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Intelligent Vehicle Highway Systems (IVHS) Communications Standards

Research Needs and Implementation Requirements

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INTELLIGENT VEHICLE HIGHWAY SYSTEMS (IVHS) COMMUNICATIONS STANDARDS

RESEARCH NEEDS AND IMPLEMENTATION REQUIREMENTS

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INTRODUCTION

One of the major impediments to the widespread implementation of Intelligent Vehicle Highway Systems (IVHS) is the absence of standards. Standards are needed for communications, databases, and human factors.

Communications standards are needed to ensure that equipment installed in a vehicle can be used wherever a vehicle is likely to travel. The value of a motorist's investment in IVHS equipment (and hence the desirability of acquiring this equipment) will be significantly reduced if its use is restricted to a limited geographic area.

Database standards are needed to encourage the development of new functions and features for IVHS equipment. IVHS is essentially a mobile information system. Thus its value to the motorist will be enhanced through the availability of multiple functions. The development of these functions will be encouraged through the existence of database standards.

Human factors standards are needed to ensure the safe operation of IVHS equipment and to minimize or eliminate the need for educating motorists in its use. Travelers using rental cars, fleet operations, and other situations in which multiple vehicles are used require that a driver can readily operate the IVHS equipment without an extensive review of the operator's manual.

The Communications Committee (A3A01), of the Transportation Research Board, sponsored a Communications Standards Workshop on June 20 and 21, 1990 in Los Angeles to address the issue of IVHS standards. The workshop was very well attended by representatives at all levels of government, consultants, universities, and private industry. Individuals came from the United States (U.S.), Canada, Europe, and Japan. Because of the committee's scope and membership, this workshop was restricted to the issue of communications standards.

The objectives of the workshop were to:

1. Develop a consensus on the need for initiating the communications standards process.
2. Identify the types of communications standards that are needed.
3. Define the research required to support the process of developing standards.
4. Determine whether compatibility with the standards being developed in other countries was desirable.
5. Identify organizations that might lead these activities.

The first morning of the workshop included presentations on IVHS Communications requirements for Advanced Driver Information Systems (ADIS), Advanced Traffic Management Systems (ATMS), Commercial Vehicle Operations (CVO), and Automated Vehicle Control Systems (AVCS), as well as IVHS-related applications (e.g., public safety and vehicle security).

Other morning presentations outlined related standard works in Europe and Japan, and described a proposed federal land mobile radio standard.

The afternoon presentations described potential processes for developing IVHS communications standards. These presentations were made by representatives from various standard setting organizations which might play key roles in IVHS communications standards. These organizations included the:

- Institute of Electrical and Electronics Engineers (IEEE)
- Society of Automotive Engineers (SAE)
- Telecommunications Industries Association (TIA)
- Electronics Industries Association (EIA)
- American Association of State Highway and Transportation Officials (AASHTO)

Also described was the role of the National Telecommunications and Information Agency (NTIA) in coordinating with the Federal Communications Commission (FCC) on frequency allocations for government use.

After the presentations, the workshop participants divided into individual working groups for the rest of the two-days to address each of the following topics:

- Specific research requirements
- International compatibility
- Commonality and interoperability
- Content and format
- Processes for developing standards

Each group sought internal consensus in defining problems or issues that needed to be resolved, considerations that should be taken into account, organizations that should be involved, and in identifying approaches for addressing the problems and issues.

A standard form entitled *Communications Standards Problem Statement* was used for summarizing the output from the various working groups. It closely follows the format used for TRB Research Problem Statements but drops the word "research", since most of the identified issues and recommended actions involve system analysis and trade-off studies rather than research.

The workshop was remarkably successful in that consensus was reached on almost all of the issues discussed. Perhaps the most significant conclusion of this workshop was the unanimous recommendation of the participants that work on IVHS communications standards be initiated immediately. Participants felt that every effort be made to achieve compatibility with existing and evolving international standards. There was also a consensus that an ANSI-accredited committee would be the most appropriate means to oversee the creation and approval of IVHS standards.

The remainder of this Circular describes the detailed findings of the workshop. This material is organized to reflect the five working groups which considered various issues associated with communications standards. The problem statements for each working group are ranked in decreasing order of priority.

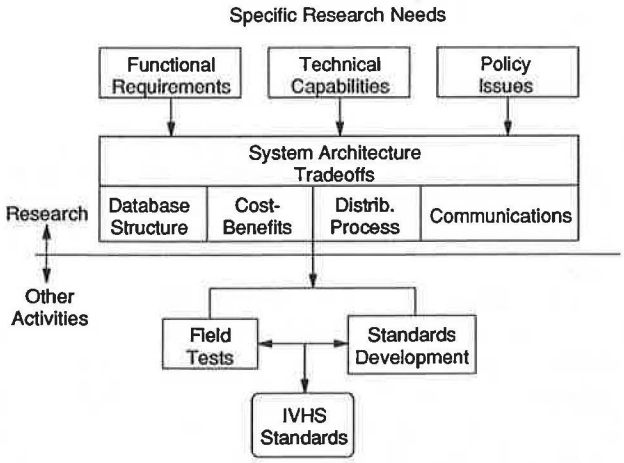
Included at the end of this document is a list of workshop attendees (Appendix A), the workshop agenda (Appendix B), the IVHS glossary (Appendix C), and an ISO (the International Organization for Standardization) reference model for OSI (Open System Interconnection) (Appendix D) which was identified by this workshop as an appropriate framework for defining IVHS communications standards.

IVHS COMMUNICATIONS STANDARDS REQUIREMENTS

Specific Research Needs (Working Group 1)

Working Group 1 members agreed that IVHS communication standards should be generated on alternative communication systems that differ but in the future can accommodate unpredicted communication needs and technologies. Research should be conducted to identify a number of alternative communication systems, narrow them down to a manageable number through tradeoff analyses, and subject them to field tests to determine which one is particularly suitable to a set of conditions (traffic pattern, terrain, priority of communication requirements, etc.).

The following problem statements are based on the above considerations and are interrelated as shown in the accompany diagram. Thus, the outputs of the first three projects (functional requirements, technical capabilities, and policy issues) feed into the fourth project (system architecture tradeoffs). The output of the last project provides the basis for field tests and standards development: these two non-research activities are expected to be mutually reinforcing and eventually lead to adopted standards.



To the extent that the problem statements are closely linked, they may be combined into a single comprehensive statement. In the interest of providing early outputs for standards development activities, the research projects should be iterated so that some preliminary results may be obtained quickly to satisfy urgent needs before more extensive work continues.

IVHS Functional Needs

Issues

IVHS requires reliable, spectrum-efficient communications to provide a variety of control, advisory, navigation, and informational data/messages. Competing communication needs must be sorted from those strictly IVHS-related.

Recommended Action

To undertake the following:

1. Prepare a listing of afl required rural and urban IVHS system functions, prioritize and organize into logical categories related to vehicle-highway, vehicle-vehicle transportation and driver information.
2. Estimate data rate requirements and frequencies of usage for all identified functions.
3. Analyze European and Japanese IVHS communication system functions for possible use in North America.
4. Provide an estimate of reasonable expansion of communication functions for the future.

Potential Acting Organizations

- Federal Highway Administration (FHWA)
- National Highway Traffic Safety Administration (NHTSA)
- Estimated cost: $200,000

Benefits
This work will lead to early implementation of IVHS, organized system growth, and opportunity for private industry to participate in IVHS. These will contribute to safer and less congested transportation networks.

Related Work
Mobility 2000 work group reports.

Urgency
This research is a prerequisite for trade-off analyses of alternative communication systems that will help prevent urban gridlock.

IVHS Technical Capabilities and Constraints

Issues
Select the appropriate enabling technologies for IVHS implementation, including both existing technologies and those emerging technologies available within the next 30 years. Technical constraints now limit and will continue to limit the scope of enabling technologies in the areas of communications, computer hardware and software, display, highway device, and traffic operational control. The capabilities and limitations of these existing and future technologies related to IVHS must be identified before alternative communication systems can be conceptually designed and compared.

Recommended Action
To undertake the following:

1. Identify current enabling technologies.
2. Identify critical and unavailable technologies.
3. Document the performance of the existing technologies.
4. Document existing limitations and development requirements for the critical and unavailable technologies.
5. Select an IVHS technology oversight committee that will be responsible for the review and approval of the findings before acceptance and publication.

Potential Acting Organizations
- University and industry
- Estimated cost: $500,000

Benefits
This is the keystone to subsequent studies of IVHS system architecture and resultant system standards.

Related Work
- IVHS functional analysis
- IVHS architecture studies
- IVHS standardization

Urgency
This must be performed before national IVHS systems can be designed with standardization considerations.

IVHS Public Policy Issues

Issues
As IVHS research progresses, issues of public policy must be addressed. Unfortunately, these issues are rarely decided in a logical fashion and may change radically over time. Typically, these issues revolve around allocation of resources. The foremost issues are frequency spectrum allocation and international standard harmonization. However, other issues which impinge upon realistic IVHS functional requirements and system design, such as information security, legal liability, jurisdiction, fees and pricing, among others, must be considered. For example, it may be technically optimal to use a previously allocated section of the frequency spectrum for IVHS. If so, should these frequencies be reassigned by the FCC? Another example: Should facilities be reserved for users who have specialized equipment such as thriving automation before the legal liability issues are resolved?

Recommended Action
To undertake the following:

1. Identify the policy issues by surveying both the policy and technical communities.
2. Have these issues discussed between both groups to formulate policies and practices.

Potential Acting Organizations
- FHWA
- AASHTO

- Estimated cost: $250,000

Benefits
Policy issues will add input into the IVHS system analysis, resulting in more realistic system design and tradeoffs.

Related Work
Recent SAE papers dealing with IVHS policy issues.

Urgency
By identifying the policy issues at this time, both the policy and the technical communities can begin internal discussion and examination, thereby leading towards a consensus.

IVHS Architecture Trade-off Analysis

Issues

Communication requirements will be highly dependent upon overall IVHS system architecture. For example, a centralized architecture requires more communications than a decentralized or distributed one. System architectures must therefore be defined before communications standards can be considered meaningfully. Definition of suitable architectures must be based on extensive analyses of trade-offs among different alternatives. These analyses are likely to be costly and time consuming.

Recommended Action

Initiate system engineering work as soon as possible, develop simulation tools and then apply them to investigate design tradeoffs. These studies should include quantification of costs and benefits of different alternatives, and should represent different distributions of intelligence and functionality among vehicles and local and central wayside facilities, and different information flows among vehicles and wayside elements. Reliability and safety concerns should be addressed together with alternative choices of media. This system-engineering work should produce several possible architectures.

Potential Acting Organizations

- Research and Development (R&D) contractors and/or universities working for federal or state government agencies.

- Estimated cost: $1,000,000

Benefits

This research is essential for defining IVHS communication needs and developing practical systems that are cost effective and efficient.

Related Work

- Functional requirements definition
- IVHS technical capabilities and constraints
- Public policy issue identification

Urgency

This work is an essential step in the path toward standardization. The process is time consuming and needs to get started quickly so results are available soon.

International Compatibility (Working Group 2)

Working Group 2 members discussed the need for international compatibility. It was agreed that international cooperation and coordination of efforts was highly necessary. Such a cooperation would minimize the proliferation of diverging systems whose compatibility would be expensive to achieve, thus jeopardizing the inherent benefits for users and industry.

The group then discussed the coordination and involvement of appropriate standard organizations. A top-down approach was suggested, based on current international telecommunications and information processing standardization practice. Generally speaking, international standards organizations are of two types: treaty-based and voluntary.

The treaty-based organization is the International Telecommunication Union (ITU), founded upon the International Telecommunications Convention (ITC). The ITU is based in Geneva (Switzerland). It acts through two technical organizations: The International Consultative Committee for Telegraph and Telephone (CCITT) and the International Consultative Committee for Radio (CCIR), to establish effective and compatible telecommunications among the member nations of the world. Western European nations, Japan, the US, and Canada are members of ITU.

The voluntary organizations are the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). These organizations work in close cooperation with ITU's CCITT and CCIR organizations and are also based in Geneva. Most industrialized countries are members of these organizations and are represented by their national standards body, trade associations, professional associations and government representatives.

Current activities indicate that ISO has been advocating the development of a universal architecture for Open Systems Interconnection (OSI) which may be applicable to Driver Information Systems (DIS). Close liaison with the CCITT and CCIR groups will ensure that the objective of international compatibility can be achieved.

To take part in this process, legitimate concerns of interested transportation administrations and industries, communications standards and protocols currently under development (e.g., IVHS, route guidance, and in-car communications) should be addressed by a special task force or committee appointed for this specific purpose. This task force should be international in nature and act as a liaison with the ITU/ISO groups working on network integration, as well as standards and protocols for OSI architecture.

International Compatibility

Issues
International agreements for communications standards and protocols need to be established.

Recommended Action
To undertake the following:

1. Forming a task force to address the standardization issues as well as to prepare the stage for a future demonstration system (if feasible) to assess the network and equipment compatibility issues.
2. Establish a liaison with European, Canadian, and Japanese groups working on IVHS communications standards and protocols.
3. Review the European and Japanese findings with respect to North American requirements.
4. Recommend CCITT and CCIR groups study the need of communications standards and protocols related to IVHS systems.
5. Plan an international demonstration of IVHS programs focusing on standards and protocols compatibility.

Potential Acting Organizations
- North American standards organizations
- European standard organizations
- Japanese standard organizations
- ECMT
(e.g., ANSI/EIA/CSA/DOC)
- Government organizations

Benefits
This research will maximize the compatibility of North American, European, and Japanese IVHS vehicle and infrastructure systems, also minimize costs and unnecessary barriers to trade, while at the same time promoting general awareness of IVHS concepts (e.g. safety and congestion).

Related Work
- CCITT and CCIR studies on communication and information technologies - including OSI reference model.
- Infrared standards for AUTOGUIDE and ALI-SCOUT.
- Program for European Traffic with Highest Efficiency and the Unprecedented Safety (PROMETHEUS), Dedicated Road Infrastructure for Vehicle Safety in Europe (DRIVE).
- AMTICS and RACS programs in Japan.

Urgency
The first to third recommended actions are highly urgent, the fourth and fifth are moderately urgent.

Commonality and Interoperability (Working Group 3)

Working Group 3 first came to a consensus on the meaning of *commonality* and *interoperability*. *Commonality* was defined as common protocols where protocol was used as in the 7-level hierarchy established by the International Organization for Standardization (ISO). *Interoperability* is the requirement that systems are able to operate across city, county, state, and national boundaries. Classification of communications requirements were then identified.

Class:
0) all on board - no communication
1) one way area-outbound from central control
2) one way local - outbound from central control
3) two-way area
4) two-way local
5) vehicle-to-vehicle

Communications requirements for each class can be identified by studying record type, length of communications, and timing specifications, or more precisely, communication protocol. The group discussion led to two problem statements:

- North American Communications Protocols for IVHS
- Frequency Allocation Requirements for IVHS

The conclusion is that research activities addressing these two areas are essential to the successful development of the information systems in IVHS.

North American Communications Protocols for IVHS

Issues
The lack of communications standards for IVHS is a major barrier to the development and deployment of such systems in North America. The task of setting IVHS communications standards is particularly difficult because of the great variety of IVHS systems under consideration, and because these systems are expected to evolve over time.

Recommended Action
Despite their differences, proposed IVHS systems appear to have common data communication needs. It is recommended that studies be conducted to identify common needs and to specify a flexible set of communications protocols that can meet these needs.

Potential Acting Organizations
- FCC
- USDOT (FHWA)

Benefits
This work would be the first step toward the establishment of common IVHS systems in North America.

Related Work
The specification of these communications protocols will depend partly on how spatial and temporal aspects of traffic networks are encoded, and on how intelligence is distributed between the infrastructure and the vehicles.

Urgency
This work is critical to the development of Advanced Driver Information System (ADIS) and other IVHS systems. Substantial ongoing European and Japanese R&D efforts in IVHS threaten our international competitiveness in this arena.

Frequency-Allocation Requirements For IVHS

Issues
ADIS and other IVHS will require new spectrum allocations for mobile communications (one-way/two-way, local/area-wide, vehicle-to-vehicle).

Recommended Action
Research should be conducted to define frequency-allocation requirements for ADIS and other IVHS systems.

Potential Acting Organizations
- FCC
- USDOT (FHWA)

Benefits
The result of these studies could serve as a basis for informing the FCC and NTIA of ADIS and IVHS communications needs.

Related Work
The frequency-allocation requirements for ADIS and IVHS depend in part on the effectiveness of dynamic traffic-network models and on the distribution of computational tasks between the infrastructure and the vehicles.

Urgency
Given the vast demands being placed on our limited communications spectrum, it is important that the communications needs of ADIS and IVHS be made known to the general public and to appropriate regulatory agencies in particular.

Content and Format
(Working Group 4)

The development of communications standards must be as general as possible to allow for a broad range of IVHS communications system designs. However, it is also necessary to define the fundamental structure of future IVHS systems in a manner that can be used to establish the framework for the standards development. For this reason, it is important to consider alternative communications architectures, message types and content required to support the IVHS functions.

The IVHS architecture will have to be capable of defining the types of information processing that will occur in the vehicle as opposed to those which will be performed at a fixed roadside location or central location. The system architecture must also define the locations at which data are stored and the manner in which data will be updated. These architectural decisions will all have a significant impact on the communications system specifications. Working Group 4 felt that the development of an overall system architecture should be performed with the objective of minimizing communications capacity requirements since this is the most critical resource used by the IVHS technology. All other aspects of the system design including processing power and data storage capacities are likely to undergo significant increases over the next decade.

The impact of system architecture on communications requirements can be readily demonstrated through the example of vehicle routing information. If optimal routing is performed by the vehicle processor, it will be necessary to transmit link travel times to the individual vehicles. However, if optimal routing is performed at a fixed installation and transmitted to the vehicle, it will only be necessary to transmit the recommended routing to the vehicle. The manner in which this is performed will have a significant impact on the type of information transmitted (message content), required communications system capacity, and the frequency of transmission.

Working Group 4 also recommended that the International Standards Organization's (ISO) Open Systems Interconnection (OSI) model (see Appendix D) be considered as an appropriate model for defining IVHS communications standards. This model has been adopted by the communications community throughout the world as the basis for defining communications standards. In addition to providing a logical structure for communications standards, the model permits their evolutionary development as various elements of the system become defined.

Finally, this working group concluded that communications standards should he considered as an ongoing activity. The history of other standards-setting processes has demonstrated a continuing need for new and revised standards as new applications are identified and technological improvements are made.

Comparison of Alternative System Architectures

Issues
The choice of alternative architectures for communications systems can have a significant impact on system cost and communications standards.

Recommended Action
Compare architectures associated with beacons against architecture associated with area-wide coverage.

Potential Acting Organizations
- FHWA
- AASHTO
- IVHS America

Benefits
The action will ensure that standards will accommodate current and future applications of IVHS applications and encourage early development of systems and communications.

Urgency
Working Group 4 felt that the definition of message types and message content depends on the overall system architecture. For this reason, a high urgency has been assigned to tills problem statement.

System Requirements Analysis for Categories of Message Types

Issues
Six categories of message types have been suggested:

1. Broadcast outbound to all vehicles,
2. Unsolicited inbound from individual vehicle
3. Outbound response to individual vehicle,
4. Outbound to an individual or group of vehicles,
5. Inbound response from individual vehicle, and
6. Low power broadcast from vehicle.

Each category should be analyzed and requirements stated for each OSI protocol layer.

Recommended Action
Analyze IVHS functional requirements in each category and translate into ISO-OSI protocol standards for each layer (see "Identification of ISO-OSI layers appropriate for IVHS" paragraph.) as appropriate for the standard. Combine categories or expand categories as needed per results of analysis.

Potential Acting Organizations
- Universities and industries with expertise in communications and understanding of IVHS objectives.

Benefits
Allow graceful (efficient and cost effective) growth of IVHS across space, time and functionality (technology).

Related Work
- Other Work Group 4 problem statements
- Mobility 2000
- IVHS America

Urgency
General categories of message types must be identified for the various functions performed by an IVHS system. This work cannot be performed until the overall system architecture has been defined. However, this work should be initiated with a high urgency as soon as the work defined by Problem Statement 1 has been completed.

Definition of Message Types for Each Category

Issues
For categories defined in the *System Requirements Analysis for Categories of Message Types* paragraph, numerous message types will be required. A basic set of message types should be defined for IVHS compatibility, and a set of extensions should be allowed to accommodate value-added future services.

Recommended Action
Evaluate IVHS functional requirements as outlined by Mobility 2000 to identify message types (e.g., traffic information, weather). Subsequently, work can identify format, dimensions, etc., as IVHS designs evolve.

Potential Acting Organizations
- Universities and industries with expertise in communications OSI models and understanding of IVHS objectives.

Benefits
Allow efficient and cost effective growth of IVHS across space, time and functionality.

Related Work
- Other Work Group 4 problem statements
- Mobility 2000
- IVHS America

Urgency
This problem statement should possibly be combined with the work in the preceding problem statement and should be assigned the same level of urgency (High).

Definition of Message Content for Each Message Type

Issues
Each message type identified in the preceding problem statement will have numerous fields containing commands, data, status, etc.

Recommended Action
Each message type should be evaluated in terms of its error correction requirements, reliability of delivery, etc., and appropriate fields defined to minimize message length.

Potential Acting Organizations
- FHWA
- IVHS America
- NCHRP

Benefits
Standardization of message contents will facilitate reduction of data loading. Also, facilitate commonality and interoperability between different systems.

Related Work
- TravTek
- Other Work Group 4 problem statements

Urgency
This problem statement might also be combined with the second and third problem statements, as it is a necessary step toward the definition of communications standards. It has been assigned the same level of urgency as these preceding problem statements (High).

Identification of ISO-OSI Layers Appropriate for IVHS

Issues
Assuming that the ISO-OSI layered protocol is the appropriate model for the IVHS communications structure, a central question is which of the seven layers are appropriate for inclusion and which are appropriate for standardization. Further investigation of those layers appropriate for standardization is necessary to propose individual protocols.

Recommended Action
Review the IVHS functional requirements as outlined by Mobility 2000 to determine which, if any, of the seven layers may be eliminated, which can be left to individual organizations to implement, and which should be standardized. For those considered appropriate for standardization, develop a candidate protocol standard. Preliminary review suggests Levels 6 and 7 are left to industry. Level 5 may not be needed. Multiple standards may be needed for multiple solutions to Levels I and 2.

Potential Acting Organizations
- Universities and industries with expertise in communications OSI models and understanding of IVHS objectives.

Benefits
Allow efficient and cost effective growth of IVHS across space, time and functionality (technology).

Related Work
- Other Work Group 4 problem statements
- Mobility 2000
- IVHS America

Urgency
The immediate urgency of this problem statement is moderate because work cannot begin in this area until architectures and message contents have been defined. This work must also wait for the results of ongoing and future field trials, many of which will serve to define better the IVHS communications standards requirements.

IVHS Applications and Communications Implications

Issues
Identify future IVHS applications to ensure that they can be accommodated by defined architectures and communications standards. The recommended action is the same as for the previous statement.

Potential Acting Organizations
- FHWA
- IVHS America
- NCHRP

Benefits
To ensure that standards will accommodate future IVHS applications and encourage early development of systems and commercialization.

Related Work
- Other Work Group 4 problem statements
- Possibly on-going and planned demos.

Urgency
The urgency of this problem statement is high following the completion of the first 4 problem statements. This work will be used to verify the applicability of the developing, standards to anticipated IVHS applications.

Processes for Developing Standards (Working Group 5)

The U.S. Secretary of Transportation's 1990 policy statement singles out IVHS as the main thrust in new road transportation initiatives over the next ten years. The central issue is learning to use existing roads better. Its success depends significantly on how well the effort is coordinated.

Proposed Process for Developing IVHS Standards

Issues
Europe and Japan are far ahead of the U.S. in defining and deploying IVHS technology, mostly due to the government sponsorship of European organizations such as DRIVE and PROMETHEUS, and Japanese organizations such as AMTICS and RACS. The European organizations in particular have repeatedly expressed their concern that they do not know which U.S. organization to approach regarding IVHS standards, issues, and cooperation. International cooperation, from which the U.S. would be the particular beneficiary, has been hampered by the lack of an organization to serve as an umbrella for IVHS standardization in the U.S.

Recommended Action
Establish a committee to oversee the creation and approval of IVHS standards, Preferably, this committee will be ANSI accredited. Membership of this oversight committee should be drawn from the transportation industry, transportation-oriented government agencies, automotive and infrastructure suppliers, and university and other research organizations. When a need for a standard is perceived by a person or organization with IVHS interests (e.g. IVHS America), it can be submitted to the oversight committee for consideration at its regular meetings. In some cases, the oversight committee may determine that such a standard is already under consideration (or has previously been considered).

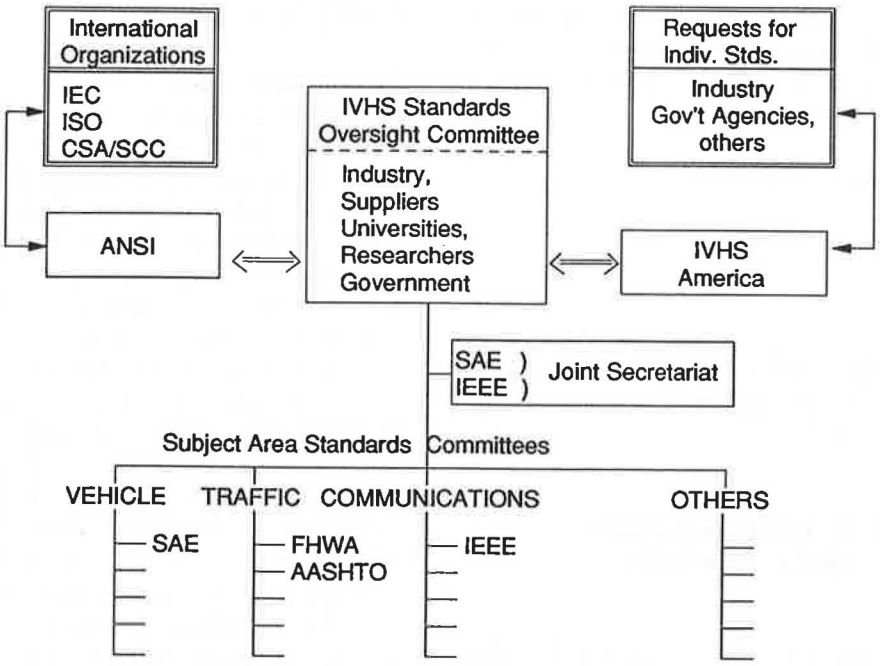
After the oversight committee decides that a new IVHS standard is needed, a committee member would be assigned to oversee the formulation of the standard. An ANSI-accredited organization (e.g., IEEE for communications standards, SAE for vehicle standards) would be assigned to sponsor and draft the standard, and a problem statement outlining the standardization need would be created and sent to the organization. The ANSI-accredited committee and the overseer would track the progress of the developing standard and prevent overlaps between development efforts. Standards drafts would be referred back to the committee for review and acceptance.

At times, standards will also be sponsored by non-accredited organizations (e.g., a standard on communicating with traffic signals by AASHTO). In these cases, the oversight committee will take a more active role in reviewing and approving the standards as American National Standards.

A major function of such an oversight committee would be to observe, track, and coordinate all IVHS standards efforts in the U.S., regardless of originating organization. As such, the oversight committee would serve as the U.S. focal point for IVHS standards with respect to the international IVHS community, a common point of contact for developing, accepting, and coordinating world-wide standards.

Potential Acting Organizations
Representatives of the IEEE and the SAE at the workshop have agreed to seek approval within their respective organizations to formulate a joint secretariat for an ANSI accredited committee for IVHS standards.

Possible Organizational Structure for IVHS Standards Oversight Committee*



Benefits

By the year 2000, an estimate of 20% of new-car cost will be for electronics. About half of these electronics (10% of cost) will relate to IVHS. With predicated annual U.S. sales of 16 million cars and an average price of $15,000 (both figures being highly conservative for 2000), intelligent vehicle systems will be a $24 billion per year industry.

Infrastructure (intelligent highway systems) can be expected to represent an annual expenditure of equal magnitude. Thus, IVHS can represent a $50 billion per year industry (or more), whose growth and prosperity in the U.S. will depend strongly on effective standardization.

Related Work

IVHS is a broad collection of inter-related technologies that are emerging in parallel from a multitude of sources. So far, very little attention, has been devoted to assuring the compatibility of these parallel technologies.

Subfields requiring standardization include:

- Driver information and support systems
- Automated traffic management systems
- Commercial and emergency vehicle operations
- Automated vehicle control systems
- Communications between roadway management systems and vehicles

Each standardization subfield will have many areas needing standards and several levels of sophistication (e.g. basic, standard, advanced). In turn, each of which should be compatible from the previous and succeeding level. Particular applications may depend on the achievement, by suppliers of standard products, of particular standardization levels.

Each standardization area also requires an interchange specification so that any consumer of a standardized commodity can receive and interpret that commodity regardless of how it was generated. For example, an on-board route guidance system should be able to make use of current traffic information whether it is produced by beacons, wide-area broadcasts, or in-road sensors.

Urgency

Standardization is needed urgently. This is a high level requirement.

*The relationship of the IVHS standards Oversight Committee to ANSI (American National Standards Institute) and IVHS America Intelligent Vehicle High Society of America) has been slightly modified to correspond with a later version presented to the IVHS America Steering Committee on January 18, 1991.

SUMMARY

A total of fourteen problems statements were generated by five working groups. These were ranked in order of importance within each Working Group and presented by the Group Leaders in the Wrap-up Session at the end of the Workshop. On the basis of the ensuing discussion of the Problem Statements, it was clear that the following four actions are of the highest priority:

1. Establish an IVHS Standards Oversight Committee at the earliest opportunity. Preferably, this committee will be ANSI-accredited. This committee would observe, track and coordinate all IVHS standards activities in the U.S., regardless of the originating organization, and would establish liaison with standards setting bodies in Canada, Europe and Japan. In particular, it should work in close cooperation with the ITU's CCITT and CCIR organizations on communications standards and protocols related to IVHS.

2. Carry out extensive systems analysis and trade-off studies to establish IVHS system architectures to ensure that standards will accommodate current and future applications and encourage early development and implementation of new systems. The overall system architecture should minimize communications capacity requirements since this is the most critical resource used by IVHS.

3. Evaluate and adopt if appropriate the ISO-OSI model* as the framework for defining IVHS communications standards, and identify which of the seven layers may be applicable and which may not be applicable.

4. Address frequency allocation and protocol standards needs for IVHS as soon as possible and make these needs known at the earliest opportunity to the FCC and other regulatory agencies as well as the general public.

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* An ISO reference model for OSI is shown in Appendix D.

APPENDIX A - IVHS COMMUNICATIONS STANDARDS WORKSHOP ATTENDEES

Albers, Walter
General Motors Research Laboratories

Barbas, Antonios
OECD

Blackburn, Ralph L.
CALTRANS

Bradley, Cedric F.
MD DOT

Case, Rye
Ministry of Transportation
Ontario, Canada

Chadwick, Jim
MITRE Corp.

Chen, Kan
Univ. of Michigan

Chung, Min
AT&T Bell Laboratories

Clark, Charles D.
CALTRANS

Cortland, Larry
UPS

Cottinet, Marcel
INRETS

Coughun, Sean
CALTRANS

Dey, Don
City of Anaheim

Donner, Robert
CALTRANS

Farber, Eugene
Ford Motor Co.

Fenichel, Robert M.
National Communications System

French, Robert L.
R. L. French & Associates

Fritz Bolte, Dr.-Ing.
BAST

Garry, Robert M.
Teletrac

Gelland, Alan
JHK & Associates

Gillan, Dr. W. J.
Transport and Road Research
Laboratory

Gomes, Lamberto
Ministry of Transportation
Ontario, Canada

Grant, Charles
WAY TO GO

Greenberg, Mark
WAY TO GO

Grencker, Gene
GA Tech. Research Institute

Havinoviski, Glenn N.
DKS Associates

Hecker, Joe
CALTRANS

Hensing, David J.
American Assoc. of State Highway &
Transp. Officials

Heti, Gabriel
Ministry of Transportation
Ontario, Canada

Johnson, Daniel L.
CALTRANS

Kaufman, Herb
Society of Automotive Engineers

Kawashima, Dr. Hiyonao
Keio Univ.

Kayton, Myron
Kayton Engr.

Kirk, Brian
Transport Canada

Kirson, Allan
Motorola

Kishore, Atul
Nissan Research & Development

Klijnhout, ir. J. J.
Rykswaterstaut Netherlands

Krage, Mark
General Motors Research Laboratories

Krueger, Michael E.
Hughes Aircraft

Lavigne, Dick
FHWA

Link, Wesley
MITRE

Lum, Wesley
CALTRANS

Mammano, Frank J.
FHWA

Marsden, Blair G.
Kimley-Horn & Associates, Inc.

Martell, Claude
Ford Motor Co.

Meyer, Stuart
IEEE/VTS + TIA

Mitchell, Beveraly
JHK & Associates

Mohaddes, Abbas
DKS Associates

Murray, Mel
Dept. of Commerce

Nakajima, Yuji
Nissan Research & Development, Inc.

Nordby, Anson
City of LA, Dept. of Trans.

Ohara, Kelly
Panasonic Industry Co.

Orne, Don
Michigan DOT

Perley, Daniel R,
Transport Canada AFCFB

Price, Charles P.
CALTRANS

Ristenbatt, Dr. Martin P.
University of Michigan

Rupert, Robert
FHWA

Schmidt, John
CALTRANS

Shields, Russ
NavTech

Schladover, Steven
U.C. Berkeley - PATH

Sullivan, Joe
US West Communications

Takasaki, Gerald M.
General Motors Research Laboratories

Wallace, C. E.
Univ. of Florida

Willis, David
The ATA Foundation

Winter, Walt
CALTRANS

Woods, John J.
The Inst. of Electrical &
Electronics Engr.

Woods, Jim
Federal Express

Wooldridge, M. J.
Dynamic Transport Mgmt., Ltd.

Zavoli, Walt
Etak, Inc.

APPENDIX B - IVHS COMMUNICATIONS STANDARDS WORKSHOP AGENDA

Wednesday Morning, June 20, 1990

8:15 am: Introduction and Workshop Objectives

- A3A01 Chairman
  Philip J. Tarnoff, Farradyne Systems

- Workshop Chairman
  Robert L. French, R. L. French & Associates

8:30 am: ADIS (Advanced Driver Information Systems) Communications Requirements and Approaches

- Allan Kirson, Motorola

9:00 am: Other IVHS Communications Requirements

- Moderator
  Frank J. Mammano, FHWA

- Topics/Panelists:

Advanced Traffic Management Systems
Philip J. Tarnoff, Farradyne Systems
Commercial Vehicle Operations
Jun Woods, Federal Express
Vehicular Automation
Steven E. Schladover, ITS/UC Berkeley
Emergency Services & Public Safety
Gary D. Gray, Orange County Communications
Vehicle Security
Eugene F. Greneker, Georgia Tech Rsrch Inst

10:30 am: Break

10:45 am: European Communications Standards Activities

- William J. Gillan, TRRL

11:15 am: Japanese Communications Standards Activities

- Hironao Kawashima, Keio University

11:45 am: Proposed Standard for Federal Mobile Radio

- Robert M. Fenichel, Nat'l Comm. System

12:15 am: Lunch

Wednesday Afternoon, June 20,1990

1:30 pm: Standards Organizations & Procedures

- Moderator
  Wesley B. Link, MITRE

- Organizations/Panelists:

Institute of Electrical and Electronic Engineers
John Woods, IEEE Standards Office
Society of Automotive Engineers
V. Herbert Kaufman,
SAE Land & Sea Technical Division
Telecommunications Industries Association & Electronics Industries Association
Stuart Meyer, Consultant
American Association of State Highway Transportation Officials
David J. Hensing, AASHTO
Nat'l Telecommunications & Info. Agency
Melvin J. Murray, NTIA
Federal Communications Commission
Stuart Meyer, Consultant

3:00 pm: Formation of Individual Working Groups

- Coordinator
  E. Ryerson Case,
  Ontario Ministry of Transportation

- Working Groups/Leaders:

Specific Research Requirements
Kan Chen, University of Michigan
International Compatibility
Lamberto Gomes,
Ontario Ministry of Culture & Communication
Commonality and Interoperability
Walter A. Albers, General Motors
Content and Format of Standards
Philip J. Tarnoff, Farradyne Systems
Processes for Developing Standards
T.Russell Shields, Navigation Technologies

3:15 pm: Break

4:00 pm: Individual Working Groups Meet to Discuss Objectives and Plan Working Sessions

5:00 pm: Adjourn

Thursday, June 21, 1990

8:15 am: Individual Working Group Sessions to Prepare Draft Problem Statements Considering:

- Specific Research Requirements
- International Compatibility
- Commonality and Interoperability
- Content and Format of Standards
- Processes for Developing Standards

12:15 am: Lunch

1:30 pm: Presentation and Discussion of Draft Problem Statements

3:00 pm: Break

3:15 pm: Wrap-up Session

- Coordinators:
  E. Ryerson Case,
  Ontario Ministry of Transportation
  Min I. Chung, AT&T Bell Laboratories,
  Philip J. Tarnoff, Farradyne Systems

- Consolidation of Research Problem Statements and Plans for Documenting Workshop Results

- Recommendations and Plans for Further Actions

4:15 pm: Adjourn Workshop

APPENDIX C - GLOSSARY

Term or Acronym	Definition
AASHTO	American Association of State Highway and Transportation Officials
ADIS	Advanced Driver Information Systems
ALI-SCOUT	Auto-Leit und Informatiossystem (an IVHS system being tested in Berlin for three years)
AMTICS	Advanced Mobile Traffic Information and Communication System (under development in Japan)
ANSI	American National Standards Institute
ATMS	Advanced Traffic Management Systems
AVCS	Automatic Vehicle Control Systems
CCIR	International Consultative Committee for Radio
CCITT	International Consultative Committee for Telegraph & Telephone
CSA	Canadian Standards Association
CVO	Commercial Vehicle Operations
DIS	Driver Information Systems
DOC	Department of Communications, Canada
DRIVE	Dedicated Road Infrastructure for Vehicle Safety in Europe
ECMT	European Committee of Transportation Ministries
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
IEC	International Electrotechnical Commission
IEE	The Institute of Electrical Engineers
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
IVHS	Intelligent Vehicle Highway Systems
ITU	International Telecommunications Union
NAS	National Academy of Sciences
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTIA	National Telecommunications and Information Agency
OSI	Open Systems Interconnection
PROMETHEUS	Program for European Traffic with Highest Efficiency and Unprecedented Safety
RACS	Road Automobile Communication Systems
R&D	Research and Development
SAE	Society of Automotive Engineers
TRB	Transportation Research Board
USDOT	United States Department of Transportation

APPENDIX D - ISO REFERENCE MODEL FOR OPEN SYSTEMS INTERCONNECTION (OSI)