radionavigation policy.

Figure 6.1.B shows the IVHS AMERICA committee structure. The Board of Directors made up of one-half public sector (state and local as well as federal) and one-half private sector members. The Coordinating Council is comprised of the chairpersons of the Technical Committees, representatives of the USDOT, and "at large" members appointed by the Board. The Technical Committees, all of which have USDOT representatives as secretaries, administer specific technical and program objectives and provide national coordination. Appendix A describes IVHS AMERICA in more detail.

Several state and local transportation agencies have contributed heavily to IVHS research, testing, and national IVHS program planning. In addition, state chapters of IVHS AMERICA started forming in 1993. However, the ultimate roles of state and local agencies are perhaps the most critical of all organizations because they are generally responsible for actual implementation and operation of most forms of IVHS.

In addition to membership in IVHS AMERICA, numerous associations and professional societies are directly involved in promoting and facilitating IVHS development through direct activities such as member education, standards development, information dissemination, etc. Examples include the American Association of State Highway and Transportation Officials, Society of Automotive Engineers, Institute of Transportation Engineers, Institute of Electrical and Electronic Engineers, etc.,

6.2.2 Europe

Transport planning in Europe is done primarily at the national level, either by transport ministries or by national road administrations. However, planning at the national level may be influenced by the European Conference of Ministers of Transport (ECMT), the Transport Directorate (DG VII) of the Commission of the European Community (EC), and ERTICO (European Road Telematics Implementation Coordination Organization), even though they lack political authority over national transport matters.

The ECMT makes joint recommendations for 28 nations in Europe, whereas the EC develops guidelines for transport planning among the 12 EC member nations. For IVHS, ERTICO develops Europe-wide implementation strategies and coordinates the necessary measures. However, final decisions on transport investments, infrastructure development, and taxation are made nationally because the umbrella organizations (ECMT and ERTICO in particular) have little power to enforce their recommendations.

Nonetheless, although some IVHS programs and activities originate at the national level, European IVHS directions have been shaped primarily by the EC through the DRIVE programs and by EUREKA through the PROMETHEUS IVHS project. The DRIVE programs are managed and financed under the EC's DG XIII for promoting Telecommunication, Information Technology, Industry and Innovation rather than DG VII, the Transport Directorate. As described in Appendix G, the EC also plays a major role in concertation activities to integrate DRIVE results with those of EUREKA's PROMETHEUS and other European projects and in establishing policy for the orderly evolution of IVHS services in Europe.

EUREKA is an industrial research coordination initiative of 19 European countries that was set up in 1985 with the objective of strengthening Europe's competitive position in the world market. To this end, EUREKA is essentially an administrative framework for facilitating transnational cooperation in high technology projects.

At the time it was created, President Mitterand of France saw EUREKA as providing the same impetus to European civil research as President Reagan's Strategic Defense Initiative ("Star Wars") was to do for US defense research. PROMETHEUS, CARMINAT, and other IVHS projects under EUREKA are originated in a bottom-up approach by project participants who provide their own funds or seek financing from private sources or their own governments.

ERTICO is a non-profit membership organization that was formed with the encouragement and support of the EC in 1991 as a coordinating link between IVHS R&D and national planning of IVHS deployment in different European countries (Camus 1992). This central relationship is depicted in Figure 6.2. ERTICO's main purpose is to develop overall implementation strategies and coordinate the necessary measures in association with suppliers and users to assure harmonized investments and services for the future IVHS network. However, ERTICO cannot set the lead or provide technical direction because of its limited membership and powers. Recent views of ERTICO's role and strategy are given in Appendix H.

Although there is considerable coordination through the above organizations, Europe is still a region of sovereign nations, each supporting its own industry in different ways.

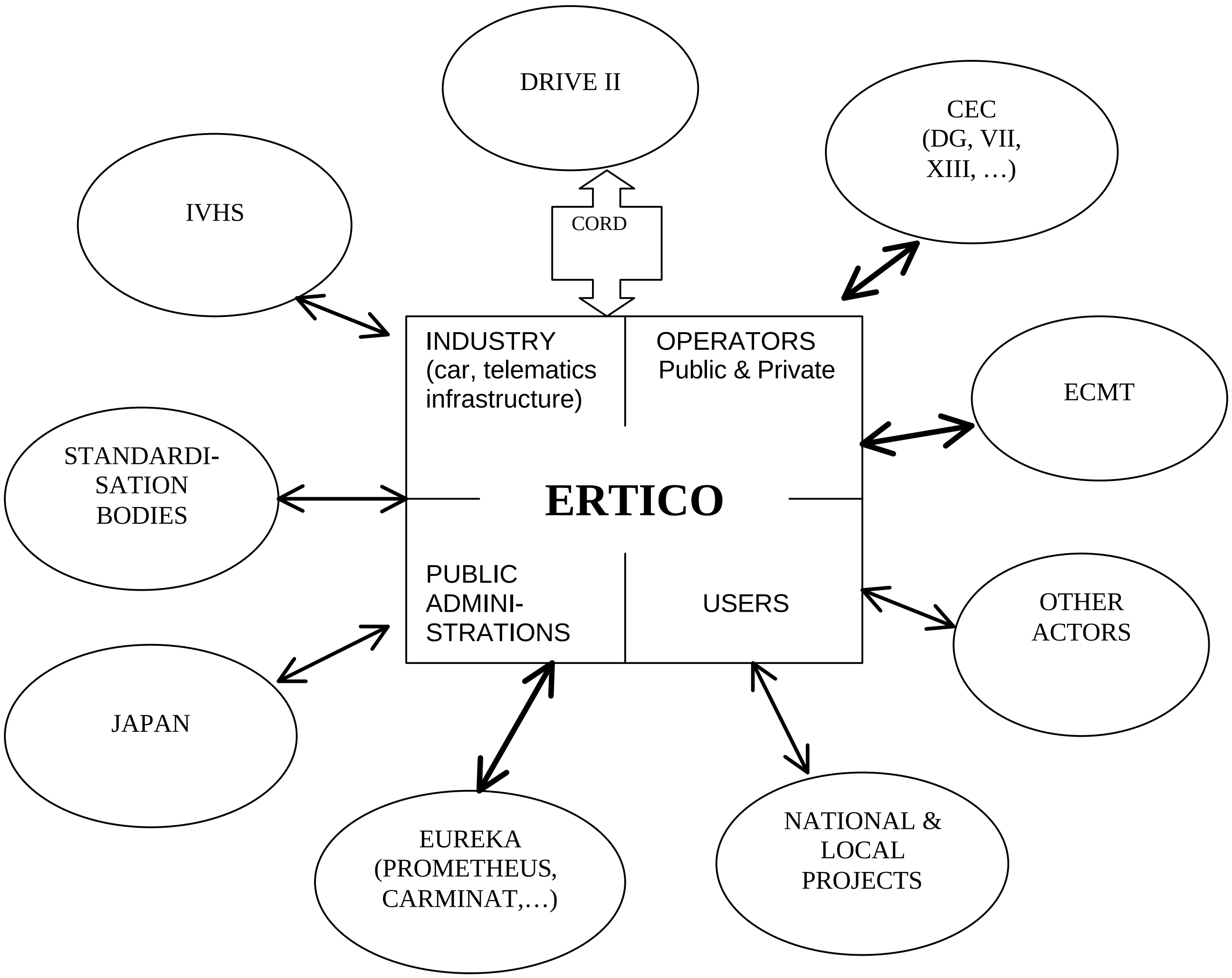


Figure 6.2 ERTICO Relationship with Other Organizations
(source: ERTICO 1993)

Furthermore, as Europe is not a continent with defined geographical borders, it still not clear which nations may eventually,be included in a unified Europe as promoted by the EC. Thus the outlook for pan-European IVHS systems-builders or coordinated procurements appears dim at present and is an obstacle to European competitiveness in the IVHS field.

6.2.3 Japan

Collectively, the major IVHS activities in Japan fall under the jurisdiction of five different central-government ministries as listed in Table 6.2 and described in the following paragraphs. Until recently, independent and somewhat rival IVHS activities were pursued unilaterally by the ministries, thus creating obstacles to the seamless communication links between the infrastructure and in-vehicle equipment.

The first step toward improving this situation occurred in 1991 when the MOC's RACS and the NPA's AMTICS (which had been underway as separate programs since the mid-1980s) were consolidated under VICS, a successor program that includes the MPT as a supporter. A bigger step occurred in 1993 when the five ministries formed an inter-ministry committee (IMC) for greater IVHS cooperation within the Japanese government. This move, along with Japan's need for a single organizational point of coordination for participating in the ATT/IVHS World Congresses starting in 1994, led to plans for establishing VERTIS (VEhicle, Road and Traffic Intelligence Society), an associated IVHS AMHRICA-like organization.

As indicated in Figure 6.3, VERTIS includes representatives from private industry and academia as well as the five ministries. A meeting to establish the VERTIS Promotional Council was scheduled for January 21, 1994. Thus it seems that Japan's individual IVHS activities are at the threshold of becoming more monolithical.

Each of the Japanese ministries supports one or more affiliated associations (shown as "third sector organizations" in Figure 6.3). It is industry's paid membership in these organizations that provides the principal interface for coordination of government and industry IVHS interests and activities. These associations accommodate the bureaucratic constraints of the agencies themselves and are typically managed and staffed by individuals formerly with the corresponding parent associations (Ervin 1991).

The Ministry of International Trade and Industry (MITI) is responsible for assuring that products produced by auto-related industries meet the needs of public welfare in terms of safety, efficiency, etc. MITI's activities are limited to the basic R&D and promotion of technologies without

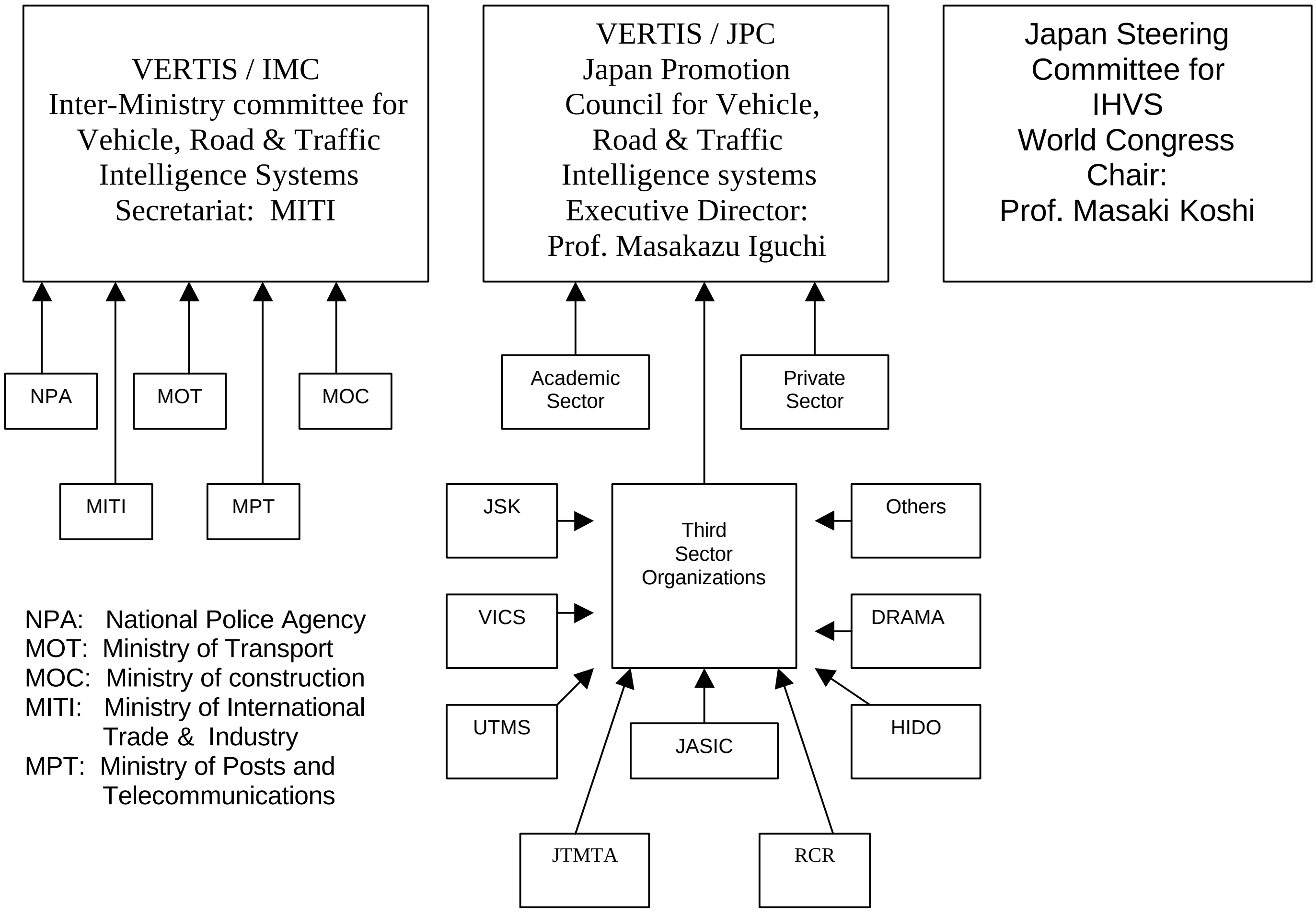


Figure 6.3 Organizations Structure for Vehicle, Road and Traffic Intelligence society in Japan(VERTIS)
(source: IVHS AMERICA Newsletter, October 1993)

jurisdiction to build the related infrastructure. Since 1979, MITI has sponsored the Association of Electronic Technology for Automobile Traffic and Driving (JSK) which, in addition to technical research, investigates social needs, technical trends, and means for introducing IVHS.

The Ministry of Construction (MOC) is responsible for proper and efficient infrastructure construction and for maintenance of national road networks as the basis for the citizen's life and economic activities. The MOC takes recent developments in advanced vehicle and communication technologies into consideration in planning the functions of highway systems. MOC sponsors the Public Works Research Institute (PWRI) and the Highway Industry Development Organization (HIDO), both of which have been active in IVHS development. The MOC also sponsors the Japan Digital Road Map Association (DRMA), which was formed in 1987 to standardize and develop digital maps.

The National Police Agency (NPA) is responsible for the safety of citizens. NPA performs traffic management to realize smooth traffic and reduce accidents. NPA sponsors the National Research Institute of Police Science (NRIPS) and the Japan Traffic Management Technology Association (JTMTA). In 1993, the NPA established the Universal Traffic Management Society of Japan (UTMS Japan), a new membership organization for promoting a Universal Traffic Management System that uses optical beacons in an IVHS communications infrastructure for automobile navigation systems.

The Ministry of Posts and Telecommunications (MPT) is responsible for the allocation of radio frequencies and is the sponsor of RCR (Research and Development Center for Radio Systems). MPT-approved "teleterminal" technology was used in the NPA's original AMTICS field trials, and the MPT is now a co-sponsor of the successor VICS program, which also incorporates the MOC's earlier RACS program.

The Ministry of Transport (MOT) is responsible for private and public transportation activities for safety and social efficiency. MOT is also in charge of vehicle homologations and is the sponsor of the Traffic Safety and Nuisance Research Institute (TSNRI). The ASV (Advanced Safety Vehicle) project is the MOT's principal IVHS project.

6.3 Research and Testing

One of the more highly visible measures of IVHS activity is the amount of IVHS-related research and testing being carried out. Research is important because it must be carried out well in advance of IVHS product development and implementation and is a good measure of the degree of support for IVHS, particularly if it is broad in scope and is sustained over a significant period of time. Testing, particularly operational testing carried out in a real-world environment, is the bridge between IVHS research and full-scale deployment of proven technologies, and is critical in evaluating innovative institutional arrangements between the public and private sectors.

Table 6.3 summarizes highlights of IVHS research and testing activities in Europe, Japan, and the United States. However, it should be cautioned that, because of different approaches used in the three regions for delineating discrete research projects and tests, the numbers of activities listed for each can be misleading without reading the accompanying text. For example, in Japan, extensive research activities as well clearly identifiable field trials have been embedded in the RACS and AMTICS projects. Thus much of the extensive IVHS research in Japan is not directly reflected in Table 6.3.

6.3.1 United States

Until recently, IVHS research in the United States was largely focussed on traffic control, particularly for urban freeways, and although there have been a number of implementations in major urban areas, there was only one large-scale operational test. This was the IMIS (Integrated Motorist Information System) project started in the early 1980s for the Long Island Expressway Corridor in New York; it is now operational and called "INFORM." Research was also carried out on automatic vehicle monitoring and control systems for transit buses and a series of operational tests carried out during the 1970s (UMTA 1981).

The situation has changed dramatically since 1989. There are now over 65 IVHS R&D projects and 29 operational tests, covering virtually all aspects of IVHS (USDOT 1993). Many of these are jointly sponsored by the USDOT, other public agencies, and various private sector organizations. These figures do not include industrial and other proprietary IVHS R&D and testing activities being carried out by the automobile, electronics, and other companies in the U.S.

Operational tests have become the cornerstone of the National IVHS Program and account for over one-half of FHWA's FY 1993 Budget of $218M. Several highly visible operational field tests (e.g. Pathfinder, TravTek, ADVANCE, HELP/ Crescent, ADVANTAGE I-75) were initiated prior to the passage of ISTEA. Many future operational tests will concentrate in the four "Priority Corridor" sites selected in accordance with ISTEA criteria, and are expected to result in the establishment of an infrastructure that will support continuing deployment of IVHS technologies and services.

6.3.2 Europe

With exception of LISB, most European IVHS/RTI research and testing has been supported primarily by the EC under the

Table 6.3 IVHS Research and Testing

EUROPE	UNITED STATES	JAPAN
• 65 DRIVE II Field Trials and Pilot Projects • 10 PROMETHEUS CEDs • 72 DRIVE I R & D Projects • 12 Other R&D Projects excluding PROMETHEUS • 2 IVHS Test Facilities (ZELT and ARENA/Test Site West Sweden)	<table><tr><th></th><th>R & D Projects</th><th>Field Tests</th></tr><tr><td>ATMS</td><td>9</td><td>8</td></tr><tr><td>ATIS</td><td>5</td><td>8</td></tr><tr><td>APTS</td><td>2</td><td>6</td></tr><tr><td>CVO</td><td>5</td><td>3</td></tr><tr><td>ARTS</td><td>2</td><td>2</td></tr><tr><td>AVCS</td><td>18</td><td>1</td></tr><tr><td>Support</td><td>19</td><td></td></tr><tr><td>Other</td><td>5</td><td>1</td></tr></table>	• 3 RACS Field Trials (ATIS) • 2 AMTICS Field Trials (ATIS) • PVS Research (AVCS) • VICS Research and Demonstration (ATIS) • ARTS Research • ASV Research • UTMS Research (ATMS)

DRIVE program and by industry as well as national governments under PROMETHEUS and other EUREKA projects. LISB was a large-scale (over 250 infrared beacons and 700 specially equipped vehicles) field trial of the ALI-SCOUT route guidance system funded primarily by Siemens, Bosch, the Federal Government of Germany, and the City of Berlin. As indicated in Table 6.1, both DRIVE and PROMETHEUS have received substantial funding, and this has resulted in wide-ranging cooperative research and testing programs involving participants from the public and private sectors throughout Europe. In both programs, the initial emphasis on R&D has now shifted more to operational field trials.

DRIVE, which is directed more toward improving the efficiency and safety of roadway transportation than the vehicle itself, supported over 72 R&D projects during the first phase (DRIVE I) from 1989 to 1992. In addition to these, there are 12 other European IVHS R&D projects which were not funded directly from the EC. This research covered all the important aspects of IVHS with the exception of AVCS, including traffic control, traveler information systems, public and freight transport, parking management, driver behavior and traffic safety, and communications. TARDIS, which defined the functional requirements and specifications for the Integrated Transport Environment (IRTE), and CARGOES, which was concerned with the integration of dynamic route guidance and traffic control, are examples of two major projects within the DRIVE Program.

DRIVE II, or the Advanced Transport Telematics (ATT) Program as it is officially called, will run three years to the end of 1995. It consists of approximately 30 field trials and pilot projects covering demand management, travel information, integrated urban and inter-urban traffic management, transit and truck fleet management, and driver assistance. Cross-cutting projects devoted to systems engineering, road-vehicle communications, environmental standards, etc., are also part of the program. These include the RDS-TMC (Radio Data Systems-Traffic Message Channel) project and SOCRATES (System of Cellular Radio for Traffic Efficiency and Safety), one of the largest DRIVE II projects.

Increased vehicle safety is the major goal of the PROMETHEUS Program, which combines both applied,research conducted by industry and basic research conducted by over 40 university and government research institutions. There were seven subprograms, three being carried out by the motor industry and four by the research community. After a detailed examination of research achievements made during the definition phase, the emphasis shifted from research to field tests and demonstrations. Ten Common European Demonstrators (CEDs) were identified, which are scheduled for completion in 1994.

6.3.3 Japan

Advanced traffic control systems have already been installed in all large cities and on most urban and inter-urban expressways employing the latest technology such as fiber optics communications and LED changeable message signs displaying both text and graphics in color. In addition, extensive bus location and operation management systems, freight management systems, etc. have already been deployed without field tests per se.

Thus the Japanese IVHS testing and research activities listed in Table 6.3 focus largely on in-vehicle systems and their communication links with the infrastructure. The main IVHS testing activities in recent years have been RACS, AMTICS, and VICS, all in the ATIS category. In addition to research activities underlying RACS, AMTICS, and VICS, other research activities include PVS, SSVS, ARTS, ASV, and UMTS.

Following research culminating in 1987 and 1988 field tests of the effectiveness of beacons for navigation and the characteristics of mobile communications by microwave beacons, an integrated RACS (Road Automobile Communication System) experiment was started in 1989 to test navigation, road traffic information, and various information services using two-way beacons. In-vehicle systems from thirteen different groups of Japanese manufacturers were involved in these tests. A comparable number of systems were involved in a pilot test of AMTICS (Advanced Mobile Traffic Information and Communication Systems) in Tokyo in 1988. This was followed by a larger-scale test in Osaka in 1990. The AMTICS concept is similar to RACS except for using cellular-like teleterminals instead of beacons for data communications.

VICS (Vehicle Information and Communication System) is a relatively new program formed in 1990 under the combined direction of the MPT, MOC and the NPA in an attempt to resolve the competition between RACS and AMTICS and define a common system which would use the best features of both. Following further research on communications, VICS underwent a public demonstration in Tokyo in 1993 to promote awareness of the need to deploy IVHS technology in order to ease Japan's traffic congestion. A combination of microwave beacons, optical beacons, and FM subcarrier data communications were used in the VICS demonstration.

Early AVCS research in Japan included PVS (Personal Vehicle System), a test bed for exploring a variety of technologies for automated route following, lane keeping, and obstacle avoidance. SSVS (Super Smart Vehicle System) is a new study activity that focuses on the development of technologies to assist drivers with the driving task, and which may eventually take over some or all the driving task. ssvs essentially encompasses the AVCS element of IVHS and has a proposed R&D budget of over $200 million. Some of the technologies being considered are automated lateral control to permit close spacing between vehicles in adjacent lanes (which would allow 3 lanes in the space of 2), an in-vehicle display of a plan view of the vehicle and its surroundings (including other traffic), active roadside lighting, and in-vehicle signing for speed limits and other roadway information.

ARTS (Advanced Road Traffic Systems) is a MOC research initiative that focuses on intelligent road facilities. ASV (Advanced Safety Vehicle), a research project of the MOT, seeks to improve safety through autonomous functions such as driver monitoring, obstacle detection, and headway keeping. UTMS (Universal Traffic Management System), an initiative of the NPA, focuses on the application of optical beacons in integrated traffic control and related areas of IVHS.

6.4 System Architecture and Standards

Development and deployment of consistent IVHS services on a national scale requires a supporting framework known as system architecture to describe the governing plan and define the relationship among the subsystems and components. The ideal architecture provides a full range of user services nationwide, is open to inter-operable products that compete on their merits and performance, and preserves the capability for expansion and modernization.

Whereas an IVHS architecture is essentially a macro-standard defining the functional relationships of the elements of the overall system, narrower standards are required at the component and subsystem levels for a variety of reasons. Standards avoid unnecessary product development costs caused by changes in the way products interconnect or the need to create multiple versions to interact with other products. Standards also help ensure system reliability, availability, and maintainability and establish a basis for limiting liability. In addition, standards will help open and expand markets for IVHS products. However, there is valid concern that developing standards too rapidly could stifle innovation and product improvement.

In addition to their national IVHS standards activities, Europe, Japan, and the United States are heavily involved in the establishment of international standards to ensure the compatibility of IVHS equipment wherever one travels. International standards for IVHS products will also provide for greater economies of scale and facilitate international competition on the basis of performance and cost. The international standards for IVHS are being developed through ISO/TC 204, a committee on Transport Information and Control Systems (TICS) that was formed early in 1993 by the International Standards Organization (ISO).

Table 6.4 lists highlights of IVHS architecture and standards activities in the United States, Europe, and Japan.

6.4.1 United States

One of IVHS AMERICA's first major recommendations in its role as advisory committee to the U.S. Department of Transportation was a top-down systematic approach to developing a nationwide IVHS system architecture. In 1993, the FHWA initiated concurrent studies by four contractor teams as Phase I of a $20M National IVHS System Architecture Program. Late in 1994, Phase II will start detailed analyses and system modeling of the most promising architectures emerging from the Phase I studies. The process will end with consensus-based selection of a national IVHS architecture in mid-1996.

The IVHS architecture program is intended to accelerate the process of architecture evolution, to achieve nationwide system compatibility, to encourage competition, and to minimize product development risk through establishment of an open architecture. However, there are concerns that ongoing operational tests of a variety of IVHS approaches, early deployment of certain elements such as AVI for electronic toll collection, and other developments may lead to de facto architectures first. In addition, there are concerns that, in spite of special outreach efforts, the top-down approach could lead to architectures that do not adequately reflect needs as perceived by state and local governments, thus hindering their "buy-in," which is required for wide-spread deployment.

One of the earliest IVHS standards initiatives was a research problem statement originated in 1984 by the Transportation Research Board that identified an urgent need for guidelines for digitized street and road maps. In 1986, the Society of Automotive Engineers (SAE) addressed this need by establishing an Automotive Navigational Aids Standards Subcommittee, which also included working groups on system interfaces and human factors. These and numerous other IVHS standards activities were subsumed by the SAE IVHS Standards Division that was formed in 1991.

Other standards-setting organizations that have become active in IVHS standards development include the ASCE (American Society of Civil Engineers) and the IEEE (Institute of Electrical and Electronic Engineers). Although not a standards setting organization, IVHS AMERICA formed a Committee on Standards and Protocols in 1991 to identify and prioritize requirements for IVHS standards and serve as liaison with standards-setting organizations.

In addition to its internal IVHS standards initiatives, the United States took the lead through the American National

Table 6.4 System Architecture and Standards Initiatives

EUROPE	UNITED STATES	JAPAN
• EUREKA DEMETER project for GDF map database standards ('87) • DRIVE SECFO synthesis of RTI system architecture scenarios ('89 - '91) • CE/ITC-278 for RTI standards ('91) • Western Europe EDIFACT Board Standardization of IVHS/RTI Messages	• SAE Automobile Navigation Standards Subcommittee ('86) • TRB Workshop on UIIVHS Communications Standards ('90, 92, & '93) • SAE IVHS Standards Division ('91) • IEEE Standards Coordinating Committee ('91) • IVHS AMERICA Committee on Standards and Protocols ('91) • National System Architecture Development Program ('93)	• JDRMA formed to develop map database standard and produce map database ('88) • JSAE VeRI Committee formed working group for standards ('91; • CD-CRAFT

Standards Institute (ANSI) to promote creation in 1993 of ISO/TC-204, the new International Standards Organization technical committee for Transport Information and Control Systems. IVHS AMERICA serves as the Technical Advisory Group Administrator for overall U.S. participation in ISO/TC-204.

6.4.2 Europe

A special SECFO (Systems Engineering and Consensus Formation Office) project was established as part of the EC's DRIVE I program with responsibilities to consolidate results from all DRIVE projects and synthesize a system architecture approach. SECFO was staffed by personnel from the major information technology and automobile industries to assure that a single integrated road transport environment for Europe would result from the joint PROMETHEUS and DRIVE efforts.

ERTICO (European Road Telematics Implementation Coordination Organization) was formed in 1991 as a coordinating link between R&D and national planning of IVHS deployment in different European countries. ERTICO is responsible for the CORD project of DRIVE II, which has a synthesis function similar to the SECFO project of DRIVE I.

Because different European countries have widely varying ideas about IVHS architecture and the division of public and private roles in funding and operation, one of ERTICO's main strategies is to promote standardization. However, as described in Appendix H, ERTICO sees dim prospects for a unique pan-European IVHS architecture and is pushing instead for early interoperability among different systems.

As for systems architecture and standards considerations within PROMETHEUS, it has long been assumed that common specifications resulting from the cooperative research, development, and demonstrations will be used by participating companies in pursuing their own competitive versions of various components and systems at the end of PROMETHEUS' seven-year life. One of the earliest European standards efforts relating to IVHS was DEMETER, another EUREKA project. DEMETER, started in 1986 by Bosch and Philips, dealt specifically with standards for digital road maps to support in-vehicle navigation and other applications. It led to the GDF (Geographic Data File) exchange format and related work continued under PROMETHEUS and DRIVE.

IVHS was recognized in the early 1990s as an issue for pan-European standardization by the CEN/CENELEC organization in Brussels. In 1992, following a period of contention among standards organizations with overlapping interests, responsibility for European IVHS standards was given to the European Committee for Standardisation (CEN) under Technical Committee TC-278, "Road Transport and Traffic Telematics." The standards topics were then allocated among approximately

12 service-, database-, and interface-oriented working groups covering most aspects of IVHS.

Some impetus for forming CEN TC-278 supposedly came from Amtech Corporation's bid to make its AVI tag the IS0 standard, and the resulting increase in profile for standards making. It was also the view of some that the purpose of the CEN TC-278 working group on traffic control was to ensure national standards were not abandoned for European ones. At the very least, TC-278 was seen as an important weapon against the United States and Japan. Nonetheless, in spite of these concerns and early foot-dragging on the formation of ISO/TC-204, TC-278 has quickly become an active supporter of the new international committee for Transport Information and Control Systems standards.

As for standards at the national level in Europe, it is noted that the UK has developed a MMI (Man-Machine Interfaces) Code of Practice for in-vehicle driver information systems. The Code is intended to give guidelines and recommendations to designers and manufactures rather than directly to users of such systems.

6.4.3 Japan

There are several distinct characteristics of the system architecture in the past Japanese IVHS projects. Although there are no national discussions or studies about system architecture per se, when a project (e.g., VICS) is started there is already some understanding about its system architecture as a result of stronger centralized planning than in Europe and the United States. Consequently, the major work on projects is to define the functions and information provided, determine specifications for data and communication links, etc. There is always a strong focus on communication media such as inductive loops for CACS, microwave beacons for RACS, teleterminals for AMTICS, and microwave and optical beacons as well as FM subcarrier for VICS.

The importance of standards for digital maps was recognized by the establishment of the Japan Digital Road Map Association (JDMRA) in 1988 under MOC auspices to standardize map formats and share the efforts and costs in quickly digitizing the major roads and highways of Japan. Although the digital road maps.that have subsequently become available to JDMRA members stop short of covering all classes of roads (e.g., residential streets) at suitable scales for IVHS applications such as navigation, the same standards have been used by individual electronics and automobile manufacturers in extending the map database to more detailed levels.

A group of Japanese manufacturers developed a standard called the "CD and CRT Applied Format" (CDCRAFT) in order to define the interface between application software borne on CD-ROMs and various in-vehicle equipment. CDCRAFT is essentially a central interpreter that handles multiple interfaces for input/output devices, computational modules (e.g., navigation), and CD drivers that support navigation and other in-vehicle functions. CDCRAFT has thus enabled the intermingling of a variety of applications software and hardware modules produced by differing manufacturers.

Other IVHS-related standards developments in Japan include establishment of the VeRI (Vehicle/Road Intelligence) committee by the Society of Automotive Engineers of Japan (JSAR) in 1991. VeRI's objectives include proposed standardization of IVHS terms.

6.5 Marketing and Deployment

Although many aspects of IVHS are still under development, a variety of commercial IVHS products are already on the market and, particularly in Japan, significant deployment of IVHS infrastructure has already occurred. Highlights of IVHS marketing and deployment progress in Europe, Japan, and the United States are listed in Table 6.5.

6.5.1 United States

ATMS deployment in the United States is furthest along for freeway surveillance and control systems (FSCS). By 1990, major FSCS systems were operational in approximately 20 cities and approximately six more were under construction or in design. At the same time, over 200 computerized traffic signal systems involving approximately 25,000 signalized intersections were operational, under construction, or in planning. The IVHS AMERICA Strategic Plan for Intelligent Vehicle Highway Systems calls for deployment of partially-featured ATMS in 10 to 20 cities and two to five inter-city corridors by 1996 and deployment of full-featured, area-wide ATMS systems in 30 to 50 metro areas and 15 to 30 inter-city corridors (IVHS AMERICA 1992).

Although standards have not been settled, ETTM (Electronic Toll and Traffic Management) systems have an early lead in IVHS deployment in the United States because of their advantages and quick return on investment. Major examples include the Dallas North Tollway electronic toll collection system that started in 1989 and now has 70,000 users of Amtech TollTagstm. Approximately 10 other electronic toll systems are operational in the United States.

The deployment of commercial vehicle location monitoring and communication systems is well advanced in the United States. For example, Qualcomm, Inc. had outfitted over 64,000 heavy trucks and had a backlog for approximately 20,000 more installations for use of its satellite-based OmniTRACS Table

6.5 Deployment and Marketing

EUROPE	UNITED STATES	JAPAN
* Widely Deployed Traffic Responsive Signal Systems * Trafficmaster Operational in UK with Over 800 Traffic Monitors and 2,000 Vehicle Units . * Extensive APTS Deployment * Electronic Toll Systems in France, Italy, and Norway	* FSCS Operational in Approximately 25 Areas * Over 200 Computerized Traffic Signal Systems * Over 10 Electronic Toll Systems in Operation * Extensive Deployment of Heavy Truck Location/Communication Systems * 1,500 Highway Buses Equipped with Collision Warning Radar * Rapidly Growing APTS Deployment	* 131,621 Signal Controllers with 46,050 Under Central Computer Control ('89) * 161 Centralized Traffic Control Centers (74 Major City & 161 Sub-City Centers) * Automobile Navigation Systems Sold: 1987 - 20,000 1988 - 25,000 1989 - 39,000 1990 - 53,100 1991 - 75,000 1992 - 90,000 1993 -

location and communications services. In addition, systems for transit bus tracking and management are proliferating now that GPS is available for determining vehicle location. Numerous test systems and a few operational systems had been installed earlier based on sign-post, dead reckoning, and Loran-C.

In 1984, Etak introduced the NavigatorTM, the world's first commercially available digital-map-equipped automobile navigation system, in California markets that were limited by digital map availability. Although not successful in the consumer market, the system has been used in several commercial applications as the basis for vehicle location monitoring and positioning reporting. Appendix K provides a comprehensive compilation of vehicular navigation and location systems that have been developed worldwide.

The VOHAD radar system, which warns drivers of unsafe closing rates and distances between equipped vehicles and others in its path, has been installed on approximately 300 Greyhound buses. Other IVHS devices to reach the market in the United States include Way To Go, a pocket-size device with a map of the San Francisco Bay area printed on a touch-sensitive panel. Upon touching a location on the map, the device selects relevant traffic information from a digital paging signal and speaks the information using synthesized voice. The Way To Go Corporation suspended operations in 1993 because their customers, while enthusiastic, were too few in number.

6.5.2 Europe

Advanced traffic management systems, particularly vehicle-actuated, adaptive traffic control systems, are widely deployed in Europe. These types of systems were pioneered by SCOOT, a vehicle-responsive traffic signal control system developed in the UK during the 1970s.

Following a successful 2-year pilot operation in the London area, General Logistics Plc was granted a 12-year licence from the UK Department of Transport in 1993 to deploy the privately operated Trafficmaster system throughout England. Trafficmaster is an in-vehicle information system that superimposes motorway traffic conditions on a liquid-crystal map display. Infrared monitors are installed on bridges and gantries collect traffic data for communication by radio to a central location where it is processed and transmitted over a commercial paging network to the in-vehicle units. More than 800 monitors have been installed on more than 450 motorway bridges and gantries and approximately 2,000 to 2,500 in-vehicle in-vehicle units were in use by the end of 1993.

France, especially, and Germany have made early investments in public transport information systems, including real-time systems in recent years. These systems have been dominated by short-range beacon communications, although a move has started to GPS-based systems.

The automatic debiting of tolls has been advanced in Italy and France, as both countries have tolled motorways. France has a special interest in smart cards. Automatic debiting is now used quite widely, with a strong interest in road pricing. Norway has pioneered the use of electronic toll collection for vehicles entering the cities of Oslo and Trondheim.

Other IVHS deployments in Europe include dynamic systems for providing parking information via changeable message signs as well as traffic information services using RDS. In addition, dynamic route guidance is provided via changeable message signs in the Stuttgart area of Germany.

6.5.3 Japan

The Japanese government has systematically invested in the deployment advanced traffic management systems over the past two decades through a series of five-year programs. As a result Japan has widely-deployed infrastructure for traffic and road environment monitoring along with numerous traffic control centers that, in addition to wide-area signal control, drive changeable message signs which present traffic information, driving times, etc. in color graphics. Figure 6.4 illustrates the overall hierarchy and architecture.

Thus the ATMS already in place needs little more than mobile communication links to service smart in-vehicle systems. On the vehicle side, industry had already sold 300,000 autonomous navigation systems (mostly as factory equipment) at prices typically in the $2,000-6,000 range by the end of 1992 and is positioned to rapidly address the large market expected once administrative decisions are made on the communication links. Many of the systems evolved from test versions developed by various companies for participation in the series of field trials (e.g., RACS and AMTICS) sponsored by government agencies since 1986 primarily to test various means of communicating traffic information to in-vehicle units. Appendix L discusses the evolution of these systems.

In addition to the OEM manufacturers, there is now keen competition among over ten manufacturers of aftermarket automobile navigation systems. Altogether, this has resulted in more sophisticated technology, lower prices, and more variations in system features. Many of the newer systems provide some form of static route guidance as well as intersection information and current location. The next major improvement is expected to be dynamic route guidance as soon as traffic data is offered through mobile data communication links.

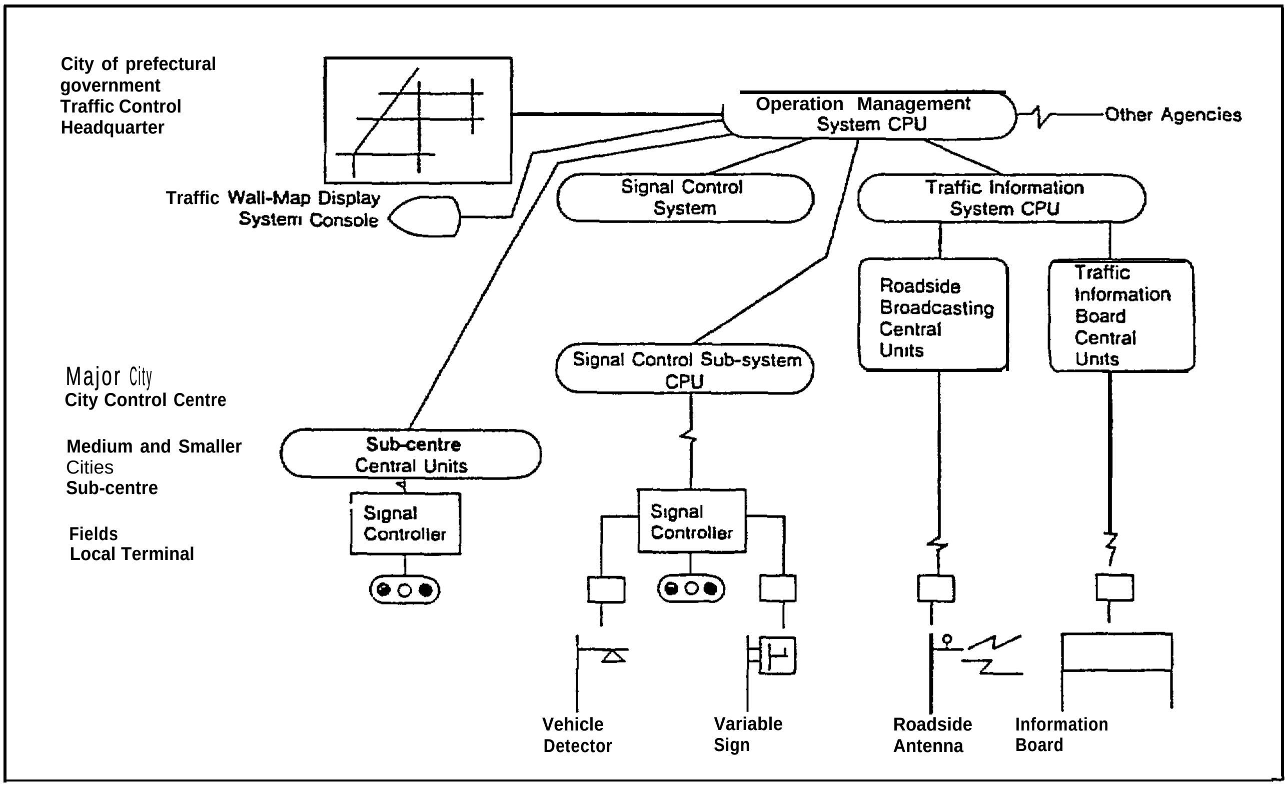


Figure 6.3 Hierarchy and Architecture of Japanese Traffic Control Systems (Source: JTMTA 1991)

During the last half of 1993, the prices of navigation systems have generally fell by 20 to 40 percent. The price reductions were apparently precipitated by Sony's announcement in July 1993 that it would sell an advanced system with color LCD for $1,940. In addition to lower prices, the success of the VICS demonstration is thought to have spurred sales. Even with the present recession, more that 20,000 navigation systems per month are being sold. A navigation system market of 350,000 units is projected for 1994 (Denpa News, February 2, 1994).

Other IVHS deployment in Japan includes transit bus location and information systems, operational management systems for emergency vehicles, and truck freight management systems. The equipped transit buses are widely used as traffic probes.

6.6 Institutional and Legal Issues

IVHS technologies and products will not be deployed on a widespread and cost-effective basis without unprecedented cooperation between industry and government transportation agencies at all levels. In the United States, successful deployment depends on collaboration between all elements of the public sector: federal administrations, state transportation departments, city/county governments, and Metropolitan Planning Organizations (MPOs). Collaboration is essential for the roadway system and information network to appear "seamless" across urban areas, state boundaries, or international boundaries (as in the case of Europe or the U.S./Canada border).

"Institutional issues" refer primarily to these challenges faced by the respective public sector organizations in attaining the extraordinary level of cooperation required for IVHS. However, a blind requirement for seamless interoperability should not necessarily preclude local consideration of customization for special needs.

The United States, Europe, and Japan all face significant institutional issues in fostering IVHS deployment. Some of the more important issues are listed in Table 6.6. In Japan, significant jurisdictional issues exist among high-level government agencies with conflicting IVHS interests. In Europe, national sovereignty issues hinder the evolution and deployment of a common system architecture. While the U.S. has a focused effort underway to develop a national architecture, a much greater level of "hierarchical cooperation" is needed among public agencies at all levels than in Europe or, especially, in Japan.

Product liability and other legal issues are also perceived to be a more significant barrier to IVHS deployment in the U.S. than in Europe or Japan. Although not discussed in this

Table 6.6 Institutional and Legal Issues

EUROPE	UNITED STATES	JAPAN
• Coordinated Implementatior of RTI • Personal Mobility • Increase Safety • Financing • Respect Privacy • Liability • Harmonization • Provide for User Fees	• Intergovernmental/ Interagency coordination • Regulatory structure • Intellectual property rights • Privacy and information security • Procurement policies	• Delineation of agency responsibilities

report, environmental issues also interact with IVHS development, certainly through the clean air act in the United States, and through the efforts of the Green movements in both Europe and North America.

6.6.1 United States

The United States transportation infrastructure is largely owned and operated by state and local entities, which has resulted in fragmented efforts, including slow growth in key enabling standards (e.g., AVI). The national IVHS system architecture now under development along with associated outreach efforts should help, but inconsistent involvement by state and local government entities remains a major concern.

Progress towards deployment is also impeded by Congressional "earmarking" (i.e., directing that certain projects be funded in specific congressional districts). This practice limits the flexibility to optimize allocation of the substantial government funding now available for IVHS development and field trials in the United States. However, unless carried to extremes, earmarking also has certain advantages. In particular, local preferences are honored, thus helping to preserve legislative support for a strong national program. In addition, recipients of earmarked funds have resources to provide input to the USDOT on concerns and ideas for implementation of the national program.

About $7 million is granted annually under an Early Deployment Program to state and local governments and MPOs to assist with feasibility studies and development of multi-year deployment plans for IVHS services. Such grants, which must be matched by at least 20 percent funding from non-federal sources, were made to 36 metropolitan areas through FY 1993. While this program is helping bring state/local transportation agencies up to speed on IVHS technologies, MPOs (which gained significant influence as a result of the landmark ISTEA legislation) remain largely on the sidelines, because they lack the tools to predict the long-term benefits of IVHS.

Most large MPOs rely heavily on the traditional four-step Urban Transportation Planning System (UTPS) process, or some derivative of it, and the impact of IVHS deployment is not well accounted for in the UTPS environment. An additional hinderance to IVHS is the possibility of litigation under the Clean Air Act Amendments of 1991. Thus, MPOs have difficulty in considering IVHS in their long-term plans.

Product liability is also an important consideration. Since there are overlapping federal and state safety regulations, vendors, manufacturers, and implementing agencies must be aware of their legal exposure to liabilities resulting from design, manufacturing and operational defects. Traffic management, route control, and driver assistance devices all imply some additional degree of responsibility for the providers of IVHS equipment.

In preliminary studies, these liability questions have appeared daunting for new technology applications in IVHS. However, literature review of tort liability for ATMS and ATIS indicates that the problem may be somewhat illusory. Proposed new applications to traffic management and driver information systems are, in a legal sense, extensions of existing practice and are believed to be adequately covered by existing case law. On the other hand, advanced systems (e-g-, AVCS) that dilute driver control may not be represented in legal precedents and may present difficult liability issues (Ramsdell 1993 and Syverud 1993).

Complying with state regulations also raises some difficulties. To start with, there does not seem to be a specialized compendium or clearinghouse on state motor vehicle regulations that is be sufficiently complete or reliable to use as a uniform means of determining the existence of state motor vehicle regulations and their potential applicability to the use of navigation displays.

Intellectual property and privacy rights are two additional legal considerations that have recently been discussed in "IVHS Legal Issues," a newsletter of the IVHS AMERICA Legal Issues Committee.

6.6.2 Europe

'In contrast to the Japan and the United States, European planners must confront the political and cultural differences of their constituent countries, although there is a similarity in coping with the various differences in the 50 states. However, the not-invented-here syndrome remains a major constraint to deployment in Europe; each sovereign nation typically identifies its own priorities and implementation approaches, thus hindering progress towards an IVHS environment that is seamless across national boundaries. This "NIH" element also means that the anticipated common market for European IVHS products may not be quickly realized. In addition, it is still not clear which nations may eventually be included in a unified Europe. Thus the dim outlook for pan-European IVHS systems-builders or coordinated procurements could be detrimental to European competitiveness in the international market.

These obstacles could, in principal at least, be resolved through ERTICO, an organization chartered to promote and assist with the coordination of IVHS implementation in Europe. However, ERTICO's limited membership and powers leave the follow-through on IVHS deployment largely up to individual countries, which have widely varying ideas about

IVHS architecture and the division of public and private roles. Thus one of ERTICO's main strategies is to promote standardization and the early interoperability of different systems available or about to become available.

An additional concern for Europe is road pricing/demand management, which has not yet got onto the U.S. agenda in the same way. For example, Germany and the UK are now talking of charging for motorway use, and city road pricing still looms. Technology will be needed to deal with the policy issues and it is proving difficult to reconcile all the conflicting interests.

European legal issues relate to personal liberties and to practical problems such as using video evidence in court. Also, distinct and different national legal systems require that contracts for IVHS products and services address the business law in each nation involved, thus preventing the use of standard contract language and adding significantly to the expense of pan-European services. As for special IVHS-related legislation, it is noted that the UK passed the Road Traffic Act in 1989 to permit the licensing of private firms to install and operate traffic data acquisition and communication services (e.g., Trafficmaster).

Language and ethnic variations also present obstacles to pan-European implementation of IVHS. Long-standing political compromises, such as place signs in Flemish or French, depending on the local jurisdiction in Belgium, or similar local practices in other multi-lingual European nations, require careful negotiation for change to true international roadway signs.

6.6.3 Japan

In spite of great progress in developing and deploying IVHS technology, and as discussed in more detail in Section 6.2.3, "turf struggles" among the concerned Japanese government agencies have been an obstacle to the consolidation of traffic data and the system-wide deployment of communication links between the infrastructure and in-vehicle equipment. However, once these agencies resolve their parochial interests, Japan is poised for rapid deployment and operation of integrated traffic management and in-vehicle information systems.

The consolidation in 1991 of RACS and AMTICS under VICS was a major first step in resolving these institutional issues. An even more important step occurred when the five agencies that share IVHS interests and jurisdiction (Ministry of International Trade and Industry, Ministry of Construction, National Police Agency, Ministry of Posts and Telecommunications, and the Ministry of Transport) formed an inter-ministry committee in July 1993 to provide greater cooperation within the Japanese government. In addition, as discussed in Section 6.2.3, VERTIS (the VEhicle, Road and Traffic Intelligence Society), an associated IVHS AMERICA-like organization, is being established with representatives from private industry and academia as well as the five government agencies.

Moreover, following the Liberal Democratic Party's recent loss of a 38-year hold on power in Japan, there is also talk of streamlining the number of government agencies. Mentioned possibilities include a single ministry with responsibility over IVHS.

6.7 Planning

IVHS involves many complex interactions among the various technologies and subsystems incorporated and among the public and private sector organizations that develop, deploy, and operate the systems. Accordingly, IVHS development requires extensive planning involving all parties to identify and sequence the necessary steps.

Table 6.7 lists highlights of IVHS planning activities in Europe, Japan, and the United States.

6.7.1 United States

The informal IVHS planning initiated by Mobility 2000 was culminated by a 1990 workshop. The workshop proceedings included identification of milestones, R&D needs, field tests, deployment, and funding requirements (TTI 1990). The Mobility 2000 planning thus provided a strong foundation for further planning by IVHS AMERICA and USDOT.

Standing out among IVHS AMERICA's achievements is a comprehensive Strategic Plan for IVHS in the United States that was published in July 1992 following a massive consensus-building process that involved the entire IVHS community including the public and private sectors and academia (IVHS AMERICA 1992a). The strategic plan gives goals, objectives, and milestones for IVHS developments over the next 20 years, and serves as a basis for an IVHS Strategic Plan through 1997 submitted to Congress by USDOT in December 1992 in response to mandates by the ISTEA (USDOT 1992). The Strategic Plan also served as a basis for federal IVHS program recommendations developed by IVHS AMERICA for FY 1994 and 1995 (IVHS AMERICA 1992b).

A five-year National IVHS Program Plan is currently being developed as a joint effort by USDOT and IVHS AMERICA (USDOT 1993). This new planning effort is designed to supplement earlier long-term strategic planning by IVHS AMERICA and USDOT. Whereas the earlier strategic plans set forth goals, milestones, and objectives, the program plan focuses

Table 6.7 Major IVHS Planning Efforts

EUROPE	UNITED STATES	JAPAN
* Original DRIVE Planning Study (1986-87) * PROMETHEUS Planning Study (1986-87) * ERTICO Strategic Plan (1992)	* Mobility 2000 (1990) * IVHS AMERICA Strategic Plan (1992) * USDOT Strategic Plan (1992) * National IVHS Program Plan (1993-94)	* MOC Series of 5-year Plans * NPA Series of 5-year Plans * MOC/NPA 5-year Road Innovation Plan * Miscellaneous "Probing Studies"

primarily on delineating the issues that must be resolved and tasks that must be accomplished to develop and deploy IVHS services to achieve the goals.

One purpose of the program plan is to describe the national IVHS program to the private sector and government leaders. It is also intended to guide investment decisions by the private sector as well as at all levels of government. In addition, the plan is intended to provide a consistent basis for coordination and integration of IVHS services and to assure that program activities lead to deployment of services in a nationally compatible system to achieve the program goals. The program plan is structured according to the 27 IVHS user services given in Table 1.3.

Several states have also developed IVHS plans.

6.7.2 Europe

Transport planning in Europe is done on a national level. The planning responsibility either is at the ministry level or performed by national road administrations. The European Conference of Ministers of Transport (ECMT) makes joint recommendations for 28 nations in Europe. The DG VII Transport Directorate of the Commission of the European Community develops guidelines for transport planning among the 12 EC nations. But in the end, the decisions on transport investments, infrastructure development, and taxation are made nationally. However, recommendations from the ECMT and EC can have influence in spite of these organizations' lack of political authority in national transport matters.

ERTICO set out in 1992 to develop a strategic plan which focuses on how to accomplish its mission of assuring a smooth transition from pre-competitive research to IVHS deployment (Camus 1992). However, the main planning for IVHS in Europe will be done at the national level, taking into account recommendations and guidelines from the ECMT, EC, and ERTICO.

Lacking a political union and a European transport policy, the initiative for IVHS development will rely much upon the industrial sector. The idea of the R&D programs of the EC is to define a potential market for industrial products, support joint research financially, and let the industry act over the European borders to deploy the results. After all, the EC is designed to create a common market for some 230 million people.

Although the EC's Fourth Framework program (1994-1998) is not yet finalized, there is a strong emphasis on transport within the EC. Thus it can be expected that DRIVE III will be established with budgets at least as large as the previous ones. Program officials expect to have a DRIVE III work plan developed by June 1994 and issue a call for proposals in July. In parallel with this, there are discussions for PROMETHEUS II as a prolongation and new phase for the automobile industry program within the EUREKA framework.

6.7.3 Japan

Planning for road facilities and traffic management in Japan is through a series of 5-year programs. The Ministry of Construction (MOC) is now in its 11th Five-Year Road Improvement Program and is starting a new Five-Year Road Innovation Program in 1994. The National Police Agency (NPA) is now in its 5th Five-Year Plan for Traffic Safety Facilities (including traffic control systems) with cooperation of the MOC.

IVHS planning and coordination in Japan has thus far been achieved largely on a project-by-project basis (e.g., RACS, AMTICS, and VICS) in the absence of any apparent long-range strategic planning effort. According to the report of the Institute of Transportation Engineers 1992 IVHS study tour to Japan (ITE 1992), "The Japanese approach of incremental advancement of technical accomplishments results in a steady convergence of vehicle and roadway technology into an overall automated highway. Though there is no 'strategic plan' per se, there is very definitely a strong sense of the inevitability of this convergence."

However, "probing studies," sometimes including laboratory or small-scale feasibility testing, are often carried out which provide a basis for planning IVHS goals (Kawashima et al. 1991, included as Appendix I). Examples of probing studies include the JSK study on SSVS, which had the objective of defining automobile transportation systems that fully utilize IVHS technologies, and the HID0 Next-Generation Highway Traffic System study, which investigated future road network functions based on advanced information technologies

Future IVHS planning in Japan should be facilitated by the VERTIS/IMC (Inter-Ministry Committee) that was formed in 1993 by the five ministries (MOC, NPA, MPT, MOT and MITI) having IVHS interests as well as by the new VERTIS/JPC (Japan Promotion Council) which includes industry, academia, and the membership associations attached to the various ministries.

7.0 FINDINGS AND CONCLUSIONS

We have broadly assessed past progress and the current status and directions of IVHS in Europe, Japan, and the United States to answer the main question (see Appendix B) that prompted this study:

> "HOW far behind foreign countries are we in the race to develop IVHS technology?"

The short answer to such questions is that Europe and Japan are still perceived as generally ahead of the United States in IVHS, albeit marginally, if at all, by many important measures. However, a comprehensive answer is much more complex, because the term IVHS covers such a broad spectrum of technologies and applications.

Although a few types of systems may operate on an autonomous basis (e.g., intelligent cruise control, navigation and static route guidance) most are nodes in a vast and highly interdependent network of sensors, communication links, and computers. As stated in the December 6, 1993, inaugural issue of *Intelligent Highway* Systems (a supplement to McGraw-Hill's Engineering *News-Record):*

> "IVHS will be more than the sum of its parts, but this inherent synergy can be tapped only if it is regarded from the start of an integrated set of capabilities."

Thus, in comparing IVHS progress in Europe, Japan, and the United States, we tried to examine (albeit only cursorily in some cases) the most important identifiable factors that propel the IVHS movement in each region. In doing so, we considered not only the current status but also the early initiatives and the rapidly accelerating developments since the mid-1980's that have shaped and lent momentum to the IVHS movements in all three regions.

We found that although government funding plays a critical role in each region, there are other factors that strongly influence differences in IVHS progress. The following paragraphs outline the more influential factors, summarize our findings in terms of the specific measures selected for this study, and suggest approaches for projecting future IVHS progress in the United States, Europe, and Japan.

7.1 Major Factors Affecting ivhs Progress

We believe that clear and consistent policy support and effective arrangements among the involved organizations are the most important factors.

7.1.1 Policy Support

The most significant single factor affecting IVHS progress is consistent policy support. In addition to providing a framework for advancing public sector interests, clear policy support from the government encourages industry to develop IVHS products and services that would have little market potential without assurances that the infrastructure for effectively utilizing the products and services will be in place.

In this regard, Japan has been ahead of the United States and Europe for about two decades. As a result of IVHS policy support, Japan is far ahead in nationwide deployment of advanced traffic management systems and in the development, and now highly competitive marketing, of autonomous navigation and route guidance systems. However, until recently, Japan has been short on the effective institutional and organizational arrangements that are necessary for definitive actions on resolving impeding jurisdictional issues and for reaching administrative decisions on mobile data communication links.

Compared to the United States, Europe has also benefitted from relatively strong policy support, particularly for coordinated IVHS research. However, sovereignty considerations still impede uniform policies among individual nations in Europe because, although influenced by the EC, ECMT, and ERTICO, these centralized organizations lack political authority over national transport matters such as infrastructure investment.

In retrospect, the United States' failure to provide policy and funding support for IVHS in the early 1970s brought a long drought to IVHS research, thus loosing the advantage of an early lead in pursuing IVHS concepts. This meant the demise of the ERGS project which, ironically, pioneered concepts that were then carried forward in Japan and Europe, thus enabling them to surge well ahead by the time the United States resumed serious IVHS pursuits.

However, strong but latecoming policy support for IVHS was expressed by the USDOT in its 1990 statement of national transportation policy. The U.S. Congress went a step further in 1991 with ISTEA's mandate for an IVHS program. ISTEA also brought greatly enhanced funding support with assurances of continuity through 1997, which is vital for programing multi-year research and testing activities.

A particularly important step in clarifying U.S. policy regarding IVHS was the establishment in 1993 of a national IVHS system architecture program to develop a governing plan and define the relationship among IVHS subsystems and components. This program should result in an overall framework that is open to inter-operable products that compete on their own merits and performance while preserving the capability for future expansion and modernization. The existence of a national system architecture will allow industry to proceed with the development of IVHS products and services with confidence that they will have a role in the overall scheme.

7.1.2 Organizational Arrangements

Although a latecomer to aggressive pursuit of IVHS, the United States has effectively applied its systems approach culture in a top-down approach to organizational structure as well as to planning and to IVHS architecture development. Established in 1990, IVHS AMERICA has quickly emerged from its Mobility 2000 underpinnings as the central coordinating body that serves simultaneously as advisory committee to the USDOT, as a forum for interfacing public and private sector interests, as a central exchange for IVHS information, and, in many ways, and as both professional society and industry association.

Europe has also excelled in organizational arrangements but faces national sovereignty issues and conflicting national priorities that give the central planning function little clout in establishing a common European IVHS framework. Both Europe's and Japan's primary "institutional issues" are high-level conflicts - Europe's at the national level and Japan's at the ministry level. However, with the new spirit of cooperation among Japan's several high-level ministries having IVHS interests and with the recent formation of VERTIS (an IVHS AMERICA-like organization), a breakthrough may be at hand for Japan to move ahead with full-scale deployment of ATIS and integrating it with the ubiquitous ATMS already in place.

The United States faces a different and, in many ways, more difficult challenge. While clear consensus now exists at the highest policy levels of the federal government, all levels of the public sector must reach consensus and cooperate if a common architecture is to be accepted for nationwide IVHS deployment.

However, the many players involved in the transportation infrastructure (federal, state, city, and county transportation agencies and Metropolitan Planning Organizations) make consensus building a major challenge. State and local agencies must put high priority on using their limited resources for maintaining and operating the existing transportation infrastructure, and may be reluctant to "buy in" during the formative stages of IVHS.

7.2 Other Findings

We found that consistent comparison of all relevant government funding of IVHS is precluded by differences in national jurisdictional responsibilities, institutional practices, and the extent to which IVHS expenditures are delineated from other expenditures. Moreover, access to details on IVHS investments by industry are precluded by proprietary considerations. Nonetheless, except for deployment expenditures, it appears that government IVHS funding in the United States is now edging ahead of Europe. More IVHS development work has already been accomplished in Japan where the main expenditures are now on deployment.

Both the United States and Europe have focused strongly on research and testing including emphasis on operational field trials at the present time. The United States leads both Europe in Japan in IVHS planning and in establishing the necessary institutional arrangements for developing and deploying IVHS. However, it should be noted that its late start in serious IVHS pursuits has enabled the United States to apply knowledge gained from the European and Japanese experiences in developing its top-down systems approach.

IVHS standards development, particularly in Europe and the United States, has involved many contentious issues as individual efforts got underway. However, great progress has been made on the international level with the establishment of ISO/TC-204 (International Standards Organization Technical Committee on Transport Information and Control Systems) in 1993 as a result of a United States initiative. In addition to assuring the compatibility of IVHS equipment wherever one travels, international standards will provide for greater economies of scale and facilitate international competition on the basis of performance and cost.

With the notable exception of Japan, where ATMS deployment has practically reached saturation and great progress has been made by industry in marketing autonomous navigation and driver information systems for automobiles, IVHS deployment and marketing is still spotty. The United States leads in operational electronic toll collection systems, Europe is close behind, and Japan has not chosen to implement electronic toll collection at this time. Europe and Japan lead in the implementation of advanced technologies for transit bus information and management systems. The United States leads in the deployment of commercial vehicle location monitoring and communication systems, particularly for heavy trucks. Private industry in the UK has deployed Trafficmaster, the world's first operational system to automatically collect and communicate real-time traffic information to in-vehicle displays.

7.3 Conclusions

We conclude that the United States has made significant progress in IVHS during the last few years, particularly in gaining government policy and funding support and in organization and planning. Although starting late compared to Japan and Europe, the United States has also made great progress in IVHS research and testing. As a result, the United States suddenly has a national IVHS program that, overall, compares quite favorably with those of Europe and Japan.

Much of the United States' progress is due to a resurgence in federal support for IVHS driven by benefits identified and priorities established in an effective national public-private IVHS planning effort at the strategic level. However, the current efforts are difficult to optimize because of inflexibility in applying the available funding due to earmarking. The extensive earmarking that has accompanied much of the funding to date may be due in part to the fact that the appropriations have often been ahead of detailed planning during the period of rapid build up of the IVHS program. Thus completion of the National Program Plan for IVHS that is now under development should provide a more coherent basis for earmarking.

International competitiveness considerations have also been a motivating factor for developing the U.S. program. However, although there are strong undertones of rivalry, international cooperation and information exchange have become hallmarks of IVHS. Progress being made on international standards and protocols should lead to much larger international markets which will be more attractive to manufacturers, and the increased volume will result in economic growth and lower prices.

Finally, IVHS may have even further-reaching implications for the United States. As suggested by Professor Daniel Roos of the Massachusetts Institute of Technology when addressing the IVHS AMERICA Coordinating Council in 1991:

> "In some ways, the most important potential of IVHS might not be in transportation, but rather as a model for how this country is going to have to operate in the future with regard to cooperation between the public and private sectors."

7.4 Recommendations

Although comprehensive comparisons of technological capabilities and prowess of the United States, Europe, and Japan could not be undertaken within the scope of this study, we recognize its fundamental significance in high-tech pursuits such as IVHS. For example, the Japan's competence in consumer electronics manufacturing has been an enabling factor for the progress they have made in developing and marketing automobile navigation systems. Many knowledgeable observers see the vehicle control area as a core competence for Europe. The United States' strength in systems engineering and organizational skills as well as in technology have been invaluable to the IVHS progress it has made.

We also recognize the accompanying importance of technology transfer capabilities, which is critical to IVHS development because of the multiplicity of technologies required. This is a particularly important issue for the United States because its late start in IVHS could be ameliorated if the surplus of defense-related technological capabilities in the wake of the cold war can be successfully refocused on IVHS. Part of that refocussing will involve retargeting defense technologies to thorny transportation challenges, and a key will be how well U.S. defense companies acquire the necessary "domain knowledge" to succeed. During the course of this study, moves in this direction were initiated through the Technology Reinvestment Program (TRP) under the auspices of the U.S. Department of Defense.

Thus we believe that core technological competencies should be compared in more detail and that the prospects for transferring them to IVHS applications should be evaluated to gain a better understanding of the future directions of IVHS in the United States, Europe, and Japan. In the same vein, manufacturing and marketing strengths should also be compared to help round out future expectations regarding international competitiveness in IVHS.

As for future IVHS deployment and the realization of its benefits in the United States, it appears that one of the most challenging issues for the next several years will be that of evoking "buy-in" by transportation agencies at the state and local levels. Although top-down outreach efforts by the USDOT and IVHS AMERICA are underway to this end, it could be helpful to supplement these efforts with an independent bottom-up study of IVHS perceptions, needs, and concerns as seen by state and local agencies.

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REFERENCES

[The list of references is still in processing and is not available for this draft.]

Appendix E: Glossary

AASHTO American Association of State Highway and Transportation Officials.

ACC Adaptive Cruise Control. A cruise control system that maintains a safe distance from the vehicle ahead.

ADIS Advanced Driver Information Systems. Vehicle features that assist the driver with planning, perception, analysis, and decision-making.

ADVANCE Advanced Driver and Vehicle Advisory Navigation Concept. A large-scale project being conducted in the northwestern suburbs of Chicago, ADVANCE will evaluate the performance of a dynamic route guidance system that uses vehicles to gather traffic information. Up to 5000 private and commercial vehicles will be equipped with in-vehicle navigation and mute guidance systems and will serve as probes, providing real-time traffic information to the traffic information center. Processed traffic information is then transmitted to the vehicles, where it is used in developing preferred routes. The routing information is presented to the driver in the form of dynamic routing instructions.

ADVANTAGE I-75 A CVO operational test along Interstate 75, this project represents a partnership of public and private sector interests along the I-75 corridor. ADVANTAGE I-75 improves the efficiency of motor-carrier operations by allowing properly documented, tmnsponder-equipped trucks to travel any segment of I-75 with minimal stopping at weigh and inspection stations. Most information transfer is carried out while the vehicle is traveling at mainline speeds. Once weight and truck size measurements are taken at any point along the corridor, the information is passed along to all upstream inspection points, where it is used for computerized credential checking and pm-clearances in each state. ADVANTAGE I-75 features both decentralized control and the application of off-the-shelf technology. Each state retains its constitutional and statutory authority relative to motor carriers and their operations.

AHAR Automatic Highway Advisory Radio.

AI Artificial Intelligence. A computer software programming technique in which a computer "learns" from past experience, allowing it to make more intelligent decisions with greater program use.

AICC Autonomous Intelligent Cruise Control, a PROMETHEUS program.

AL1 Autofahrer Leit- und Informationssystem. A route guidance system that was tested on the German autobahn beginning in 1979 and continuing until 1982. The system was jointly developed by Blaupunkt and Volkswagen. It used inductive loops to both detect traffic and communicate with the vehicle. Equipped vehicles could transmit and receive information using the loop antennas. Testing was sponsored by the West German Government. See also ALI-SCOUT.

ALI-SCOUT A route guidance system that uses infrared beacons to transfer navigation and mute guidance information from the infrastructure to equipped vehicles. On-board displays provide the information to the driver. The system was developed in West Germany by Bosch/ Blaupunkt and Siemens. It combines features of both the Blaupunkt AL1 system and the Siemens AUTOSCOUT system. The system was extensively tested in West Berlin. See also LISB and EURO-SCOUT.

AMTECH Dallas firm, developer and pioneer of an electronic toll collection system.

AMTICS Advanced MobileTraffic Information and Communication Systems. A Japanese traffic information system demonstration project under the direction of Japan's National Police Agency with support from the Ministry of Posts and Telecommunications.

ANSI American National Standards Institute.

APC Automated Passenger Counting.

APTS Advanced Public Transportation Systems.

ARCS Automatic Route Control System, early 1970's; first map-matching system for land vehicles.

ARI Autofahrer Rundfunk Information. A European traffic information broadcasting system that alerts users to tune their radios to a specific station in order to receive the traffic information transmissions. It is similar to American HAR systems.

ARISE Automobile Road Information System Evolution, first study to address IVHS from vehicular viewpoint, Sweden, 1985.

ARTS 1. Advanced Rural Transportation Systems.
2. Advanced Road Traffic Systems (Japan).

ARTT (or ATT) Advanced Road Transport Telematics. Also called DRIVE II, ARTT (or ATT) is the second phase of DRIVE. It will focus on field trials involving local and regional transportation agencies throughout Europe.

ASCE American Society of Civil Engineers.

ASTM American Society for Testing and Materials.

ASV Program in Japan for an Advanced Safety Vehicle.

ATA American Trucking Associations.

ATC Automated (electronic) Toll Collection.

ATCC Area Traffic Control Centers, developed by the NPA in Japan from 1970 onward.

ATICS Automobile Traffic Information and Control System, eight-year R&D project under NPA in Japan.

ATIS Advanced Traveler Information Systems.

ATISS Advanced Traffic Information Supply Service, Tokyo.

ATMS Advanced Traffic Management Systems.

ATSAC Automated Traffic Surveillance And Control.

Autoguide A British mute guidance system that uses infrared beacons to transfer navigation and route guidance information from the infrastructure to equipped vehicles. On-board displays provide the information to the driver. A test of the technology is being planned for a corridor between central London and Heathrow Airport.

AutoscopeTM A system that uses a video camera and computer software to analyze roadway images and extract traffic flow information. It was developed by the University of Minnesota and is undergoing testing on Interstate 394 in the Minneapolis/Saint Paul area.

AVC Automated Vehicle Classification. Used in CVO, AVC electronically identifies a vehicle's type. Using this system decreases the amount of time required at border crossings by reducing the amount of paperwork drivers have to process.

AVCS Advanced Vehicle Control Systems.

AVI Automated Vehicle Identification. A system that combines an on-board transponder with roadside receivers to automate identification of vehicles for purposes such as electronic toll collection and stolen vehicle recovery.

AVL Automated Vehicle Location system. A computerized system that tracks the current location of vehicles in a fleet. It is used to assist in applications such as dispatching.

AVM Automatic Vehicle Monitoring.

Beacon See proximity beacon.

CACS Comprehensive Automobile Control System. A six-year, $52 million Japanese project guided by the Ministry of International Trade and Industry (MITI). Completed in the 1970's, it established that vehicle/road information systems with dynamic route guidance could yield significant benefits.

CAD Computer-Aided Dispatching.

Caltrans The California Department of Transportation.

CARGOES DRIVE program to integrate route guidance and traffic control.

CARIN CAR Information and Navigation system. Autonomous mute guidance system developed by Philips Electronics.

CARMINAT CARIN+MINERVE+ATLAS. A EUREKA project, that developed an in-vehicle electronic system for communication, navigation, mute guidance, and car performance monitoring. It combined features of the Philip's CARIN system (route guidance and navigation) with the information system concepts of Sagem's MINERVE and Renault's ATLAS projects. The system gains information via an RDS receiver, a CD-ROM, and various vehicle sensors.

CDCRAFT CD and CRT Applied Fomat Japanese standard for interface software for in-vehicle equipment.

CD-ROM Compact Disc – Read Only Memory.

CED Common European Demonstrators -- PROMETHEUS field tests and demonstrations.

CEN/CENELEC European Committee for Standardization/Electric Equipment.

CMS Changeable Message Sign. Used in ATIS and ATMS to display real-time information to drivers.

Corridors Parallel roadways or transportation facilities, that generally serve major metropolitan areas.

COST European Cooperation in the Field of Scientific and Technical Research.

CVO Commercial Vehicle Operations.

CVSA Commercial Vehicle Safety Alliance.

DACS Data Acquisition and Control System, Wichita Falls, Texas, 1966.

Dallas North Tollway Project An ETTM system operated by the Texas Turnpike Authority on 18 miles of urban tollway.

Dead-Reckoning Dead-reckoning is a technique that calculates the current location of a vehicle by measuring the distance and direction that the vehicle has traveled since leaving a known starting point.

DEMETER Digital Electronic Mapping of European Territory. A EUREKA project started by Bosch and Philips in 1986. Its objective is to create a standardized European digital mad map at 1:10,000 scale. The project has resulted in the development of GDF, a proposed standard for the acquisition and representation of the highly detailed digital map data that is required by dead-reckoning/map-matching navigation systems.

DIME Dual Incidence Matrix Encoded files. Computer-based map files created under contract to the U.S. Census Bureau and used for the 1980 census. The comparable files for the 1990 census are called the TIGER files.

DOT Department Of Transportation.

DRIVE Dedicated Road Infrastructure for Vehicle safety in Europe. A European Community program to find ways to alleviate road transportation problems through the application of advanced information and telecommunications technology. DRIVE has more than seventy projects, including CIDER, DACAR, IMAURO, INVAID, PAMELA, PANDORA, SIRIUS, SMART, SOCRATES, TARDIS, and VIC. The ultimate target of the DRIVE effort is to produce an integrated road transport environment (IRTE).

DRIVEII See ARTT.

ECMT European Conference of Ministers of Transport.

ECPA Electronic Communications Privacy Act.

ECU European currency unit.

EFTA European Free Trade Association.

EGT European Geographical Technologies B.V. European consortium formed to create and manage digital street map databases in Europe.

Its initial focus is on defining and fulfilling the needs of traffic and transport related applications.

ENTERPRISE Evaluating New Technologies for Roads Program Initiative in Safety and Efficiency. U.S. IVHS cooperative initiative to facilitate the rapid development and deployment of IVHS technologies. Intended to be a consortium of public and private organizations with compatible IVHS goals that will identify and exploit opportunities for cooperative ventures.

ERGS Electronic Route Guidance System. A 1968 to 1971 route guidance project supported by the Federal Highway Administration. The system provided in-vehicle directional guidance to the driver. Although it was not implemented in the US, the Japanese CACS project established the feasibility of the ERGS technology.

ERTICO European Road Transport Information and Communications systems. A EUREKA project with the objective of deploying systems that automatically communicate motor freight information to commercial drivers. ERTICO is a $2.7 million, three-year project to develop a common mad information and communications system for motor carriers across Europe.

ETAK Silicon Valley firm, first to market a vehicle navigation system, the Navigator TM in 1984.

ETTM Electronic Toll and Traffic Management. Uses AVI to electronically collect tolls, enabling vehicles to pay tolls without stopping at tollbooths.

EUCO-COST 30 Continuation of COST 30 project to include demonstration on road/vehicle communication research (see COST).

EUREKA European Research Coordination Agency. A European program designed to stimulate cooperative research and development between industries and governments in Europe. The EUREKA program includes projects such as CARMINAT, DEMETER, ERTICO, EUROPOLIS, PROMETHEUS, and TELEATLAS.

EURO-SCOUT An infrastructure-based information, navigation, mute guidance and traffic management system. Developed by Siemens, EURO-SCOUT is a derivation of the previously demonstrated ALI-SCOUT system. Like ALI-SCOUT, it also uses infrared beacons to transfer information between the infrastructure and equipped vehicles.

FAST-TRAC Faster And Safer Travel through Traffic Routing and Advanced Control. A demonstration project that integrates ATMS and ATIS, FAST-TRAC utilizes the SCATS adaptive, coordinated traffic control system with video image processing for vehicle detection and is linked with the Siemens's ALI-SCOUT technology.

FCC Federal Communications Commission for the U.S.

FHWA Federal Highway Administration. A branch of the U.S. Department of Transportation.

FSCS Freeway Surveillance and Control System, Chicago.

FTA Federal Transit Administration. A branch of the U.S. Department of Transportation.

FTMS Freeway Traffic Management System.

GAO U.S. Government General Accounting Office.

GBF/DIME Geographic base file, dual independent map encoding, U.S. Census Bureau digital map project from the 1960's.

GDF Geographic Data Fomat. A transfer file specification for digital roadway and topological map databases produced by Bosch and Philips under the DEMETER project of DRIVE. The format includes specifications for database encoding.

GIS Geographic Information System. A computerized data management system designed to capture, store, retrieve, analyze, and report geographic and demographic information.

GPS Navstar Global Positioning System. A government-owned system of 24 earth-orbiting satellites that transmit data to ground-based receivers. GPS provides extremely accurate latitude and longitude ground position in WGS-84 coordinates. However, for U.S. strategic defense reasons, deliberate error (called selective availability) is introduced into the code that is provided for civilian users.

GSM Groupe Speciale Mobile. European digital cellular radio standard.

HAR Highway Advisory Radio. A traffic information broadcasting system used in the U.S. Drivers are alerted to tune their car radios to a specific channel in order to receive transmitted information. HAR is similar to the European ARI system.

HAZMAT Hazardous Material(s).

HELP See HELP/Crescent.

HELP/Crescent Heavy vehicle Electronic License Plate program. CRESCENT is a demonstration project within the HELP program. It includes a multi-state, multi-national research effort to design and test an integrated, heavy vehicle monitoring system using AVI, AVC, and WIM technologies. The project will take place along I-10 and I-20 from central Texas, west through New Mexico, Arizona, and California to the greater Los Angeles area, then north along I-5 through California, Oregon, and Washington to the international border, continuing into British Columbia along portions of both the trans-Canada and Alaska highways. Data will eventually be monitored at more than 30 locations.

HIDO Highway Industry Development Organization, Japanese organization for R&D under Ministry of Construction, 1984.

HOV High Occupancy Vehicle. Any vehicle — bus, van, car — with multiple riders. An HOV lane refers to a roadway lane reserved for use by HOVs.

HUD Head-Up Display. A type of display that projects information in front of the user.

HUFSAM Highway Users Federation for Safety And Mobility. A Washington-based coalition of 400 corporate and association members (plus some 2,000 individual members) with affiliated groups in each state and 14 regional offices around the country. Its main goal is to serve the common interests of business and industry in advancing highway transportation safety and efficiency. HUFSAM was instrumental in the formation of IVHS AMERICA. The Highway/Vehicle Technology Committee of HUFSAM, composed of representatives from major U.S. transportation companies, has been charged with identifying the value of IVHS and defining how such systems can be effectively utilized.

IEEE Institute of Electrical and Electronics Engineers, Inc. A professional society and standards-making body, IEEE is composed of some 30 individual societies, including the Computer Society and the Vehicular Technology Society. It has established an IVHS Standards Coordination Committee.

IIASA International Institute for Applied System Analysis, Austria

IMIS Integrated Motorist Information System, Long Island urban freeway research project, now operational and called INFORM.

IMPACT

INMARSAT International Maritime Satellite organization.

INRETS National Institute for Research in Transportation and Related Safety, a French institute.

Intelligent Vehicle-Highway Systems Act of 1991 IVHS Act. Included in the ISTEA, this act proposes the establishment of a national IVHS program to include evaluation and implementation of IVHS technologies; development of standards; establishment of an IVHS information clearinghouse; utilization of advisory committees (one of which is IVHS AMERICA); and funding of an IVHS research, development, and testing program.

In-Vehicle Signing On-board display of roadside sign information. The information can be obtained either by short-range transmission from roadside beacons or from on-board data storage. In-vehicle signs are utilized to improve driver effectiveness, especially when driving at night or during inclement weather conditions.

IR Infrared.

IRTE Integrated Road Transport Environment.

ISATA International Symposium on Automotive Technology and Automation. A yearly symposium held in Florence, Italy.

ISO International Standards Organization.

ISTEA Public Law 102-240, Dec. 18, 1991 (H.R. 2950 [early Senate version, S 1204]). The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 provides the primary federal funding for highway programs in the U.S. It contains the Intelligent Vehicle-Highway Systems Act of 1991 (Title VI, Part B).

ITE Institute of Transportation Engineers, an international scientific and educational association. ITE's 10,000 members are transportation professionals — from over 70 countries — who are responsible for the planning, design, and operation of surface transportation systems.

IVHS Intelligent Vehicle-Highway Systems.

IVHS AMERICA Intelligent Vehicle Highway Society of America A nonprofit, public/private scientific and educational corporation that is working to advance a national program for safer, more economical, energy efficient, and environmentally sound highway travel in the U.S. IVHS AMERICA is a utilized federal advisory committee for the USDOT.

JDRMA Japan Digital Road Map Association, 1987, to standardize map formats for vehicle navigation systems.

JSAE Japanese Society of Automotive Engineers.

JS K Foundation Japanese Association of Electronic Technology for Automotive Traffic and Driving.

JTMTA Japan Traffic Management Technology Association.

LCD Liquid Crystal Display.

LED Light Emitting Diode.

Liaison Council for IVHS/RTI Japan A council formed by representative members of the IVHS community in Japan to smoothly carry out information interchange inside and outside of Japan. Membership includes personnel from the Japan Traffic Management Technology Association, the Highway Industry Development Organization, and the Association of Electronic Technology for Automotive Traffic and Driving (JSK Foundation).

LISB Leit- und Information System Berlin. A full-scale trial of the ALI-SCOUT system that was conducted in West Berlin. The trial was completed in 1991, but the system remains operational. The project was carried out by Bosch/Blaupunkt and Siemens with funding from the West German government and the Senate of West Berlin.

LORAN-C Land-based radio navigation system operated by the U.S. Coast Guard as a public service. This hyperbolic system uses signals broadcast from laud-based radio towers.

Map-Matching A technique to enhance and correct in-vehicle dead-reckoning. Computer software follows the progress of the vehicle through an on-board digital map and matches the dead-reckoned estimate of the current position to the closest point on the map in order to correct for accumulated sensor errors.

MDTRS Mobile Digital Trunked Radio Systems. A standard for pan-European public and private digital trunked mobile voice and data networks.

MECC Metropolitan Express Control Center, installed in Japan in 1973.

MITI Japan's Ministry of International Trade and Industry.

Mobility 2000 An informal assembly of government agencies, automotive companies, electronics suppliers, communications companies, large fleet operators, universities, and private individuals. Mobility 2000 served to define and promote IVHS in the late 1980's.

MOC Japanese Ministry of Construction, one of the several agencies responsible for IVHS development in Japan.

MPO Metropolitan Planning Organization.

MPT Ministry of Posts and Telecommunications in Japan.

MTO Ontario (Canada) Ministry of Transportation.

MVMA Motor Vehicle Manufacturers Association.

NHTSA National Highway Traffic Safety Administration. A branch of the U.S. Department of Transportation that focuses on safety and standards.

NPA National Police Agency, one of several agencies responsible for IVHS developments in Japan.

NRIPS National Research Institute of Police Science, sponsored by Japan's National Police Agency.

OmniTRACS Satellite-based commercial vehicle location and communication service offered by Qualcomm company.

PATH Programs on Advanced Technology for the Highway. More recently referred to as Partners for Advanced Transit and Highways. PATH is a California state-wide program of IVHS research, development, testing, and evaluation headquartered at the University of California/ Berkeley's Richmond Field Station. It is sponsored by the California DOT.

Pathfinder An operational test of an in-vehicle urban freeway navigation and information system. Sponsored by CALTRANS, FHWA, and General Motors, it is being carried out in conjunction with the development of a Smart Corridor in the Los Angeles area

Platooning The technique of electronically coupling vehicles together in small groups that follow a lead vehicle. It generally refers to high-speed, high-density travel on limited access highways under the control of AVCS.

PROMETHEUS Program for a European Traffic system with Highest Efficiency and Unprecedented Safety. A EUREKA project, PROMETHEUS is primarily a private sector initiative aimed at developing a uniform European traffic system that incorporates IVHS technology.

Proximity Beacon A short range transmitter of radio, microwave or infrared location-coded signals. It can also be used as a communication link for traffic information, road sign information, and other localized information.

PVS Personal Vehicle System. A Japanese program coordinated by the Ministry of International Trade and Industry (MITT).

PWRI Public Works Research Institute, sponsored by Japan's Ministry of Construction.

RACS Road/Automobile Communication System. An experimental Japanese ATMS effort being carried out under the direction of the Ministry of Construction. RACS was integrated with AMTICS to fonn the VICS program.

R&D Research and Development.

RTI Road Transport Infonnatics.

SCATS Sidney (Australia) Coordinated Adaptive Traffic System.

SCOOT British traffic control software.

SMART A DRIVE project aimed at developing an intelligent information carrier (such as Smart Card) for use in various transportation applications and to develop specifications for the most promising applications.

Smart Card An electronic information carrier system that uses plastic cards — about the size of a credit card — with an imbedded integrated circuit that stores and processes information.

SMART Corridor The SMART Corridor is a joint demonstration project located along 12.3 miles of the Santa Monica freeway corridor in Los Angeles. The objectives of the project are to provide congestion relief, reduce accidents, reduce fuel consumption, and improve air quality. Those will be accomplished using advanced technologies to advise travelers of current conditions and alternate mutes (using communication systems such as HAR, CMS, kiosks, and tele-text), thereby improving emergency response and providing coordinated inter-agency traffic management.

SOCRATES System Of Cellular Radio for Traffic Efficiency and Safety. A DRIVE project that is developing techniques for using GSM digital cellular radio as the basic communication medium for dynamic mute guidance within IRTE. SOCRATES, the largest of all DRIVE projects, conclud-ed with the West Sweden Field Trial in 1991.

SSVS Super-Smart Vehicle Systems. A Japanese program coordinated by the Ministry of International Trade and Industry. The project emphasizes driver control assistance. It includes systems for accident recognition and avoidance and systems for other direct aids to vehicle operation.

TARDIS Traffic And Roads-Drive Integrated Systems. A DRIVE project to establish common functional requirements for systems that are not wholly vehicle-based and that depend on communication between vehicles and a roadside infrastructure. It includes investigating the possibility of combining communication for route guidance with that for automated toll debiting. It also plans to specify the functional requirements of the IRTE in order to provide a common framework for technical developments.

Teletrac An AVL system undergoing operational testing by Los Angeles Rapid Transit. Teletrac provides vehicle locations for emergency vehicles, corporate vehicles, and stolen vehicle tracking systems. Communication is limited to location and vehicle status information.

TICS Traffic Information and Control System.

TIGER Topologically Integrated Geographic Encoding & Referencing files. Computer-based map files created for the Census Bureau in support of the 1990 census. They contain DIME file data augmented with information for new suburbs and small cities (as of 1987) that were not included in the DIME files.

TMC
1. Traffic Management Center.
2. Traffic Message Channel. See RDS-TMC.

Trafficmaster Trafficmaster is a General Logistics PLC infonnation system for drivers. It is licensed under the United Kingdom's 1989 Road Traffic Act, and has been in operation since September 1990. The system is installed on Britain's M25 London Orbital Motorway and interconnecting motorways within a 35-mile radius of central London.

TravTek Travel Technology. A public/private partnership (1991-92) involving the City of Orlando, the Florida DOT, FHWA, General Motors, and the American Automobile Association. TravTek provided traffic congestion information, motorist services ("yellow pages") information, tourist information, and route guidance information to drivers of vehicles that were equipped with TravTek in-vehicle systems. The route guidance that was provided reflected the real-time traffic conditions in the TravTek network. A Traffic Management Center obtained traffic congestion information from various sources, integrated the data, and then provided the integrated information, via digital data broadcasts, both to the TravTek vehicles and back to the various data sources.

TravelPilot An enhanced version of the Etak Navigator system that was developed by Bosch/Blaupunkt. TravelPilot uses a CD-ROM for map data storage. The system is used in both the PANDORA and Pathfinder projects.

TRB Transportation Research Board. Under the direction of the National Academy of Science's National Research Council, TRB serves to stimulate, correlate, and make known the findings of transportation research.

TRRL U.K. Transport and Road Research Laboratory.

TSC Traffic Systems Center, control center for FSCS.

TSNRI Traffic Safety and Nuisance Research Institute, sponsored by Japan's Ministry of Transport.

TTI Technology Transfer Institute. TTI was established as a private company in 1969 in order to develop international cooperation in the fields of science and technology. It is affiliated with the Japan Technology Transfer Association.

UMTA Urban Mass Tmnsportation Administration. Former name of the U.S. Federal Transit Administration.

USGS United States Geological Survey.

UTC Japan's Universal Traffic Control System.

UTCS Urban Traffic Control System, FHWA project, 1960's and 1970's.

UTMS Universal Traffic Management System (Japan).

UTPS Urban Transportation Planning System, a traditional metropolitan planning process that does not account for IVHS deployment.

VeRi Vehicle/Road Intelligence Committee of SAE of Japan.

VERTIS Vehicle, Road and Traffic Intelligence System (Japan).

VICS Vehicle Infonnation and Communication System. A Japanese IVHS program. It is a combination of RACS and AMTICS and is overseen by the Japanese Ministry of Posts and Telecommunications.

VORAD TM Vehicle On-board Radar. A vehicle detection and driver alert system that uses a low-power radar unit. The VORAD system has been installed in 1,700 Greyhound buses, with USDOT participation in evaluation of system performance and effectiveness.

WIM Weigh-In-Motion. A technology for detennining a vehicle's weight without requiring it to stop on a scale. WIM uses automated vehicle identification (AVI) to identify the vehicles, employs technologies that measure the dynamic tire forces of the moving vehicle, and then estimates the corresponding tire loads for a static vehicle.

NOTE This Glossary was adapted from ***the Strategic Plan for Intelligent Vehicle-Highway Systems.***

APPENDICES

A. IVHS AMERICA

B. Congressman Frank R. Wolf's Questions

C. IVHS Categories

D. Ove Sviden, "ARISE: Automobile Road Information System Evolution," Swedish National Road Association (1986).

E. Lyle Saxton, "Mobility 2000 and the Roots of IVHS," *IVHS Review,* pp. 11-26 (Spring 1993).

F. Hans-Peter Glathe, "PROMETHEUS Common European Demonstration: A Tool to Prove Feasibility," Proceedings of the IVHS AMERICA 1993 Annual Meeting, pp. 174-179.

G. Peter O'Neill, "The DRIVE Programme of the European Community, *Automotive Design Engineering,* pp. 298-307 (1993).

H. Federico Filippi, "ERTICO's Present Strategy on Advanced Transport Telematics," Proceedings, PTRC Summer Annual Meeting, Volume P367, Developments in European Land Use and Transport, pp. 115-123 (1993).

I. Hironao Kawashima, Haruki Fujii, and Kozo Kito, "Some Structural Aspects on the Info-mobility Related Projects in Japan," SAE Technical Paper Series, No. 911676 (1991).

J. Sadao Takaba, "Current Status of the IVHS/RTI Programs in Japan," Proceedings of the IVHS AMERICA 1993 Annual Meeting, pp. 280-285.

K. Edward J. Krakiwsky, "Comparison of IVHS Navigation Systems in North America, Europe, and Japan" (1993).

L. Robert L. French, "The Evolution of Automobile Navigation Systems in Japan," Proceedings, Institute of Navigation 49th Annual Meeting, pp. 69-74 (1993).

IVHS AMERICA

IVHS AMERICA encompasses agencies and organizations consisting of government at all levels, the private sector, academia and surface transportation users. IVHS AMERICA is the partnership of these constituents and serves as a pro-active forum for identifying and accelerating the most appropriate technologies and strategies to foster IVHS deployment.

The mission of IVHS AMERICA is defined *in* the *Strategic Plan for IVHS in the US:*

> "Coordinate and foster a public/private partnership to make the US surface transportation system safer and more effective by accelerating the identification, development, integration, and deployment of advanced technology."

The notion of accelerating the process acknowledges that the development and acceptance of advanced technologies needs to be quickened and coordinated if the full benefits of deployment — increased safety, mobility, productivity, environmental protection and energy efficiency — are to be realized.

To assist in coordinating this effort, Congress supported the start-up of IVHS AMERICA as a non-profit scientific and educational association in the FY 1991 Transportation and Related Agencies Appropriations Bill. In March 1991, USDOT chartered IVHS AMERICA as a utilized Federal Advisory Committee on IVHS matters.

Organization

The work of IVHS AMERICA is performed by a committee structure augmented by a small IVHS AMERICA staff, university and industry fellows, and loaned industry executives. IVHS AMERICA's strength is its committee structure which has a three tier arrangement: the Board of Directors, the Coordinating Council and the Technical Committees. Information regarding committee structure, membership and procedure can be found in IVHS AMERICA's articles of incorporation, bylaws, committee organization and operating procedures. Specific duties and responsibilities of Committee Chairs and Secretaries can be found in the IVHS AMERICA Committee *Handbook.*

Overall direction of IVHS AMERICA is vested in the Board of Directors. The Board is elected by members and deals with broad issues of policy. organization, mission and scope, membership requirements and fees, The Board has established six committees: Nominating, Membership, By-Laws Annual Meeting, International Liaison, and Administrative Policy and Finance. The Board also has created an Executive Committee, with the authority to act in its behalf on selected matters. Other ad hoc committees are established as needed.

In addition to guiding the business aspects of the Society, the Board sets the overall strategic policy, and approves and transmits official recommendations to USDOT, allowing IVHS AMERICA to serve in its utilized Federal Advisory Committee role, The Coordinating Council, subject to Board approval, defines and directs the technical activities of IVHS AMERICA Subcommittees of the Coordinating Council deal with broad issues of technical concern to the entire membership.

The major role of the Coordinating Council is to oversee and coordinate the activitics of a varying number of technical committees. The Coordinating Council is comprised of the chairpersons of each technical committee.

The Coordinating Council guides technical committee and subcommittee activity, including:

- Recommending to the Board of Directors consensus resolutions for approval adn where applicable, submission to USDOT;
- Ensuring that each committee has a clearly defined charter and quantifiable milestones;
- Minimizing redundancy and overlap in committee activities
- Identifying which committee(s) will serve a lead role in major issues; and,
- Ensuring that each committee meets its milestones and responsibilities.

Much of IVHS AMERICA's value as a utilized Federal Advisory Committee is due to its technical committees. Participation in these committees is open to any IVHS AMERICA member from any of its constituencies: public sector (federal, state and local entities), private sector (individual companies and associations), or universities. Although referred to as technical committees, the scope of these groups is not restricted to strictly technical issues. The Technical Committees are reviewed every year to determine if they should be continued and, if so, in what form and with what responsibilities {the last such review was in the spring of 1993).

The current set of committees fall into three categories:

Applications. Committees that address technologies by logically grouped sets of applications and/or by specialized user bases.

Cross-Cutting. These committees deal with issues of needs and benefits, integration and deployment that cut across all of the functional areas.

Task Forces, These groups are shorter term and are concerned with issues that are most effectively addressed through specialized attention.

Each technical committee serves to accelerate the national program by recommending action in its area of expertise, providing input and feedback into high-level activities and serving as a forum to allow exchange of information and ideas among the IVHS community.

To augment the committee structure and to lead activities not well suited to a volunteer committee environment IVHS AMERICA maintains a small professional staff. The staff organization consists of an Executive Director Office, Directors, Managers, technical staff and administrative support. To obtain skill and expertise in areas and levels that would not otherwise be possible, IVHS AMERICA utilizes university and industry fellows and loaned executives to the greatest extent possible.

IVHS AMERICA Operations

To fulfill its mission, IVHS AMERICA has identified and organized its activities into 13 operational areas. To address these areas, IVHS AMERICA can call on its 20 technical committees, subcommittees, and task forces, full-time staff and a number of full-time volunteers.

As part of its role as a utilized Federal Advisory Committee (FAC) for the USDOT, IVHS AMERICA is coordinating the planning efforts of the National IVHS Program This is accomplished through consulting with representatives from the public/private partnership, participating in meetings of technical committees, the IVHS Planning Committee, the Coordinating Council and the Board of Directors, publishing strategic and program planning reports and providing advice to USDOT.

USDOT and IVHS AMERICA have initiated a program to develop an open National IVHS Architecture by 1996. An IVHS architecture is needed to ensure that cost-effective systems are built and will continue to meet system goals and objectives as traffic environmental and energy conditions, travel demand and patterns, technologies and system solutions, and the political scene change and progress over the next several decades. It is vital that the architecture is designed in a systematic fashion so that these issues are ail addressed openly, directly and carefully, rather than having the architecture evolve in an ad hoc fashion or having it dictated by the commercial interests of a dominant equipment supplier,

IVHS AMERICA plays a key role in the development of standards and protocols that will ensure mutual compatibility of systems and subsystems and speed the development and deployment of new technologies. These standards are called enabling standards and are being developed carefully and methodically to ensure that they do not stifle innovation or creativity.

The IVHS program requires the public and private sectors to collaborate like never before. IVHS AMERICA does not develop or deploy any technologies directly, but plays a role in the development of new public/private partnerships which encourage IVHS development or deployment. IVHS AMERICA focuses on aspects of the IVHS program that either lead to or accelerate implementation and identifies those areas that might inhibit development and deployment. Some of these areas are technical, but many are institutional.

Non-technical challenges to the future adoption of IVHS technologies are as important as technical challenges. Institutional issues include interagency cooperation in the management and operation of IVHS across multiple geographic jurisdictions, along with many other new public-private, public-public and private-private institutional relationships. Legal issues include antitrust, product and tort liability, privacy, intellectual property, procurement and regulatory concerns. Through its' Institutional and Legal Issues Committees, IVHS AMERICA is addressing these aspects of the IVHS program.

The National IVHS Information Clearinghouse is a legislatively mandated repository that IVHS AMERICA administers and contains the latest national and international information about IVHS technologies, related programs and issues. Users can easily browse the database and conduct searches for information related to their areas of interest. Ease-of-use remains a primary objective as the system is expanded to include new functionality.

IVHS AMERICA has formalized plans for the first IVHS World Congress to take place in Paris November 14, 1994. The US surface transportation system can benefit from the progress that has occurred in international research and development. By gaining knowledge of and access to international developments, American product and service suppliers have the opportunity to expand their markets. With open availability of foreign progress, international cooperation will also speed deployment of IVHS in the US by eliminating duplication.

To deploy IVHS on the scale that is planned will make it one of the largest public works programs in US history. Keeping Congress advised is essential for the vision of IVHS is to be realized, Congress must be willing to provide a large portion of the fundign needed for infrastructure development and deployment and be willing to adopt new, or revise old, laws and policies if necessary to ensure program success. The Congressional Relations Program seeks to continually expand the number of people on Capitol Hill who are interested in IVHS and inform those interested of the latest developments. Information dissemination is the cornerstone of the effort. As the overall visibility of IVHS grows in Congress and the national program moves towards full scale deployment, Congress will have the capacity to take action effectively.

To achieve complete deployment the IVHS community must garner the attention and support of a variety of constituencies, including transportation consumers. Education and outreach are essential as a base for developing markets — be it consumer, commercial or public sector. Prospective suppliers must become aware of the potential of IVHS, The IVHS community must reach out to safety, environmental, and other interests with a stake in TVHS development, not only to inform them of the potential benefits of IVHS but also to learn from them about reservations and concerns and to respond to those concerns.

IVHS AMERICA has initiated the Public Education and Outreach Program and is seeking to increase awareness of IVHS issues and benefits to many levels of stakeholder with differing views. From transportation consumers who are barely cognizant that IVHS exists to government officials and transportation professionals who may be convinced of IVHS benefits and who can be mobilized to win the cooperation of others. This program relies on news media relations, publications, public presentations, regional meetings, direct mail, and interaction with other involved organizations to accomplish its goals.

IVHS AMERICA Publications

IVHS AMERICA publishes a wide variety of material to keep its membership and other interested parties infromed. The material includes:

- Newsletters: IVHS AMERICA, the Society newsletter, informs the IVHS community on current activities thoughout the world. It contains news, the latest information on MIS AMERICA activities, the latest, state and local initiatives, the views of opinion leaders in the IVHS community, an up-to-date calendar of upcoming events, and references to additional information in the Clearinghouse and other publications. The monthly 8-16 page newsletter is dostributed free to the membership, congressional members and staff, federal officials and the press.

- Journals: The IVHS Review is a quarterly journal that presents articles principally devoted to policy issues. The Review is also distributed by subscription

  In addition, IVHS AMERICA cooperates in publishing the IVHS Journal With a more technical focus than the IVHS Review, the Journal is the first scholarly refereed publication to focus exclusively on IVHS. Though not published by IVHS AMERICA,. the Society has editorial control. Members have the opportunity to receive a discounted subscription to the Journal, The inaugural edition of both the IVHS Review and IVHS Journal were published in Spring 1993.

- Documents: In addition to periodic publications, IVHS AMERICA publishes an Annual Report, Annual Meeting Proceedings, workshop proceedings technical reports and a variety of brochures, booklets and other materials.

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COMMITTEE ON APPROPRIATIONS
SUBCOMMITTEES
TRANSPORTATION
TREASURY-POSTAL SERVICE-GENERAL GOVERNMENT
COMMISSION ON SECURITY AND COOPERATION IN EUROPE

April 16, 1993

Mr. Frederick T. Tucker
Executive Vice President
Motorola, Inc.
4000 Commercial Ave.
Northbrook, Illinois 60062

Dear Mr. Tucker:

Thank you for taking time out of your busy schedule to testify at the transportation appropriations subcommittee's hearing on Intelligent Vehicle Highway Systems (IVHS).

I found your testimony very interesting and I regret that time limitations precluded the opportunity for more dialogue on this critical part of our transportation network's future. Since I did not have time to ask further questions, I would appreciate it if you would answer the enclosed questions for the record. If you would return your responses to my office, attention: Janet Powell, we will make sure they are included in the official hearing record.

Best wishes and thank you again for giving us the benefit of your expertise in this important matter.

Sincerely,

Frank R. Wolf
Member of Congress

FRW:jp

QUESTIONS FOR THE RECORD
IVHS HEARING
April 15, 1993

MR. WOLF

FOR MR. TUCKER:

1. You indicated in your testimony that our international counterparts have outspent us and that we are behind. How far behind foreign countries are we in the race to develop IVHS technology?

2. In your opinion, how much federal funding is needed to level the playing field so the U.S. private sector does not face a competitive disadvantage in the worldwide market for IVHS?

3. How much government funding is provided for IVHS in Japan? How does the U.S. compare to Japan in government support for IVHS?

4. You noted in your testimony that private sector participation in IVHS "is discouraged by a cumbersome procurement process" and that legislation may be necessary to change this. What legislative changes do you propose?

IVHS SEGMENTATION

The vast scope of IVHS is made easier to comprehend by subdivision into several interrelated and overlapping segments: Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Advanced Vehicle Control Systems (AVCS), Commercial Vehicle Operations (CVO), Advanced Public Transportation Systems (APTS), and Advanced Rural Transportation Systems (ARTS).

The segmentation is highly artificial and is eschewed by some organizations. However, it is already well established (dating largely from Mobility 2000 days) and is likely to prevail for some time because it reflects the committee structure of IVHS AMERICA. In addition, the segmentation has been used extensively as a framework for IVHS strategic planning in the United States. Thus it is important to understand the scope of each segment and how it relates to other efforts now under the IVHS programmatic umbrella.

Advanced Traffic Management Systems (ATMS)

ATMS includes freeway surveillance and incident detection, changeable message signs, electronic toll collection, and coordination of traffic signal timing over wide areas in response to real-time traffic conditions. Major elements of ATMS have been around for decades. The first computerized traffic signal control systems were developed in the 1960s, and approximately 200 computerized traffic signal control systems were in use in North America by the end of the 1980s. About 25 major freeway surveillance and control systems were in use, including many dating from the 1960s and 1970s. Electronic toll collection did not start experiencing significant implementation until the 1990s.

An additional ATMS function is to supply real-time traffic information (e.g., link travel times) over mobile data communication links to ATIS. The final selection of one or more communication links is unsettled because, among other things, their requirements (e.g., data rates) are highly dependent upon system architecture and the division of functions between infrastructure and in-vehicle equipment.

Advanced Traveler Information Systems (ATIS)

ATIS systems acquire, analyze, communicate, and present information to assist surface transportation travelers in moving from one location to another. Initially called ADIS (Advanced Driver Information Systems) by Mobility 2000 and essentially limited to navigation, route guidance, and traffic information presented by in-vehicle systems, ATIS concepts now also encompass the provision of transit schedules and connections to home, office, kiosk and hand-held PPATIS (Portable ATIS) units as well as in-vehicle units. Vision enhancement devices for drivers also fall under the ATIS category.

Although concepts for PPATIS are proliferating, most ATIS market activity is expected to be what was originally called ADIS and will be centered on in-vehicle navigation and route guidance systems. A 1991 Delphi study by the University of Michigan forecasts some form of navigation incorporating GPS will be used in 5% of all vehicles sold annually by 2000 and in 50% by 2012. IVHS strategic planning is based on manufacturers selling 2.5 million vehicles annually with factory-installed ATIS by the year 2000.

The potential of the ADIS market is also illustrated by the fact that approximately 500,000 sophisticated automobile navigation systems have already been sold (mostly as factory options) in Japan, even though they must operate autonomously because mobile communication links to ATMS traffic operations centers for enabling dynamic route adjustment according to traffic conditions have thus far been limited to developmental tests.

Advanced Vehicle Control Systems (AVCS)

Whereas ATIS assists drivers by providing information to facilitate efficient and safe operation, AVCS provides direct assistance with vehicle control. An existing example is ABS (anti-lock braking system). Other early forms of AVCS include obstacle detection and warning systems and intelligent cruise control. Intelligent cruise control automatically adjusts speed according to distance and speed of the vehicle being followed, and will lead to platooning concepts wherein closely-spaced vehicles travel in groups to increase lane capacity and safety. AVCS may ultimately lead to fully automated chauffeuring.

Most of the more advanced forms of AVCS such as automatic lane keeping (lateral steering control) are still in the laboratory stage. Although driver warning, perception enhancement, and assistance/control systems are under active research and testing in the United States, Europe, and Japan, the most comprehensive demonstrations to date have been accomplished under Europe's PROMETHEUS program.

Commercial Vehicle Operations (CVO)

In addition to benefiting from ATMS, ATIS, and AVCS functions, commercial vehicle operations may be made more productive through other IVHS functions. These include automatic vehicle location monitoring, computerized dispatch and fleet management systems including dynamic scheduling and routing, weigh-in-motion (WIM), automatic vehicle classification (AVC), automatic vehicle identification (AVI), on-board data acquisition computers, etc.

The earliest CVO applications were for managing critical urban fleets (e.g., police vehicles starting in the 1970s). However, extensive application to long-distance trucking fleets got underway in the 1980's and much of the present CVO activities (e.g., AVI, AVC, WIM) focus on this application with the objective of eliminating stops and regulatory paperwork now required when traveling from state to state.

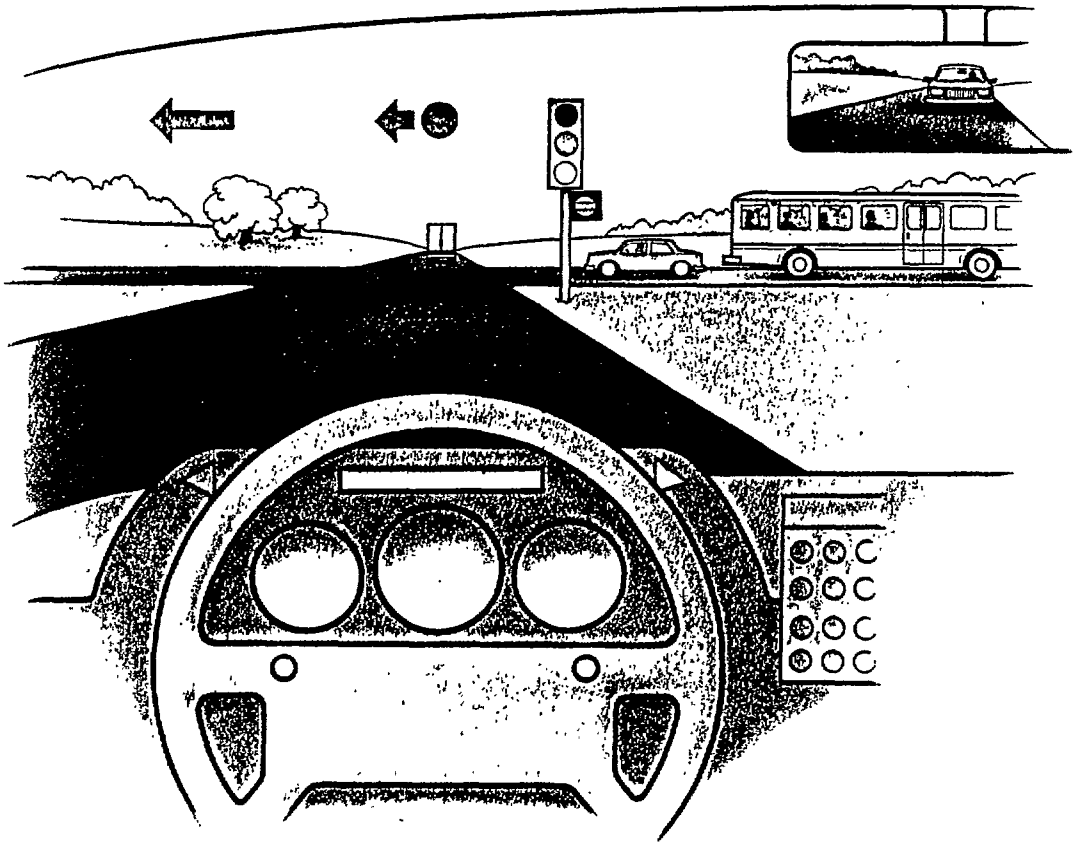
Advanced Public Transportation Systems (APTS)

APTS encompasses some forms of CVO (e.g., automatic vehicle location reporting) as well as additional functions such as schedule monitoring for transit buses. APTS also includes HOV (high occupancy vehicle) lanes and instant car-pooling services. Although AVL implementation for transit buses was limited until the present generation of GPS-based systems started becoming available, extensive research and trials were conducted during the 1970s under auspices of the Urban Mass Transit Administration (recently renamed Federal Transit Administration). The use of AVL and communications technologies to monitor, control, and manage public transit continues to be a central thrust of APTS.

New APTS thrusts include making timely and accurate information on traffic conditions and on transit and ride-sharing alternatives readily available to travelers (especially commuters who normally drive alone) for pre-trip planning. Another is to improve the customer interface through the use of integrated electronic fare systems such as smart cards valid for all transportation modes, and through the provision of real-time transit service information at homes, offices, and public places as well as at stops, aboard vehicles, etc. APTS also includes systems for controlling HOV access and enforcing proper usage.

Advanced Rural Transportation Systems (ARTS)

ARTS has the greatest overlap with other segments of the IVHS industry in that few, if any, additional functions or technologies are required. Instead, safety dominates rural IVHS planning with emphasis on in-vehicle safety advisory and warning systems, prevention of single vehicle off-road accidents, prevention of passing accidents, warnings of animals on or near the roadway, vision enhancement, and Mayday calls from stranded vehicles. Although virtually all of the above may evolve under other IVHS segments, ARTS communications considerations differ significantly from those of urban areas because lower population densities and fewer roads combined with greater distances among facilities require greater dependence upon wide-area communications.



arise

AUTOMOBILE ROAD INFORMATION
SYSTEM EVOLUTION

ARISE

- Arise is a system concept. It is not a product. It has a time dimension,

- Arise represents a perspective on the introduction of information systems for road transport with functions for:

  - route planning
  - route guidance
  - route service information
  - transport management
  - vehicle fleet management
  - road traffic and safety management

The proposed systems will include information technologies both in vehicles and in the road infrastructure.

Today, commercial vehicles usually have some form of communications channel to a central office. In the future, all types of road vehicles could have a data link to a roadside information infrastructure. Together with on-board sensors, computers and displays, a completely new on-line information standard can be achieved providing:

- Information about road, traffic and weather conditions ahead;

- Information about useful facilities ahead (available parking spaces, service stations, restaurants, motel , post-offices etc) ;

- Selected information about speed limits, vehicle weight and height restrictions, parking regulations etc., which is specific to the particular journey undertaken and the vehicle being used;

- Navigation via an optimum route to any selected destination;

- Guidance to an available parking space close to the selected destination;

- Functions for automatic distance keeping between vehicles in dense traffic; and,

- Functions for automatic speed-keeping to create a smooth, “green-wave” traffic-flow.

-

ARISE FEASIBILITY STUDY

A feasibility study of future use of information systems for road transport was made by ConNova in 1985.

The study was sponsored by:

VAGVERKET	Swedish National Road Administration
STU	National Swedish Board for Technical Development
TELEVERKET	Swedish Telecommunication
TFB	Swedish Transport Research Board
AB VOLVO	Technological development

The general conclusions from the feasibility study are:

- By decreasing distances driven and time spent in traffic, information systems for route planning, route optimisation and route guidance could be cost-effective across all forms of road transport activity;

- Commercial vehicles form an important market segment for the immediate introduction of autonomous, vehicle-borne information systems;

- However, in the Iong run, societal benefits would be greatest from integrated systems using a data-link between vehicles and "intelligence" in the road infrastructure;

- Highly integrated systems are needed to realise the full potential of information technology, eg. in the area of road safety, and to avoid the potential pit-falls of unsuitable, crude technologies;

- Comparing expected costs and benefits, society would achieve a marginal gain from autonomous systems for route guidance, but a substantial gain from integrated systems for route guidance and dynamic traffic management.

Research and development activities recommended for 1986-87 include:

- Applied feasibility studies of information systems for commercial road traffic (ConNova Research) ;

- Man-Machine studies of the performance of information systems using a dynamic vehicle simulator (Swedish Road and Traffic Research Institute) ;

- An information system study within IIASKs research programme on the evolution of world transport systems (IIASA, the International Institute for Applied Systems Analysis).

- Development of a new generation Road Data Bank (Swedish National Road Administration).

DATA LINK

Motoring involves intricate interplay between driver, vehicle and traffic environment.

At present the driver receives most of the information via a suboptimal and uncertain sensory link with the outside road and traffic environment.

By introducing a DATA LINK between vehicles and road, the driver's situation can be greatly improved.

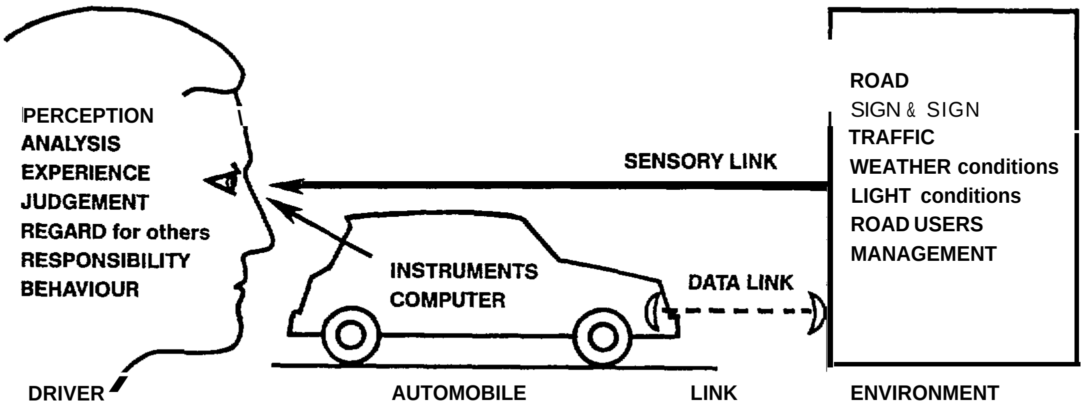
Selected, relevant and important items of information can be made accessible in the vchiclc.

Driver's can be given assistance to:

- Navigate to a chosen address;
- Avoid potential hazards, and obstructions or other causes of delay;
- Locate a free parking space;
- Make automatic payment of parking charges etc.;
- Maintain a suitable and safe speed in accordance with prevailing road conditions and prevailing speed limits;
- Arrive at traffic signals when the light is on green.
- Maintain a safe driving distance from the car ahead;
- Change lanes safely;

The assistance can be presented as straight-forward text information or as symbols. Recommendations for navigation Purposes can be given as symbols, colours and/or audio signals of two sorts:

- Drive straight ahead, change lane or turn; and,
- Increase, maintain or reduce speed.



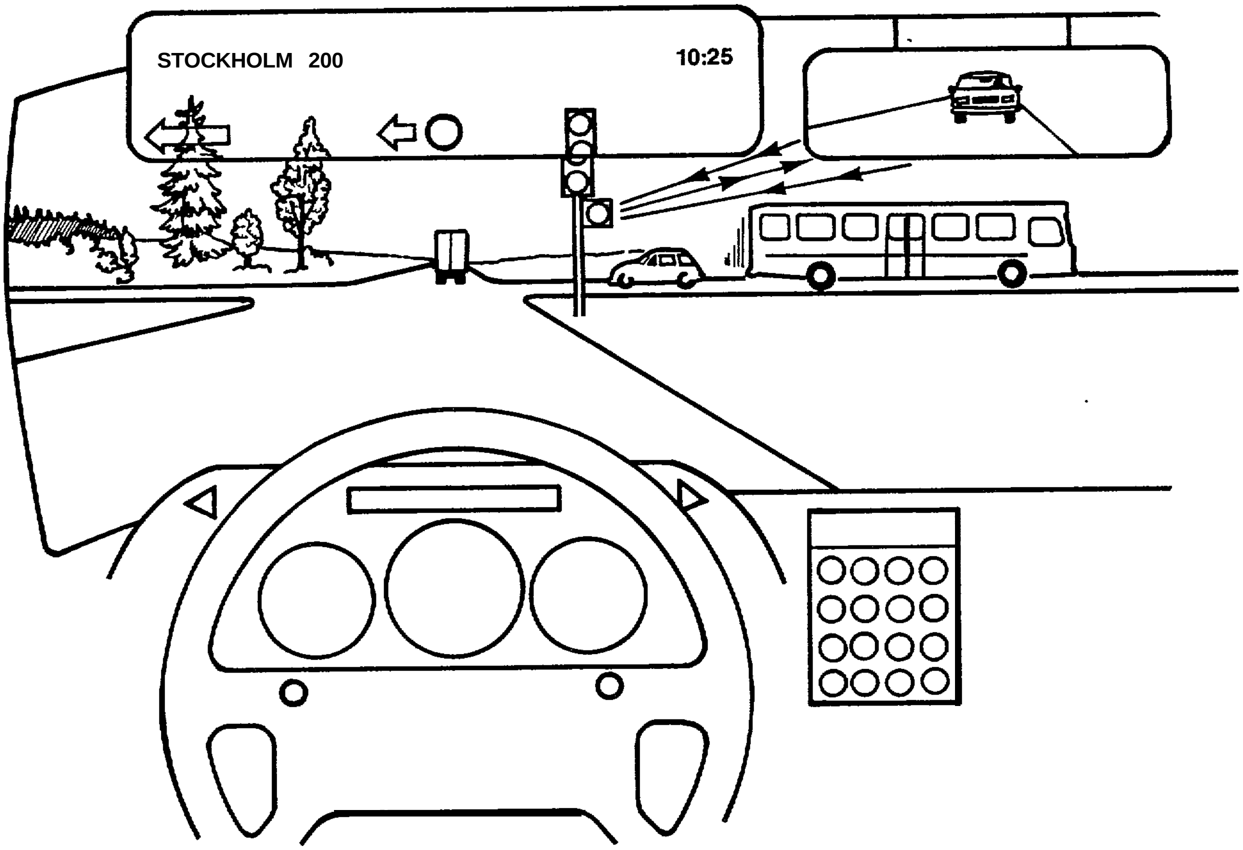
THE ROAD TRAFFIC SYSTEM

Information via the data link must be coherent with and a complement to information from the sensory link.

The in-vehicle computer edits and process information from the data link. It presents only information relevant to the driver and his situation.

Instruments will be needed that reflect the information to the driver's central field of view and make use of the driver's peripheral vision. The head-uP display is a feasible solution to this problem

Information from the data-link can also be conveyed to the driver as accoustic signals and/or synthetic speech.



ARISE FEATURES

- A data link is established between transceivers on the traffic light pole and behind the rear mirror of the car.

- Information for my route guidance is presented in the transparent information mirror (head-up display) in front of me.

- The green light in the information mirror indicates that my speed is OK.

- The two arrows guide me to turn left.

- I can enter my destination via a keyboard or a voice command.

- The optics of the Arise system enables me to read the text and see the symbols as an image about 30 metres in front of me – there is little effort needed to shift attention between the text and the traffic.

A JOURNEY TO STOCKHOLM

A SIMULATED USE OF ARISE FUNCTIONS

ConNova	199	10:25
STOCKHOLM	198	
Norrköping	43	

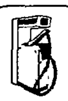
- An itinerary is presented giving the distance to my destination and to major towns en route

- An estimated time of arrival is included which takes account of the weather and traffic conditions en route

- When driving at correct speed and straight ahead only the green O.K. signal is lit

- If my speed becomes too high (say 10 km/h above the limit) the light turns yellow, recommending me to slow down

- By pushing a button on the steering wheel I can have the itinerary presented again – it is normally blanked out after 15 seconds in order not to disturb driving



ESSO Södertälje	82
GULF Järna	72
SHELL Nyköping	11

- I receive a warning that my fuel level is becoming low and that I should re-fuel

- A number of alternative filling-stations and the distances to them are presented

- I select my preferred alternative by moving a cursor and pushing a button on the steering wheel to confirm my selection

- The Gulf alternative is included in my itinerary and I am guided by arrows to that station

ConNova	44	10:35
STOCKHOLM	43	
GULF Järna	1	

- A yellow light and arrow recommend me to slow down and turn right to reach the selected service station

- 10 minutes have been added to my predicted arrival time and an extra kilometre to my journey distance

- The updated itinerary is presented for 15 seconds – for my information

ConNova	10:30
Gamla Brogatan 19	Fee SEK 5/h
Walk 700	CHECKED IN
CITY GARAGE	

- Upon arrival in Stockholm I am guided to a parking house with available space

- The check-in is automatic – the parking fee is displayed and charged automatically to my company's account

- I have to walk 700 metres to reach my final destination – my arrival time at the ConNova office is estimated at 10.30 assuming my usual 5 km/h walking pace

Our cost/benefit analyses indicate that it is economically beneficial to society to introduce qualified functions for navigation, traffic control and manoeuvring of vehicles in road traffic.

Our conclusions about the evolution of road infrastructure systems are presented below in the form of a scenario.

SCENARIO SCENE 1990

Information society is coming closer. Industrial production is becoming ever more automated and offices ever more computerised Houses in built-up areas become connected to data networks for cable TV, cable radio, text telephone ("teletext") and home computers.

Computerised route planning for commercial trafficis an established function for many vehicle fleets.

Information systems for road vehicles have been dcveloped and tested in simulators and in several pilot experiments. The results are being assessed. Many systems are proposed in Europe. Standardisation of data links is obstructed by national policies and prestige. Investment decisions are being delayed.

Autonomous, vehicle-borne navigation systems are available. The main market is for commercial traffic.

SCENARIO SCENE 1995

Navigation devices in commercial vehicles, eg. trucks, taxis and limousines, have become commonplace.

The services provided by such devices (giving directions to the correct address, estimating the time ofarrival, preparing a driving log etc.) are appreciated by drivers.

Many of the systems are autonomous, which means that all the equipment is in the vehicle. The digital map carried in the memory is updated every three months at best.

Navigation aids of this kind are introduced in trucks, company cars, hired cars and leased cars. My company appreciates that I quickly find the right address and that I receive a receipt for my travelling expenses.

The autonomous "navigators" are now so established that some of their shortcomings are becoming apparent: drivers are often directed to roads already carrying heavy trafficsince drivers of other navigator-equipped vehicles have received the same advice from their route optimizer. Commercial traffic often use route planning from office terminals. Systems exist that transfer the route plan to vehicles on the road over the traditional radio links or via the mobile telephone. The information is then edited into route guidance by the onboard computer.

Route planning at head-office has partly been improved since it is now possible to access daily information about road repairs, weather conditions etc. held on a central traffic computer.

The new traffic-integrated systems are eagerly awaited.

SCENARIO SCENE 2000

Road traffic is unmistakably flowing more smoothly now.

The new integrated road information systems give me information about the route, my place in the traffic stream and the navigation assistance that I need.

The voice synthesiser plus the text and symbols reflected in the transparent information mirror provide me with information that is easy to assimilate and to interpret. Gone are the strips of er and the long dialogues with the of Pce about route planning.

Two-way communication with data beacons makes it possible for me to find a suitable restaurant, to receive the necessary route guidance, and to have a parking space reserved for me. Since it is so convenient, I prefer automatic debiting for most of the road charges.

Traffic is flowing more smoothly beacause my navigation computer informs each data beacon how long ago I passed the last beacon. This information is passed to the connurbation's central traffic computer which directs "green waves" along the through-streets.

Thanks to the new technology, the Road Authorities have obtained an invaluable aid in their work – to ensure that the progressively decentralising city (its industry and trade, workplaces and offices, homes and schools etc.) can still operate as an integrated system.

Next to the information network, the quality of transport is the most important means of competing in the international labour market.

SCENARIO SCENE 2010

Integrated road information systems are now fitted in about half of all road vehicles. Sales are still increasing. The system of data beacons has made the in-vehicle e uipment relatively cheap, approximately 45% of the price of a compact passenger car. It pays off within five years. It is becoming part of thestandard equipment of new cars.

Traffic levels have increased, but traffic flows more smoothly and safer than before. However, there are still possibilities for improvement. By effectively creating gaps between vehicles driving in convoy, most of the earlier risk of accidents between vehicles and unprotected road users has been removed. Accidents associated with "catching up" and at crossroads now tend to prevail.

The obvious need is for anti-collision functions. Non-locking brakes are now standard equipment. With electronics mature they can be used radically to improve road safety. Sensors are used to measure, economically and accurately, the position relative to the vehicle ahead. Systems exist for dynamic vehicle following.

Automotive industry has expanded into the area of developing the road infrastructure. Technological development of the future road transport systems is mainly performed by these transnational institutions. They determine the international standards for technology which previously had caused so many problems for national authorities.

SCENARIO SCENE 2025

By now, nearly all vehicles are equipped with highly integrated systems. Owing to the linking of vehicles, traffic is flowing smoothly through the labyrinths of built-up areas. When I use the automatic speed-distance monitor, I no longer have to be anxious or afraid of bumping into the vehicle ahead. As a driver I am still responsible for driving the car, but the automatic speed-distance monitor helps me out of sudden and critical traffic situations.

I do not worry so much about the costs of this technology. I rent the car. I benefit because the leasing company finds it advantageous to reduce both my running costs and my accident risk. This is reflected in the rental charge.

Noise and air pollution in built-up areas were once street corner problems as a consequence of jerky driving. "Green-wave" traffic has reduced these problems to a minimum. Now, traffic is murmuring rather than roaring.

Charges for parking, congestion, insurance, taxes, tolls and speeding offences are automatically debited. At the same time I receive a traffic bonus when I lead a traffic queue in a responsible manner.

As usual, innovation is being led by commercial traffic. The heavy, long-distance road haulage industry is testing a system for driving in file on motorways. A cable in every lane makes it possible automatically to steer vehicles, provided they are equipped with servo technology. Automatic speed-distance functions electronically connect each vehicle to the one in front. In this way, files of trucks can be driven at night from terminal to terminal by a crew in only the first vehicle.

SCENARIO SCENE 2040

This concluding scenario scene pictures a possible, maybe even a probable and desirable, future for road transport information technology.

Society in 2040

About **12** million people now live in Sweden. The Northern Republic is still a highly industrialised part of Europe do minated by information culture. Housing and working life are strongly decentralised. They rely heavily on a well-functioning and integrated transport system.

Road, sea and air transport are carefully balanced against each other so that each is used to its best advantage. Motoring and the activities of regional aviation are coordinated with international air transport.

The coordinated introduction of information technology and transport technology have made it possible tostop the growth of the big cities. Town-dwellers obtain no physical, commercial or cultural benefits from concentration. From Urbia to Suburbia during the 20th century, thereafter a continued development to Transurbia during the 21st century.

Information and mobility dominate the new way of life: "High Info-Mobility". The working day varies between 4 and 6 hours. Education demands 2 to 4 hours daily from every working person between 15 and 70 years of age. A lifetime career with three professions is normal. Commuting to work has been replaced by a combination of working at distance in the nearby office and extensive business journeys. Education mainly takes place at home computer terminals, but many journeys toseminars and conferences abroad are required.

Road Transport in 2040

The road network is the physical structure linking together the decentralised way of work and the dispersed way of life. The roads are the infrastructural foundation of society. Information and energy are supplied through the cable ditch along the roadside. Information is transported in glass fibre optical cables. Energy, as gas and electricity, is transported by pipelines and cables.

Passenger transport is mainly by car. These are used privately, for travelling in small groups, for limousine and taxi services, as a form of demand-responsive public transport and for providing services to the disabled. They are also used to transport small packages and parcels. Information technology makes it possible for every driver who is willing, to help in demand-responsive transport of people and goods.

Long distance road haulage between terminals is achieved using files of unmanned vehicles. The volume of goods traffic has increased substantially. Fewer goods are now sold through department stores and self-service shops. Most goods are bought via the home computer terminal and are transported home by private car or delivery vehicle.

There is extensive transport of industrial raw materials, intermediate products, component parts, and end-products. There is a high demand on guaranteed on-time delivery. This is one consequence of the dispersed pattern of production within the country. In earlier days, people commuted to their jobs. Instead, goods and information are now transported by companies to local and regional work places.

Motoring in 2040

My car is parked in the parking-space between my home and the road. It is connected to the house by an "umbilical cord" which is used to fill the tank with natural gas. Petrol is really expensive now. Natural gas is a widely used as a alternative. For most of the short distance trips the car is fuelled by gas. Refuelling takes place overnight.

When I come closer to the car I hear a weak "click" in the central lock. The car can recognise its owner and all other members of the family who are entitled to drive. My identity card is a responder to the car's information system. The door is unlocked when I am about one metre from the car.

I start driving as soon as I have taken up my place in the car. The car is equipped with a gasistor engine, ie. a hybrid engine with both electric power drive and an internal combustion engine of the continuous combustion type. It is easy to start, silent, low-polluting and reliable. It is powered by natural gas for trips up to 100 km. and has an auxiliary fuel tank with synthetic petrol for another 250 km.

I programme my destination auto matically using a code-word and speaking into the voice recogniser. Previous destinations are stored in the computer's memory. A new address has to be written via a keyboard. A few seconds later, my chosen destination, driving distance from home and estimated time of arrival are displayed on the instrument panel.

I am guided through the road network by means of recommendations about the most appropriate choice at each successive function. Occassionally I am asked whether I intend to be coupled to the car in front of me. This option can be accepted by pushing a button on the steering wheel, after which the automatic speed-distance device takes over.

On the highway I can be coupled to the automatic steering system. With exact precision, the car now follows the electronic cable in the middle of the lane.

During the trip, two colleagues who will attend the same meeting get in touch with me. They need a lift. I programme the extra destination with my voice and I am driven there. I am informed that this detour will delay arrival at my final destination by just eight minutes. 1 accept this information, although I have the feeling that this is rather optimistic. My fellow passengers are admitted to the car.

During our trip together weareguided to a collective lane for some ten minutes, which allows us to travel faster than the rest of the road-users. We have been classified as public transport, which entitles us to priority treatment. Now I understand why the computer added only eight minutes to my estimated time of arrival.

When we are almost at our destination we are guided to an emptyparkingspace which has been reserved for us. It is not the one that originally had been reserved, but one somewhat closer to our destination; it became available during the eight extra minutes of travel.

In the evening I make a short detour to the storehouse since I have received a message telling me that I can pick up a parcel sent to me – as well as one sent to my neighbour.

DEMANDS ON THE DRIVER

Driving places multiple and simultaneous demands on the driver: to navigate; to operate his vehicle; and to involve in a complex interplay with other road users in a dynamic road and traffic environment. The actions he takes are the end results of continuous information gathering and decision making processes. These require him to be attentive at all times, and may also require periods of intense concentration.

Whilst there arc great differences in the quality ofperformance of these tasks both between drivers and for the same driver in different situations, all drivers are fallible.

The human factor is alleged to be the main cause in GO-90% of road accidents.

In 70-90% of these accidents, the human error occurred during the information gathering, information processing and decision making stages.

Modern technology can offer functions for gathering, processing and presenting information that could greatly improve driving performance.

The increase in relevant information releases much of the pressure on the driver. This has the potential to reduce accident risk, increase efficiency, and generally improve the quality of the driving experience.

Yet in presenting information, it is important not to distract the driver. It follows that a worthwhile step forward would be to research into the precise requirements drivers might have of information technology.

GENERAL INFORMATION SERVICES

Discussions about information technology in road traffic applications have so far neglected the potentially important benefits from providing general information services to road users.

Trip pre-planning is a much neglected area. Access to basic information (eg. by means of “videotext”) would help in making more rational decisions about the itinerary, what mode to use, and about the timing of the trip. It would also help prepare the driver for what to expect during the course of his journey.

What a driver expects can be an important determinant of his driving performance. Unexpected events and situations create dangers in traffic. Information about weather and road conditions, potential hazards etc. enable the driver more realistically to anticipate the conditions ahead.

Information reduces driver uncertainty. Ordinary road signs are often a poor, uncertain and inadequate means of providing information. There is no certainty of a driver seeing a sign that is relevant and essential to his trip. On the other hand, many signs redundant to the driver’s current information needs will be seen. At best, road signs can only pro vide static information.

Modern information technology can provide the driver with information as and when it is needed.

The information shown to the driver can be edited by the on-board computer so that only information relevant to the driver’s current situation is shown, eg. vehicle weight and height restrictions may be critical to a heavy goods vehicle driver, but irrelevant to theprivate motorist.

The economic benefits to society of a vehicle-related electronic information system for road traffic are important. Even in the case of a complex two-way communication system, the quantifiable benefits are judged to surpass the costs.

ROUTE GUIDANCE – NAVIGATION

A study by the transport and Road Research Laboratory (TRRL) in England, points out thatabout 4% of total national vehicle kilometrage can be attributable to poor navigation.

A study in which a sample of 48 volunteer drivers were asked to drive to unfamiliar destinations showed that distances travelled and journey times were 10-14% above optimum levels. In built-up areas the search for the precise address at the end of the journey took twice as long and involved driving twice as far as was strictly necessary (TRRL).

Sweden's Taxi 80 information system is estimated to have reduced taxi-cab driving distances by l0-30%.

Systems already exist for determining optimum routes through networks.

Commercial and service traffic (delivery vehicles, taxi-cabs, ambulances etc.) stand to gain most from information technology for route guidance.

Business travel by car, especially in rented cars used in unfamiliar surroundings, provides another potentially important market for route guidance systems.

Private individuals using cars for mainly routine trips, eg. for regular commuting to work, should have less interest in these systems.

TRAFFIC MANAGEMENT

Road networks in built-up areas are characterised bya high density of nodes or junctions. These greatly impede the traffic flow and could be characterized as "the street corner problem".

The overall trafficflow becomes jerky and the progress of each vehicle irregular with rapid cycles of acceleration and braking punctuated intermittantly by irritating periods of total standstill.

In these conditions fuel consumption doubles compared with driving at constant speed.

Emissions of atmospheric pollutants and noise increase and are concentrated at street corners.

Accident risk increases owing to crossing and turning traffic coming into conflict with other vehicles, cyclists and pedestrians.

The installation of traffic signals represents a way of handling the traffic flow.

By linking traffic signals in built-up areas, a "green wave" effect can be achieved which allows the traffic to flow more smoothly.

By monitoring traffic, signal settings can continuosly be adjusted to meet current traffic demands and optimise flow through the network.

Systems for bus priority and preemption at traffic lights can achieve travel time savings of about 8% (TRRL) .

A system with data links between vehicles and a traffic-management centre could achieve:

travel time savings between 5 and 10%,

- fuel consumption savings of 10 to 30%,
- reductions in pollutant and noise levels, and

a safer and smoother traffic flow.

In a densely populated country with a high proportion of traffic in densely built-up areas, a system with traffic-adjusted guidance may generate advantages that are ten times higher than a developed system for autonomous route guidance (Siemens).

PARKING

Locating an available parking space represents both an information and a navigation problem for the driver. Finding a parking space close to the final destination often becomes the main problem at the end of a car trip.

Searching and queuing for a parking space also create traffic problems. They generate extra traffic and obstruct local traffic flow.

The additional operating costs and delays to the driver and to other motorists can be large.

The secondary effects of parking on traffic should be studied.

TECHNOLOGY

The rapid development of microelectronics now makes it possible to introduce qualified functions and systems to improve road and traffic conditions. General information services, navigation and traffic management can all be improved.

Systems for locating goods in transit and emergency vehicles, eg. ambulances, fire engines and patrol cars, could also be introduced.

Mass memories are needed to store digital maps.

Data links are needed to carry information between vehicles and traffic control centres.

Systems for autonomous navigation and data communication with traffic control are being developed. Many different solutions and sub-systems are under development and some already exist at the prototype or near-commercial level.

Autonomous systems for navigation are likely to be rather expensive. In the first place they would be of most interest to commercial traffic.

Integrated systems which make use of equipment in the road infrastructure would require less in-vechicle equipment and would be cheap to produce. Consequently, they have the potential to generate more general interest.

It should be noted that, in the long run, information technology may be regarded as part of a vehicle's basic equipment.

FUTURE PROSPECTS FOR MOTORING

The number of vehicles and vehicle kilometrage have increased rapidly during the 20th century until the crises during the **1970's.**

These crises have temporarily impaired economic growth. They have also increased our awareness of societal dependence on a well functioning road transport system.

The future information society will lead to further decentalisation and dispersal of homes and work-places. The physical transportation system will have to meet new demands and satisfy much higher expectations.

In the future information society road traffic is likely to play a more important role than today.

The demands on the performance of the road transport system, eg. for comfort and safety, are likely to increase. These system qualities are likely to form new dimensions for competition within the automotive industry.

Economic realities are likely to force the automotive industry actively to seek to assimilate information technologies.

A number of vehicle manufacturers may become suppliers of integrated road transportation systems with the road construction, information technology, and car component manufacturing industries acting as sub-contractors.

THE ECONOMIC SIGNIFICANCE OF ROAD TRAFFIC

Road traffic in Sweden is valued at about SEK 65 billion per annum, i.e. about 8% of the country's GN.P`

Passenger cars constitute the largest share: SEK 36 billion. This amount includes initial costs, fuel, service, maintenance, taxes, insurance and parking charges.

Trucks account for SEK 25 billion per annum, including drivers' wages.

Buses account for SEK 4 billion per annum.

Commercial traffic – with trucks, buses and passenger cars – is equivalent to SEK 30 billion per annum, i.e. the same order of magnitude as private motoring.

The total time spent in traffic by unpaid drivers and passengers is approximately 1 billion hours per year. According to the National Swedish Road Administration's norms for evaluating timecosts, this represents about SEK 20 billion per year.

The direct costs to society for traffic accidents are estimated at SEK 7 billion per year. In addition, subjective costs are estimated at SEK 4 billion per year.

The annual benefit to society from a route guidance system for all commercial vehicle and passenger car traffic is in the order of SEK 2 billion.

The annual benefit to society from an integrated information system for navigation and dynamic traffic management covering all road vehicles in Sweden is in the order of SEK 5 billion.

Preliminary estimates of the equipment costs (for both road vehicles and the road infrastructure) show that the investment needed would broadly be the same for either an autonomous or an integrated system, despite the much greater benefits associated with the latter.

Comparing expected costs and benefits, society would achieve a marginal gain from autonomous systems for route guidance but a substantial gain from integrated systems for route guidance and dynamic traffic management.

THE ARISE CONCEPT IS THE RESULT OF A SYNERGISTIC PROCESS WITHIN A NETWORK OF PEOPLE, WITH IMPULSES AND PARTICIPATION FROM THE FOLLOWING PERSONS:

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arise

Lyle Saxton

MOBILITY 2000 AND THE ROOTS OF IVHS

The Intelligent Vehicle-Highway System (IVHS) program is a major new national program that has dramatically come of age in the last five years. Internationally, similar events have occurred in both Japan and Europe. Less well known is the evolution of IVHS. The roots of the technology include early research activities by universities and industry and a substantial research program similar to IVHS, undertaken in the 1960s by the federal government. They also include a changing national context during the 1980s, which increasingly encouraged an IVHS program. Finally, they include certain key actions, which viewed from today's vantage point turn out to be important strategic building blocks in the most recent, highly successful establishment of the IVHS program.

Early Program Activities

In the 1960s, the Bureau of Public Roads (BPR) of the Department of Commerce, the predecessor to the Federal Highway Administration, undertook a major research and development initiative to improve the safety and efficiency of highway-based travel. The program was a startling departure from past research activities sponsored by the organization, in size, vision, and content. At the core of the new effort was the premise that existing and evolving modern electronic communications and control systems could be applied to vehicle/highway operations in ways that would substantially benefit the nation and the user.

And why not? The world, and the United States in particular, were excited by new technology. We were in the space age and had been getting weather pictures since the launch of the first TIROS weather satellite in 1962. We were also committed to put a man on the moon by the end of the 1960s. We had semiconductors and the transistor as a basic enabling technology. The transistor's availability and performance were both growing at a dizzying pace, even as its price dropped. Large and powerful transistor-based mainframe digital computers were available and the software sciences were evolving rapidly. The consumer had color television, microwave ovens (although expensive), and transistorized portable radios.

Given those kinds of technological breakthroughs, it seemed obvious that the nation should gear up a major program to realize projected benefits in highway transportation that would derive from the application of the same basic technology. Several key people were behind the new program. Robert Baker was the BPR's director of R&D and a prime mover of the initiative. Baker was not a long-time career employee of BPR, having come from the Ohio State University to BPR in the early 1960s. Dr. William Wolman was a mathematician who had been recruited from NASA and was the Chief of the Traffic Systems Division, the organizational focal point of the program. I was recruited from NASA by Wolman in 1968 for my electronics and system expertise. Frank Mannano and Burton Stephens are two FHWA employees, still with FHWA, who had major roles.

Probably the best known system to be remembered from the program is the Electronic Route Guidance System (ERGS) -a major leap forward in highway operational performance and driver assistance. ERGS envisioned providing a driver with routing guidance that was not based solely on the best physical route, but on real-time traffic conditions. Selected intersections, strategically located throughout the street network, would be instrumented with roadside hardware, which included communications with passing vehicles over inductive loops, communications with a central computer over hard wire, and a limited buffer storage and processing capability. Vehicles would have on-board displays, possibly even a "head-up display," an inductive loop-based two-way communication capability, and an encoder to enter a destination.

But ERGS was only one of many visionary new systems. Another major activity included the Urban Traffic Control System (UTCS). Its goal was to revolutionize network traffic signal control by interconnecting individual signalized intersections to a central control center, where a mainframe computer would control the entire network by selecting the most appropriate timing pattern. The selection was made from a family of precomputed timing plans that had been optimized for different sets of traffic conditions. The Passing Aid System (PAS) was intended to bring a new level of safety and driver convenience to rural two-lane driving. It would signal to a driver whether or not there was oncoming traffic and whether it was safe to pull out into the opposite lane to pass the vehicle ahead.

Other significant projects included a system to assist in freeway merging situations; a system for motorists to signal when they observed a disabled motorist (FLASH); a roadside radio motorist information system; a major activity to model the overall processes and functions of highway travel; and a project to develop a fully automated highway system. An excellent summary of many of these technologies exists in a special issue published in 1970 by the Institute of Electrical and Electronics Engineers.

Substantial programs were mounted and resources applied to research, develop, and field test the various new systems. In two Washington, D.C. area intersections, ERGS was tested, and PAS experimentation was carried out along a 15-mile rural setting in Maine. The FLASH system was evaluated in central Florida; the freeway merging aid system was tested in Tampa, Florida; automated highway experiments were performed on test tracks and unopened interstate lanes; and UTCS was installed and became operational at approximately 300 intersections in Washington, D.C.

Industry and universities were also involved in selected research aimed at using advanced electronics technology to enhance highway and motorist performance. General Motors, most notably, sponsored early research with the Radio Corporation of America on automated highways. General Motors was also an early pioneer in motorist information and assistance systems. Robert Cosgriff, then with the Ohio State University, was active in similar projects.

A broad transportation strategy was developed by the U.S. Department of Transportation (USDOT) during this period. An energetic program that focused on the needs of the Northeast Corridor was prepared during 1970 and published in May 197 1. The 1970s action program included "development and implementation of a real-time highway information system to assist inter city drivers in making route choice decisions." The longer-term program focused on automated highways and included two recomrnendations "to provide alternatives to continued proliferation of conventional highways." The recommendations were 1) expansion of the automated highway research and development program to define and evaluate possible concepts and 2) preparation of proposed legislation for a "Post Interstate Highway Program" that would permit highways to be planned and built to accommodate automated operation.

But the required major policy and funding support for a full-blown national program did not develop. The ERGS program specifically was terminated when its budget request was not approved by a congressional appropriations committee in 1971. Other projects generally did not proceed beyond the early concept evaluation phase.

Intervening Years

During the remainder of the 1970s FHWA did continue a modest level ofresearch in some areas of IVHS. The Traffic Systems Division continued important research in traffic operations, motorist information and communications, and automated highway systems. Some specific examples include preliminary work on in-vehicle safety hazard warning systems, initial development of a family of traffic simulation models, a television based wide-area detection system, and advanced highway advisory radio. The research program also was instrumental in working with the Department of Interior and the Federal Communications Commission to establish the Traveler's Information Service, which allows for the operation of Highway Advisory Radio stations on 530 and 1610 kHz.

During the intervening years, the Urban Mass Transit Administration also supported development of advanced technology in mass transit operations. Programs included an automatic vehicle location (AVL) system and a dual-mode program. A driver would operate normally on most streets, but once on a restricted guideway operation, control would be passed to an automatic system.

Starting in 1981, however, there was a further dramatic downturn in IVHS research. The new administration brought new policies and political appointees who generally opposed advanced research activities and certainly did not support IVHS activities. Thus, the early 1980s became a low point in staff morale and agency productivity in developing advanced motorist information systems and vehicle control technologies. The lack of longer research program support by the new administration also translated into little backing for underlying research to support activities such as human factors and computer modeling.

But broader national and international events were occurring that would result in a resurgence of activity. Congestion was becoming a much more serious national concern. IVHS projects were continuing in Europe and Japan. Technological advances were occurring rapidly in semiconductors, electronics, and computers. Cellular telephones became operational, the age of the personal computer and networking was emerging, and there was a growing realization by society that the advanced systems were not, in fact, the stuff of science fiction, but of daily reality.

The dominant national problem for which IVHS systems seemed to offer a solution was congestion. Although IVHS always had the potential for safety benefits, the mid-1980s resurgence of interest was focused on congestion relief. Total number of vehicle miles traveled had doubled since the late 196Os, and the percent of peak hour traffic on congested urban interstates now exceeded 50%. In 1986, Jeffrey Lindley of the FHWA's Traffic System Division published a staff research study that identified the top U.S. cities with the worst congestion. The study, which received wide press coverage, also estimated the total urban freeway delay at the time, and made predictions for 2005.

Efforts had also been continued to develop a much more aggressive national research program in traffic operations. The Traffic Systems Division of FHWA had formulated a proposal for a major "R&D Program in Traffic Operations to Combat Urban Traffic Congestion" that emphasized seven major initiatives, including navigation and vehicle control. That program was formally submitted to ten state Departments of Transportation for comments. Also, in March 1986, the Transportation Research Board (TRB) hosted a workshop in Baltimore, Maryland that would lead to a broad, multi-year traffic research effort under the National Cooperative Highway Research Program 3-38. Many of the subsequent leaders in IVHS participated in those deliberations.

Re-emergence of National Interest

The event that is broadly recognized as the pivotal meeting in bringing about a resurgence of national interest and support for IVHS occurred in the fall of 1986. The California Department of Transportation (Caltrans) had been examining its needs for future construction and funding requirements, and the studies had resulted in the unnerving prediction that no realistic construction program could even keep congestion at its present levels. Further, state gasoline tax increases to support such efforts would be politically unacceptable. Given that reality, Caltrans sponsored a three-day conference for its mid- and senior-level managers in October 1986 to consider the role of advanced vehicle-highway technologies in ameliorating growing congestion.

Several outside experts were invited as speakers and participants. John Vostrez of Caltrans and William Garrison of the University of California at Berkeley were two of the principals in organizing this crucial event. The conference became a watershed for IVHS as it established a new level of national credibility and interest in the systems. For example, Richard Morgan, then FHWA's Executive Director, was also a participant and subsequently took various actions that were instrumental in awakening a new national awareness of IVHS.

Soon after the conference, ad hoc national efforts were initiated to follow up on the rekindled interest. For example, FHWA research hosted a small group in December 1986, which laid the foundation for the Pathfinder project as a joint cooperative undertaking between Caltrans, General Motors, and the FHWA. William Spreitzer of General Motors, who had also been at the Caltrans Conference, was one of the principal leaders in that early effort to evaluate a motorist navigation system. California followed up its conference with efforts to find other states and universities that would join a broad-based national program to apply advanced technology to deal with congestion and safety needs.

On a broader front, there were nascent efforts to develop a national consensus group to set goals, scope, and a vision of where the reemerging national interest might go. The activity quickly attracted a core group of about 20 individuals from government, universities, and industry. The common denominator was current involvement in highway transportation and a sense that a major national window of opportunity was now opening for what was to become known as IVHS. Their agenda recognized a need to articulate the national highway transportation needs that would benefit from such a program, broad program activities that should be undertaken, and, most importantly, to move to some form of permanent program coordination arrangement. That core group is still essentially intact and remains a key force in today's IVHS program.

The above mentioned activities occurred in a national environment that was becoming increasingly supportive of a new program, much as in the 1960s. National effort was being focused on planning for an anticipated major change in the nation's highway program that would be occasioned by the next highway authorization legislation — the legislation that ultimately became the Inter-modal Surface Transportation Efficiency Act, or ISTEA. That impending legislation was to define the post-interstate era; there was almost universal support for programs that would enhance the efficiency and effectiveness of the existing physical highway system. Internally, FHWA was devoting considerable resources to a loosely structured process to develop position papers on an assortment of "futures" topics to help describe the setting and needs for the future highway program. Several of the topics dealt directly with IVHS.

In March 1988, the ad hoc group met in Berkeley, California to further develop a national agenda and to search for a consensus on how to establish a permanent organizational structure. Although the meeting did not achieve its second objective, it did serve to further consolidate the sense of national need and commitment to develop an advanced technology program.

Around that time, a national group known as Project 2020 was also engaged in similar activities. Composed of key highway transportation organizations, such as the American Association of State Highway and Transportation Officials (AASHTO) and the Highway Users Federation for Safety and Mobility (HUFSAM), it sponsored many activities. One of those led to a June 1988 TRB conference, sponsored by Project 2020, that broadly discussed the opportunities presented by advanced electronics highway technology and systems.

Mobility 2000

Following the Berkeley meeting, on behalf of FHWA, I wrote to the principals of the core ad hoc group, suggesting an interim ad hoc organization and offering to assist in staffing such an activity until a more permanent organization was established. The offer was positively received, and a meeting was scheduled for June 21, 1988, at the National

Academy of Sciences in Washington, D.C. Nineteen individuals from government, industry, and academia attended the meeting, which was a major step in the evolving IVHS program. By consensus, it was decided to move forward with national planning using the ad hoc management and coordination structure and to name it Mobility 2000.

A two-day TRB conference, "Look Ahead to 2020," was held in Washington, D.C. immediately after the Mobility 2000 meeting. Sponsored by the Transportation Alliance Group and others, it brought together 250 invited participants. The decisions of the Mobility 2000 group were informally presented and discussed during the conference and interest in IVHS was fueled.

. ..In the mid 1980s a core group of individuals became convinced of the national need and value of IVHS. From divergent interests and backgrounds, they banded together and shaped a common vision and consensus now embodied in the present IVHS program.

With its national emergence, Mobility 2000 immediately started planning for a national workshop. Several of the core members volunteered their services and plans were laid for a three-day meeting in San Antonio, Texas in February 1989. Two individuals stepped forward and took on the heavy burden of finding a location and providing all the mailing, registration, program, and logistical support essential for a national meeting. Dr. William Harris and Sadler Bridges of the Texas Transportation Institute (TTI) volunteered both themselves and TTI to the purpose. Their combined support leading to and during the workshop were invaluable. But perhaps even more important was their preparation of a workshop record, which subsequently received broad national distribution and attention.

During the fall of 1988, two smaller two-day meetings of invited participants met to consider one of the dominant areas of interest —

Advanced Driver Information Systems. Substantial national publicity for IVHS also resulted from a press event in held in Ann Arbor and organized by the University of Michigan and its Transportation Research Institute. Through the efforts of two early leaders, Dr. Kan Chen and Robert Ervin, several IVHS systems were displayed and demonstrated, giving credence to the substance of the new IVHS program. The name Intelligent Vehicle-Highway Systems was originally used by Ervin and Chen.

Fifty-seven invitees attended the first Mobility 2000 National Workshop. Held in San Antonio, Texas, February 15 through 17, 1989, it became the first major national event to bring together key decision makers and the core group of those planning .an IVHS program. The workshop was cast around five breakout groups. Four dealt with functional areas of IVHS, including traffic management systems, driver information systems, commercial vehicle operations, and vehiclecontrol systems. The fifthdealt with organization and program issues. In setting the objectives of the workshop, which I moderated, I summarized the goal as "getting down to specifics" including:

- describing a vision of what an IVHS system would look like and what it would do for the nation,
- describing the most promising plan of evolutionary steps to get there, and,
- putting special emphasis on identifying specifics of programs for the next five years.

It is worth noting that by the time of this workshop, the name Intelligent Vehicle-Highway Systems had been embraced by Mobility 2000group and its content had been grouped into the four broad areas: Advanced Traffic Management Systems (ATMS), Advanced Driver Information Systems (ADIS), Commercial Vehicle Operations (CVO), and Advanced Vehicle Control Systems (AVCS). That program grouping had taken form in planning for the workshop during the fall of 1988 and was used as the basis for breakout groups during the workshop. Later, ADIS was broadened to Advanced Traveler Information Systems (ATIS), and a fifth group, Advanced Public Transportation Systems (APTS), was added. Since then, a sixth group has been added, Advanced Rural Transportation Systems (ARTS), in recognition of the potential of IVHS in rural as well as urban areas.

A highlight of the first workshop was the attendance of James Pitz, then the Director of the Michigan Department of Transportation and also that year's President of AASHTO. Pitz had become a strong champion of the program both in his state and nationally through his presidency of AASHTO. The workshop had been structured for an evaluation by three speakers. Pitz was the first speaker; he strongly supported IVHS and encouraged Mobility 2000's continued national efforts to establish a firmer understanding of the program.

With the first workshop a national success, the leaders of Mobility 2000 scheduled a late March meeting in Cambridge, Massachusetts, to be hosted by Joseph Sussman of MIT, another early Mobility 2000 activist. The purpose was to review the progress and consider the next steps for developing further support for a national IVHS program. It was agreed that .a second national workshop should be organized to further develop the program's scope, goals, and benefits. Each meeting was effective in bringing in new national participants and expanding the base of support. Planning and supporting activities for that next meeting began in earnest in late summer.

A cornerstone of the effort was the establishment of five committees that would work through the fall and early winter to develop a working paper with substantive program content prior to the workshop. The committees were the now-classical foursystemareas plus anew committee on operational benefits. Already, a firm philosophy of IVHS as a national partnership had been established — co-chairs were selected for each committee, one from the federal government and the other from a non-federal organization. The chairs of the committees and their members met many times and a more detailed consensus of the IVHS program rapidly emerged as they focused on their individual working papers.

In retrospect, one of the major legacies of Mobility 2000 is a foundation of consensus vision that has led IVHS program development from the intervening years to the present. Indeed, even the IVHS AMERICA Strategic Plan, which is the most substantive national document to date, dramatically reflects the definitions, scope, and milestones developed in those meetings during 1989.

While the workshop planning activities were under way, two other significant events focused positive attention on IVHS. On June 7,1989, the House Subcommittee on Transportation, Aviation, and Materials of the Committee on Science, Space, and Technology held a one day hearing on

Advanced Vehicle-Highway Technology and Human Factors Research. That hearing served to continue to establish national program credibility and nourished a developing congressional interest in the program.

The second event occurred at the HUFSAM annual meeting in Washington, D.C., in November 1989. It was proposed that HUFSAM and the USDOT join as partners in sponsoring a National Leadership Conference on IVHS. The objective was to pull together 100 of the top leaders in industry and government to discuss the potential of IVHS. General Motors had been instrumental in making that proposal through HUFSAM and later assisted in financing the conference. In a subsequent informal, executive-level planning meeting between HUFSAM and USDOT, it was proposed that the primary focus of the conference should be the establishment of a permanent national IVHS organization to follow the successful path charted by the ad hoc Mobility 2000. Further, it was decided that the major features of that proposed national organization should be prepared before the conference so it could be presented to the attendees of the planned Leadership Conference and be the primary focus of their discussions.

One of the major legacies of Mobility 2000 is a foundation of consensus vision that has led IVHS program development from the intervening years to the present.

An important meeting with international implications also took place during this period. Peter Glathe of Europe's PROMETHEUS project met with key United States representatives and supporters of the IVHS program to share views on the status of the respective programs and to discuss the opportunities for cooperation. One of the most important consequences was a feeling for the credibility and direction of the programs. To the representatives from the United States, it further confirmed the international commitment to IVHS activities and the importance of a strong national program.

Meanwhile, planning and supporting committee work for the second National Mobility 2000 Workshop was very active. Professor Bill Harris and Sadler Bridges of TTI had once again volunteered to organize the workshop and Dallas, Texas was selected as the site. The workshop was held from March 19 to 21,1990, and was attended by over 200 participants. The working groups had each prepared a detailed working paper that included sections on vision, objectives, milestones, and benefits.

The workshop was then organized around the following fivecross-cutting groups:

- Program milestones
- Research and development
- Operational tests
- Program investment requirements
- Organizing for IVHS

The Dallas workshop served to cement the vision and major program features that had been evolving through many prior meetings and national activities. There was a strong consensus that Mobility 2000 had established a sound basis justifying the undertaking of a major national IVHS effort.

Much discussion and emotional energy was devoted during the workshop to developing an estimate of program costs -especially deployment costs. Richard Braun of the University of Minnesota had been assigned that working group and they labored into early morning hours to develop meaningful estimates. The debate centered on whether to publish the estimates or whether they might seem so high that they would scare off support for the program. In the end, the majority view was to publish the projections, as it was strongly felt that the benefits were substantial and certainly supported the estimated investment of $35 billion over approximately 20 years.

Following the second Mobility 2000 National Workshop a flurry of activity produced a written record of the results and recommendations in time for the May National Leadership Conference. With considerable hard work from the principals involved in the workshop, especially TTI, an excellent executivesummary was prepared by late April The summary was updated and printed as a glossy 20-page document entitled Mobility 2000 ***Presents Intelligent Vehicle-Highway Systems.*** It was widely distributed and was one of the most effective succinct descriptions of IVHS ever prepared. Its 11 action items have become the main elements of the national program. They include: establish a strategic plan, determine appropriate architectures, create a national organizational structure, provide mechanisms for international cooperation, and promote technical standards.

From May 3 through 5,1990, the National Leadership Conference was held, with USDOT Secretary Sam Skinner and Alan Smith of General Motors as co-chairs. Later that year IVHS AMERICA would be formally established and Congress would substantially increase funding for federal IVHS programs. The USDOT would establish a formal IVHS program office and recognize IVHS AMERICA as a utilized Federal Advisory Committee. Clearly, a national IVHS program was in place.

In retrospect, the work of many dedicated individuals, especially the core group who had started in the mid- 198Os, was successful in developing the vision and description of IVHS that continues today. In the process, they brought national attention to the area through their efforts in Mobility 2000. They had, in fact, succeeded in being the catalyst and agent of establishing a robust national IVHS program.

Many of the earlier programs undertaken in the 1960s by the Bureau of Public Roads were never implemented. But it would be a serious error to discount the positive results and role of the earlier programs in leading to the successful establishment of the current program. In fact, there were many successful products from that earlier program. One very tangible product was the UTCS and the national emphasis and focus it placed on modem computer traffic signal control. The FHWA became a leader in developing, encouraging, and providing federal funding assistance to the installation of such modem systems.

A second result was the international attention that the program fostered — especially in Japan. For example, around 1972 the FHWA R&D offices hosted a major delegation from Japan and discussed research efforts, with special emphasis on ERGS. Mr. Yumoto, of Surnitomo Electric, and Mr. Fujii, now with JSK, weremembers of the delegation. The discussions contributed to Japan's efforts from 1973 to 1978 to develop and evaluate its Comprehensive Automobile Communication System (CACS). That system was, in turn, the precursor of Japan's efforts in Road/ Automobile Communication System (RACS) and Advanced Mobile Traffic Information and Communication Systems (AMTICS). Similar activities were undertaken in Europe during the 1970s, especially in the United Kingdom and West Germany. For example, the Federal Republic of

Germany developed and field evaluated a route guidance system very similar to ERGS and CACS.

A third contribution of the earlier BPR program was the recognition that modem electronic communication and control systems do indeed hold tremendous promise for future highway operations and would someday achieve that potential. In that respect, the program provided a level of expectation and opportunity waiting in the wings for the national need. Even though theearlierprogramcontributedto the establishment of IVHS, the question still remains: Given the substantive program in the 1960s, what happened? Why weren't programs brought to successful completion and deployed? In short, why aren't we operationally using those systems today in our highway operations?

There are at least six principal reasons for today's strong IVHS program that did not exist earlier. First, there is a very serious congestion problem today that is recognized as affecting mobility and commerce. Further, the problem has not stabilized but is continuing to grow in severity, and no adequate traditional solutions are available. In the 196Os, the beginnings of that problem were recognized, but the problem was not particularly serious, and there was no national support for a resolution of it.

Second, our society has become increasingly familiar with and dependent upon technologies of information, communications, and control. We accept and even demand technology such as cellular phones, cordless phones, personal computers, portable miniature televisions. We are used to having access to such state-of-the-art electronics technology. In the 196Os, high-tech personal and business devices did not exist; much of the technology envisioned for the implementation of advanced technology to transportation was viewed by budget and program decision makers as Buck Rogers stuff, costly and unrealistic.

Third, the interstate highway construction era is over and no new construction of similar magnitude is anticipated. In the last decade our mindset and highway program philosophy has shifted from that of system expansion through new construction to that of efficient operation of the existing physical plant. Those technologies such as IVHS that hold promise for efficiency and safety benefits are now a high priority. By contrast, in the 196Os, although good operation of the highway systems was acknowledged to be desirable, it was generally not seen as a particularly important program priority. The ISTEA of 1991 is a dramatic legislative statement embracing that new emphasis on operations.

Fourth, today's enabling technology state of the art, especially in electronics and semiconductors, has reached the stage where very powerful and highly sophisticated devices are available for processing, storage, and display functions. Further, such devices allow for the small packaging and affordable cost that the market requires. The 1960s technology did not include microprocessors, integrated circuits — especially the very large scale integration (VLSI) of today, CD ROM, flat screen displays, and so forth. The list seems almost endless. Thus, the resulting systems were far less powerful and intelligent, packaging was much more bulky, and the system architecture favored centralized systems utilizing large mainframe computers instead of the distributed systems used today. On-board vehicle systems were much less robust in the services and features they could provide to the motorist.

Although the earlier programs certainly intended eventual implementation, they were research activities and did not provide a sense of operational application in the near future.

Fifth, today's program evolved from a new partnership among industry, academia, and state, local, and federal government. That partnership recognized early the different roles and objectives of each, but in so doing it built in the necessary features that have made the partnership strong. Out of that partnership, key national figures have become program "champions." In contrast, the earlier program in BPR was a standard federally run research program, with the government both setting design goals and developing prototype designs. A lack of true partnership with industry and other governments almost guaranteed no buy-in or commitment to take the systems to production and operation.

Finally, the present IVHS program, while having a major research element, has deliberately and wisely focused on a balanced program that also emphasizes operational testing and early implementation of results.

Further, the various agencies have stepped forward with a strong commitment to the deployment of state-of-the-art systems that have demonstrated operational benefits. Although the earlier programs certainly intended eventual implementation, they were research activities and did not Provide a sense of operational application in the near future.

The six characteristics of the mid- and late 1980s discussed above provided a supportive environment for the research and application of advanced electronic highway systems and what has become the IVHS program. But perhaps most importantly, in the mid 1980s a core group of individuals became convinced of the national need and value of IVHS. From divergent interests and backgrounds, they banded together and shaped a common vision andconsensus now embodied in the present IVHS program.

PROMETHEUS COMMON EUROPEAN DEMONSTRATION: A TOOL TO PROVE FEASIBILITY

Dipl.-Ing. Hans-Peter Glathe,
PROMETHEUS Office

SUMMARY

PROMETHEUS is a joint effort by the European automotive industry to improve the transport and traffic situation in Europe. The integration of vehicle control and traffic control has evolved as the essential means to higher efficiency and safety in road traffic. The implementation of such an integrated system is a difficult process requiring the demonstration of technical feasibility, the assessment of the impact on traffic and a consensus on the interfaces between different components. The Common European Demonstrations (CED) serve these purposes. As an exemplary CED takes a closer look at the AICC, an innovative system with extended cruise control functions is taken. Like no other system before, AICC will improve safety, comfort and driving style. The intelligent vehicle of the future must help the driver in a manner which is natural and acceptable. The driver must remain an integral part of the driving and vehicle control task. Further interdisciplinary research will be needed to achieve systems integration. Implementation of PROMETHEUS results requires the integration of public and private interests.

INTRODUCTION

The precompetitive research program PROMETHEUS is a joint effort by the European automobile industry to contribute to the improvement of the transport and traffic situation in Europe, working on the basic themes to balance supply and demand within the entire transport system and to optimize road transport as an integrated component of that system.

PROMETHEUS will deliver an integrated concept for the future transport world and, as spin-offs, compatible short- and medium-term solutions for acute problems (Fig. 1). The PROMETHEUS approach is characterized by no longer treating vehicles as passive objects in traffic but as actuators of the future road traffic control system.

Traffic safety must not suffer when improving the major problem for road transport efficiency, congestion. There is a close correlation between safe driving and individual vehicle control and between transport efficiency and collective traffic control. Therefore, the integration of vehicle control and traffic control evolves as the essential means to improve efficiency and safety in road traffic. This will be done on three levels of control:

- Travel and Transport Management: Trip planning and reaction to actual traffic situations for better use of the available infrastructure.
- Harmonization of Traffic Flow: Cooperation within local groups of drivers for safer and smoother traffic.
- Safe Driving: Improved vehicle control by informing or supporting the driver.

COMMON EUROPEAN DEMONSTRATIONS

Modern technology will improve the functionality of vehicles. The interdependence of the various functional systems being developed within PROMETHEUS is the driving force behind the integration activities, which are concentrated into five working groups. They are responsible for thematic research into sensors and processing, actuation and vehicle operation, in-vehicle architecture, driver-vehicle interaction and safety/dependability.

These groups coordinate the requirements of the Common European Demonstration programs into common specifications, allowing the participating electronics and supply industries to develop the necessary hardware or software. As centres of expertise in these fields, they provide guidelines for the demonstration programs on how to solve specific prob-

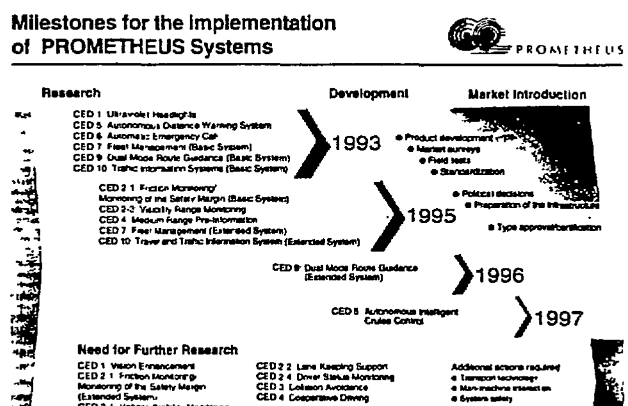

Figure 1

lems. Basic research teams are supporting the work where there is more fundamental lack of knowledge or understanding, e.g., in the areas of custom hardware for the intelligent acquisition and processing of data or intelligent software and processing techniques.

The implementation of a system for integrated vehicle and traffic control is **a** difficult process which, as a minimum, requires demonstration of technical feasibility, assessment of the impact on traffic and consensus on the functions of interfaces between different components.

The Common European Demonstrations (CED) serve these purposes. They are tools for verification and for proving feasibility. Definition of a CED requires analyzing the problem and setting the goal. This task involves problem analysis, system specification and development, evaluation and assessment.

The concept of CEDs allowed contributions to be made at many levels from components (hardware or software), to subsystems, to complete systems, promoting their integration both as an autonomous solution and their further integration into the overall PROMETHEUS "systems engineering" approach. The precompetitive cooperation of several companies in one CED is an essential means to reach a consensus on the basis of common experience (Fig. 2). ln addition, the CEDs prepare field trials as the next step for a realistic evaluation.

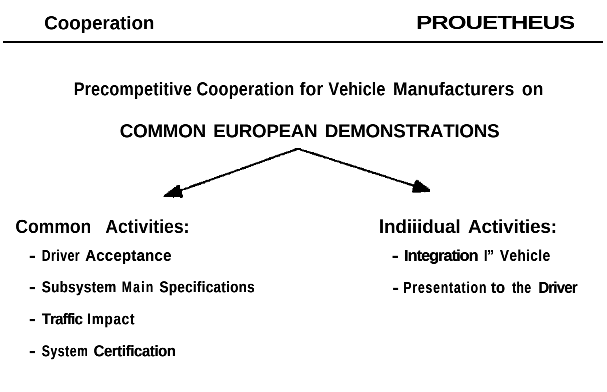

Figure 2

CEDs are not prototypes of future vehicles or devices. When a consensus on functionalities has been reached, the partners will develop products and serve the market in competition.

As an example for a CED, a more detailed look at the AICC will follow.

Autonomous Intelligent Cruise Control, AICC **(Active system for automatic control of the speed and distance to the preceding vehicle)**

Like no other system before, AICC will improve traffic with respect to safety, comfort and driving style. In its fmal version AICC will be an assisting system for controlling relative speed and distance between two adjacent vehicles in the same lane (Fig. 3). As an extension of the existing cruise control systems, AICC will not necessarily keep a fixed set speed but adapt the speed of the controlled vehicle to that of a slower vehicle ahead to keep an adequate distance. AICC is an assisting system the driver can override by braking or accelerating. AICC is an autonomous system and does not rely on communication between vehicles nor require for its basic function any equipment to be carried by other vehicles. AICC exclusively deals with longitudinal control and does not feature any elements of lateral control.

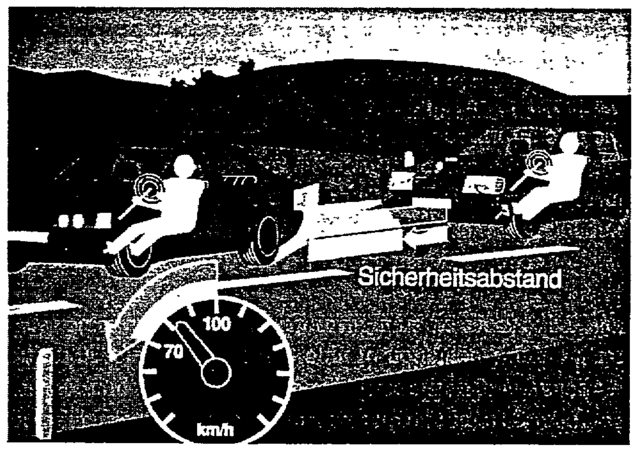

Figure 3

Steps of Development

- First generation: Autonomous Distance Warning System: Warning to the driver when the distance to the preceding vehicle **is** insufficient. 1993 : Start of product development.

- Second generation: Intelligent Speed and Distance Control: Automatic control of speed and distance in relation to the preceding vehicle. 1997: Start of Product Development.

TECHNICAL FEATURES

The AICC controller, an on-board multiprocessor system, has to handle in real-time a wide range of information to provide the AICC-function (Fig. 4). Different sensors are measuring acceleration, speed and steering angle in the controlled car, and distance and relative speed between the controlled car and the vehicle ahead.

Control loop: The driver activates or deactivates the system and sets the maximum speed the system can control (Fig. 5). If there is no target vehicle, the AICC system works in sped control mode like an ordinary cruise control. If a target vehicle is detected the system switches to distance control

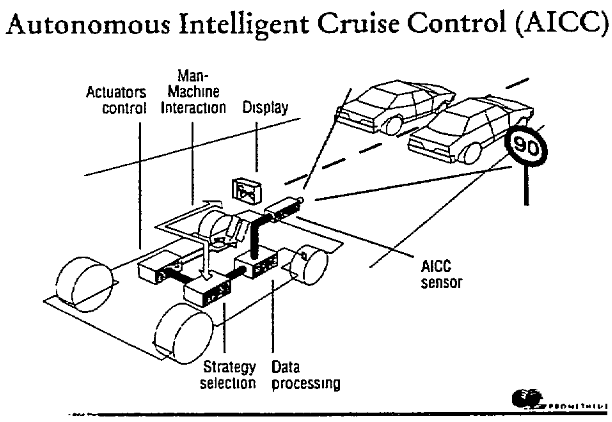

Figure 4

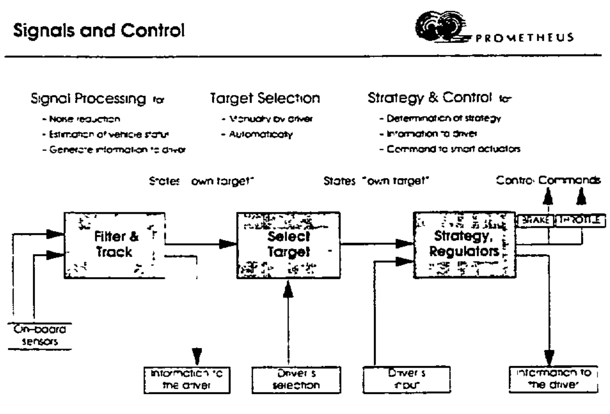

Figure 5

mode. The speed and distance controller calculates the deviations between actual speed and set speed or between distance and safe distance and operates on throttle and brake in order to nullify these deviations.

Example of control task: Vehicle 2 is closing in on vehicle 1. As the initial speed of vehicle 2 is higher than the speed of vehicle 1 the distance is decreasing; the first task of the AICC is a controlled approach where vehicle 2 is decelerated to zero relative speed exactly in the safe distance. The second task for the controller is to keep vehicle 2 in this position whatever vehicle 1 is doing. Automatic deceleration is limited to 25% and if the target is detected late actual distance for some time is closer than safe distance. If this overshoot is too great a warning tone sounds.

The ultimate controller must act softly for driving comfort, yet strong and fast in an emergency. A predictable and human-like behavior of the controller will lead to high driver's acceptance. Quality and quantity of sensor outputs and the performance of the actuator system determine the quality of the whole control loop.

Today we have to live with certain limitations like sensor range, sensor angle and quality of data; the actuator systems are not optimized. Missing preview information as controller input allows only limited interpretation of traffic situations and has negative effects on the performance of the AICC system.

A future AICC generation should include information on parameters that influence the vehicle speed profile and distance-keeping behavior of drivers, namely road friction, visibility, driver status, driving style, road type and traffic situation.

Therefore, possible extensions of the basic AICC system are:

- the measurement of the friction coefficient of the road to determine safe distance
- the measurement of the visibility range to adapt the AICC system behavior to driver perception capabilities
- the connection with short-range communication systems to acquire local information like traffic conditions and speed recommendations, and the acquisition of the road geometry to improve detection and tracking capabilities.

Road friction detection and monitoring already has some useful results. Roadside information like speed limits, traffic flow information or local weather information will be sent to the vehicle by transponder systems. The ability to detect and recognize obstacles under any weather conditions, daylight intensity or even at night requires high-performance systems. First assessments of possible sensors indicated that for technical reasons one type of detector may not give a satisfactory performance. Therefore, three different technological concepts are being tested: a microwave detection using a RADAR, an active infrared detection with a silicon photodiode for detecting the beams emitted by LASER diodes (LIDAR), and a far-infrared detection as a fully passive approach (Fig. 6).

AICC takes all these inputs and calculates outputs for driver information like warnings, safety margins or current state and for the controller that acts on throttle, brake and transmission.

HUMAN-MACHINE INTERACTION

The driving task is so complicated that it requires almost all the human's mental capacity to perform it well and safely (Fig. 7). It involves the interaction of the driver with the vehicle

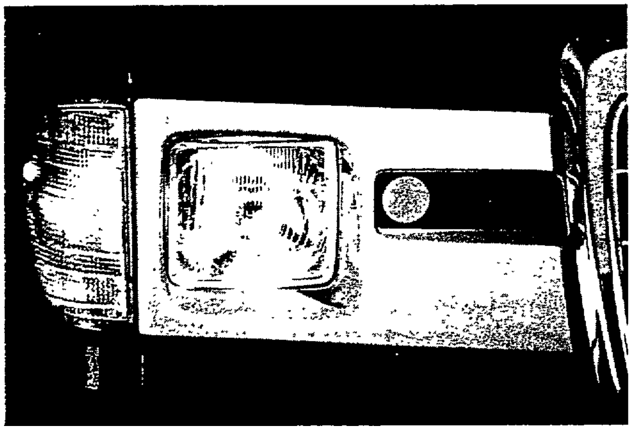

Figure 6

Common Activities

Driver Acceptance

Objective: Agreement on minimum MMI standard

Means
Tests with drivers

Partners
Institutes on traffic safely, e.g. INRETS in France a.s.a.

Figure 7

and their environment, made up of other vehicles and drivers, the road signs, weather conditions, all of which are changing temporally and the environment spatially as well.

The involvement of the human element makes the definition, modelling, simulation and evaluation of the driving task extremely difficult. The infinite variety of human behavior, reactions and attitudes make the successful application of technology in the driving task an enormous undertaking.

The driver must remain an integral part of the driving and vehicle control task. He must perceive the benefit of the system, trust the system, and feel comfortable interacting with the system whether it provides information, advice or warnings, helps him control the vehicle or provides support by performing a part of the driving task. It is not acceptable that different modules of a complex control system try to "access" the driver independently of the others. When systems intervene in the driving task, the process of delegation from the driver to the system should be clear and natural and, equally important, so should the process of handing back control.

The "intelligent vehicle" of the future must help the driver in a manner which is natural and acceptable, meeting the driver's needs in a timely manner, otherwise the system will fall intodisreputeandbe ignored or switched off, negating any possible benefits. If a "copilot" system is to be an acceptable part of the vehicle of the future helping, not replacing, the driver, it needs to lmow the status of the driver and, particularly, indicating reduced driver vigilance in order to improve the safety margin of the driving situation.

The acceptance by the users and the impact on traffic cannot be assessed reasonably on the basis of functional specifications alone. It is realized that, although guidelines may be developed on general principles of MMI the final solution must allow for the different philosophies of vehicle manufacturers.

INTERDISCIPLINARY RESEARCH AND FUTURE DEVELOPMENTS

Future systems will have many components and sensors in common and will be very much more interdependent than today's systems, requiring considerable exchange of data to provide enhanced functional performance and redundancy. An open architecture (Fig. 8) is being developed that will allow the exchange of data between processing units and the sharing of information from, and the control of, "intelligent" components on the network. Here the experience of the computer industry is being applied in the areas of networking, real-time operating systems, multi-tasking executives, and the application of the OSI 7-layer model to define the necessary interfaces.

Systems integration, with many of the systems linked together, can form a part of the foreseen copilot function, enabling a wide-ranging definition of the proper operation of the "intelligent vehicle" to be implemented, providing the driver with a vehicle, which gives necessary warning and advice to help maintain an adequate safety margin, which intelligently adapts its response to the driver's control inputs and which provides support in the performance of certain driving tasks, reducing the driving workload, only intervening should the situation become critical.

IMPLEMENTATION OF PROMETHEUS RESULTS

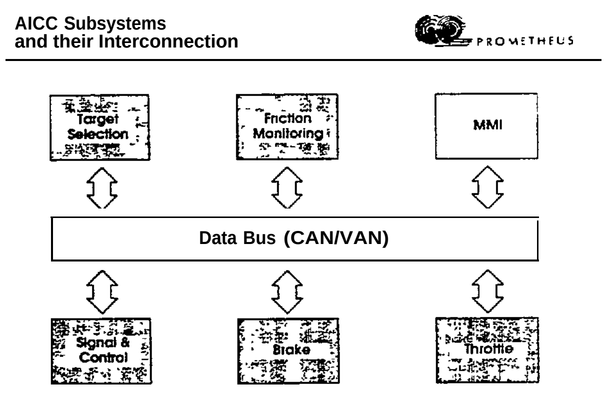

Figure 8

In an engineer's traditional way of thinking the introduction of a technical system depends on whether the desired functions can be realized with the necessary precision and whether the benefits achieved justify the costs. The technical feasibility of essential functions of PROMETHEUS systems with the prospect of short or medium-term implementation has been demonstrated during the Research Phase from 1989 to 1992.

The systems in question are:

- For short-term implementation basic systems for:
  - Autonomous Distance Warning
  - Fleet Management
  - Dual-Mode Route Guidance
  - Travel Information Services
- and full systems for:
  - Supplementary UV-Headlights
  - Emergency Call
- and formedium-term implementation basicsystems for:
  - Visual Range Monitoring
  - Friction Monitoring/Safety Margin Monitoring
  - Medium Range Prefinformation
- and second generation systems for:
  - Autonomous Intelligent Cruise Control
  - Fleet Management
  - Dual-Mode Route Guidance
  - Travel Information Services.

What remains open is the benefit and cost issue which, in most cases, cannot be answered yet due to the complex and hard-to-model nature of a transport system (Fig. 9), this especially given the circumstances that political directives aim at a different future transport world that is not just an extrapolation of previous conditions. Therefore, tests where interdisciplinary research accompanies the transition to operational systems and that also allow to determine changes in the behavior of traffic participants are an essential prerequisite for the implementation of innovative technologies in traffic that make sense on an industrial as well as social scale.

Technology can support quite different scenarios; its impact, however, greatly depends on the conditions inherent in the system. Therefore, it is up to politicians to engage authorities on European national and local levels to determine the role informatics will play in future transport systems. In particular, by funding relevant transport pilot shemes or tests, research has to generate data as a basis for rational decisions regarding possible systems and the individual acceptance of

Common **Activities** PRO

Impact on Traffic

Objective: **To evaluate the effects of AJCC system introduction in traffic and study the htegratkn of AICC system in rood transport infrastructure**

Means **Test sites and simulation**

Partners **Traffic engineers and transport authorities**

Figure 9

measures connected with them. By combining tests with research, conceptual weaknesses and flaws in future operational systems can be detected in advance and subsequent corrections be minimized. Such tests also offer material that enables experts to study – among else -- secondary impacts of technology, systems with multiple-cause interdependence as well as human-machine interaction and thus create an informed partnership for systems development. There will not be substantial progress towards a more elaborate transport system without the integration of public and private interests in a mutual resolution.

Basis for the introduction of innovative technologies in road traffic is the integration of vehicle and traffic control into transport policy and its subordinate goals. These innovative technologies can only reach social acceptance when considered as tools of one comprehensive transport system.

Basic PROMETHEUS strategy for implementation is an evolutionary introduction of optional equipment bought for personal advantage. At first there will be equipped vehicles in an unequipped environment and others. With regard to the impendingtrafficproblems, Europeneedsshort-termprogress towards a long-term solution. The Common European Demonstrations give an impression of the contributions to be expected from the automotive industry. The effectiveness of the industry's contributions to road transport informatics depends on a close cooperation between national, regional and local bodies of authorities, infrastructure operators and the industry in developing a European strategy for introduction and implementation. A platform to achieve this consensus is offered by ERTICO, the European Road Telematics Implementation Coordination Organization.

CONCLUSION

The "intelligent vehicles" of the future will have many more electronic systems capable of improving the safety, comfort and convenience of the individual vehicle. Considerable integration of these systems will be required to achieve their full functional This integration is to be achieved with common components, interfaces and defined interactions to ensure compatibility, interoperability, and the maximum possible economies of scale and flexibility in manufacture, installation and maintenance.

Integration entails the adoption of systems engineering techniques, especially considering the complete picture of the intelligent vehicle as part of an intelligent group of vehicles, which in turns is a part of an intelligent traffic system, linked by Communication systems, benefiting the individual driver and the whole traffic and transport network.

Certainly no individual automotive company is capable of researching, developing and implementing all the systems envisaged (Fig. 10).

PROMETHEUS is enabling the distribution of the research tasks, the exchange of information and results, and the preparation of guidelines and recommendations to industry, traffic authorities and regulatory bodies. These will form the basis of future standardization and possible legislation, allowingthemany possible solutions to be researched, the best solution to be identified, in the sknowledge that the intelligent vehicle of the future together with the driver will form a partnership of unprecedented safety, comfort and convenience.

Common Activities PROMETHEUS

system Certification

Objective

- to present on agreed concept with consensus on main functionalities / Industrial Standard
- To define respective responsibilities for the utilization ct AICC
- To define and agree on test procedures
- TO agree on control distance difinition

Means

- System engineering - System Safety Analysis

Partners

- Traffic authorities
- Certificatrion bodies

Figure 10

The DRIVE programme of the European Community

By Peter O'Neill, Commission of the European Communities, Brussels.

"Dedicated Road Infrastructure for Vehicle Safety in Europe": this is the formal title underlying the now-familiar pcronym DRIVE, the European collaborative programme of research and development in the application of ndvanccd telematics tp the roads and transport environement.

Now in 115 **second phase** DRIVE contributes up to half the cost of each of a serices of **project** undertaken by multi-national consortia whose partners are drawn from the Member Sta tes of the Community and from their neighbours in the European Free Trade Association.

The rogramme includes the lull range of information-technology based services in support of the management of transport t **demand,** the control of road traffic the operation of freight **and** public transport fleets, **and** the information and guidance of indiviual travelfers and transport users. The emphasis in DRIVE is on the external infrastructure required for these services. It therefore complements the product development undertaken by the automotive incfustry and its suppliers, including the cooperative PROMETRI E U S programme of the European motor industry.

BACKGROUNO

The application of information technology to road traffic control pre-dated the computer: controllers for isolated junctions utilised pneumatic detectors and electro-magnetic relay technology to control the signals. The arrival of solid-state electronics and of externally programmable memory chips transformed the traffic control industry, and linked area-wide systems were introduced: at first, using fixed-time operating plans, and subsequently incorporating loop detectors to drive traffic-responsive algorithms.

Advances in trallic control went hand-in-hand with increasing volumes, so that the emphasis shifted from that of enhancing safety at junctions, to the maximisalion of capacity and the optimal management of circulation throughout an entire network. At the same time, the falling cost of information capture, processing and storage stimulated interest in two associated fields. The ability to detect interruptions to traffic flow on high-capacity roads offered the possibility of providing drivers with advance warning of stationary or slow traffic ahead, so as to minimise the risk of multiple rear collisions, especially in poor visibility. The digitisation of road maps and the perfection of minimum-path algorithms opened the way for the provision of navigational guidance, which could be further enhanced by the automatic monitoring of traffic speeds on the links in the network, thus enabling the generation of minimum-time itineraries, constantly up-dated.

T he application of electronic traffic aids is primarily a public-sector function, in which the competitive element lies in the rost and performance of the technological components, while the highway authorities operate what is necessarily a monopoly service to road users. There was thus a natural incentive to international co-operation in learning lessons from alternative techniques, and a specific need for joint action on roads crossing international frontiers. The application of traffic electronics to motorways therefore formed the subject of the European collaborative programme COST 30, under the aegis of a framework of scientific and technical research linking the Community countries with their European neighbours.

Navigation and route guidance, on the other hand, evolved as essentially a market-orientated service utilising individually-provided in-vehicle equipment, coupled with a limited need for external infrastructure for services such as vehicle location and tracking for fleet managers. This situation persists to the present day, some 20 years after these developments began: motor manufacturers compete to offer autonomous navigation systems requiring no external interface, while fleet management service providers rival each other in offering tracking and communication facilities using satellites, low-frequency radio and cellular networks.

The public and private sectors come together, however, where extensive infrastructure investment is involved, and in particular where equipment has to be installed in urban streets or on limited-access highways. This relates particularly to the installation of vehicle detection devices and of short-range communication beacons. Individual agreements between administrations and companies are beginning to emerge in response to their joint interes in the use of elements of the infrastructure both for traffic management and for the provision of information services susceptible to the mechanisms of the private market.

While the incentive to international collaboration was evident in the COST project, industry has traditionally been more guarded in sharing development other than in the context of very specific technology, manufacturing and marketing agreements. By 1985, however, European industry perceived that it faced a global challenge arising from several coincident factors. One of these was the undeniable technical and market power of the Japanese companies, acting in vigorous competition with each other but within an institutional framework beneficial to their national industries as a whole. Another was the impetus to the development of advanced technologies given by the inauguration of the Strategic Defense Initiative of the US Government, which was likely to offer valuable commercial spin-off in the non-defence activities of the participating companies. A third factor was the fragmentation of European industry, not least in the automotive sector, where an increasing number of companies could no longer hope to be able to bear the costs of technical developmknt needed in order to remain competitive. Finally, the European companies recognised that, in a world in which the production and assembly of automotive components and vehicles was fast spreading to the low-labour cost countries of the developing world, their future lay in the addition of sophistication and value to a basic vehicle offering in itself less and less scope for competitive product differentiation.

This situation led to the creation of the EUREKA programme, extending to most countries of Western Europe, at a time when the imminent dissolution of the Comecon region was not generally foreseen. The emphasis in EUREKA lies in joint technical development at a pre-competitive stage among industrial companies, linked in some cases with public research institutions. Among the many projects registered with the EUREKA Secretariat, several were concerned with road transport but the predominant one was PROMETHEUS. The equipment and systems under development are primarily for incorporation within the vehicle, but contributory sub-projects study the necessary interfaces with infrastructure to be provided by highway authorities, telecommunications network operators, or other service providers.

There is thus a natural complementarily between DRIVE and PROMETHEUS, where the R & D activities proceed largely separately but with a mutual understanding of progress and of needs.

THE GENESIS OF DRIVE

Against a growing awareness of the possibilities for the better application of the vast mass of information generated - but often not even collected - by the movement of vehicles and goods, an additional and critical factor was that of road safety. The European Parliament had long been concerned, not only that progress had been slow in the evolution of a common transport policy, but that there was no common approach towards reducing the toll of road accidents in Europe. The Parliament therefore called on the commission to put forward proposals in this field, with a particular interest in what could be done through the application of information technology.

The two Directorates-General of the Commission primarily concerned - those responsible for Transport (DG VII) and for Information Technology and Telecommunications (DG XIII) therefore initiated jointly a study of what the recent advances in the integration of communications it had to offer. A report was presented to the Member States in 1986; they agreed in principle to support a research programme, and the Commission worked with national nominees to develop a work plan and the proposal for a formal Council decision. This was adopted in June 1988; bids were invited, and the work started in January 1989. A smaller supplementary call for proposals was published soon after, and in total 72 projects were supported. The cost to the Community was 60 million ECU, of which just over 50 million was spent on shared-cost research, the balance being devoted to the costs of administration, "concertation" (regular meetings between participants), dissemination and activities in support of the exploitation of the results.

The DRIVE contracts were all due for completion by the end of 1991; extensions in time were negotiated with some projects and the final reports were being received early in 1992. The Commission reported to the Council and Parliament on the achievments of the programme, and called on an independent expert panel to conduct a strategic audit of the work. This endorsed the value of what had been achieved, while recognising that the ambitious expectations of some of the projects had not been wholly fulfilled; and issued advice on the continuation of DRIVEi and on future actions for the Community.

THE OBJECTIVES OF DRIVE

The strategic aims of the programme were to contribute towards the efficiency of the European transport system, the reduction of road accidents, and the amelioration of the adverse environmental impacts of transport - in particular, the pollution of the urban atmosphere resulting from road traffic. The operational objectives were more precise. In general terms, the research was to contribute towards providing better services for transport users, while at the same time assisting European industry to become and to remain competitive in this field, subject to the constraints imposed by Community policy on competition and by the GATT rules. The research was, in accordance with community research policy, generally "pre-normative and pre-competitive", and the financial contribution towards product development was small.

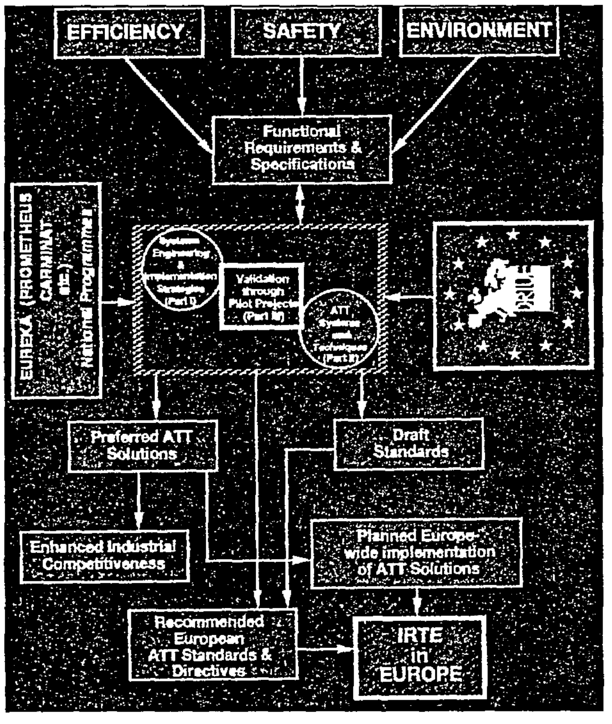

Figure I: Objectives, Structure and Outputs of DRIVE.

The primary aim was to achieve the harmonisation necessary for the inter-operability of mobile (in-vehicle) equipment communicating with fixed infrastructure throughout Europe, across which there is extensive through traffic. The adoption of common specifications would benefit not only the user; it would also provide a secure platform

for the development by industry of hardware, software and services using the communications network thereby created. It soon emerged that the direct benefits would be principally towards efficiency: through reduction in time wasted due to traffic congestion, through better management of fleets, and through the processing and provision of the information needed by drivers and travellers to make their individual decisions on journey mode, timing and route. The potentially very great benefits to safety and environment would result not from the existence of the relevant technologies, but rather from the willingness of the public to see them applied: to law enforcement, and to demand management influencing the volume of road traffic and the level of congestion. Important progress was however made in perfecting the tools needed for the achievment of these social objectives as and when the political process so decides. There has however been work on other devices of direct benefit to safer driving, including equipment to provide warning of dangerous conditions, proximity of other vehicles, or loss of alertness by the driver.
The diagram in Figure 1 shows how DRIVE interacts with the EUREKA and national programmes in translating its basic objectives into operational outputs and finally into the specification and implementation of the Integrated Road Transport Environment.

THE SCOPE OF DRIVE

In common with other aspects of engineering science, micro-electronic technologies into nearly all types of equipment and service. When the detailed planning of DRIVE began, the expertise available for this process reflected four largely separate fields of application, and the structure of the programme was based on these. The four groups, whose identity was broadly maintained throughout the concertation process and the annual independent technical audit of progress, covered respectively: system modelling and economic analysis; traffic management and control; behavioural sciences and safety issues; and telecommunications.
The specification of the projects proposed, and the execution of those selected, has demanded the integration of many technical skills and therefore the cooperation of researchers belonging not only to different companies and institutions but also to different specialist departments.
Among the subjects to which research in DRIVE was particularly devoted were the following:

- automatic vehicle identification and toll collection
- alternative short-range communication links between vehicle and infrastructure, including the specification of a universal roadside information processor
- architecture and communication protocols for the integration of the transport telematfcs network
- communications in tunnels and confined locations
- modelling of road traffic flow and optimisation of management and control strategies
- application of dynamic route guidance and its interaction with area traffic control systems
- passenger information and operational management systems for public transport undertakings
- information systems for freight fleet management and forwarding of goods
- the tracking of hazardous consignments and the vehicles carrying them
- improvement of safety for pedestrians and pedal cyclists
- safety and efficiency aspects of the man-machine interface in vehicle driving and control centre operation
- video image analysis for traffic monitoring and incident detection
- techniques for assessment and appraisal of transport telematics services
- preliminary examination of market prospects for transport telematics
- review of the legal, institutional and social constraints on development
- the relationship between road traffic and air pollution, and the impact of management options
- the efficient utilisation of car parking space, and guidance of drivers to accommodation
- the provision of trip planning and tourist services to motorists
- the specification and coding of traffic messages and event location using the Radio Data System of the European Broadcasting Union.

THE ACHIEVEMENTS OF DRIVE

DRIVE constituted a major step forward in European cooperation in its field, building on the valuable but narrower experience of COST 30 and 30bis, and it was launched at the right time to complement PROMETHEUS. The strong public and political endorsement of DRIVE followed from a recognition, first that worsening road traffic congestion required the deployment of a broad range of tools if anarchy was to be averted; and second, that uncoordinated activity dispersed throughout Europe would lead to disastrous operational and technical incompatibility. With the issue of all necessary formal standards as the medium-term requirement (in default of the practical possibility of achieving this in the sort timescale ideally desirable), the more direct aim was the progressive reduction in diversity. Equally, it had become clear that only the Commission could provide the necessary technical, administrative and political focus for this task.

DRIVE has been successful in this aim; by no means is there yet complete agreement on the necessary functional and interface specifications to achieve interoperability, but the range of solutions under serious consideration has been greatly diminished, sometimes to no more than two alternatives. In other instances, complete convergence has been reached. A particular example has been the recommendation by the European Radiocommunications Office for the allocation of common radio frequencies for transport telematics applications, allowing both for the current generation of equipment and for the mullimetre-wave developments foreseen in future applications. This agreement has been underpined in so far as the Community Member States are concerned by a Council Directive requiring adherence to these bands.

THE SECOND DRIVE PROGRAMME

The tasks requiring Community cooperation in this field were by no means completed with DRIVE. A valuable stimulus was given, not only to the process already mentioned of achieving technical convergence, but also to many aspects of research which might otherwise have been neglected. Two years into the programme, it had become clear that the next step would be to concentrate on monitoring the performance and the impact of the systems and services in public application. Consultation with the Member States and informally with the EFTA associates revealed unanimity on this point, which implied both that more money would be needed, and that those technologies which were not yet ready for exposure to the environment of the public roads and transport services would have to receive a smaller proportion of the funds to be sought.

DRIVE had been adopted by the Council of Ministers as a separate project under the Second Community R & D Framework Programme. Twoother Community programmes had also been undertaken essentially as exploratory actions, and the need for joint R & D in several other applications of the evolving integration of IT and telecommunications had been identified. Following agreement between the Community Institutions on a Third R & D Framework programme, a specific programme was therefore adopted in June 1996 under the title "Telematics Services of General Interest': this covers seven parallel actions, of which that on Transport is individually the largest and will be known, not legally but inevitably, as "DRIVE II". The Community resources identified as necessary total 124 million ECU, of which about 110 million will be spent in contributing to shared-cost projects.

About 70 per cent of this money will be devoted to urban and inter-urban pilot projects and to supporting "kernel" activities providing common technical support. The 150 bids submitted for support in the autumn of 1991 in response to the Commission's call requested a total of 1200 million ECU, more than ten times the amount available. An independent technical evaluation was followed by detailed discussion with the Management Committee of the Member States, and this led to the retention of some 56 projects for detailed negotiation, now complete. Most of these projects were awarded substantially less than they had requested, but this meant that a fairly high proportion of those who entered the bidding process have been enabled to play a part in the new programme, even if on a narrower scale than they had proposed.

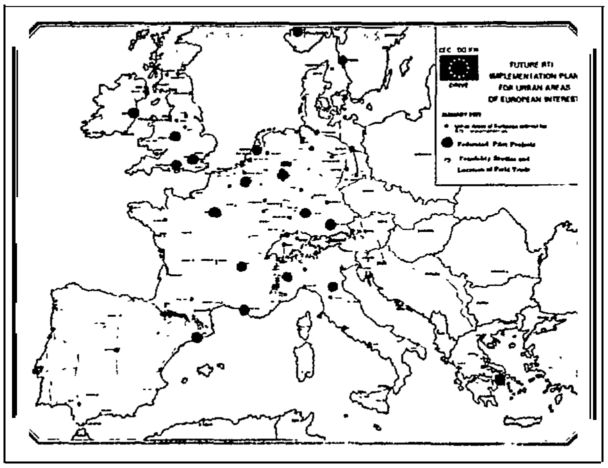

Figure 2: Urban participation in "DRIVE II"

Two complementary frameworks had helped proposers to develop coordinated plans, thus respecting the obligation to work in multi-state consortia, planning experiments jointly and exchanging information as experience was gained. For urban areas, an organisation entitled POLIS (Promoting Operational Links between Integrated Services) had been created by the EUROCITIES association between major urban authorities within Europe: this extends beyond the Community, but POLIS received a modest grant from the Commission to help it to establish networks of technical collaboration for the benefit of the "less-favoured regions" of the Community. The map in Figure 2 shows the distribution across Europe of the urban sites at which work is in progress within DRIVE II. The Commission's DRIVE infrastructure Group, composed of nominees of the Member States and of EFTA, sponsored the setting-up of the CORRIDOR group to fulfil a broadly complementary function for inter-urban corridors; these have always included one or more roads, but sometimes also parallel rail routes. Figure 3 shows the principal inter-urban corridors included in DRIVE II.

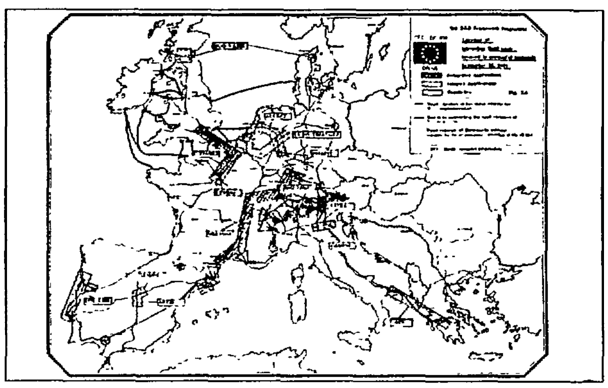

Figure 3: Inter-urban participation in "DRIVE II"

In response to this shift in emphasis toward operational experience, the basic structure of the new programme has been changed. No longer is this set in a discipline-based framework, but rather in the context of responsibilities for implementation. The work plan, and the negotiation of the project contracts, has therefore concentrated on ensuring that adequate experience was gained from the programme as a whole in seven "Areas of Major Operational Interest", as follows:

- Demand management: comprising measures to regulate transport activity in relation to network capacity and to safety and environmental constraints; this includes tolling and pricing for the use of road and parking space.

- Traffic and Travel Information: covering users' needs in relation to trip planning, navigation and guidance, modal interchanges, meteorological information, tourist information, parking guidance, park-and-ride facilities, incidents and delays.

- Integrated Urban Traffic Management: this relates primarily to the needs of public authorities and traffic control centres, in applying new sources of real-time data to improve efficiency and control environmental impacts.

- Integrated Inter-urban Traffic Management: the corresponding requirements of motorway and regional authorities for the gathering, processing and presentation of information and the control of traffic.

- Driver Assistance and Cooperative Driving: this includes assessments and trials of a range of technologies to help drivers, including the elderly and disabled, and to minimise or eliminate the risk of collisions; together with means of encouraging respect for traffic laws and for their enforcement.

- Freight and Fleet Management: this complements the general pilot trials included in nos 2 and 3 by developing and testing systems for integrated freight handling, including vehicle fleet control and the utilixation of "combined" (multi-modal) transport

- Public Transport Management: the application of telematics systems to the complete information needs of public transport operators, including both management and passenger information.

The attached diagram sets these Areas in the framework of the three types of work embodied in this and the other telematics programmes. These comprise "Part I" activities: studies into the integration of the entire system, in this case what is known as the Integrated Road Transport Environment; Part II, the development of subsystems, components and other technical elements; and Part III, the pilot projects, towards which most of the other effort also provides support

It should be noted that the financial assistance provided under this programme is spread relatively thinly. The principle behind the Community's decisions on allocation of resources has been that of meeting up to half the cost of the experimental and monitoring activities, and of completing developments up to the point required for pilot trials. The formula applied may meet 50 per cent of costs for some partners, but those whose salary costs are relatively high are supported only at a lower percentage. The Community contributes nothing towards the cost of capital investment: most of the pilot projects are based on firm plans for the introduction of proven up-to-date services (such as traffic-responsive network control, or comprehensive variable message signing), and the advances sought under DRIVE II are essentially additional to these. Thus the Community's share of the whole European investment behind the Projects is quite modest; for some multi-site pilots it could be as little as 10 per cent of the total financing needs. Nevertheless this "seed funding" has been sufficient to bring about a level both of investment and of cooperation which would not otherwise have been possible, so convinced are the partners of the need to work together towards the necessary harmonization.

ERTICO

The key to the industrial, administrative and public reception of DRIVE and to the strong support enjoyed by the new programme lies in its involvement of the actors confronting all of the real-world problems inherent in the provision and use of transport facilities and of road space. The successful exploitation of the results of these programmes will depend on the commitment of three broad groups of investor and operator: the public authorities (generally responsible at national level for major networks and at regional and local levels for the roads suffering particularly from urban congestion); the service providers, who may be touring clubs, other commercial concerns, or public offices providing transport information; and the "industrial" actors including manufacturing industry and both public transport and freight operators.

With the encouragement and administrative support of the Commission, a number of these key actors (including several national governments) have combined to form ERTICO: the European Road Telematics Implementation Coordination Organixation This body, situated in Brussels, has as its function to ensure the harmonised implementation of the investments and services which will comprise the future transport telematics network. Thus the members, among whom it is expected to count all of the major companies or their relevant subsidiaries, will pool their ideas: so as to promote the common interest of users, manufacturers, and providers, but without detriment to the necessary element of competition for alI practicable components of the system.

ERTICO will draw on the contacts and expertise of all those in the DRIVE community, and will depend on the outputs from continuing research and trials. One of its key functions will be to promote effective and timely standardisation and in this it will work alongside the Commission in the support given to the European (or, where appropriate, the

International) standardization bodies. The furtherance of consensus on key technical aspects is the objective of the Topic Groups formed from among the DRIVE II projects, and this represents a shared interest of the Commission and of ERTICO. A shared-rost project entitled CORD has therefore been negotiated whereby ERTICO will carry out a range of activities in support of the research, and reflecting these joint interests: close liaison with the Topic Groups will be among these tasks.

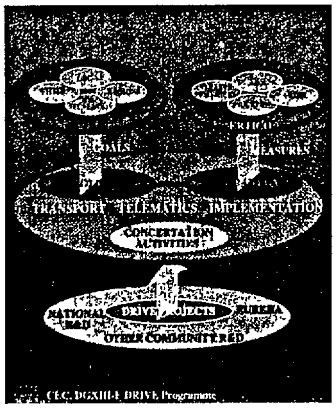

Figure 4: Links between ***DRIVE, ERTICO and other activities,***

Figure 4 shows the linkage between the R & D foundation of European transport telematics, through the DRIVE concertation process to the twin pillars of Policy, where the Commission acts in support of the Community's interests; and Strategy, where ERTIGO is to coordinate the necessary measures in association with suppliers and users.

STANDARDIZATION

In conclusion, it will be appropriate to mention a few of the issues in which the promotion of consensus is vital to the success of the European network.

Foremost among these is perhaps the short-range communication link, where there is contention between the proponents of transmission by micro-wave radio and by modulated infra-red beams. The latter solution formed the basis of the extensive LISB experiment in Berlin; while a **review** showed that this had not yet achieved all that could have been hoped from it, nevertheless the operation of the vehicle-roadside link was successful. There are however counter-arguments in favour of micro-wave: behind the controversy lies the strong wish of the automotive industry to have to install in its products only a single set of equipment, and the need for financial transactions (such as tolling) to be compatible with the requirements of the European clearing houses.

The next outstanding issue conrems the alternatives to the use of roadside beacons. experience in DRIVE has testified to the merits of utilising the existing communication networks, including those of the PTTs, the cellular telephony service providers, and the suppliers of other data transmission and value added networks. It may be difficult and inefficient to create a wholly new network for transport needs: growth may best be accommodated by the progressively increasing **use** of already-existing facilities, and by the adoption of established communication protocols wherever practicable. Behind this fundamental consideration lie several individual issues, but among these is the prospect of very extensive use of the future pan-European digital cellular network, GSM, on which trial use has already begun in several States. Compared with the existing analogue networks, GSM offers two advantages. First, it is intrinsically suited to the digital information which will constitute the majority of that to be carried: both because this represents and efficient use of capacity (because most messages can be compressed to coded form) and because linguistic translation will be needed by many European users. Second, and even more inportant, is the universal coverage which it is the target of GSM eventually to provide, even though its spread will inevitably be piecemeal. Extensions to the basic GSM (voice transmission) specification will be needed, and this case is being pressed urgently.

The final issue to be mentioned here is that of the future use to be made of FM public broadcasting capacity. As mentioned, RDS offers valuable facilities already coming into use, and one achievement of DRIVE has been to define a message-coding protocol to make effective use of the limited data capacity available at present. However, broadcasters expect later in the 1990s to progress to the transmission of Digital Audio Broadcasting signals, offering the prospect of much greater data capacity without detriment to the basic speech and music function. Introduction will necessarily take many years because of the need for new receivers, but the transport telematics community must play its full part in Influencing technical standards and implementation plans in this field

SUMMARY

DRIVE and its successor are providing a vital catalyst to the orderly evolution of services in Europe, and a corresponding contribution to what may widely become international formal standards in due course. Corresponding initiatives exist in USA (IVHS-America) and in Japan (VICS) The three communities are watching each other's activities with acute interest; it is to be hoped that the spirit of competitive collaboration thereby engendered will be to the eventual benefit of transport users throughout the world.

THE AUTHOR

Peter O-Neill graduated in civil engineering at the University of London, and worked subsequently in the Ilelds of hydro-electric power, thermal power, highway and bridge design, and airport planning. Entering the British civil service, ***he worked on the management of natural resources and*** water ***supplies and the modelling of energy use. From 1979 he was engaged exclusively In transport, where he became chief administrator of the research programme of the Department*** of Transport, from ***which he was seconded irom 1990 to work in Directorate-General XIII of the Commission of the European Communities.***

EDITOR'S NOTE

ERTICO's PRESENT STRATEGY ON ADVANCED TRANSPORT TELEMATICS

Federico Filippi
ERTICO Managing Director

1 THE R&D BACKGROUND.

During the eighties it became increasingly evident that traditional measures alone would neither be sufficient nor possible to cope with the severe increase in European transport demand and especially for road transport. The transport industry, the vehicle manufacturers, the EC Commission and local, regional, national Authorities became aware that future development of European economics was confronted with a potential "mobility" crisis, even more severe than the "energy' crisis of the seventies, the effects of which would be

- traffic congestion (especially road and air traffic);
- decreased travel safety,
- increasing environmental problems.

Since it is clearly impossible, for physical, environmental and economic reasons, to expand the existing European infrastructures up to the point at which they could cope with the foreseen increase in transport demand, the only feasible way to face the problem was recognised as the need to make a better use of all infrastructures. This means first of all avoiding any capacity wastage and secondly using new technologies to increase the effective capacity and efficiency of existing infrastructures.
A similar strategy was used successfully to cope with the "energy crisis" of the previous years. Up to 1973 it was widely accepted that GNP and energy consumption had to grow at the same rate. Ten years later this became no longer true. Could the same approach be used to solve the "mobility crisis"?
The modern development of electronic and informatic technologies prompted therefore all those concerned to investigate their applicability as a very important tool to optimise the use of available resources.

For the sake of clarity let us define Transport and Traffic Telematits as follows:

Transport and Traffic Telematics are a group of services, utilising information technology and telecommunications, in vehicles and infrastructures, to improve transportation from the points of view of safety, efficiency, comfort and environment.

Other services from electronic systems totally self-contained in vehicles such as navigation, telecommunication making use of existing infrastructure for non-traffic related purposes, on-board controls, are only included to the extent they share functions or components with the transport and telematics system.
This field is known also under other names, some specific to a single transport mode, like Road Transport Telematics, Road Transport and Traffic Telematics, Intelligent Vehicle-Highway Systems (in the US), Vehicles Systems for Roads or Infomobility (in Japan) or as Advanced Transport Telematics (ATT), which is the name most commonly used in Europe when dealing with R&D and which will be used thereunder.

Here we will mostly concentrate on the application of ATT to road traffic and its interfaces to other transport modes.

Many R & D projects were therefore launched at company, local, regional, national, international and Commission level. The need for public financing, especially in the pre-competitive phase, led these individual projects to conglomerate into many European Programmes:

- the EUREKA Programmes, individually financed by national Governments within a European framework: PROMETHEUS, CARMINAT, EUROPOLIS, ERTIS, LOGIMAX, TRANSPOLIS, launched in 1986, ROADACOM and others.
- the European Community Programmes : DRIVE (1988-1991) and the current ATT Programme (DRIVE II) plus some projects in THERMIE and in other programmes.
- the National Programmes which span from very wide integrated field trials, like the Swedish ARENA Programme, to those intended to test specific technologies, as the German BEVEI project or the German field test for choosing an ADS (Automatic Debiting Systems) on the German motorways.'

At present these projects are so interconnected that, even if one cannot speak of a single European Programme, sponsored by a single central organisation (as it's the case for the more recent IVHS Programme in the US), at least we can speak of a common R&D European Action. Due recognition must be given to the EC Commission that, with remarkable foresight, saw from the beginning the need for giving to the individual projects a European scope, even outside the boundaries of the EC itself.

The results from these projects, especially from PROMETHEUS and DRIVE, have been very promising so that today many technologies are already commercially available or could reach this stage in a short time scale:

- Automatic Debiting Systems for toll collection, user charges, congestion road pricing, etc.;
- Dual mode route guidance and traffic information systems based on radio broadcast (like Trafficmaster, CARMINAT, and others), on cellular phone (like SOCRATES), on beacons (like Euro-Scout) ;
- Fleet management systems using satellite and/or cellular phones or trunked radio for positioning and communication

- Travel Information Systems, primarily for pre-trip planning, at home, in the office and in public places.

In addition, "Intelligent Traffic Control and Management systems with different levels of interface to drivers like SCOOT, SIRIUS, MOVA, GERTRUDE, PRODYN and many others are increasingly being put in operation.
In the Public Transport sector ATT systems that can provide bus positioning, and bus schedule control in real-time interacting with the traffic system are also being implemented in many European cities.

The field trials so far conducted have shown that ATT is a powerful tool for alleviating the European "mobility crisis" resulting in:

- opportunities to introduce transport demand management, to encourage inter-modal travel, and to integrate different transport systems resulting in an improved efficiency of the transport network;
- the introduction of better techniques for traffic management and control, for infrastructure maintenance and operation, and for vehicle or fleet management, resulting in better use of the existing infrastructure and reduced transport costs both for the private and public sectors;
- increased safety and improved management of emergency situations;
- reduction of the environmental impact due to transport;
- increased driver comfort due to decreased congestion, better information both before and during the trip, more predictable journey times, reduced stress;
- increased efficiency of the logistic chain in freight transport;

while offering the opportunity to develop an entirely new business sector for the European industry and improving the European competitiveness vs. US and the Pacific rim countries.

Admittedly some of the systems quoted above still lack full validation, especially from the cost-benefit and users' acceptance points of view, but this will only come from large scale implementation.

2. IMPLEMENTATION: PROBLEMS AND OPPORTUNITIES.

It could be expected that in view of the many benefits foreseen and the successful completion of the first part of the European R & D projects, ATT would have been quickly implemented on a large scale. This apparently is not the case. Many reasons are behind this relatively slow transfer from R & D to exploitation, in addition to the general shortage of funds due to the present recession phase of the economy.

The major obstacle is that, in general terms, ATT implies a new "horizontal culture" cutting across various traditional boundaries between different countries and between transport modes and, within each transport mode (especially in road transport), between those responsible for providing the infrastructure, those operating it, those using it, the vehicle manufacturers and their suppliers, the many information sources, and the telecommunication world. The change from

a regulated but basically uncontrolled infrastructure utilisation to one controlled for optimum efficiency is not an easy one.
New institutional, organisational, legal arrangements have to be invented. In some cases existing legal barriers have to be removed or to be modified. Ways to share costs and responsibilities between those who collect data/information, who handle it and have to control traffic at the urban, regional, national and international level, who will make them available to the final users, are to be found.
ATT implementation will need the establishment of private consortia working together with public authorities. The operational details of these consortia will differ from country to country but there is a general inertia by the public sector bodies (with some exceptions) in accepting this sort of public/private partnership.

A second problem area is that of costs: in order to show to the public authorities, to the service providers and operators, to the equipment manufacturers, and to the final users its full benefits ATT has to be implemented on a large scale and therefore quite large initial investments are necessary. Some ATT functions, like ADS, might become a major tool for financing an ATT infrastructure, but this requires clear political decisions at all levels.
Unfortunately, and paradoxically, the success of the many different R & D projects is leading to a situation where the increasing number of local and national initiatives will generate a proliferation of systems differing considerably from one country to another or even from one city to another. This state of affairs does not minimise the necessary investments in all kind of resources.

Clearly a unique pan-European ATT architecture will never exist. It is evident that different systems with different levels of sophistication will be implemented in order to satisfy the needs of different users. The free market forces will then dictate the choice.
What has to be avoided is that users find that they are confronted on their journeys by a' large number of incompatible systems using different techniques that vary considerably in quality and, even worse, render the provision of continuous service impossible.
Nobody can expect that all vehicles will be equipped with more than one vehicle - infrastructure communication device for the basic traffic information and control functions (others could be added to fulfil additional functions, on a case by case basis).
At the same time the user, who will have to pay for any given service in some way or another, will expect to receive that same service everywhere with an acceptable standard of quality, especially in unfamiliar or emergency situations. That will be the mandatory basis for a large scale implementation.
It is also clear that each Traffic Control Centre will choose its own most appropriate operating procedure. But it will not be able to exchange information and data with other Traffic Centres in a cost effective way if protocols and interfaces are incompatible.
Unless sufficient compatibility is assured, required equipment and infrastructure investments may remain very high, since European manufacturers would be unable to mass produce in such circumstances and would accordingly be exposed to keen competition from imports.
The users will be confronted with having to pay high fees for services of inconsistent quality or no service at all as soon as they

move from one area to another. The end result could be that funds invested by public authorities and individual companies in R&D Programmes may be wasted if only small-scale, non-harmonised operations develop without a European focus.
The answer is clearly the standardisation of the critical physical and operational interfaces. On the contrary, up to now, only objectives like "harmonised functional interfaces" or ' interoperability" (without further specification) have been used. It is now time to act to achieve the objective of interoperability of systems and functions at pan-European level.
The European standardisation organisation, through the ad-hoc Technical Committee, CEN TC 278, has already a programme for creating standards capable to harmonise the most relevant aspects of ATT.
But CEN can only standardise what the relevant actors want to be standardised. On this point the industry position is somewhat contradictory. On one side everybody is asking for quick action on the part of CEN. On the other side most actors have deeply entrenched attitudes and are inflexible when it comes to consideration of ideas that deviate from their own system. The result is either stalemate or delay.
To express it in a different way: apparently, instead of concentrating efforts in developing a potentially large business, in which everybody could have his own market share, too many people are trying to demonstrate that their system or concept is the "best" *one.* The European standardisation process is therefore confronted with increasing difficulties. However this is a field in which the market cannot be expected to make its choices before standardisation acknowledges them since there are two risks:

- either no pan-European market will develop.
- or the most urgent users.' needs will be partially satisfied by products built according to American (or Japanese) standards which do not necessarily fit European needs.

One indication about the second possibility being the more probable one is the current attempt to bring all current European standardisation efforts under the IS0 umbrella (with an American self-appointed Secretariat). This is equivalent to postponing European harmonisation for many year and coming to a de-facto standardisation dictated by the economically strongest area.
This is partly due to the fact that development has been up-to-now mostly technology-led rather than customer-led (and customer in this context means both those who will be responsible for using ATT to solve the mobility problem and those who will benefit from a more "sustainable mobility").
The "usual" scenario might repeat itself:

- Europeans innovate
- North Americans implement
- the Pacific rim countries take the market.

ATT implementation requires that the telecom operators, who are an essential component of many "architectures", look at it as a potentially large business capable of generating higher volumes of traffic through their existing or future networks. While they actively participated in the R&D phase, many of them need still to be convinced that ATT will develop outside'"niche" markets and therefore justifies large investments.

In view of the lack of clear institutional arrangements and of harmonisation it is difficult to blame them. The history of the free market has always shown the "private" sector to be capable of responding to market opportunities provided these opportunities are not blocked by the "public" sector.

A third obstacle is caused by the fact that ATT is sometimes seen as and end in itself and not as a potent tool (but a tool only) to solve a current problem. There is sometimes a tendency to look for always better systems or for the final "integrated" system that will solve, at once, all the problems. This "integrated" system will come in due time and R & D shall accordingly never stop. One has only to look at the analogy with the cellular phone. In the meantime let us use what is available or will be available in a reasonable span of time, to solve to-days problems. Priorities might be different, at local, regional, national, international level. ATT is fortunately a flexible tool, provided it is not made totally inflexible by some "parochial" choices. In fact, being just a tool, it can be used either to facilitate a pan-European sustainable mobility or to create new barriers.

The solution of these problems cannot clearly be expected from the European research community even if its contribution could be determinant in finding ways to apply ATT to some fields up to now almost neglected like road maintenance, interconnection between different transport modes, optimisation of overall mobility.

It cannot be expected from the EC Commission alone, even if it will be able to promote it and has identified the problems since the end of DRIVE.

It cannot come from a single industry sector, taking the burden to initiate it and then involve the other sectors. That was already attempted in Japan, where more than 500,000 autonomous car navigation systems (in practice: electronic map displays) have been sold, even if nobody knows how many of them are actually used. This did not result in implementation of ATT, in the sense we defined above. On the contrary, the process had to be started again.

Some specific applications can be mandated by national or local authorities to solve specific problems. But the costs of exploiting the full benefits of ATT on a purely national or local basis are so high that it will be almost impossible to get beyond those specific applications on a time scale compatible with maintaining the European ATT industry in a competitive position.

The problems listed above are apparent also in other areas.
In Japan R&D programs have up to now mostly been technology-led. This, and the competition between the different Authorities which have sponsored these programs, has apparently delayed a mass implementation of their results. However this situation might quickly change.

In contrast, the US launched their IVHS Programme taking all implementation aspects into account from the very beginning. In addition

the IVHS Programme in managed and funded by the Federal Highway Administration so it can be expected to be mainly user-led.
Of course FHWA also is having its share of problems in dealing with States and local authorities. However, early acknowledgement of the problems usually leads to quicker solutions.

3. ERTICO ROLE AND STRATEGY.

Identification of the problems mentioned above led, in late 1991, the European Community to promote the foundation of ERTICO (European Road Transport Telematics Implementation Co-ordination Organisation) which currently has 27 Members from industry, infrastructure service providers and operators, public authorities, users, public transport, in addition to the EC Commission and the ECMT (European Conference of Ministers of Transport).
The main objective of ERTICO is to encourage, promote, and assist with the co-ordination of ATT implementation in European transport infrastructures, assuring a smooth (and quick) transition from pre-competitive R&D to market driven investments.
ERTICO is therefore the natural outcome of the European R&D actions on ATT and was created at the critical moment when the results from these actions gave the indication that ATT, if properly implemented, can and will be an extremely powerful tool to achieve sustainable mobility throughout Europe.

Of course each ERTICO member has his own detailed strategy to achieve his own objectives. But these objectives are not necessarily mutually incompatible, at least as far ATT implementation is concerned.
The first action by ERTICO was to establish a Working Group between its members (code name BACKUP) to create a common understanding and a common approach to problem solving. Now, after 16 months of operation of ERTICO, it is apparent that there is, between the ERTICO Members, an ever increasing awareness about the problems that have to solved by common action.
Even competitive actors acknowledge that you first have to cook a large cake (pan-European implementation) before cutting a sizeable slice out of it.
Home-made biscuits might be excellent but it is difficult to live on them unless your are the French Queen Marie Antoinette. Even she did not live very long on biscuits.
Also the choice of priorities has to be made according to strategic criteria. Ten years ago priority one was safety. Later dynamic route guidance become more fashionable. Today, apparently, the first large scale application of ATT might come through ADS. An attempt to identify the real priorities for ATT implementation is being therefore carried out by another ERTICO Working Group, code named STRASS.

At least it is more and more acknowledged that successful implementation of ATT needs the solution of many "detail" problems which normally are overlooked during the R&D phase (a common location referencing system, a common way to exchange information between all the relevant actors, the establishment of clear institutional arrangements, etc.). This solution could be easier for relatively simple systems and "architectures" making use of what is already avail-

able in the different countries but capable to perform the most important functions of ATT with an acceptable cost/benefit ratio and pan-European application. Future, more integrated and technologically advanced systems can then be built on them or added to them, provided a sound "open" operational basis is established.
These problems have been, and are being dealt with by specific ERTICO Task Forces (AUDIT on ADS, LOCAT on geographic location, TRADIT on traffic data dictionary, TANIT on normalised interfaces) whose purpose is to identify them and then promote their solution by the relevant actors. It is in fact a clear ERTICO policy not to duplicate any effort which could be performed by others.
In this respect the participation of ERTICO to the "DRIVE II" Programme, through the CORD Project, is of utmost importance since these problems can become apparent even during the current small scale field trials and can be solved by co-ordination of the existing Pilot Projects in addition to setting common rules for the evaluation of their results. For instance, the results from TRADIT led to the establishment of a specific DATEX Task Force within the Community Programme
In addition a common Working Group has been set up together with ECMT in order to clarify the many institutional, legal and contractual differences that might slow down ATT implementation in Europe, so that timely action could be taken.

Technology development is important, but even more important is the demonstration of the advantages resulting from the application of that technology to those who have not directly participated in its development. This cannot be achieved through small-scale field trials. ATT implementation still needs a demonstration of its benefits on a scale large enough to convince everybody. At that point finance, public or private,. will no more be a problem. In this respect, the extension of the EC Commission role beyond that of supporting pre-competitive R & D and establishing common transport policies, might be very important without breaking the "subsidiarity principle". It is difficult to see a single national government taking alone the burden to demonstrate that a pan-European approach to ATT implementation is what we need to facilitate the achievement of sustainable mobility.
Here again, through the CORD Project, ERTICO is establishing some "User Fora" to support co-ordination, especially at the public authority level, and to disseminate the results of the R&D projects.

A pan-European approach to ATT implementation requires early harmonisation of the different systems available or about to be available. This harmonisation has first to be carried out at the European level not because of any "Fortress Europe" syndrome but simply because this is the quickest way to achieve the objective. Global standardisation will come later and will pose no insurmountable problems starting from "open" systems.
Besides having an observer status in CEN TC 278, ERTICO has taken up in the CORD Project the role of managing the so-called Topic Groups and a range of Task Forces. They are in fact the main actors in extracting from the R&D projects the information necessary for timely and efficient European standardisation.

Standardisation and harmonisation are not theoretical issues. Therefore ERTICO has launched two parallel projects:

- the first one (DEFI) is currently examining the feasibility of connecting the ATT systems which will be already in place after the end of "DRIVE II" and the many connected national programmes to practically test their interoperability and to establish some large scale trans-European demonstration projects, involving both inter-urban and urban environments.
- the second one (TELTEN), which just started with a grant from the EC Commission, is intended to propose a telematic traffic management architecture for the trans-European Road Network which should be in operation by the year 2002. With reference to the time scale involved, TELTEN has a "practical" implementation approach, making use of what is already available or could become available in the near future.

Of course the two projects are in some way interconnected, since DEFI could be the test ground for TELTEN.

These are the main points on which ERTICO, through its Members, is active.

A lot has,to be done. But we are trying hard.

911676

Some Structural Aspects on the "Info-mobility Related Projects in Japan

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ABSTRACT

In order to successfully launch the info-mobility or IVHS/RTI systems in the society, many advanced technologies could be properly utilized with necessary R&D and related activities. The realizations of the info-mobility related systems also require relatively long time range from concept and R&D stages to final realization of the systems. How to efficiently coordinate these different stages ranging many years could be one of the important and difficult problems we face today to successfully launch the systems in the society. This paper describes the following items with some examples of the past and presently on-going info-mobility related projects in Japan, i.e., roles of public organizations, phases of activities, cooperations between public and private sectors, etc.

TOTAL NUMBER OF THE AUTOMOBLIES in use in Japan has reached to a level of 58 million units in 1990, meaning that one of two people owns an automobile in the total population of 120 million. Whereas the road infrastructures satisfying the automobile traffic are not well established compared with the US and Europe. The expressway extension per 1000 vehicles accounts for ca. one fifth and one third of those in the US and Germany, respectively, i.e., high density traffic with extended expressways of 5200km. As for normal road, the situations are similar to those of expressways. Narrow and small flat area of Japan makes also difficult to construct the road network.

Under these circumstances, National Police Agency and Ministry of Construction have been making their respective investments for the constructions of traffic control system and road traffic information providing-device continuously rather from early days. Presently, the traffic control systems are already introduced in 74 cities across the nation.

As for the domestic market of automobiles, the auto manufacturers have been placed under severe competitive conditions in terms of launching new models especially equipped with new features favorable for consumers. In these regards, the intensive uses of micro-electronics and communication technology are strongly acknowledged as the market trend compared with those of the US and Europe, enabling the launch of automobile navigation system.

Beside these typical Japanese backgrounds above, those problems, such as increasing traffic accidents, growing number of elderly people, global environmental problems, etc., have come out. In order to meet the existing and newly coming out problems Japan faces today, extensive use of information technology, moreover the integration of automobile and road functions, i.e., the realization of the info-

* Numbers in parentheses designate references at end of paper.

mobility [1]* have been under intensive discussions with cooperations between public and private sectors on the various on-going related projects. The auto and electronics manufacturers have much interest in the constructions of the infrastructures in this field, seeking out new auto functions as the routine practice among competitive market.

The realizations of the info-mobility related systems also require relatively long time range from concept and R&D stages to final realization of the systems. How to efficiently coordinate these different stages ranging many years could be one of the important and difficult problems we face today to successfully launch the systems in the society.

The purpose of this paper is to provide basic information for planning the info-moblility related projects [2][3] and also for mutual understandings on the international cooperations in these fields. This paper describes the following items with some examples of the past and presently on-going projects in Japan: roles of public organizations, phases of activities, cooperations between public and private sectors, etc.

ROLES OF PUBLIC ORGANIZATIONS

The public organizations are classified mainly into two areas, i.e., national and local governments, etc. Major activities in this info-mobility field, especially discussions on their feasible future course, have been mainly done by some of ministries and agencies in the national government described below. However, some of the local governments and public coorperations, which have been affected by the recent development of the information society, are gradually acknowledging the importance of utilizing the information technology to solve the serious traffic problems they have today.

NATIONAL GOVERNMNET - Five ministries and agencies described below are involved in the info-mobility activities basically based on the respective roles restrictly specified by the law and the policy-making and promotion of the related activities are being done rather independently. Generally speaking, the public function to investigate and examine the road transportation from the views of integrated transportation system is not well established in Japan mainly due to the short history of automobiles after getting the predominant roles in the road transportation. Beside, the discussions on the info-mobility activities have just begun including those on how to tackle these problems. Therefore, more time will be needed to define the respective roles of governmental ministries and agencies and necessary ooop-rations among them. Presently, the activities of each ministries and agencies in this area are limited to respective roles conventionally acknowledged or the area which can be treated within each bodies. These situations above mean that the info-mobility activities in Japan are characterized as an experimentally trial-and-error stage before they are finally approved as the social system or social infrastructures.

(1) National Police Agency - The task of the police is basically to secure the safety of citizens. After the automobile appeared as the transportation means, the role of road traffic management have been performed broadly by the police emphasizing previously on the preventions of traffic accidents and now rather on good traffic flows. Advanced Mobile Traffic Information & Communication Systems (AMTICS) [4], now being extensively experimented under the leadership of National Police Agency (NPA), can be characterlized as a possible future type of traffic control system.

(2) Ministry of Construction - Ministry of Construction (MOC), another major actor in the public sector in this field, has been involved in the efficient and proper constructions, maintenances and uses of national road networks as the basis for the citizens' life and economic activities. However, it is being become difficult to construct new highways in Japan, especially in the large city areas, due to increasing price of land. The efficient utilization of present road networks and the related infrastructures is getting importance. That means MOC thinks it is a right time to examine the highway system considering the development of recent vehicles with advanced functions, i.e., the intelligent highway systems corresponding to the intelligent automobiles. Road and Automobile Communication System (RACS) [5] and the Next Generation Road Traffic System, under the leadership of MOC, are examples of these concepts.

(3) Ministry of International Trade and Industry - Ministry of International Trade and Industry (MITI) is responsible for any products produced by auto-related industries to meet the public welfare at the various stages of production, distribution, consumption, etc. in terms of safety, efficiency, etc. From these points of views, they are active for the R&D of advanced technologies, putting themselves in the position paying attention on what functions and features the automobiles should have as a social system. The development of Comprehensive Automobile Traffic Control System (CACS) [3] and presently on-going Super Smart Vehicle System (SSVS) project were initiated under these backgrounds. Note that MITI's activities sre limited to the basic R&D and promotions of the technologies and that they have no function to build the related infrastructures.

(4) Ministry of Post & Telecommunication - Ministry of Post & Telecommunication (MPT) has been involved in the postal service and general communication areas including telephone, etc. Recently, they began to be involved in the automoible information and communication system, relatively expanding their influences in terms of the assignment of radio waves.

(5) Ministry of Transportation - Ministry of Transportation (MOT) puts themselves to control-private and public transportaion activities in the areas of land, sea and air, corresponding to the public convenience and benefit. In the road transportation, they are responsible mainly for the vehicle homologation., As for the info-mobility area---their main concerns are the safety of vehicle and its social efficiency as a public transport system. The investigation of Advanced Safety Vehicle (ASV) system, recently launched by MOT, is an example of their activities to define the future safetv standard in Janan.

(6) Other related agencies - The activities on the traffic safetv of land. sea and air transportations, both-on national and local levels, are managed by the Traffic Safety Policy Office of the Management and Coordinations Agency. They are responsible for the total coordination on the respective tasks done by their related national organizations and for the promotions of traffic safety drive across the nation.

LOCAL GOVERNMENTS - Local governments are trying to solve local traffic problems themselves depending on the conditions of each area. The constructions and maintenance of traffic control systems are strongly infuluenced by the policies of governmental ministries and agencies in Tokyo, despite that such activities are basically local ones. Beside these activities, some of the local governments are rather active to promote economic activities of respective areas and to provide traffic and sightseeing information. The parking guidance information should be especially mentioned. The project on Automobiles' Roadside-transceiver Infrastructure for Extensive Services (ARIES) initiated by the Association of Electronic Techhology for Automobile Traffic and Driving (JSK) was also performed aiming at the promotion of local area activities in this field.

PHASES OF ACTIVITIES

Various info-mobility projects were and now are being performed in Japan. These activities are classified four phases, i.e., probing, system experiment, pre-introduction/testing and practical operation phases. Some of the projects started with multiple objectives described here, depending on the roles of the operation body involved.

(1) PROBING PHASE - The probing phase corresponds to those to find out new ideas or to test ideas conceived on the desk and their feasibility on a small scale or in the laboratory. Most of the researches at universities and governmental research institutes fall into this category. The preliminary studies on the SSVS and the Next-Generation Highway Traffic System, respectively being done at JSK and The Highway Industry Development Organization (HIDO), are also classified into the phase described here.

The objective of the preliminary study on the SSVS is to define the final goal of automobile transport system fully utilizing advanced information-processing, communication and control technologies, etc. and to propose the R&D projects in order to realize the system, based on the discussions how the automobile should be in the future of 20-30 years from now. Whereas those of the Next-Generation Highway Traffic System is to investigate broadly the future functions of the road networks, based on the policy how the functions of road networks should be implemented under the advancing information society. Both projects also aim at the incubations of new experiments and research projects in these areas.

The Personal Vehicle System (PVS) project [3] is now being performed at the Mechanical Social Systems Foundation (MSSF) under MIT1 aiming at the development of autonomus vehicles. The purpose of this project is to clarify the limit or capability of the autonomus vehicles with existing technologies and to bridge the gap between present and future R&D in this field.

(2) SYSTEM EXPERIMENT PHASE - The purpose of the system experiment phase is to implement the system under the real urban traffic environment and to find out not only the technical problems but also the institutional ones. Through these processes what kind of the problems will appear toward their realization are clarified. Typical examples in this area are the CACS project in which the system experiment on the dynamic route guidance were performed during 6 years from 1973 to 1979 using ca. 1330 vehicles with ca. 100 minicomputers on the road networks in the area of 30 km2 in south-west part of Tokyo. Although the project was partly characterized as the probing ` the main emphasis was to get comprehensive practical knowledges when the system was installed and operated in the real traffic condition. The fact that these projects were done in Japan where good road environments were not available over 10 years ago compared with the US and Europe is worth to mention.

(3) PRE-INTRODUCTION/TESTING PHASE - The pre-introduction/testing phase corresponds to the social consensus-formation stage in which the understandings and cooperations from the society and related sectors are expected to be obtained regarding possible benefits and effects of the system in the realization of the system concerned and the use of high technologies.

Although the RACS project contains the system experiment phase in terms of examining the applicability of communication technology by the beacons under real urban traffic environment, the RACS and AMTICS projects belong to this phase, especially considering that both projects are utilizing the products which are already or will be marketed soon like navigation systems.

The ARIES project, which was done by JSK with subsidy from MSSF during 1987-1988, is also characterized as this phase. The ARIES showed some feasibilities to bulid and operate the information and communication infrastructures between vehicle and road by private and local government funds in the area with many sightseeing sites. The combination of CATV business and information service with the use of vehicle/road communication system was the main feature of the system which was designed to be operated by the people of related tourism industries including hotels, restaurants, gasoline-stations, delivery service business, etc., with subsidy from local governmental bodies. Unfortunately the ARIES project can not enter into the practical operational phase yet.

(4) PRACTICAL OPERATIONAL PHASE - The projects described so far are not characterized as practical operational phase. However, RACS and AMTICS projects, increasing their cooperations -between them as the Vehicle Information and Communication System (VICS) project, are going into this phase. In the near future the governmental activities regarding the info-mobility infrastructure are expected to start as the practical operational phase, triggerd by the VICS project.

COOPERATIONS BETWEEN PUBLIC AND PRIVATE SECTORS

The activities described earlier are all performed by the cooperations between public and private sectors. The activities are classified into four types, i.e., activities fully funded by the government, voluntary activities for the governmental guideline, joint research and preliminary policy-making activities through semi-governmental bodies. It should be mentioned that a lot of small-scaled non-profit organizations, existing from way back, have been playing implicitly substantial roles for the development of public and private coorperations in this field.

(1) ACTIVITIES FULLY FUNDED BY THE GOVERNMENT - The activity of this type is carried out basically fully at the government expense. The actors involved are governmental research institutes, private companies, etc. The CACS project were carried out by the MITI's large-scaled R&D programs with the budget of ca. 7.3

billion JPY during 6 years.

These methods are applied to the long terms and high-risky future-oriented R&D programs. The results obtained through the program, including related patents, know-how, etc., basically belong to the government. However the part of the report can be often made public through the presentations regarding technical contents of the program at academic societies by the researchers and engineers involved in the program. These publications are, of course, performed under the permission of the government.

(2) VOLUNTARY ACTIVITIES FOR THE GOVERNMENTAL GUIDELINE - The activity of this type is rather common in Japan. The private sectors participate voluntarily in the activities at the existing or newly established non-profit organizations under the control of the governmental body concerned. This means that they cooperate with the government in line with their guideline concerned, supplying their money and manpowers. Note that the activities of the non-profit organizations are carried out after the government decided to begin small-scale related investigation budgeted. Basically these cooperations are valid when the private sectors find their business chance in the field concerned or respect the R&D guideline proposed by the government. However, private sectors are apt to follow the government for the most part. The reasons seem to come from their historical experiences that the active obedience of the private sectors to the government had helped the the government consequently in terms of the rather quick modernization of Japan. The AMTICS project of NPA and the ASV system of MOT fall into this cateway. The treatments regarding patents, know-how, etc. are defined by the non-profit organization and basically shared among the participants.

(3) JOINT RESEARCH ACTIVITIES - The activity of this type is carried out based on a certain agreement made between the government and private sectors on the specified field corresponding to the governmental administrative or R&D policies. On the government side, the related governmental research institutes are responsible for the respective roles. The RACS project falls into this category in which the Public Works Res. Institute has performed the related R&D activities.

(4) PRELIMINARY POLICY-MAKING ACTIVITIES THROUGH SEMI-GOVERNMENTAL BODIES - The various studies and investigations to define basic concept and obtain the data for the policy-making in the related fields, i.e., pre-policy stage activities, are done at the non-profit organizations under the control of respective ministries and agencies. In these cases, the funds from private voluntary actions and the Machine Industry Promotion Funds are used. The typical examples are the PVS and SSVS of MIT1 and the Next Generation Road Traffic System of MOC.

CONCLUDING REMARKS

The area of the info-mobility involves not only technological factors but also social ones. The strong implications with public sectors should be especially mentioned. The close and appropriate cooperations and collaborations among government, industires, academic fields, etc. are another indispensalbe factors.

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The opinions and ideas expressed in this paper are exclusively those of the authors, not of their affiliations.

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CURRENT STATUS OF THE IVHS/RTI PROGRAMS IN JAPAN

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INTRODUCTION

During the rapid economical growth in 1960s and in 1970s, the explosive increase of automobiles drastically changed land transportation in Japan. Shortage of roads, increase of traffic jam and accident and environmental deterioration necessitated continuous countermeasures on traffic management and operation from 1970s.[1, 2]

The dream for IVHS was born in the same ages. Starting from the CACS project (1973-79) and its follow-up in the early 1980s launched the RACS and the AMTICS projects requesting the rapid application of traffic information offering systems. At the same time, stimulated by the international activities in the area, various new projects were recently launched.[1]

The VICS project, which started by focusing the early implementation of the fruit already obtained, now confronts difficulty in realizing its operation body. The rapidly advancing circumstances give ambiguity to its goal.

PROJECTS/PROGRAMS IN JAPAN IN 1990s

The most prominent feature of the activities of IVHS area in Japan now is the concurrent runs of the projects supported by the different governmental agencies. It was reported at the 1992 Annual Meeting of IVHS AMERICA last year in the International Session on Japan[3, 4, 5] and by Mr. Randy Doi as IVHS AMERICA: Japan Trip Report.[6]

As shown in Fig. 1, there exist four projects:

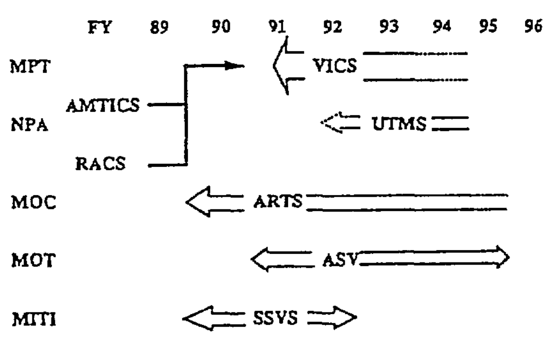

Fig. 1 PROJECTS/PROGRAMS OF JAPAN IN 1990'S

- VICS: Vehicle Information and Communication System
- ARTS: Advanced Road Transportation System
- ASV: Advanced Safety Vehicle
- SSVS: Super Smart Vehicle System

supported by the five governmental agencies:

- the MPT: the Ministry of Post and Telecommunications
- the NPA: the National Police Agency
- the MOC: the Ministry of Construction
- the MOT: the Ministry of Transportation
- the MITI: the Ministry of International Trade and Industries

and the new project, UTMS : Universal Traffic Management System, is recently proposed by the NPA.

Among them, the VICS project, which is supported jointly by the three agencies: MPT, NPA and MOC; is the inheritance of the two projects RACS and AMTICS, and it aims at the early implementation of the systems already developed in the late 1980s. VICS belongs basically in the area of ATIS. On the contrary, the other projects: ARTS, ASV and SSVS aim at R & D for the future realization from 2000s to 2010s. They cover the area including AVCS. The new project, UTMS, aims at the early implementation of the system belonging to ATMS and, at the same time, R & D in the vast area.

VICS-THE PROJECT FOR EARLY REALIZATION[3]

Purposes and Features of VICS

Through the experience of conducting projects RACS and AMTICS in the late 1980s in Japan, the necessity of the early realization of the information offering systems using radio communication was recognized by those who promoted RACS and AMTICS. The purposes and objectives of the new system VICS were set as:

- Contribution to the progress in safety and smoothness of road traffic as well as environmental protection with offering road traffic information to vehicles.
- Effective use of the radio wave resources with integrated and harmonized development of the road traffic information system for vehicles.

Based on the wide use of in-vehicle navigation systems in Japan, VICS attempts the realization of social benefit through pursuing personal benefit. That is, through giving dynamic traffic information to the equipped drivers who utilize it for their route selection, it gives not only time saving and economic benefit to those drivers, but also propagates it to all transportation relatives by effective use of road network. Features of VICS is that of the comprehensive ATIS, but it does not cover the whole area of IVHS.

Organization and Activities of VICS Promotion Council

At the end of the AMTICS and the RACS projects, their relatives sought the way for early realization of the systems. In March 1990, three governmental agencies, the National Police Agency (NPA) which supported AMTICS, the Ministry of Construction (MOC) which supported RACS, and the Ministry of Post and Telecommunication (MPT) which was responsible for radio wave management started institutional negotiation for developing the new system at the VICS contact office.

After one year and a half, in October 1991, the VICS Promotion Council was established with about two hundred supporting organizations. As shown in Fig. 2, the council is organized with three committees and seven subcommittees managed by the headquarters and the board of directors. Both the Commerce Committee and the Research Committee were

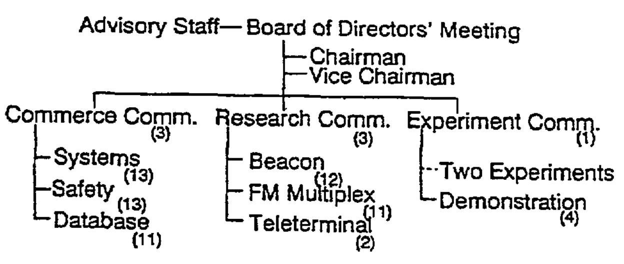

Fig. 2 ORGANIZATION OF VICS PROMOTION COUNCIL

established in December, 1991. The former studies keys for realization of VICS and investigates various issues necessary for its practical use, and the latter investigates application of various media for use in VICS.

Analysis of social benefit of the system and planning for installation of VICS operation body are investigated by the System Subcommittee. Safety in driving with use of the in-vehicle unit is handled by the Safety Subcommittee. Construction of database for easy handling of traffic data and their integration is covered by the Database Subcommittee.

The original plan of VICS realization was to establish VICS operation body in March 1993 through investigations by these committees and through two experiments both in Tokyo and in Osaka areas. The plan was amended in September 1992 to a more steady realization and a demonstration experiment was newly planned. The Experiment Committee as well as the Demonstration Subcommittee which promotes the demonstration experiment was established in October 1992. Recently, in April 1993 the plan for the demonstration experiment was fixed.

Another new movement in January 1993 is the establishment of the Optical Beacon Special Subcommittee which investigates the feasibility of optical beacon system proposed by the NPA.

System Configuration of VICS

As already reported, the system configuration of VICS is assumed as in Fig. 3. The key of the system is the two items shown below:

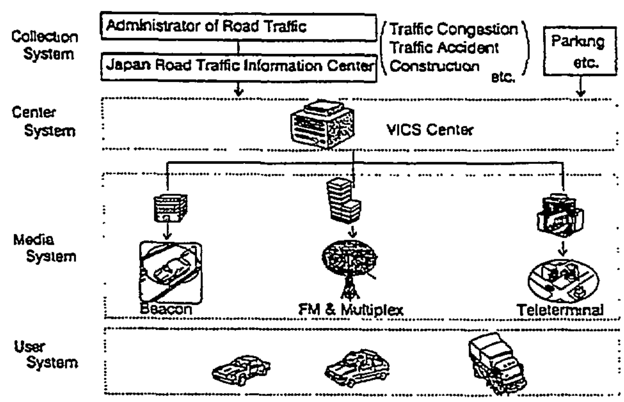

Fig. 3 SYSTEM CONFIGURATION OF VICS

- Integration of information from the different sources
- Integrated use of communication media supported by the different bodies.

Though the system configuration covers data collection systems supported by road traffic administrators and application systems for a variety ofusers, VICS operation will be rather restricted to a center system with/without media systems.

Keys for VICS Realization

Keys for VICS realization discussed by the Commerce Committee are as follows. As the basic constituent for realization, construction of the cost basedsystem with beneficiary paying should be considered where not only the personal benefit of the drivers of equipped vehicles but also the benefit which the society receives must be estimated. And the rule of impartial paying both public and private should be established. Introduction of the inexpensive operation body is also desired.

The point of realization will be user oriented services which are balanced with the administrative measures and fit with the purposes of the administrations. On making a plan with these features, the union of public, academic and private sector's will and wisdom is essential.

Demonstration Experiment

For achieving the objectives of VICS, conditions of VICS demonstration experiment were featured as:

- Integration and fusion of the information from two or more sources
- Arbitrary selection of two or more media by the users
- Real-time information accessing from the users

Purpose of the experiment is to increase understanding and enlightening of VICS.

Outlined Plan of the experiment is as the following:

- The experiment is scheduled to start in June 1993 and to end in November of the year.
- The experiment with public is also scheduled in early November 1993.
- The area for the experiment is set in the center of the Tokyo district.
- For the expense of the experiment, the fund of three hundred million Japanese yen was gathered from corporate members of VICS. It is mainly used for construction of a modeled center system, and a media system is expected to be installed and offered by public sectors.

The more detail on the experiment will be introduced at the different session in the meeting

PROJECTS/PROGRAMS AIMING AT FUTURE DEVELOPMENT

Following the RACS and AMTICS projects which intended early realization of ATIS in the late 1980s, new projects were launched in early 1990s for the future development of advanced, integrated systems for roads and vehicles, which covers technologies not only for ATIS but also for ATMS and for AVCS.

Advanced Road Transportation System (ARTS) Project

The ARTS project aims at the intelligent coordination between vehicles and road infrastracture in the future road traffic But the emphasis is given to the development of intelligent road facilities due to the responsibility of the Ministry of Construction (MOC) which supports the project. Expected time of realization will be in the first decade of 21st century.

The way of promoting ARTS is almost the similar to that of RACS By the support of the MOC, the study group for ARTS was established in 1989, at the Highway Industry Development Organization (HIDO) which promoted RACS. After two years of preliminary study, joint research work was established between the Public Work Research Institute (PWRI) of the MOC and private companies. Outline of the R & D and future study plan of ARTS was introduced at the last year's meeting.")

One recent activity in ARTS is making the concept for long term plan of the project. In ARTS, the following two subsystems were organized. The one is the Advanced Highway Safety System (AHS S), in which the key technologies are road monitoring and collision warning. The another is the Advanced Transportation Efficiency System (ATES). in which advanced freight operation and automated toll collection were picked up as the important applications. In the name of the project, a word "traffic" was recently alternated by the one "transportation" due to the widening of the concept of ARTS. In the ARTS project, the optimum route guidance system and the high value-added information system are also aimed as the future extension of VICS.

In FY 1991, in the first yeart of joint research project, the concept of ARTS was broadly discussed and six candidate systems were picked for the conceptual design. Also the common/key technologies to realize those systems were selected. In FY 1992, the following three investigations were done as they were planned:

Data Transmission Experiment through LCX

Apart from the technology for data transmission with microzone in RACS, the research is focused on the technology for data transmission with continuous zone, as it would be essential in the future applications for ATMS or AVCS. The target of the research is to realize high-speed, real-time communication between road and vehicle with its location information. The experiment is still in the fundamental stage, and the basic data transmission characteristics with leakage coaxial cable (LCX) for 1 05GHz and 2.6 GHz in the operating circumstances such as the height of cables and the speed of vehicles were investigated.

Guide Lighting System

The system shows the enhanced indication of obstacles to the drivers by variable lighting on the road. A system for indication of road alignment and passing vehicles, and a system with message board for warning at an intersection are implemented and examined.

Vehicle Headway/Margin Control System

The system aims to control the headway between vehicles and the margin between vehicles and road facilities. The concept of the system and the strategies for realizing its basic functions were discussed. Elemental technologies were investigated and a specification of the system is discussed. In the coming two years, an experimental system will be planned designed and examined.

Advanced Safety Vehicle (ASV) Project

Objective of the ASV project is to develop highly intelligent, safe vehicles for realization in the beginning of the 2 1 st century. It is promoted by the Ministry of Transportation (MOT) as the five-year project form FY 199 1 to FY 1995. In the first year, basic specifications of ASV were discussed. From the second year to the fifth year, production of the prototype ASV's and testing and evaluation of them are done, through which the guiding principle for ASV will be established.

In ASV, the technologies for vehicle's safety are classified into four categories: preventive safety through reduction of driver's load in the normal situations; avoidance of accident through warning and automated operations; reduction of damage at collision with measures in vehicle's structure; and prevention of enlargement of disasters through reporting. Key technologies for them will be vision-enhancement, in-vehicle monitoring and radio communication.

In the project, development of ASV and operation of their experiment are expected to be done by car manufacturers. Meanwhile, planning and evaluation will be done by the MOT with assistance of academic people. Improvement of the already developed autonomous systems are approached at first. A dose warning system, an obstacle detecting system and a headway keeping system are the examples. The innovative technologies for autonomous systems will be challenged next. Systems with new infrastructure and those which relate to legal issues will be left as the future tasks.

Super Smart Vehicle System (SSVS) Project

SSVS was promoted by the Ministry of International Trade and Industries (MITI) as a three-year project from FY 1990 to FY 1992. It aims at to make a R & D plan for development of intelligent road/vehicle system which will be realized in the 2010S. The investigation was done by a study committee at JSK Foundation organized by members from universities , governmental institutes, non-profit organizations and auto/electronic industries.

In the first year, FY 1990, the concept and elemental technologies of the system were discussed. In the second year. FY 199 1 a scenario for future development as well as the role sharing of organizations in it was discussed. Six systems were selected as the typical examples and they were investigated in the more detail."

In FY 1992, further investigations were done by seven working group. Among their activities, R&D planning for the system for intelligent driving in streets, the one for the system automated driving in freeways, a detailed case studies on vehicle to vehicle communication and also a discussion on the technologies for experiment and evaluation can be paid attention. The detail of the project will be reported by Dr. Tsugawa in the another session of the meeting.

RECENT ACTIVITIES IN THE PROGRAMS/ PROJECTS

Administrative Issues

In the recent activities in the programs/projects in Japan, it is seen that the following administrative issues give influence on them:

The 5th Five-year Plan for Traffic Safety Facilities

The administration on traffic safety in Japan has been conducted with the implementation based on the laws of the five-year plans for traffic safety facilities from 197 1. Presently the 5th five-year plan from FY 1991 to FY 1995 is active(2) The NPA and the MOC are mainly responsible for executingtheplan. Fromthepreviousplan startedin 1986,the concern of the NPA spread to keep the smoothness of traffic as a basis for traffic safety. Traffic information offering to the drivers as well as parking management was enhanced and strongly promoted in the existing five-year plan. The coming years will be to obtain the results and to evaluate them for the future plan.

The 11th Five-year Plan for Road Consolidation

Construction of the road network in Japan has been consequently promoted with the five-year plans for road consolidation. The 1lth five-year plan from FY 1993 to FY 1997 will start in this April under the responsibility of the MOC with the total proposed budget of 76,000 Billion Japanese yen. The plan is based on "the long-term plan for road consolidation" which includes a plan to realize 14,000 km of high grade trunk road in 2010 - 2015 In the llthfive-year plan, it shall be increased from 5,900 km to 7,800 km with a budget of 15,300 Billion Japanese yen. The main concern of the road administrator in Japan is to realize a road network not inferior to the other advanced countries. Increase of the road traffic information systems is also considered. With the budget of 380 Billion Japanese yen, the road information offering equipments shall be increased form the existing 4,400 to 9,600 during the five years. Meanwhile 12,000 beacons shall be newly installed for implementation of the road/ automobile communication system (RACS). The planning and financing for the ARTS project will be done based on the five-year plan.

The Recommendation for Future Transportation Technologies

In March 1992, the Council for Transportation Technology submitted "the recommendation for future transportation technologies" to the Minister of Transportation. ln the recommendation,thetechnologicaldevelopmentwhichshould be aimed at in each area of transportation was extensively discussed, and the guide line for the policy of the MOT was shown. In the area of safety in automobile traffic, the MOT will execute the policy for regulation and recommendation in the near future, and that fo rR&D such as the ASV project with this guide line.

Recent Activities in the NPA

The new policies which the NPA disclosed recently gave strong surprise to those in the IVHS community in Japan. The first one is to commence anew traffic information service named ATISS in Tokyo Metropolitan area. In this service, real-time traffic information is provided from the traffic control center of the Tokyo Metropolitan Police Department to the terminals at home or in offices through telephone line. Drivers can receive the same information through mobile telephone. An operation body is to be established in this June **with the** support of Tokyo Metropolitan Government. The motivation of this is to enhance the providing of traffic information from the new traffic control center which is scheduled to open in the end of FY 1994.

The second one is the development of the new type of optical vehicle detectors and the proposal of the universal tmffic management system (UTMS).(7) The NPA executed the development and the installation of microwave vehicles detectors, which they planned to use also for location and communication beacons. The optical detectors have recently been proposed as they have advantages in cost and in freedom from use of radio wave. The NPA has the plan to install 5,000 of them every years. The UTMS is based on the concept **that** every aspects of M-IS should be supported by ATMS which is already developed in Japan. The detail of them **will be** reported in the other sessions.

Recent Situations in VICS

Demonstration Experiment Plan

As stated before, the largest activity in VICS is presently the execution of the demonstration experiment, the plan for which has just been determined. Provision of the experiment in technical, financial and legal aspects has almost well arranged. Two featured conditions of the experiment; the integration and fusion of information from various sources of the different administrative organization, and the use of various media according to the preference of users; will be successfullyexamined.

Examination of Optical Beacons

Following the proposal by the NPA, the special subcommittee was established to examine the technological as well as other aspects of optical beacons. In case the examination was cleared, they will be installed and operated at the demonstration experiment.

Participation of the MOT to MCS

The VICS Promotion Council started with the support of three Governmental Agencies, NPA, MOC and MPT. Many sources informed the author that the MOT recently proposed to join as the supporter of the Council. Considering the responsibility and the future plan which the MOT has, the proposal should be welcomed.

FUTURE SCOPES

With the exception of the CACS project held in 1970s by the MITI, any projects in Japan were supported financially more by the private sectors than the public sectors. In these situations, further advancement to realize infrastructure for IVHS is difficult and more strong participation of the public sectors is desired. Their recent attitude shows that they are activated from the approaching chance of practical use.

In the RACS and AMTICS projects in the late 1980s, and in the VICS project as the ancestor of them, the early realiition of the ATIS was aimed at with the information offering infrastructure for functional enhancement of already propagated autonomous navigators. Reflected form the trend of international activities, the importance of the other areas such as ATMS and AVCS were recognized. As the matter of fact, rearrangement and the integration of the programs such as ARTS, ASV and SSVS is probable. After the demonstration experiment is achieved in the VICS project, the new aspect would be seen for realization of the system.

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COMPARISON
OF
IVHS NAVIGATION SYSTEMS
IN
NORTH AMERICA, EUROPE, AND JAPAN

by

Edward J. Krakiwsky

Prepared Expressly for IVHS America

Under Subcontract to

Robert L. French and Associates

December 1993

1.0 INTRODUCTION

The objective of this report is to compare IVHS vehicular navigation systems in North America with those in Japan and Europe. In the comparison, several attributes are used, namely: year of entry, type of system, version, and positioning sensors used.

This report has been prepared under the direction of Edward J. Krakiwsky using the **IVHS Navigation Systems Database™** developed by the author. The information in the Database was accessed and printed using a tool called **IVHS Navigation Systems ReporterTM** which is part of the tool set for this "electronic book". A second tool is the **IVHS Navigation System Editor™** which is used to record and edit information in the Database.

The Reporter ™ uses the information about different IVHS navigation systems recorded in the DatabaseTM to prepare and print out different customized reports. The reports available from the current version 1.0 display general information about the various navigation systems developed worldwide. This information consists of the name of system, type of system, country of origin, developing company, year of market entry, and positioning technique used in each system. Later versions of the Reporter™ will deal with the map database components of each navigation system as well as the computer interface and communications technologies employed

Given in this report are two types of information: summary statistics on the types of navigation systems and positioning techniques used in different systems developed in different countries, and more detailed reports listing each individual system. Five different customized reports are available from Version 1.0 of the Reporter™ The user can choose a report sorted by one or more of the following schemes:

Name of System,
Year of Market Entry: Name of System,
Type of System: Name of System,
Type of System: Country of Origin: Name of System, and
Country of Origin: Type of System: Name of System.

The following is a more detailed description of the information given in these reports.

2.0 CUSTOMIZED REPORTS

2.1 System Name

The name given to a navigation system is either its registered name or trademark name. This name comes from the reference publications that have been included in the Database. If the name of the system is declared to be a trademark (TM) or registered(@), it is trailed by the appropriate mark. Some of the navigation systems do not have a specific marketing name. In these cases, the company name is used to denote such system.

2.2 Type

IVHS navigation systems are classified into four types: Autonomous, Fleet Management, Advisory and Inventory.

Autonomous systems are stand-alone vehicles with an on-board positioning device and a map database. No communications link is available with the outside world.

Fleet management systems, on the other hand, consist of fleets of vehicles linked to a control center via a communications link. Although positioning sensors are available onboard of vehicles, the map databases are not necessarily on board as well. The control center may be responsible for the transmission of the necessary information from the database to the vehicle on call. Generally, fleet management systems are for groups of vehicles controlled by a dispatch center such as police cars and ambulances.

An **advisory navigation system** is a blend of autonomous and fleet management architecture. It is an autonomous system in the sense that it is not controlled by a dispatch center, yet it is a part of a fleet that is being served by a traffic control center. Advisory system vehicles receive updated information regarding traffic and weather information without the control center being able to identify them. The control center, in this context, is a service center that will supply information to those vehicles with the appropriate equipment.

Finally, **an inventory system** usually includes autonomous vehicles equipped with video or digital cameras to capture time and coordinate tagged site information necessary for road inventory or any other surveillance purposes. Inventory vehicles may have a communications link with a control center.

2.3 Country

The country field refers to the name of the country of origin of the system. It is not the region of operation. For example, if a system is developed in Japan to be used purely in the United States, the country of origin will be considered to be Japan.

2.4 Version

IVHS navigation systems usually undergo several different phases of development. These phases have been classified into the following versions: Concept, Prototype, First Generation and Second Generation.

A **Concept system** is one that has been developed theoretically and has not been implemented practically , not even in a single experimental unit. A **prototype** is a system that got beyond the concept phase by being implemented in a single product in experimental mode. **First and second generation systems are** those that have been put on the market. Clearly, a second generation system is understood as being a modified version of a first generation.

The available information found in the supporting documentation of a specific IVHS navigation system is used to determine the version of this system. The documentation is cited in the reference section of the Database™.

2.5 Year

Year of market entry of a system is obtained from the publications on the given system. It is considered to be the year when the current phase of the system was first available. If it is a concept system, the year of the invention or the patent is used as the year of market entry of the system. If a prototype, the year of completion of the successful prototype version of the system is said to be the year of market entry.

Some of the IVHS navigation systems included in the Database™, however, lack the information regarding the year of market entry. Consequently, the year of publication of the earliest reference to the system is considered to be the year of introduction of the system to the market. This will be updated when further information is received.

2.6 Originator/Company

It is important for IVHS navigation systems developers to be able to get information about other companies involved in IVHS development. Therefore, this information has been briefly included in the Reporter output. This information can be found in more detail in the DatabaseTM; it includes the company's address, phone and fax numbers as well as the names of contacts within that company, and associated navigation products developed or being marketed.

2.7 Positioning Technique(s)

Positioning technologies used in IVHS navigation systems have undergone a major evolution over the past few years. Several positioning techniques are being used in IVHS navigation systems worldwide - examples of which are listed and explained below in the order of appearance on the attached reports.

2.7.1 GPS *Global Positioning System* **-** A satellite positioning system developed by the US Department of Defense. The system is available to civil users under certain accuracy and reliability constraints. In general, signals received from four satellites by the on-board receiver are enough to determine the vehicle position.

2.7.2 DR *Dead Reckoning*- This includes compass, rate gyro, odometer, and speedometer. These sensors determine the distance traveled, speed, and heading of a moving vehicle. The accuracy of such sensors is fairly high over short periods of time, but they require assistance over longer periods to avoid error accumulation

2.7.3 INS *Inertial Navigation System* - It is comprised of three accelerometers and three gyroscopes. Inertial systems are capable of data capture at very high rates with very high levels of accuracy. Nevertheless, the accuracy decreases over time so aiding sensors such as GPS are needed.

2.7.4 TRF *Terrestrial Radio Frequency* **-** Systems that use TRP technique receive radio frequency signals from a number of beacons scattered around the area of operation of the system. The intersection of the incoming signals from several TRP beacons determine the exact position of the vehicle, which can then be reported to the driver or control center via a communications link. Examples of such radio-frequency-based techniques include Omega, Loran C and Decca.

2.7.5 S P *Sign Posts* - These are infra-red microwave, RF devices mounted on the sides of the streets (often by traffic signal posts). These sign posts, or beacons, are capable of transmitting and receiving data from vehicles equipped with transceivers when they come in close proximity. Data being transmitted could be traffic information, a segment of a map database required for vehicle navigation and the coordinates for position initialization.

2.7.6 MM *Map Matching* - This is a technique used to determine the location of a vehicle on a map with respect to street names and addresses. The vehicle's trajectory is correlated with the graph of the road network, and the coordinates of identifiable features such as intersections are used to position the vehicle.

2.7.7. RDSS *Radio Detemzination Satellite Service* **-** These are non-GPS based satellite tracking systems having a symbiotic relationship between positioning and communications; the satellites are used for both positioning and communication.

3.0 SUMMARY STATISTICS

The summary statistics section of the IVHS Navigation Systems Reporter™ output is important for market analyses and studies related to the evolution and progress made in vehicle navigation regarding the diverse array of positioning techniques. The Reporter™ computes the different counts of different types of vehicle navigation systems and the count of systems using different positioning techniques in single- or multi- sensor modes. The statistics are performed for the main countries involved in vehicle navigation and these countries have been grouped into three main blocks: North America, Japan, and Europe. The user is requested to specify the time interval, in years, for which the summary statistics is required. The following is a description of a typical summary statistics output.

3.1 System Type Statistics

The four different types of vehicle navigation systems: autonomous, fleet management, advisory, and inventory are tabulated against the three major blocks: North America, Japan, and Europe. The count of each type of systems is determined in each block as well as the percentage each type contributes to within each block.

Statistics on the period 1975 to 1993 show that fleet management systems contribute the most to the number of vehicle navigation systems developed in North America and Europe at a rate of 62% of a total of 71 systems in North America and 51% of 41 systems in Europe. In North America, autonomous and inventory systems contribute equally to the total number of systems at a rate of 17%, while only three advisory systems at a rate of 4% have been developed. In Europe, autonomous and advisory systems make up for 22% and 24% of the total, while only one inventory system has been developed.

In Japan, on the other hand, autonomous systems constitute 55% of the 31 systems developed during the same period. The ratio of advisory systems is 42%. Fleet management and inventory systems make up for equal shares of 3% of the total

In summary, North America and Europe have been focusing on the development of fleet management type systems whereas Japan has developed advisory type systems the most. Only one inventory type system has been reported in each of Japan and Europe while 12 inventory systems have been developed in North America.

3.2 Positioning Technique Statistics

The seven positioning techniques mentioned above are used. Sensor integration has been one of the prime interests and concerns of system developers seeking highly accurate and reliable navigation systems. The Reporter™ therefore computes, for each of the positioning techniques, the number of single- and multi-sensor systems separately. The total number of systems in each of the three regions using each positioning technique is also computed as well as the percentage out of the total number of systems in each block, and worldwide, in which each positioning technique is being used.

Statistics show that 57% of the systems developed worldwide since 1975 to 1993 use GPS among their positioning sensors: 72% of North American systems, 48% of the Japanese systems, and 37% of the European systems. Dead reckoning techniques are prominent in Japan with a rate of 68% of the Japanese systems, whereas only 30% of the North American Systems use dead reckoning. Nevertheless, systems using dead reckoning in North America and Japan are equal in number; 21 systems. Dead reckoning systems constitute 45% of the worldwide total number of systems.

Inertial Navigation Systems are only available in North America at a rate of 3% of the total North American systems and 1% of the worldwide total. On the other hand, terrestrial radio frequency positioning has been used more extensively in North America; 15 out of 71 systems, 21%. Only one Japanese system and 8 European systems have been reported to be using this technology.

As far as sign post technology is concerned, only four out of 71,6%, North American systems employ this technology whereas 10 out of 31, 32%, Japanese systems and eight out of 41,20%, European systems use sign posts.

Map matching technique seems to be common in Japan as 17 Japanese systems, 55%, employ this technique. Seven systems in North America and 9 systems in Europe, 10% and 22% respectively, use map matching. In total, 23% of worldwide systems employ map matching.

Only few RDSS-based systems have been reported worldwide. Two systems in each of North America and Europe have been developed at a rate of 3% and 5%, respectively. No RDSS-based systems have yet been developed in Japan.

IVHS Navigation Systems Reporter™

Information on Positioning Techniques used in Selected IVHS Navigation Systems Sorted by NAME

Statistics On number of IVHS Navigation Systems Implementing Difference Positioning Techniques

Total Number of IVHS Navigation Systems Developed Worldwide is 147

	GPS	Dead Reckoning	INS	Sign Post	Terrestrial Radio Frequency	Map Match	RDSS
Used	71	65	2	11	18	35	4
Optional	11	1	0	11	7	0	0
Proposed	5	2	0	1	0	1	2
Total	87	67	2	23	25	36	6
Percentage	59%	46%	1%	16%	17%	24%	4%

IVHS Navigation Systems Developed Worldwide

SYSTEM NAME	TYPE	COUNTRY	VERSION	YEAR	ORIGINATOR/COMPANY	GPS	DR	INS	SP	TRF	MM	RDSS
						POSITIONING TECHNIQUE(S)						
AMSC skycell	Fleet Management	United States	F	1994	American Mobile Satellite Consortium							
ARRAY	Fleet Managcmcnt	United States	P	1992	Pinpoint Communications Inc.					x		
AUTO-TRAC	Fleet Management	United States	F	1992	AUTO-TRAC Inc.	x						
AVLN2000	Autonomous	Canada	P	1988	Geomatics Engineering, The University of Calgary	x	x				x	
AgInfo	Inventory	United States	P	1993	Stennis Space Center	x						
AgriCAD	Inventory	United States	P	1992	AgriCAD	x						
Alberta Highway Inventory '89	Inventory	Canada	P	1989	Alberta Department of Transportation	x		x				
Ali-Scout	Advisory	Germany	F	1986	Siemens AG		x		x		x	
Aran	Inventory	Canada	P	1989	Roadware Corporation		x					
Ashtech VTS	Fleet Managment	United States	F	1989	Ashtech Inc.	x	x					
Autoguide	Advisory	United Kingdom	P	1986	GEC Traffic Automation Limited		x		x		x	
Autoaav	Fleet Management	United States	F	1993	American Technologies Inc.	x						
Autoscout	Advisory	Germany	P	1983	Siemens AG.		x		x		x	
Blaupunkt Ali	Advisory	Germany	P	1980	Blaupunkt Werke GmbH.				x			
Blaupunkt Berlin	Autonomous	Germany	S	1994	Robert Bosch GmbH.	0	x				x	
Blaupunkt Travelpilot	Autonomous	Germany	S	1989	Blaupunkt Werke GmbH.	0	x				x	
Bosch Car Pilot	Autonomous	Germany	P	1986	Robert Bosch GmbH		x					
Bosch Fleet Management	Fleet Managment	Germany	F	1989	Robert Bosch GmbH.	0	x				x	
Buchncr AVLS	Fleet Managcmcnt	The Netherlands	F	1992	Buchner Transport B.V.	x						
Bus Tracker	Fleet Management	United Kingdom	F	1993	GEC Marconi Ltd.							
C&MT GPS **Tracking**	Fleet Management	United Kingdom	F	1993	Communications and Measurement Technologies Ltd.	x						
CARIN	Autonomous	The Netherlands	F	1987	Nederlandse Philips International B.V.	P	x				x	
CURSOR	Fleet Management	United Kingdom	P	1991	Cambridge Research and Innovation Ltd.					x		
Class	Autonomous	United States	P	1984	Chrysler Corp.	x						
Co-Pilot Car Pilot	Autonomous	The Netherlands	F	1989	Co-Pilot International		x					
Dalabakis AM	Fleet Management	United States	C	1977	E-Systems Inc.					x		
Datatrak	Fleet Management	United Kingdom	F	1988	Datatrak Limited							

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RDSS = Radio Determination Satellite Service

Version: C = Concept P = Prototype F = First Generation S = Second Generation

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0 = Optional
p = Proposed

IVHS Navigation Systems Developed Worldwide

SYSTEM NAME	TYPE	COUNTRY	VERSION	YEAR	ORIGINATOR/COMPANY	GPS	DR	INS	SP	TRF	MM	RDSS
						POSITIONING TECHNIQUE(S)						
Delco NAVICAR	Autonomous	United States	F	1989	General Motors Corp.	0	x				x	
Driver Guide	Autonomous	Japan	P	1983	Nissan Motor Co., Ltd.		x				x	
Driver's Associate	Advisory	United Kingdom	P	1993	GEC Marconi Ltd	x						
EURO-SCOUT	Advisory	Germany	S	1991	Siemens AG.		x		x		x	
ELJTELTRACS	Fleet Management	France	F	1989	Alcatel Qualcomrn							x
Electro Gyro-cator	Autonomous	Japan	P	1983	Honda R&D Co. Ltd.		x					
Elsy C90	Fleet Management	Canada	F	1991	ND Resources Informatique Limitee	0	x					
Etak Fleet Management	Fleet Management	United States	F	1986	ETAK Inc.	0	x				x	
Etak Navigator	Autonomous	United States	F	1985	Etak Inc.	0	x				x	
Eva	Advisory	Germany	F	1983	Blaupunkt Werke GmbH.		x				x	
Expert Cruise	Advisory	Japan	F	1988	Clarion Co., Ltd.	0	x		0		x	
FLAIR	Fleet Management	United States	F	1976	Boeing Co.		x				x	
FLEETCON	Fleet Management	United States	P	1993	Arrowsmith Technologies Inc.	x						
FMS MapSight	Inventory	United States	F	1992	Farm Management Systems	x						
Fairchild MIS	Fleet Management	United States	F	1992	Fairchild Defense	0				0		
Fleet-Trak	Fleet Management	United States	F	1989	Navigation Data Systems Inc.	x	x		0	0		
Fletcher AM	Fleet Management	United States	C	1975	North American Aeronautics and Space Administration					x		
GARMIN Personal Navigator	Autonomous	United States	S	1991	GARMIN International Inc	x						
GDI Tracker	Fleet Management	United States	F	1993	Geotechnology Development Inc.							
GEC Tracker	Fleet Management	United Kingdom	F	1988	GEC Traffic Automatton Limited		x		x			
GP&C	Fleet Management	Sweden	F	1990	GP &C Systems International	x						
GPS PAL	Autonomous	Israel	F	1991	Rokar International Ltd.	x						
GPSensor	Autonomous	United States	F	1991	Stanford TELECOM	x						
GeoVAN	Inventory	United States	F	1992	Geospan Corporation	x	x					
Geolink	Autonomous	United States	F	1991	GeoResearch Inc	x						
Geostar	Fleet Management	United States	F	1986	Geostar Corporation							x
Global Vehicle Tracking	Fleet Management	United States	F	1993	FaciliTech Systems International Inc.	x						

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Version: C = Concept P = Prototype F = First Generation S = Second Generation

x = Used
0 = Optional
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IVHS Navigation Systems Developed Worldwide

SYSTEM NAME	TYPE	COUNTRY	VERSION	YEAR	ORIGINATOR/COMPANY	POSITIONING TECHNIQUE(S) GPS	DR	INS	SP	TRF	MM	RDSS
Highway Master	Fleet Management	United States	F	1992	Highway Master L.P							
Humminhird	Fleet Management	United States	F	1992	MARCOR Inc.	x						
Huntington Beach AVLS	Fleet Management	United States	S	1981	Gould Information Identification Inc.				x			
ICL AVL	Fleet Management	United Kingdom	F	1993	ICL Enterprises Ltd.							
II Morrow VTS	Fleet Management	United States	F	1985	II Morrow Inc.	0				x		
JRC Portable GPS	Autonomous	Japan	F	1992	Japan Radio Co., Ltd.	x						
LOGIQ AVL	Fleet Management	The Netherlands	F	1992	Simac Systems B.V.	x						
LoJack	Fleet Management	United States	F	1993	LoJack Corp.							
Locstar	Fleet Management	France	F	1989	Locstar SA.							
METS Tracker	Fleet Management	United States	F	1986	METS Inc.		x			x		
MacMillan Bloedel AVL	Fleet Management	Canada	P	1988	MacMillan Bloedel Research					x		
Magnavox Terrain Navigator	Autonomous	United States	F	1984	Magnavox	0	x					
Mapix	Advisory	Japan	F	1987	Nippondenso Co., Ltd.	x	x		0		x	
Maria	Advisory	Japan	P	1988	Mitsubishi Electric Corporation		x				x	
Matsushita AVC	Advisory	Japan	P	1988	Matsushita Communication Industrial Co., Ltd		x		0		x	
Mazda CCS	Advisory	Japan	F	1991	Mazda Motor Corporation	x	x		0		x	
Mazda Satnav	Autonomous	Japan	P	1983	Mazda Motor Corporation	x						
Metroview	Fleet Management	United States	F	1993	Ball Aerospace Corporation	x						
Micropilot	Autonomous	United Kingdom	P	1981	Wootton Jeffereys Plc.		x					
Millirad	Inventory	United Kingdom	F	1993	GEC Marconi Ltd.							
Mitsubishi GPS Nav	Autonomous	Japan	P	1988	Mitsubishi Electric Corporation	x	x					
Mitsubishi MCS	Autonomous	Japan	S	1992	Mitsubishi Electric Corporation		x		0		x	
Mitsubishi Map Match	Autonomous	Japan	P	1987	Mitsubishi Electric Corporation		x		x		x	
Motorola ATIS	Advisory	United States	F	1991	Motorola Inc.	x	x				x	
Motorola AVLS	Fleet Management	United States	F	1986	Motorola Inc.					x		
Motorola VTS	Fleet Management	United States	F	1992	Motorola Inc.	x				0		
NAVMATE	Advisory	United States	S	1990	ZEXEL USA Corporation	x	x				x	
Nav-Corn AVLS	Fleet Management	United States	S	1988	Magnavox Nav-Corn Inc.	x	x		0	0		

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Version: c = Concept I' = Prololypc F = First Gcncration S = Second Gcncration

x=used
0 = Optional
p = Proposed

IVHS Navigation Systems Developed Worldwide

SYSTEM NAME	TYPE	COUNTRY	VERSION	YEAR	ORIGINATOR/COMPANY	POSITIONING TECHNIQUE(S) GPS	DR	INS	SP	TRF	MM	RDSS
NavARC	Inventory	Canada	F	1990	Pulsearch Navigation Systems Inc.	x	x					
NavTrax	Fleet Management	Canada	F	1990	Pulsearch Navigation Systems	X	X					
Navstar lVN	Fleet Management	United Kingdom	P	1990	Navstar SA.					o		
Newcomb Vehicle Tracking	Fleet Management	United States	F	1993	Newcomb Commumcations	X						
Nissan Delivery Van	Autonomous	Japan	P	I985	Nissan Motor Co , Ltd.					x		
Nissan GPS Nav	Advisory	Japan	P	1986	Nissan Motor Co., Ltd.	X	X					
Nissan Mobile Mapping	Inventory	Japan	P	1989	Nissan Motor Co., Ltd	p						
Nissan Multi-AV	Autonomous	Japan	F	1989	Nissan Motor Co., Ltd.		X				X	
Nissan Nav	Autonomous	Japan	F	1986	Nissan Motor Co., Ltd		X				X	
Nukem Location	Fleet Management	Germany	F	1989	NUKEM GmbH.	X	x		O	O		
OCS Technologies AVL	Fleet Management	United States	F	1993	OCS Technologies	X				X		
OSU Inventory	Inventory	United States	P	1990	The Ohio State University	X	P					
OmniTRACS	Fleet Management	United States	F	1990	QUALCOMM Inc.							x
Omron Navicom	Advisory	Japan	P	1983	Omron Tateishi Electronics Co.		X		O		X	
Orbcomm GPS	Fleet Management	United States	F	1993	Orbital Sciences Corporation	X						
PacTel Teletrac	Fleet Management	United States	F	1992	PacTel Teletrac Systems Inc.					X		
Pan-Drive	Autonomous	Greece	F	1992	Pan-Drive SA.		X		X		X	
Pioneer AVIC-MCC	Autonomous	Japan	S	1992	Pioneer	X						
Pointer GPS Navigation	Fleet Management	Israel	F	1993	Azimuth Limited	x	x					
Pyxis	Autonomous	Japan	F	1992	Sony Corporation	X						
Q-Route	Advisory	Canada	P	1989	Civil Engineerm g Department,		p		p		l’	
QUIKTRAK	Fleet Management	Australia	F	1987	Advanced Systems Research Pty, Ltd					X		
RoadKIT	Fleet Management	Canada	F	1989	TMI Communications and Company	p				X		P
Roadshow	Fleet Management	United States	S	1987	Roadshow International Inc.	X						
Rockwell SCS	Fleet Management	United States	F	1992	Rockwell International Corporation	X						
Routen-Rachner	Autonomous	Germany	P	I984	Daimler-Benz AG.		X					
Routemare,ARCS	Autonomous	United States	F	1970	R.L. French and Associates		X				X	
SEREL AVL’	Fleet Management	France	F	1993	SEREL							

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IVHS Navigation Systems DatabaseTM

Table

IVHS Navigation Systems Developed Worldwide

SYSTEM NAME	TYPE	COUNTRY	VERSION	YEAR	ORIGINATOR/COMPANY	POSITIONING TECHNIQUE(S) GPS	DR	INS	SP	TRF	MM	RDSS
SNEC VTS	Fleet Management	France	F	1992	SNEC	x						
SYLETRACK	Fleet Management	France	F	1977	SERCEL		0			X		
Sanyo System	Advisory	Japan	P	1988	Sanyo Electric Company Ltd.	x	x					
SmartTrack	Fleet Management	United States	F	1993	Westinghouse Electronic Corporation	x						
Sony Car Navigation	Autonomous	Japan	P	1993	Sony Corporation	x						
Sony MIS	Advisory	Japan	P	1988	Sony Corporation		x				X	
Star-Track	Fleet Management	United Kingdom	F	1992	GEC Marconi Ltd.	x				0		
StellarTrak	Fleet Management	United States	F	1992	TransTrak Inc.	x						
Sumitomo Electric ADNS	Advisory	Japan	T	1991	Sumitomo Electric Industries Ltd.	P	x		0		X	
SuperSport GPS	Autonomous	United States	F	1992	Micrologic	X						
Suzuki Navigation	Autonomous	Japan	P	1985	Suzuki Motor Co., Ltd.		x				X	
TJDGET Tracking	Fleet Management	United States	F	1992	NAVSYS Corporation	X						
Teldix Co-Pilot	Autonomous	United States	F	1993	J&W Marketing Associates	x						
Telecom Van	Fleet Management	Japan	P	1986	Mazda Motor Corporation	x						
Telemobil AVL	Autonomous	Norway	P	1990	Norwegian Telecom TLK.	X	X					
Terrafix AVL	Fleet Management	United Kingdom	S	1991	Terrafix Limited	X	x			X		
Terrapin FM	Autonomous	United States	F	1993	Terrapin Corporation							
Toshiba TNS	Autonomous	Japan	F	1992	Toshiba	x						
Toyota CD Information	Advisory	Japan	P	1988	Toyota Motor Corporation		x		X		X	
Toyota Electro-Multivision	Advisory	Japan	F	1987	Toyota Motor Corporation	x	x		0		X	
Toyota FX-V	Autonomous	Japan	P	1985	Toyota Motor Corporation	x						
Transportation Manager	Fleet Management	United States	F	1993	Computer Science Innovations Inc.	x	x		X			
Trastar	Inventory	United States	F	1988	Nu-Metrics Instrumentation	x	x					
Traxar	Autonomous	United States	F	1992	Motorola Inc	x						
Trimble FleetVision	Fleet Management	United States	F	1990	Trimble Navigation	x	x					
Trimble Pathfinder	Inventory	United States	F	1991	Trimble Navigation	x						
Tripmonitor	Autonomous	United States	P	1984	Ford Motor Co		x					
Trooper	Autonomous	United States	F	1992	Rockwell International Corporation	x						

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IVHS Navigation Systems Developed Worldwide

SYSTEM NAME	TYPE	COUNTRY	VERSION	YEAR	ORIGINATOR/COMPANY	POSITIONING TECHNIQUE(S) GPS	DR	INS	SP	TRF	MM	RDSS
TruckMate	Fleet Management	Canada	F	1986	Maddocks Systems Inc.	x				x		P
UCNW Navigator	Autonomous	United Kingdom	P	1985	School of Electronic Engineering Science		x			x		
V-Track	Fleet Management	United States	F	1992	Radio Satellite Integrators Inc.	X						
VDO City Pilot	Autonomous	Germany	P	1986	VDO Adolf Schindling AG.		x					
VELOC	Fleet Management	Germany	F	1989	AEG AG.	x	x					
VISAT	Inventory	Canada	P	1993	Geofit Inc.	x		x				
VehicleTracker	Fleet Management	United States	P	1992	DF Crane Associates Inc.	P						
Volkswagen FM	Advisory	Germany	C	1989	Volkswagen AG.					x		
Yazaki Navigator	Autonomous	Japan	P	1987	Yazaki Corporation		x				x	

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IVHS Navigation Systems Reporter

Summary Statistics

From 1975 To 1993

System Type Statistics

		Autonomous	Fleet Management	Advisory	Inventory	Total
North America	N	12	44	3	12	71
	%	17	62	4	17	100%
Japan	N	17	1	12	1	31
	%	55	3	39	3	100%
Europe	N	9	21	10	1	41
	%	22	51	24	2	100%

Positioning Technique Statistics

		GPS	**Dead Reckoning**	**INS**	**Terrestrial Radio Frequency**	**Sign Post**	**Map Matching**	**RDSS**
North America	Single	27	2	0	7	1	0	2
	Multi	24	19	2	8	3	7	0
	Total	51	21	2	15	4	7	2
	%	72	30	3	21	6	10	3
Japan	Single	8	1	0	1	0	0	0
	Multi	7	20	0	0	10	17	0
	Total	15	21	0	1	10	17	0
	%	48	68	0	3	32	55	0
Europe	Single	7	5	0	3	1	0	2
	Multi	8	17	0	5	7	9	0
	Total	15	22	0	8	8	9	2
	%	37	54	0	20	20	22	5
	N	**81**	**64**	**2**	**24**	**22**	**33**	**4**
Worldwide	**%**	**57**	**45**	**1**	**17**	**15**	**23**	**3**

THE EVOLUTION OF AUTOMOBILE NAVIGATION SYSTEMS IN JAPAN*

by
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BIOGRAPHY

Robert L. French is a physicist (BS, Murray State University, MS, Vanderbilt University), and is the inventor of map matching for automobile navigation. As an independent consultant in navigation and intelligent vehicle highway systems (IVHS), he advises automotive, electronic, cartographic and transportation organizations in the United States, Europe and Japan. He has authored over 60 publications on vehicular navigation and IVHS. In addition to the ION, his me-mberships include the RIN, IEEE, ITE, SAE, WFS, and IVHS AMERICA.

ABSTRACT

As in the United States and Europe, the development of automobile navigation systems in Japan has been spurred by their role in IVHS (Intelligent Vehicle Highway Systems). However, commercial development and marketing of automobile navigation systems has been pursued far more vigorously in Japan even though (like the United States and Europe) IVHS communication links are not yet in place for providing real-time traffic information to in-vehicle units. As a result, some one-half million autonomous systems have already been sold in Japan.

Most of these systems were sold as factory-installed equipment in top model automobiles, and many are integrated with entertainment features such as AM-FM, tape cassette, CD, and color TV. Virtually all of the systems use dead reckoning with map matching, and the majority of the new models incorporate GPS satellite receivers as well. Superimposition of present car location and destination on a map display is the most common format for presenting navigation information to the driver. However, a few of the most recent systems also offer route guidance features.

This paper outlines goals of government programs for IVHS infrastructure support and other important factors that have contributed to this burgeoning private-sector business activity in Japan. It then traces the development of automobile navigation through several generations in Japan and describes examples of state-of-the-art systems.

INTRODUCTION

Approximately one-half million automobile navigation systems have been sold in Japan since Toyota's introduction of the Electra-Multivision navigation system on September 1, 1987 initiated the era of navigation computers, color map displays and CD-ROM database storage as factory-installed equipment. Although there is some slowing with the current recession, the number of automobile navigation systems sold in Japan has grown by an average of approximately 50 percent annually since 1987.

All major Japanese motor companies now offer navigation systems (e.g., Honda, Nissan, Mazda, Mitsubishi, Toyota, and Suzuki). Most major electronic companies are also in the automobile navigat-

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ion systems business, either as OEM or aftermarket suppliers (e.g., Sumitomo Electric, Matsushita Electric, Toshiba, NEC, Sanyo, Yazaki, etc.),

Virtually all of the present generation Japanese navigation systems use CD-ROM for digital road map storage and use map matching in combination with dead reckoning as the basic navigation platform* Most of those sold in the last two years also include GPS satellite receivers which are fast becoming a standard feature. All have color CRT or LCD displays which show road network, current location, location of the destination, etc.

Many of the navigation systems include limited "yellow pages" directories, and most OEM versions are integrated with entertainment and convenience features such as AM-FM radio, cassette and CD players, color TV, climate controls, etc. Although the cost of the navigation features is blurred by such bundling, almost all of these systems have sold in the 200,000 - 600,000 yen price range.

IVHS INFLUENCE

How did Japanese industry- manage to come so far in only five or six years after sophisticated automobile navigation systems were introduced on the market? Part of the answer lies in IVHS initiatives that have been underway in Japan continuously since the 1970s.

CACS

Starting in 1973, the Ministry of International Trade and Industry (MIT11 sponsored CACS (Comprehensive Automobile Traffic Control), a seven-billion yen, six-year route guidance research project. Much like the earlier ERGS (Electronic Route Guidance System) research in the United States, CACS used inductive loop antennas buried in the roadway as a digital communication link between the equipped vehicles and the infrastructure. However, unlike ERGS (which was tested only at the subsystem level), CACS infrastructure was established in a 28-square kilometer area in southwestern Tokyo and used for trials involving a fleet of 330 test vehicles equipped with route guidance and driver information displays.

JSK

The CACS operational trial, along with related computer modeling, confirmed the efficacy of dynamic route guidance and led to MITI's establishment in 1979 of JSK (Association of Electronic technology for Automobile Traffic and Driving). JSK is a non-profit membership foundation whose initial objective was to popularize CACS results and expedite the introduction of in-vehicle route guidance and information systems.

Subsequent JSK activities included investigations of social needs, technical trends, and means for introducing such systems. JSR also performed extensive technically-oriented research towards developing specifications and protocols for digital communications between vehicles and IVHS infrastructure. Present JSK activities focus on advanced IVHS technologies such as those of the SSVS (Super Smart Vehicle System) project.

RACS and AMTICS

From the mid-1980s until 1990, parallel and somewhat competitive field tests involving data communication links between navigation-equipped vehicles and IVHS infrastructure were carried out by the Ministry of Construction (MC) and the National Police Agency (NPA). The RACS (Road Automobile Communication System) project of the MC and the AMTICS (Advanced Mobile Traffic Information Communications System) project of the NPA differed mainly in the types of communication links tested and in the jurisdictions of the sponsors (the MC manages expressway traffic whereas the NPA manages surface street traffic).

Both AMTICS and RACS offered communications infrastructure for field testing of open-architecture navigation systems with standardized communications interfaces. Following earlier experiments with inductive radio, RACS settled on two-way microwave beacons whereas AMTICS initially focused on teleterminals, a cellular-like mobile data communications system.

Industry Participation

Navigation systems from approximately 12 different automobile manufacturers and electronic firms were entered in both RACS and AMTICS field tests. Participation required paid membership in associations attached to the sponsoring agencies: the MC's Highway Industry Development Organization (HIDO) in the case of RACS and the NPA's Japan Traffic Management Technology Association (JTMTA) for AMTICS.

Many of the navigation systems entered in the RACS and AMTICS tests included features such as color CRT map displays and CD-ROM digital map storage. Some were prototypes or adaptations of systems marketed for autonomous operation.

JDRMA

The MC provided a special digital road map database for use with the RACS trials and, in 1988, established the Japan Digital Road Map Association (JDRMA) to standardize map formats and share the efforts and costs in quickly digitizing the major roads and highways of Japan. JDRMA has since digitized road maps at a scale of l/25,000 or l/50,000 for all of Japan which are available to its members for a fee. Individual developers enhance and supplement the JDRMA map database in a variety of ways (e.g., with larger scale maps for local streets) for use in current navigation systems.

VICS

In 1990, a plan was announced for the MC and NPA to cooperate with the Ministry of Posts and Telecommunications (MPT) to establish VICS (Vehicle Information Communication System), a project that integrates RACS and AMTICS traffic information data for communication to vehicles via alternative communication links such as FM sideband, microwave beacons, and teleterminals. However, VICS remains thwarted by lack of agreement on a VICS operational body to consolidate and distribute traffic data for city surface streets, express toll roads, and intercity roads.

UTMS

In April 1993, the NPA announced plans for a Universal Traffic Management System (UTMS) that includes IVHS communications infrastructure for automobile navigation systems. UTMS will enhance the existing traffic control systems to include traffic data collection and information supply as well as traffic signal control. The NPA's authority for this move is based on it being the only government agency with explicit constitutional responsibility for managing traffic in Japan.

One of the key elements of UTMS is a new optical beacon that, in addition to serving as vehicle detector, will provide high bandwidth two-way IVHS communications with equipped vehicles. Installation is already underway, and 50,000 beacons are planned by the year 2000. The beacon communications network will be coupled with comprehensive computerized traffic control systems that are already in operation.

As in the case of the earlier AMTICS, RACS, and VICS initiatives, a membership association (Universal Traffic Management Society of Japan, or "UTMS Japan") has been established for the promotion of UTMS under the auspices of the sponsoring government agency (the National Police Agency).

EARLY NAVIGATION SYSTEMS

In 1981, shortly after the completion of the CACS project and MITI's establishment of JSK to promote IVHS concepts, Honda, Nissan, and Toyota all introduced first generation navigation systems for their automobiles in the domestic market. The development of these relatively simple systems involved considerable research on the characteristics and limitations of several different sensor approaches for dead reckoning, and set patterns that have been refined and continued in the more sophisticated systems that began to appear in 1987.

Honda Electro Gyro-Cator

The Honda Electro Gyro-Cator was the only one of the early navigation systems to include a form of map display. Dead reckoning based on odometer signals and a helium gas-rate gyro for sensing heading changes was used to calculate the approximate route driven by the automobile.

The route was graphically traced on a CRT screen behind a transparent map overlay of appropriate scale to show present location and direction of travel. Provision was made for manually adjusting the map position to keep it in registration with the vehicle route, a process not unlike that performed by map-matching software in newer systems.

Nissan Driver Guide

The Nissan Driver Guide used a dynamic magnetic compass and odometer for continuous dead-reckoning calculations of the distance and direction to a given destination. At the start of a trip, the driver entered (via keyboard) the destination in terms of distance in east-west and north-south directions. As the trip was made, a bar graph displayed the remaining fraction of the straight-line distance and an array of indicator lights showed the direction to the destination.

Toyota Navicom

The Toyota Navicom, which was developed jointly with Nippondenso, used a solid-state compass and odometer as sensors for dead reckoning calculations. In addition to east-west and north-south distances, the actual distance along a planned route could be entered from an appropriate map.

As the route was driven using Navicom, a vacuum florescent display showed the estimated time of arrival, remaining distance along the planned route, and remaining straight-line distance. LEDs arranged in a compass-like pattern indicated both direction of travel and direction to the destination. Other LEDs showed the remaining fraction of the original straight-line distance.

COMTEMPORARY NAVIGATION SYSTEMS

The following are two leading examples of state-of-the-art systems which illustrate the recent evolution and present trends for automobile navigation systems in Japan:

Toyota Electro Multivision

Like Navicom, the Electra-Multivision is a joint development of Toyota and Nippondenso. The original version was introduced in 1987 as the first factory-installed automobile navigation system to include digital maps stored on CD-ROM for display on a color CRT. The Electra-Multivision has since undergone numerous refinements including addition of map matching and a GPS receiver for improved positioning. The most recent additions consist of routing and voice guidance features.

The digital maps for the first version of Electro-Multivision were of limited detail, and the navigation function gave only approximate position based on simple dead reckoning alone. Nonetheless, even the first version included limited "yellow pages" information that gave the location of facilities likely to be of interest to motorists.

The first Electra-Multivision also set patterns with its functionality as a reference atlas. An initial display showed a color map of all Japan with 16 super-imposed rectangles. Touching a particular rectangle causes the map area it encompasses to zoom and fill the entire screen, again with grid lines superimposed to form 16 rectangles.

Thus a few touches of the screen would take the viewer from an overview of the entire country down to major roads and landmarks in some section of a major city. The destination as well as vehicle position could be shown as icons on the map display.

Improved digital maps along with map-matching software and a GPS receiver were added in subsequent versions of the Electra-Multivision. In 1991, a routing feature was added to calculate a suggested route to the destination and highlight the trace on the color LCD map display.

The newest version added synthesized voice route guidance instructions. It also has a video camera for rear-view monitoring on the LCD and, as with the previous versions, comprehensive TV and audio entertainment features are included.

Nissan Multi AV System

The Multi AV system, which has been available on top-line Nissan automobiles since 1989, includes a navigation subsystem developed by Sumitomo Electric. The original Multi AV was the world's first factory-installed navigation system to feature map matching, and the newest version is the first production automobile navigation system to include a microwave beacon receiver.

The receiver is for information transmitted by microwave beacons installed in limited quantities under a pilot program by the Ministry of Construction. Although traffic and routing information may be added later, for the moment only static information such as the beacon location and intersection information is transmitted. In addition to enabling the navigation system to display the destinations of roads emanating from the intersection, the static beacon data is use for correcting vehicle location.

The system configuration of the latest version of the Multi AV includes a fiber optic gyro (FOG) in lieu of the Differential odometer that was used in earlier versions. The FOG, which has long been recognized as having potential for automobile navigation provided its cost could be reduced, has the advantages of being rugged and easy to install. Sumitomo Electric achieved relatively low cost for the FOG through relaxed specifications which still give sufficient accuracy for use in combination with map matching.

Other recent Multi AV enhancements include an added layer of map-matching software that takes over automatically when the basic map-matching algorithms used in earlier versions fail to estimate the current vehicle location with suitable confidence. The enhanced map-matching software seeks correlation between the shape of long travel paths over very wide areas of the road network. Overall, the Multi AV map matching software gives location errors of 10 meters or less almost two-thirds of the time, and of 80 meters or less 99 percent of the time.

The map data base used with the Multi AV has been enhanced by Sumitomo Electric to include minor roads encoded from l/2,500 scale maps for major metropolitan areas which contain approximately one-half of Japan's population. The remainder of Japan is covered by road network data encoded from l/25,000 or l/50,000 scale maps by the Digital Road Map Association.

CONCLUSIONS

Automobile navigation evolved rapidly and has already been commercialized in Japan because of, among other reasons, promises of IVHS traffic data communications infrastructure which have been dangled by the public sector off and on since the 1970s. Other factors inciude the promotional and research efforts of the JSK Foundation under the auspices of the Ministry of International Trade and Industry (MITI) and the availability of a standardized nation-wide digital map database developed by the Japan Digital Road Map Association (JDMRA) under the auspices of the Ministry of Construction (MC).

Yet another factor may be the coordination and focus provided by industry membership in the government-sponsored associations related to each new IVHS initiative. These include HIDO, JTMTA, JDRMA, VICS Promotion Association, UMTS Japan, etc.

The early public-sector pursuit of IVHS was a response to the serious state of traffic congestion in Japan. However, as a result of jurisdictional issues among the various government agencies involved, the movement towards establishing an IVHS infrastructure has not been seamless.

Nonetheless Japan's existing traffic management systems are highly advanced, and almost all elements are already in place for supporting in-vehicle navigation and information systems with traffic data. One of the principal missing elements is consensus on an organizational body for accumulating, fusing and distributing traffic data. Another critical element which is still missing is the final selection and implementation of one or more IVHS communication links.

It is also recognized that one major objective of industry's strategy of aggressively seeking early market penetration for autonomous navigation systems has been to help encourage the government to take decisive actions to establish the institutional arrangements and the IVHS communications infrastructure required for supplying traffic and other dynamic information for the next generation of navigation systems.

At the very least, the present generation of navigation systems is acclimating domestic users and preparing the Japanese market for future versions which will receive real-time information support. In the process, Japanese industry is also gaining a significant head start in the practical aspects automobile navigation design and manufacturing that will facilitate entry in the international IVHS market as automobile navigation and supporting IVHS infrastructure are deployed in other countries.

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