Precursor Systems Analyses of Automated Highway Systems

RESOURCE MATERIALS

Legal, Institutional and Societal Issues Related to the Deployment and Operation of an Automated Highway System

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FOREWORD

This report was a product of the Federal Highway Administration's Automated Highway System (AHS) Precursor Systems Analyses (PSA) studies. The AHS Program is part of the larger Department of Transportation (DOT) Intelligent Transportation Systems (ITS) Program and is a multi-year, multi-phase effort to develop the next major upgrade of our nation's vehicle-highway system.

The PSA studies were part of an initial Analysis Phase of the AHS Program and were initiated to identify the high level issues and risks associated with automated highway systems. Fifteen interdisciplinary contractor teams were selected to conduct these studies. The studies were structured around the following 16 activity areas:

> (A) Urban and Rural AHS Comparison, (B) Automated Check-In, (C) Automated Check-Out, (D) Lateral and Longitudinal Control Analysis, (E) Malfunction Management and Analysis, (F) Commercial and Transit AHS Analysis, (G) Comparable Systems Analysis, (H) AHS Roadway Deployment Analysis, (I) Impact of AHS on Surrounding Non-AHS Roadways, (J) AHS Entry/Exit Implementation, (K) AHS Roadway Operational Analysis, (L) Vehicle Operational Analysis, (M) Alternative Propulsion Systems Impact, (N) AHS Safety Issues, (O) Institutional and Societal Aspects, and (P) Preliminary Cost/Benefit Factors Analysis.

To provide diverse perspectives, each of these 16 activity areas was studied by at least three of the contractor teams. Also, two of the contractor teams studied all 16 activity areas to provide a synergistic approach to their analyses. The combination of the individual activity studies and additional study topics resulted in a total of 69 studies. Individual reports, such as this one, have been prepared for each of these studies. In addition, each of the eight contractor teams that studied more than one activity area produced a report that summarized all their findings.

Lyle Saxton
Director, Office of Safety and Traffic Operations Research and Development

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16. Abstract

This report documents a study of Institutional and Societal Aspects of Automated Highway Systems (AHS) for the Federal Highway Administration (FHWA). This study covers one of sixteen activity areas in FHWA's program "Precursor Systems Analysis of Automated Highways." Automated highway systems (AHS) will likely incur the most institutional, legal and societal impediments of any IVHS user service. The basic assumptions for an AHS include a reduction in the level of personal control individual drivers have over their vehicles. Several non-technical, but critical issues have been examined that will help identify and develop the institutional frameworks required to deal with AHS. These issues include vehicle/operator certification, product liability, project financing and the impact of AHS on other transportation services and land use development patterns. This study was based on an integrated "legal-technical" perspective of the institutional and societal aspects of AHS in a systems analysis that is grounded in actual implementation experience. Insight is presented into institutional problems at the state and local level by focusing on planning and operations processes and multi-jurisdictional issues. Potential financing alternatives are examined as well as evolutionary deployment strategies. Recommendations on preferred institutional frameworks for the various AHS concepts are also discussed.

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EXECUTIVE SUMMARY

This report documents a study of Institutional and Societal Aspects of Automated Highway Systems (AHS) for the Federal Highway Administration (FHWA). This study covers one of sixteen activity areas in FHWA's program "Precursor Systems Analysis of Automated Highways." Automated highway systems (AHS) will likely incur the most institutional, legal and societal impediments of any IVHS user service. The basic assumptions for an AHS include a reduction in the level of personal control individual drivers have over their vehicles. Several non-technical, but critical issues have been examined that will help identify and develop the institutional frameworks required to deal with AHS.

Suggested approaches to mitigating the issue of tort liability have centered around tort reform, that is placing caps on damage awards, limiting the terms under which punitive damages may be sought and special exemptions from liability for protected products. Federal tort reform measures have been difficult to pass. The Systems Definition phase of the AHS program should seek to minimize the risk of failure (and the coincident cost of liability) through a comprehensive and iterative design process. This should be a pro-active approach, which seeks to prevent injuries due to product failure, and not a defensive approach against possible litigation. This pro-active approach will compliment any possible tort reform or special protection that may be found politically feasible.

The FAA regulatory model is recommended as a potential AHS regulatory model. The AHS vehicle designs, infrastructure design and operation, and driver certification will need to be uniformly safe across all manufacturers and within all states. However, this does not mean that the AHS regulatory process has to be solely vested in the federal government. The path that leads to an AHS regulatory model must start with the existing regulatory framework. As AHS matures and is deployed, the regulatory framework will have to evolve toward one which is inclusive of all the current stakeholders (NHTSA, FHWA, FTA, state DOTs and state DMVs, state and local public safety agencies) and capable of regulatory functions similar to those used in the airline industry.

Many of the current regulatory roles assumed by stakeholders will be familiar, but will take on added importance within the context of AHS. Some of the recommended roles are different in ways not as subtle as the table entries suggest. For example, FHWA has never been in the business of setting standards. Roadway design criteria have been the responsibility of the American Association of State Highway and Transportation Officials (AASHTO), with support from FHWA. An AHS will require much more stringent design criteria.

The funding of an AHS facility will likely be undertaken much like any other transportation system improvement. This issue was examined in light of ISTEA and CAAA requirements and emerging trends in public/private and wholly private financing of transportation projects. The good news is that all existing forms of funding for conventional roadway and transit projects are available for AHS projects. Even with the completion of the interstate program, however there is still a shortfall in funding for all transportation infrastructure improvements.

This means that AHS projects will have to provide benefits that exceed those offered by conventional projects. Funding alternatives available will depend on how much better the AHS project is than competing alternatives. This includes the null or “do nothing” alternative where the cost of the improvement must be weighed against the cost of continued congestion and poor mobility. Given a benefit/cost ratio only slightly greater than the competing alternative, an AHS project will be too great a risk for private financing (including toll financing) and would require public funds to implement the project. With a greater improvement in the benefit/cost ratio, public-private partnerships or toll financing allow the leveraging of public funds with reduced risk to private investment. Only AHS projects with a significant advantage in terms of benefits and costs will be attractive enough to be considered for wholly private financing.

A number of structural and organizational issues were examined concerning public-private partnerships. These include the issue of differing roles, private use of public funds and authority, mistrust between partners and apportionment of liability. The most important issues within this list can be mostly solved through better

communications between the partners. This means taking the time to explain what each partner_s roles are and what the expectations will be for the project.

It is recommended that standards of practice be established for public-private partnerships. These would include model ordinances spelling out the “rules of engagement” and the general require ments of all parties. These standards should be developed by FHWA or some other third-party entity. These standards of practice could then be used by the state or local agency to serve as a basis for contracts or enabling legislation.

The potential public acceptance of AHS vehicles and services was projected by studying the results of the evaluation of the TravTek operational field test. The TravTek results showed a high enthusiasm for the IVHS user services offered. The level of control that the guidance system had over the drivers_ route choice was not reported as a concern. Perceived safety and other benefits contributed to a reported positive influence on the quality of life by the technology.

A recommended approach to developing and maintaining public acceptance and support of AHS must include highly visible demonstration projects like TravTek. This should include a series of public tests of various elements of an AHS (e.g., intelligent cruise control, collision avoidance, etc.). Coordinated with the planned 1997 demonstration of a full AHS prototype, this campaign will make the public aware of the capabilities and potential for all elements of an AHS. This will stimulate market demand and allow a more natural evolution and deployment of AHS enabling technologies in both the automobile industry and the transportation infrastructure.

The TravTek results that showed a higher regard for personal mobility and safety over environ mental concerns should be reviewed in light of the fact that these were private responses. Public sentiment will include these personal desires, but tempered with a desire to protect the environment as well. Therefore, any public relations campaign must be able to show positive energy and environmental benefits attributable to AHS.

The approach to dealing with the environmental requirements of ISTEA and CAAA in urban areas centers on two aspects of how an AHS might be planned and developed. One aspect is the type of vehicle to be used. The mobility needs of most urban areas cannot be met by conventional mass transit because of low development densities. Nor can these needs be met with additional conventional highway lanes. The use of AHS technology by transit and other HOVs could provide the missing link between line haul mass transit and less dense areas. A second aspect is the type of corridor served. A highly developed corridor with excess demand and too little room for expansion could increase peak period through-put via an AHS. Vehicle miles of travel would not increase, but levels of service would improve during peak periods. Finally, the projected benefits of AHS must offer real solutions to both mobility and the environment.

It has become clear, even given the brief history of the IVHS program, that the institutional framework which builds and operates conventional highway and transit systems cannot continue to do "business as usual" and expect to efficiently deploy and operate high technology transporta tion systems. This finding is supported by studies of the IVHS operational test program and interviews conducted as a part of this PSA study.

As the required skills and duties of those involved in delivering transportation services change with more and more highway and transit automation, the organizational structure of state and local DOTs will have to adapt. A recommended way for local governments to approach this change is through a coordinated program of in-house training and privatization. This approach builds a base of knowledge within the organization while encouraging the wide spread dissemina tion of methods and procedures within the private sector. The operational framework for an AHS should be an outgrowth of that now emerging for IVHS technologies.

Findings Critical to the Success of AHS

The following are three key findings that should be included as some of the most important non-technical issues to be resolved for the future success of AHS.

Tort Liability

- Product liability presents a potential impediment to the deployment of AHS since the cost to settle tort claims could make the cost of the system prohibitive.

- Product liability costs can be controlled or transferred, but not eliminated

  - The primary way to control tort liability costs is through careful design of AHS products and careful operation of AHS facilities. Such due care and diligence will reduce the probability and/or severity of injury due to product failure, malfunction or misuse.

  - Federal or state legislation which limits damage awards or grants a special "exemp tion" from product liability for the AHS industry (as for the airline and pharmaceu tical industries) transfers some of the cost of product caused injuries from manu facturers or operators to the injured parties.

  - Product liability costs are transferred to all users of the AHS service through incremental costs added to products and services. This type of "cost transfer" is currently practiced by the automobile industry to cover damage awards and settlements in product liability cases.

Financing & Deployment

- All financing options open to conventional highway or transit construction modes are available to potential builders of an AHS.

- All deployment criteria (e.g., ISTEA and CAAA) that apply to conventional transportation improvements will apply to AHS products. CAAA conformity determinations will apply to both public and privately financed projects.

- All financing options will be heavily dependant on the ability of AHS to provide expected benefits. For public financing, the AHS must satisfy a major investment analysis for the use of public funds. For private financing, property values and/or user fees must be able to provide a profit motive.

Organizational Frameworks

- Most State and local DOTs are ill-equipped to handle the complex tasks associated with deployment and operation of an AHS. This is a structural shortcoming that will likely require a revamping of state and local personnel and organizational frameworks.

- Even with the private development and operation of AHS, a public supervisory bureau cracy will be required to support public acceptance of AHS. NHTSA not withstanding, this bureaucracy does not now exist and must be created.

Issues and Risks That Will Have Significant Impact on AHS

The issues surrounding tort liability represent a moderate level of risk to further development of AHS. This risk is not seen as a potential showstopper unless total costs cannot be contained or if safety is less than a sure thing. Either of these events may result in a total product cost that is financially infeasible once the product liability costs are built in.

The resolution of regulatory issues will shape the ultimate mode of deployment and operation of AHS. At the federal level, a design and production certification process that quickly processes manufacturer AHS design submittals will enable the quickest most cost effective deployment of AHS ready vehicles. Whether this federal involvement is from NHTSA or some other agency depends on the evolving mission of FHWA .

Issues and Concerns for Further Study and Resolution

The ability of AHS to meet environmental requirements will depend heavily on the primary and secondary benefits of this user service. Projections for conventional travel and ridership demand are often only educated guesses. The role of AHS as a potential tool for transportation planners to use in solving mobility problems will depend on ongoing and future studies of the benefits and impacts of transportation system improvements. This must also include the demonstration of projected AHS benefits.

Market acceptance of AHS is an area where there is still too little data to make a projection regarding future demand for this user service. The concept of fully automated travel is still a far fetched one for many consumers. Future market acceptance studies should not only measure the consumer's desire for AHS user service, but should correlate this desire with their understanding of the concept and willingness to pay for the service.

1. INTRODUCTION
BACKGROUND OF AUTOMATED HIGHWAY SYSTEMS PROGRAM

The concept of fully automated highway travel has been studied, at varying levels of intensity, for several decades. This concept, defined as an un-tracked vehicle (automobiles, trucks, and/or buses) under full automated control travelling along a roadway that, except for the automation capabilities, is not unlike a conventional roadway section. Early efforts failed to find a feasible technological solution at a price that could be justified either by the benefits received or the demand in the marketplace.

More recent technological advances, however, have suggested that fully automated vehicle/highway travel could be developed at a reasonable cost to users. These breakthroughs come also at a time when there is a high demand for solutions to the mobility needs of urban centers across the United States. Many of the potential solutions used in the past -- additional lane-miles of roads and freeways -- are no longer acceptable due to their high costs and impacts on neighbor hoods and the environment.

The concept of an automated highway system (AHS) began to take place within the overall context of other technologically advanced ways of enhancing urban mobility while at the same time improving highway safety. Efforts to reduce the number and severity of vehicle crashes on our highways led to the development of concepts for improving the ability of the vehicle to avoid crashes and deal with adverse situations such as weather. Recent research in this area suggested that automated control of the vehicle would be a feasible and cost effective solution for some problem areas. With automated control of the vehicle, certain limitations on highway capacity can be raised. For example, vehicle headways can be reduced, thus increasing vehicle throughput, since automated control is much faster that human perception and reaction. Speeds can also be increased for the same reasons. Automated merge and diverge operations can be accomplished with higher precision and capacity. Preliminary studies showed that automated control could offer significant benefits to the travelling public.

These emerging AHS concepts showed enough promise that Congress included a requirement in the Intermodal Surface Transportation and Efficiency Act (ISTEA) for the study of automated vehicle-highway systems and a demonstration of a fully automated highway system by 1997[1]. In response, the AHS Program was formally begun in 1992 and integrated into the Federal Highway Administration's (FHWA) ongoing Intelligent Vehicle-Highway Systems (IVHS) initiative. Since its initiation, the AHS program has developed closer ties to the Automated Vehicle Control Systems (AVCS) program being advanced by the National Highway Traffic Safety Administration (NHTSA) and the Advanced Public Transportation Systems initiative under the direction of the Federal Transit Administration (FTA).

Overview of Precursor Systems Analysis Program

The AHS program has been organized into three phases. The first of these is the ***Analysis Phase*** which includes a wide range of technical, human factors, and non-technical studies that will provide a technical and procedural basis for further refinement of the AHS system design. This will be followed by the ***Systems Definition Phase*** which will be conducted, in part, by a consortium of researchers and stakeholders including the automotive industry, highway builders, state and local transportation agencies in partnership with the Department of Transportation (DOT). An interim output of this phase will be the 1997 demonstration of an AHS prototype. The third and final phase, the ***Operational Evaluation Phase*** will begin early in the 21st century to deploy one or more AHS facilities at selected U.S. locations.

A major element of the analysis phase is the Precursor Systems Analysis (PSA) program of which this study is a part. In the summer and fall of 1993, FHWA awarded 15 contracts to study 16 activity areas related to AHS development. The PSA activity areas under research include:

- Urban and Rural AHS Comparisons;

- Automated Check-In;
- Automated Check-Out;
- Lateral and Longitudinal Control Analysis;
- Malfunction Management and Analysis;
- Commercial and Transit AHS Analysis;
- Comparable Systems Analysis;
- AHS Roadway Deployment Analysis;
- Impact of AHS on Surrounding Non-AHS Roadways;
- AHS Entry/Exit Implementation;
- AHS Roadway Operational Analysis;
- Vehicle Operational Analysis;
- Alternative Propulsion Systems Impact;
- AHS Safety Issues;
- Institutional and Societal Aspects; and
- Preliminary Cost/Benefit Factors Analysis.

Each of these activity areas is being addressed by at least two contractors with some areas being worked by up to six different contractors. The research in all areas was conducted in a very collaborative manner. Interim results were presented at a workshop held in April, 1994. Discussions among contractors working similar activity areas were held frequently at conventions, committee meetings or via tele-conference.

It is the intent of FHWA that the PSA program present a package of results to the AHS Consor tium to use in the Systems Definition Phase. This package will include the findings, recommenda tions and remaining concerns developed throughout the PSA research areas.

INSTITUTIONAL AND SOCIETAL ASPECTS ACTIVITY AREA

The study of institutional and other non-technical issues that can affect the deployment of all IVHS technologies has been the focus of on-going FHWA projects ever since the inception of the IVHS initiative. These issues were deemed so important to the IVHS program that Congress included a special requirement in the ISTEA bill that the DOT prepare two special reports on the subject1[1]. The first of these reports has recently been released[2] with a follow-up report scheduled for 1996.

For the AHS PSA effort, the Broad Agency Announcement stated the primary objective of the study of Institutional and Societal Aspects is to *"identify and analyze the institutional portions of the AHS system that must be in place before the AHS is deployed and becomes operational; also, analyze the major societal issues and risks faced by the program. Define potential courses of action for dealing with them."*

Within the PSA program, this activity area will address a wide variety of issues, including:

- Regulatory - dealing with insurance, vehicle manufacturing, and roadway construction;
- Legal aspects of AHS including tort liability, legislative requirements and zoning;
- Licensing of operators and vehicles, including both the pre-operational phase and the real-time check-in requirements during operation;
- Funding alternative AHS including federal and state deployment and operations, licensing fees, use fees, vehicle purchase costs, taxation, penalties for non-AHS vehicles, etc.;

1 Section 6054, Part D of the Intermodal Surface Transportation Efficiency Act of 1991. Public Law 102-240.

2 Non-Technical Constraints and Barrier to Implementation of Intelligent Vehicle-Highway Systems - A Report to Congress, Office of the Secretary, U.S. Department of Transportation, June, 1994.

- Zoning and environmental impacts;
- Access and priority for local fire, ambulance and police; and
- Impact on interstate commerce.

Additionally, this activity will identify the major societal aspect faced by AHS. This will include issues of public acceptance, market incentives, liability, legislation and impact on the quality of life and quality of environment.

For each real or potential issue, the activity will suggest possible courses of action for dealing with the issue.

SPECIFIC FOCUS OF THIS EFFORT

This study has used "legal-technical" perspective to focus its study of the institutional and societal aspects of AHS. This perspective is also shaped via a systems analysis process that is grounded in actual implementation experience. The approach is designed to complement more academic assessments (e.g., legal briefs, interpreta-tions, legal case histories, etc.) of institutional barriers being conducted by FHWA in other forums. It also is structured to provide particular insight into the operation of institutional problems at the state and local level by focusing on transportation and land use planning processes and multi-jurisdictional issues at that level.

ISSUES ADDRESSED

A long list of institutional and societal issues related to IVHS have been developed based on the experience of the operational test and early deployment programs. Many of these issues have been carried over from the IVHS program with the expectation, at least, that these issues will have some of the same impact on the AHS program.

As one of several contracts to study these issues as they relate to AHS and with a somewhat unique legal-technical approach, this effort has focused on the following specific issues:

- **Legal** Tort liability (and in particular product liability) and sovereign immunity are among the most important legal issues addressed. These issues have been important to other IVHS technologies; however, the AHS concept will likely magnify these issues due to the higher level of control and responsibility assumed by the system;

- **Regulatory** The institutional framework in which AHS is deployed and operated will govern how AHS infrastructure and operators are licensed and/or certified. From the standpoint of the system operator, this issue has risen in other IVHS technologies. ATIS systems, for example have had to deal with how to regulate the flow of information, especially when a private enterprise is involved. With an AHS, regulation or licensing of the consumer may be necessary to assure safety.

- **Funding Alternatives** The funding of an AHS facility will likely be undertaken much like any other transportation system improvement. This issue is addressed in light of ISTEA and CAAA requirements and emerging trends in public-private and wholly private financing of transportation projects.

- **Public-Private Partnerships** In addition to the issues related to public-private financing, there are a number of other issues related to these types of arrangements. These include the issue of differing cultures and roles, private use of public authority (e.g., eminent domain and condemnation) and apportionment of liability.

- **<u>Societal Aspects</u>** The acceptance of a new technology is always based on each individid ual's assessment of cost (and risk) to perceived benefit. This issue is addressed by evaluating some recent operational test data from the TravTek project.

- **<u>Environmental</u>** Recent legislation (ISTEA and CAAA) have outlined specific environ mental requirements that must be addressed prior to the public deployment of an AHS facility. Parallel activity areas are just beginning to assess the potential impact of an AHS on the environment. These impact assessments will suggest the potential for AHS to provide a solution to these environmental concerns.

- **<u>Organizational</u>** It has become clear, even given the brief history of the IVHS program, that the institutional framework which builds and operates conventional highway and transit systems cannot continue to do "business as usual" and efficiently deploy and operate high technology transportation systems. Without attempting to "re-invent" government, this study addresses potential institutional frameworks that could provide the necessary bureaucracy to oversee AHS deployment and operation.

OVERALL APPROACH FOR THIS EFFORT

The goals of this effort, a systems study of the institutional and societal aspects, are to identify the major institutional impediments to the implementation of AHS; identify a deployment approach that minimizes the impact of AHS on society and; develop an institutional framework that facilitates AHS systems while working within accepted limits of legal and regulatory practice.

As new technologies are developed and deployed into the marketplace, they emerge into a society governed by a legal framework that has evolved, in the United States, over a period of two hundred years and which is based on English law that has several hundred more years of history. Thus, new technologies, such as AHS, must be able to function within this existing framework. A prime objective of this study has been to identify what elements of this legal framework might be a barrier to the full deployment of AHS. "Evolution" is a key word in the study of this legal framework as the law and its application have changed over the years in response to the needs of society. Therefore, a sub-objective of this study is to recommend what changes will be needed (and which might be feasible) to enable the implementation of AHS.

There are three basic categories of transportation facility ownership that have been used in the past: 1) wholly owned and operated by public agencies; 2) privately owned and operated and; 3) public/private partnerships. The realities of public sector fiscal constraints have all but eliminated the first category. The inherent risks involved with new technology, especially an AHS, will make the second category, private development of an AHS, an unlikely situation. The third category, a public/private partnership, offers the most promise for deployment of many IVHS services. The ***Strategic Plan for IVHS in the United States***, prepared by IVHS America, projects that nearly 80 percent of the development and implementation costs of IVHS will come from the private sector. Thus, one objective of this study of the Institutional and Societal Aspects of AHS is to assess the capability of various forms of public/private partnerships to form the basis of imple menting an AHS.

Another objective is to assess the capability of current institutional frameworks that deploy and operate conventional transportation systems -- namely state and local departments of transportation (DOTs) -- to deploy and operate an AHS. These existing institutions will be required to incorporate AHS into the transportation planning process as a potential solution for the mobility needs of each local region.

Inventory and Review of AHS System Configurations and Comparable Systems

When deployed, AHS could take one of several different configurations. The current PSA studies and the subsequent systems definition phase will design how all of the components will come together. In order to provide a basis upon which to conduct this study of institutional issues, a set of probable system configurations were developed. Known as Representative System Configura tions (RSCs), emphasis was on system concepts offering the widest range of challenges to the institutional framework and impacts on society.

A starting point for this work lies in AHS analyses conducted earlier for FHWA. One particular study by Bender[3] presents the results of an extensive series of preliminary systems studies of AHS. The basic configurations studied in this report may be divided between two system types: a "smart vehicle" system in which each vehicle carries its own (permanent or detachable) control systems and requiring only basic information from the infrastructure; and an "average" system in which the control intelligence is distributed more or less equally between the vehicle and infrastructure.

The definition of RSCs allows the evaluation of trade-offs between the technological, administrative and political aspects of these basic system concepts. Bender's "smart vehicle" and "average," configurations will form the starting point for the development of RSCs with some refinement to allow for technology considerations advanced as part of other activity areas of the PSA program. A third category is termed the "hybrid" system configuration and would allow for the best features of the smart vehicle and average concepts as improved technology allows. A set three RSCs, based on these concepts, was developed for use a basis for further analysis. These RSCs and their operational concepts and are defined in more detail in Section 2. It should be noted that these RSCs will not necessarily be the same as developed in other PSA studies. They are sufficiently broad in concept, however to allow findings based on these RSCs to be applied to other concepts and configurations.

Institutional & Legal Issues Associated with Each System Configuration

The approach for this element of the study was to identify overall legal and institutional issues for an AHS. Then each RSC was evaluated to identify key issues that may be unique to a particular configuration.

The identification of these issues was led by a team of legal experts with experience in the financing and deployment of transportation improvements. Particular reference is made to recent experience with the development of a private toll road in Virginia including the issues associated with both the financing and land acquisition associated with this project. Additional review is provided by legal experts with national experience in innovative financing of transportation and other public works projects.

Equally important to this approach is a focus on deriving procedural and institutional models from the frameworks developed for comparable systems. For example, the certification process under development for automated aircraft take off and landing systems provides lessons for a similar process for AHS certifications. In general, aviation law offers a number of parallels for address ing legal and regulatory aspects of AHS.

Societal and Behavioral Issues

One of the key issues affecting the implementation of an AHS will be the ability (or willingness) to pay for the system. An important resource to resolving this issue is the results of some important IVHS operational tests. The TravTek test in Orlando, Florida provides some meaningful insights into the behavior of the travelling public.

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[3] Bender, James G., "An Overview of Systems Studies of Automated Highway Systems," IEEE Transactions on Vehicular Technology, Vol. 40, No. 1, February, 1991.

This evaluation includes the acceptance of the technol ogy by the drivers as well as an assessment of the willingness to pay for a premium service. This approach is not a study of human factors, but of social acceptance.

Develop & Evaluate Candidate Institutional Frameworks for Implementation of AHS System Configurations

The results of previous tasks will recommended candidate institutional frameworks for AHS system configurations. The analysis first identifies how each framework addresses the legal, regulatory, social and behavioral issues raised so far in this study. Then, each candidate frame work is evaluated on the basis of the feasibility of constructing, maintaining and operating the AHS system. The analysis focuses on the financial structure, licensing requirements, and other institutional and legal issues raised by each particular AHS configuration.

An important step in this evaluation process is the assessment of the political acceptability of different institutional frameworks. To accomplish this, a series of interviews were conducted with key officials involved with transportation planning and implementation in two major metropolitan areas: Atlanta, Georgia and Washington, D.C. The interviews were conducted informally and discussions were centered around a "straw-man" description of how AHS would operate and what some of benefits would be. The resulting comments and concerns from these transportation officials were recorded.

Assessment of "Lessons Learned" and Recommended Next Steps

This step will extract the key lessons learned in this activity area. Experience has shown that institutional arrangements do not spring up quite as quickly as technology advances. Thus, the recommendations presented focus on ways to enable existing frameworks, such as state and local DOTs and emerging frameworks, such as public/private frameworks, to take AHS from demon stration to deployment.

GUIDING ASSUMPTIONS

Several baseline assumptions guided the implementation of the approach outlined above. These assumptions were stated in the Broad Agency Announcement (RFP No. DTFH61-93-R-00047) and are summarized as follows:

1. All vehicle types (automobiles, buses, trucks), although not necessarily intermixed, must be supported in a mature system.

2. The vehicles will contain instrumentation that will allow the AHS to control the vehicle when it operates on instrumented segments of the roadway.

3. Not all vehicles will be instrumented and not all roadway will be instrumented:

   a. instrumented vehicles will be able to operate on non-instrumented roadways,
   b. only instrumented vehicles will b e allowed to operate on instrumented roadways, and
   c. non-instrumented vehicles will instrumentable on a retrofit basis.

4. Operation in a freeway type of roadway is assumed.

5. The AHS will perform better than today's roadway in all key areas including:

   a. Safety
   b. Throughput
   c. User Comfort
   d. Environmental Impact

6. The AHS will be practical, affordable, desirable, and user-friendly.
7. The AHS will operate in a wide range of weather conditions typical to that experienced in the continental U.S.

8. AHS primary system control and guidance will rely on non-contact electronics-based technology as opposed to mechanical or physical contact techniques.

In addition to the baseline assumptions listed above, early research results and presentations by the automotive industry led to another realization: the technology needed to construct a viable AHS exists now or will in the very near future. This realization also guided this study of the institutional and societal aspects and, in fact, emphasized the importance of dealing with the non-technical barriers to AHS implementation.

2. REPRESENTATIVE SYSTEM CONFIGURATIONS

BACKGROUND

Since no operational AHS has been deployed and few concepts have advanced to any appreciable level of detail, the PSA process requires one or more starting points for the various activities. These starting points have been defined as Representative System Configurations (RSCs). Each RSC represents both a system design or architecture and an operational concept and differs from one another in one or more distinguishing characteristics.

The AHS program has identified four distinguishing characteristics that separate different concepts from one another. These characteristics are *Infrastructure Impact, Traffic Synchronization, Instrumentation Distribution, and Operating Speed*. Further analysis within each of these categories is described in a report by MITRE, "Supplementary Description of Automated Highway Systems." In the MITRE study, the major physical and functional components of an AHS are identified as:

- Vehicle
- Roadway Infrastructure
- Command and Control
- Entry/Exit Infrastructure
- Communications
- Operations and Maintenance

The function and distribution of the first three components will distinguish all AHS concepts from each other, however, the last three have implications for this study of institutional issues. The different concepts of AHS Command and Control are what define the difference between the Smart Car/Dumb Highway and the Smart Highway/Dumb Car configurations.

The vehicle type may not play that much of a part in distinguishing between different concepts. Vehicles that manufactured as "AHS ready" could be outfitted, at a latter date, with a detachable electronics package (DEP) as described in the Bender study[4] . The DEP used by an AHS facility in one particular corridor may be different from that used on another AHS facility. The concept of operations could be different as well.

Roadway infrastructure includes the physical dimensions of the AHS roadway and the interaction between the vehicle and the roadway. Most concepts envision a self-powered rubber-tired vehicle on a freeway type surface. The concept of special "trucks" or pallets that could carry a conven tional vehicle in fully automated mode is clearly a separate and distinct concept. In one sense there is an existing comparable system for this concept in the Amtrak Auto-Train. Further development of this concept as an AHS configuration would include fully automated operation on a freeway type facility. This type of configuration would have very different institutional and legal issues since the level of interaction between the driver and vehicle is greatly reduced when on the pallet. Also, there is third major system component, the pallet, with its own issues of product liability and operation and maintenance responsibility.

The roadway infrastructure category of distinguishing characteristic also includes the type and distribution of power from the roadway to the vehicles. The idea of an AHS providing electric power to the vehicles while they are on the facility is being explored. The means of transmission could include a physical connection similar to the "third rail" used by electric trains or a non-contact method that used microwaves or induction. The provision of power as another "service" of an AHS brings another institution, the power company, into the system. It would seem, however, that the provision of power is more of a variable within a configuration type, especially for the purpose of examining institutional issues.

This brings us to the Command and Control functions as distinguishing characteristics. The MITRE paper describes the primary command and control variables as (1) the location of the inter-vehicle coordination and incident management functions and (2) the location of (some of) the vehicle control functions. These variables can be defined within three basic strategies **-subordinate, autonomous** and **combined**. In a subordinate strategy, the vehicle is subordinate to the roadway based command and control system which is aware of all vehicles in a given zone of operation and gives precise control instructions to each vehicle. In the autonomous strategy, the vehicles are more autonomous and are therefore each responsible for inter-vehicle coordina tion and vehicle control. The roadway, in the autonomous system, is more passive, but could provide the vehicles with roadway condition and regional congestion information. The combined strategy represents a more equally distributed level of processing and control functions. This combined strategy matches more closely with the "average" concept described by Bender.

Each of the PSA contractors independently developed their own set of RSCs. Some contractors evaluated a set of 15 or more RSCs while the lower limit was typically a set of three RSCs.

CONFIGURATIONS CONSIDERED

After examining all of the variables used in describing an AHS configuration, it was recommended that the characteristics of command and control be the basis for distinguishing between different RSCs for this study of institutional and societal issues. As described earlier, this would lead to three basic RSCs for the further evaluation of institutional frameworks and societal aspects. Table 1 presents an outline of the RSCs developed for this study along with a sample of the types of issues impacted by each configuration.

TABLE 1. Assumed System Configurations: Institutional and Societal Issues Involved with Alternative System Concepts

Distinguishing Characteristics	System Concept[2]		
	Smart Vehicle Configuration	Average (or Distributed Intelligence) Configuration	Hybrid Configuration
Infrastructure Impact	lower public sector capi tal, O & M costs, but re duced control over vehi cle config. and operating modes	higher public sector costs, but increased control on vehicle configuration and operating modes	public sector role in regu lation & certification; private sector role in pro vision of system compo nents
Traffic Synchronization	requires vehicle to vehicle communication; merge negotiation and control based on local conditions	requires system-based traffic management systems; control strategy based on global conditions	system-based control strategies to optimize global through-put with local control for vehicle positioning
Instrumentation Distribution	higher emphasis on prod uct liability; potential for incompatibility	significant investment of public funds for limited market; social equity is sues	minimal public sector investment to provide basis/incentive for private sector market
Operating Speed	speed limited by current technology; could affect system capacity and user appeal	higher potential speeds & denser platoons increase system capacity and user appeal	improved technology could allow "smart vehi cles" to approach charac teristics of "average" con cept

RSCs DEFINED FOR THIS ANALYSIS

Using the initial research cited above and the distinguishing characteristics of an AHS as defined by the MITRE study, the following RSCs were developed provide a basis for further analysis.

Subordinate Control System

Also known as the Smart Highway/Dumb Car, this configuration places most (if not all) of the processing, communications, command and control functions within the roadway infrastructure. AHS vehicles would be required to have actuators to control vehicle operations (steering, accelerator, braking, etc.) and some type of communication transponder to receive instructions from the roadside controllers and transmit acknowledgements. Sensors to determine vehicle position and potential roadway obstructions are within the roadway infrastructure.

Autonomous Control System

Also known as the Smart Car/Dumb Highway, this configuration requires that, in addition to control actuators, each vehicle must have on-board sensors to determine lane position and relationship with other vehicles and obstructions and an on-board information processing capability to determine control actions for navigation and to respond to changing conditions. The roadway would provide passive guidance and perhaps some regional information on traffic and weather conditions.

Combined Control System

Also known as the Average or Distributed Concept, this configuration would allow a more widely distributed level of command and control. Both vehicles and the roadside would have some elements of the sensor, communications, processing and control systems. The roadside based command and control system could provide a backup system to the vehicle based system or could take over to provide more tightly controlled platoons as congestion increased.

A fourth configuration, the concept of using pallets on an automated guideway, is one which would require a very large infrastructure investment. This requirement makes the pallet or AGT system an unlikely candidate for widespread implementation within the next 20 to 25 years. Because of this, we do not recommend examining this configuration for institutional and societal issues. Some of the institutional frameworks may be applicable to the pallet configuration and some of the societal aspects may also be analogous, but the limited nature of this study suggests that efforts be directed to the more promising configurations for an AHS.

OPERATIONAL CONCEPTS

The operational concepts for each of the three RSCs have been selected to highlight the institu tional, legal and societal issues of interest for this study. Sufficient technical detail is provided only as needed to fully describe the operation.

Also a part of each description is an assessment of how each configuration would operate under each of the seven scenarios developed in the Honeywell study[5] :

1. Mixed traffic with free agents and self-contained automation
2. Shared highway with no barrier and individual vehicles
3. Shared highway with no barriers and grouped vehicles
4. Shared highway with barriers and individual vehicles
5. Shared highway with barriers and grouped vehicles
6. Segregated highway with individual vehicles
7. Segregated highway with grouped vehicles

It is these detailed descriptions of the configurations and operational concept that were used to develop candidate institutional frameworks for supporting implementation, operations and maintenance.

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[5] H.S.J. Tsao, R.W. Hall, and S.E. Shladover of PATH; T.A. Plocher, L. Levitan of Honeywell; "Human Factors Design of Automated Highway Systems," Task A.5 First Generation Scenarios, FHWA Contract No. DTFH61-92-C-00100, April 8, 1993.

Representative System Configuration DescriptionsSUBORDINATE CONTROL

DESCRIPTION OF MAJOR SYSTEM COMPONENTS:

Vehicle:

- AHS vehicles would have to be meet a minimum level of capability for automated control. It is generally assumed that AHS vehicles would have to have all major actuators (steer ing, braking, acceleration, etc.) installed during manufacture.

- AHS vehicles would have to have basic performance characteristics (acceleration, top speed, braking distance, etc.) within a specified range.

- Both personal and commercial vehicles would be allowed. Large commercial trucks may have a separate facility.

- Driver destination (and possibly preferred route) would be communicated from the vehicle to the roadside control system upon check-in.

- Commands, sent from roadside control systems, would be accepted and acknowledged by each vehicle.

- Vehicle-based control system would continuously self-monitor operational status and transmit vehicle readiness and capabilities to roadside control system.

- Vehicle location, lane tracking, and inter-vehicle communication would be handled by the roadside control system.

Driver:

- AHS drivers will likely require some minimum level of training with periodic testing and/or re-training.

- Driver certification and safe-driving record would be verified upon check-in to the automated lanes.

- Full-time attention will not be required under automated travel, however availability of a driver, in the case of system malfunction, will be critical.

- Driver readiness to assume manual control at the end of the trip must be demonstrated to the command and control system before it will relinquish control.

Highway:

- Construction materials are assumed to be similar to existing freeway materials (e.g., asphalt and concrete). Lane widths in fully automated lanes could be narrower than the standard 3.6 meters (12 feet). Some scenarios may call for a barrier between automated and manual lanes.

- A highly instrumented, "active" highway infrastructure is required. This includes sensors, communications, command and control systems as well as facility for checking vehicles into and out of the automated lanes safely and efficiently.

- The sensor system would cover virtually all of the automated lanes with spacing on the order of every 5 meters (16.4 feet). Sensors must be able to track vehicle position (lateral and longitudinal) as well as environmental conditions (weather, obstructions in road, etc.). Sensor overlap into manual lanes necessary in areas were encroachment possible by non-AHS vehicles.

- Automated operations could take place in one of the three basic infrastructure scenarios: shared facility with no barriers, shared facility with barriers or a completely segregated facility.

- Check-in and check-out procedures will require one of several infrastructure options depending on the operational scenario:
  - a buffer-lane in which control is shifted from manual to automated
  - rapidly movable barriers synchronized to the entering/exiting vehicle
  - plazas for temporary storage of vehicles before and after automated travel

Command & Control System:

- All processing of entry requests, command and control decisions, exit negotiation, environmental monitoring would be located within the roadside control system.

- Command and control system must respond to each entry request and designate a "Go" or "No-Go" based on the following checks:
  - vehicle condition (system check of vehicle)
  - valid destination request (you can get there from here)
  - vehicle priority (commuter, recreational, or emergency)
  - driver certified for AHS travel
  - fee paid (if any)

- The command and control system will track the lateral and longitudinal position of all vehicles at all times while under automated control.

- All inter-vehicle communication (notice of speed change, intent to enter/exit, etc.) will be processed by the roadside command and control system.

- Hand-off of controlled vehicles from one zone to another will be fully automatic (similar to the hand-off of mobile phone calls as callers pass from one cell to another).

- Command and control system would be hierarchical. AHS networks would consist of corridors which are further subdivided into traffic control zones.

- The AHS command and control system will be integrated into the regional traffic manage ment system for passing of information on traffic flows and area congestion.

SYSTEM ACTIONS UNDER VARIOUS SCENARIOS:

1. Mixed traffic with free agents and self-contained automation. By definition, this RSC (subordinate control) is not compatible with this operational scenario.

2. Shared highway with no barrier and individual vehicles. The same basic highway structure would be shared between automated and manual vehicles, however, the automated lanes would be separated from the manual lanes

by a transition lane. The primary actions of the roadside control system will be to control lane keeping, longitudinal spacing and maximum speed. Choice of lanes is made manually by the drivers, but can be initiated by the roadside control system to negotiate lane blockages or to move the vehicle into a breakdown area. Check-in and check-out occur in the transition lane with manual entry and exit.

3. Shared highway with no barriers and grouped vehicles. This scenario is the same as Scenario 2 above, except that vehicles travel in groups with individual vehicles spaced as close as 1 meter (3.2 feet) apart. In addition to lane keeping and maximum speed, the control system is responsible for coordinating the groups within each fully automated lane. Groups in different lanes may move at different speeds and lane selection will still be under manual control by the drivers. Lane changes can be initiated by the control system to avoid lane blockages; in this case the entire groups will change lanes together. Individual vehicles would be moved into and out of a lane (or group) by the control system upon driver request or to move vehicle into a breakdown area. Check-in and check-out occur in the transition lane with manual entry and exit.

4. Shared highway with barriers and individual vehicles. Barriers would separate the automated lanes from the manual and transition lanes. There may also be barriers between adjacent automated lanes. Entry and exit will be via "gates" in the barriers or via dedicated (automated) on and off-ramps. Entry and exit maneuvers, as well as all lane change maneuvers in the automated lanes, will be fully automated and controlled by the roadside system. Full control of the traffic flow, including lane and speed selection, lateral and longitudinal spacing, will be made by the roadside system. Check-in and check-out occur in the transition lane or automated entry/exit ramp.

5. Shared highway with barriers and grouped vehicles. This scenario is similar to Scenario 4 above, except that vehicles travel in groups with individual vehicles spaced as close as 1 meter (3.2 feet) apart. The roadside control system is still responsible for all lateral and longitudinal spacing, lane assignment and speed control. The roadside control system must also coordinate the group assembly and exit maneuvers. Check-in and check-out occur in the transition lane or automated entry/exit ramp.

6. Segregated highway with individual vehicles. This scenario is similar to Scenario 4 above in basic operational concept. The difference is that the highway structure is completely separate from any manual highway and entry and exit is only possible via fully automated on and off-ramps. Check-in and check-out occur on the ramps. The entry maneuver is under automated control and is metered by the roadside control system.

7. Segregated highway with grouped vehicles. This scenario is similar to Scenario 5 above in basic operational concept. The difference is that the highway structure is completely separate from any manual highway and entry and exit is only possible via fully automated on and off-ramps. Check-in and check-out occur on the ramps. Groups may be formed on the ramps prior to entry and would then enter as a group. Depending on traffic flow conditions, individual vehicles would be brought into the automated lanes and merged with a group. The entry maneuver is under automated control and is metered by the roadside control system.

SAMPLE INSTITUTIONAL AND SOCIETAL ISSUES SPECIFIC TO THIS CONFIGURATION:

Regulatory Issues:

- Who will be responsible for the regulation and inspection of AHS roadway systems? (e.g., state DOTs, NHTSA, OSHA, etc.)

Legal Issues:

- Liability exposure transfers to owner-operator of roadside command and control system.
- Need for strict enforcement against trespassing by non-AHS vehicles.

Funding Alternatives for Implementation and Operation:

- High infrastructure costs limit options for private participation.

Vehicle Priority Issues:
- Roadside based control could more easily coordinate emergency procedures.
- Traffic management based on vehicle or destination priority possible with roadside based control.

Societal Aspects:
- Will users accept complete control from outside the vehicle.
- Reduced on-vehicle systems make AHS vehicles more affordable.

Representative System Configuration Description AUTONOMOUS CONTROL

DESCRIPTION OF MAJOR SYSTEM COMPONENTS:

Vehicle:

- AHS vehicles would have to meet a minimum level of capability for automated control. It is generally assumed that AHS vehicles would have to have all major actuators (steering, braking, acceleration, etc.) installed during manufacture.

- AHS vehicles would have to have basic performance characteristics (acceleration, top speed, braking distance, etc.) within a specified range.

- Both personal and commercial vehicles would be allowed. Large commercial trucks may have a separate facility.

- Vehicles would receive position information from the roadside (possibly augmented by GPS), but would navigate autonomously.

- Vehicles would receive advisory information from the roadside (local speed limits, current environmental conditions, etc.), but would make operational decisions based on driver preferences and internal rules.

- Vehicle-based command and control system would require sufficient redundancy to provide for safe system shut-downs in case of malfunction.

- Vehicle would require on-board sensors for autonomous lane keeping and longitudinal positioning.

- Inter-vehicle communication would be the responsibility of each vehicle to relay vehicle intentions.

Driver:

- AHS drivers will likely require some minimum level of training with periodic testing and/or re-training.

- Driver certification and safe-driving record would be verified upon check-in to the automated lanes.

- Full-time attention will not be required under automated travel, however availability of a driver, in the case of system malfunction, will be critical.

- Driver readiness to assume manual control at the end of the trip must be demonstrated to the command and control system before it will relinquish control.

Highway:

- Construction materials are assumed to be similar to existing freeway materials (e.g., asphalt and concrete). Lane widths in fully automated lanes could be narrower than the standard 3.6 meters (12 feet). Some scenarios may call for a barrier between automated and manual lanes.

- A relatively passive highway infrastructure is all that is required. A minimum configura tion for an automated highway would include only painted lane-edge lines. Beacons could be positioned at critical points to continually transmit position information and updates on regional traffic congestion and environmental conditions.

- Automated operations could take place in one of the three basic infrastructure scenarios: shared facility with no barriers, shared facility with barriers or a completely segregated facility.

- Check-in and check-out procedures will require one of several infrastructure options depending on the operational scenario:
  - a buffer-lane in which control is shifted from manual to automated
  - rapidly movable barriers synchronized to the entering/exiting vehicle
  - plazas for temporary storage of vehicles before and after automated travel

Command & Control System:

- All command and control decisions, including lateral and longitudinal positioning, negotiation with adjacent vehicles for entry/exit or lane changes, and safety monitoring would be located within the on-board vehicle control system.

- The on-board command and control system must confirm, prior to initiating automated travel, that the vehicle is in a "Go" or "No-Go" condition based on the following checks:
  - vehicle condition (system check of vehicle)
  - highway condition (sufficient guidance information available)
  - valid destination request (you can get there from here)
  - driver certified for AHS travel
  - vehicle authorized for requested facility

- The on-board command and control system will track the relative position of adjacent vehicles at all times while under automated control.

- All inter-vehicle communication (notice of speed change, intent to enter/exit, etc.) will be processed by the on-board command and control system.

- The on-board command and control system would have the capability to interact with a regional traffic management system (e.g., for passing of information on traffic flows and area congestion), but would not be dependant on it for operation.

SYSTEM ACTIONS UNDER VARIOUS SCENARIOS:

1. Mixed traffic with free agents and self-contained automation. Fully autonomous vehicles, with sufficient on-board sensors (e.g., "machine vision") and processing capability, would freely mix with manually operated

automobiles. Navigation would take place in much the same way as human drivers navigate, a preprogrammed destination would be reached by tracking periodic signposts or beacons and the distance travelled. The negotiation of the vehicle within the traffic stream would also be the responsibility of the vehicle command and control system. Certain operational aspects could be programmed by the driver, with limits based on internal rules for maximum speed, car following distances, etc.

2. Shared highway with no barrier and individual vehicles. The same basic highway structure would be shared between automated and manual vehicles, however, the automated lanes would be separated from the manual lanes by a transition lane. The on-board control system will control navigation, lane keeping, longitudinal spacing and maximum speed. Choice of lanes is made manually by the drivers, however lane-changes can be initiated by the on-board control system to negotiate lane blockages or to move the vehicle into a breakdown area. Check-in and check-out occur in the transition lane with manual entry and exit.

3. Shared highway with no barriers and grouped vehicles. This scenario is the same as Scenario 2 above, except that vehicles travel in groups with individual vehicles spaced as close as 1 meter (3.2 feet) apart. In addition to lane keeping and maximum speed, the on-board control system is responsible for communicating with other vehicles in the group. Requests to join or form a group would be made manually with confirmation by the on-board systems of all affected vehicles. Groups in different lanes may move at different speeds. Lane and group selection will still be under manual control by the drivers. Lane changes can be initiated by the on-board control system to avoid lane blockages; in this case the entire groups will change lanes together. Individual vehicles would be moved into and out of a lane (or group) by the control system upon driver request or to move vehicle into a breakdown area. Check-in and check-out occur in the transition lane with manual entry and exit.

4. Shared highway with barriers and individual vehicles. Barriers would separate the automated lanes from the manual and transition lanes. There may also be barriers between adjacent automated lanes. Entry and exit will be via "gates" in the barriers or via dedicated (automated) on and off-ramps. Entry and exit maneuvers, as well as all lane change maneuvers in the automated lanes, will be fully automated and controlled by the on-board control system. This scenario will require more active methods of communication between the vehicles and the infrastructure in order to coordinate the entry and exit via the gates in the barriers. However, the vehicle control system is still responsible for negotiating all maneuvers and navigation within the automated lanes. Check-in and check-out occur in the transition lane or automated entry/exit ramp.

5. Shared highway with barriers and grouped vehicles. This scenario is similar to Scenario 4 above, except that vehicles travel in groups with individual vehicles spaced as close as 1 meter (3.2 feet) apart. The on-board control system is still responsible for all lateral and longitudinal spacing, lane assignment and speed control. Group formation is requested manually and coordinated via the control systems of all group vehicles. As with Scenario 4, the negotiation of the barrier gates will require more active communication between the vehicles and the infrastruc ture. Check-in and check-out occur in the transition lane or automated entry/exit ramp.

6. Segregated highway with individual vehicles. This scenario is similar to Scenario 4 above in basic operational concept. The difference is that the highway structure is completely separate from any manual highway and entry and exit is only possible via rigorously enforced on and off-ramps. For this scenario, the roadside traffic management system would have the capability to "meter" the entry of vehicles into the system as traffic conditions warrant. Entry and check-in to a segregated AHS facility would only be allowed if the vehicle were capable of fully automated travel. Once cleared for entry, the entry maneuver would be under automated control. Exits would be fully automated and check-out would occur on the ramp.

7. Segregated highway with grouped vehicles. This scenario is similar to Scenario 5 above in basic operational concept. The difference is that the highway structure is completely separate from any manual highway and entry and exit is only possible via rigorously enforced on and off-ramps. Also with this scenario, the roadside traffic management system would have the capability to "meter" the entry of vehicles into the system as traffic conditions

warrant. Check-in and check-out occur on the ramps. At the option of the drivers, groups may be formed on the ramps prior to entry and would then enter as a group under the joint command and control of all vehicles in the group. Depending on traffic flow conditions, individual vehicles that enter the automated lanes may merge with a group if they so request.

SAMPLE INSTITUTIONAL AND SOCIETAL ISSUES SPECIFIC TO THIS CONFIGURATION:

Regulatory Issues:
- Will fully automated vehicles be able operate under a different set of rules (e.g., higher speeds)?

Legal Issues:
- Product liability exposure increases for vehicle manufacturers.

Funding Alternatives for Implementation and Operation:
- Reduced infrastructure costs could speed implementation.

Vehicle Priority Issues:
- Vehicle control systems could be "over-ridden" by police or public safety officers.
- More difficult to manage traffic without direct knowledge of vehicle destination or control of vehicle travel.

Societal Aspects:
- High vehicle costs may limit market viability.
- More critical maintenance requirements will increase total ownership costs.

Representative System Configuration DescriptionCOMBINED CONTROL

<u>DESCRIPTION OF MAJOR SYSTEM COMPONENTS:</u>

Vehicle:

- AHS vehicles would have to be meet a minimum level of capability for automated control. It is generally assumed that AHS vehicles would have to have all major actuators (steer ing, braking, acceleration, etc.) installed during manufacture.

- AHS vehicles would have to have basic performance characteristics (acceleration, top speed, braking distance, etc.) within a specified range.

- Both personal and commercial vehicles would be allowed. Large commercial trucks may have a separate facility.

- Vehicles could navigate autonomously, receiving only position information from the roadside, OR, the roadside control system could override the vehicle control system as traffic conditions warrant.

- Vehicles could operate autonomously while in the automated lanes, however the roadside control system would be responsible for check-it/check-out and entry/exit maneuvers.

- Vehicles would require on-board sensors for autonomous lane keeping and longitudinal positioning with an interface to communicate with the roadside control system during override control.

- Inter-vehicle communication would be the responsibility of each vehicle to relay inten tions. The roadside control system would monitor inter-vehicle communications and be able to assume that function for override control situations.

Driver:

- AHS drivers will likely require some minimum level of training with periodic testing and/or re-training.

- Driver certification and safe-driving record would be verified upon check-in to the automated lanes.

- Full-time attention will not be required under automated travel, however availability of a driver, in the case of system malfunction, will be critical.

- Driver readiness to assume manual control at the end of the trip must be demonstrated to the command and control system before it will relinquish control.

Highway:

- Construction materials are assumed to be similar to existing freeway materials (e.g., asphalt and concrete). Lane widths in fully automated lanes could be narrower than the standard 3.6 meters (12 feet). Some scenarios may call for a barrier between automated and manual lanes.

- A moderate level of command and control system functions are assumed for the highway infrastructure. This would require that the infrastructure would have a method for communicating this information with all vehicles under automated control.

- Automated operations could take place in one of the three basic infrastructure scenarios: shared facility with no barriers, shared facility with barriers or a completely segregated facility.

- Check-in and check-out procedures will require one of several infrastructure options depending on the operational scenario:
  - a buffer-lane in which control is shifted from manual to automated
  - rapidly movable barriers synchronized to the entering/exiting vehicle
  - plazas for temporary storage of vehicles before and after automated travel

Command & Control System:

- The vehicle based command and control system would have primary responsibility for all operational decisions, including lateral and longitudinal positioning, negotiation with adjacent vehicles for lane changes, and safety monitoring. The roadside based control system would provide backup control and override control based predetermined condi tions.
-
- Because of the increased complexity and the need to maintain overall traffic control, the roadside control system would be responsible for entry and exit maneuvers as well as check-in and check-out.
-
- The roadside control system would have the ability to override vehicle based control systems for such functions as lane selection, lane changes and group formation. The decision to override would be for two basic reasons: (1) detection of a malfunction in the control system of an individual vehicle (the roadside control would then override the disabled vehicle and, perhaps temporarily, that of adjacent vehicles until the disabled vehicle is brought to a safe stop) or (2) traffic conditions in the AHS reach a critical point where the speed and density of the entire automated traffic stream can more safely be handled by the roadside control system.
- The roadside control system would provide a redundant system that could take over individual vehicle control in the case of vehicle system malfunction or the inability of the driver resume manual control.
-
- The on-board command and control system must confirm (internally) that the vehicle is in a "Go" or "No-Go" condition based on the following checks:
  - vehicle condition (system check of vehicle)
  - highway condition (sufficient guidance and control information available)
  - driver certified for AHS travel
- Then the vehicle control system would initiate a request to enter the AHS to the roadside control system. This secondary "Go" or "No-Go" condition would be confirmed by the roadside control system based on the following additional checks.
  - traffic conditions can handle additional entry
  - valid destination request (you can get there from here)
  - vehicle authorized for requested facility (e.g., fee paid)

- The on-board command and control system will track the relative position of adjacent vehicles at all times while under automated control. The roadside control system would, as a minimum, monitor the presence of all vehicles in the AHS. Under override control, the roadside control system would use the vehicle based sensors as input into its control processing.

- All inter-vehicle communication (notice of speed change, intent to enter/exit, etc.) will be the responsibility of the on-board command and control system with monitoring by the roadside control system. The roadside system could augment or supplant inter-vehicle communication as conditions warrant.

- The roadside command and control system would be hierarchical. AHS networks would consist of corridors which are further subdivided into traffic control zones. Under override control, the hand-off of controlled vehicles from one zone to another will be fully automatic.

- The vehicles' on-board command and control system would have the capability to interact with a regional traffic management system (e.g., for passing of information on traffic flows and area congestion) during either autonomous or combined automated control.

SYSTEM ACTIONS UNDER VARIOUS SCENARIOS:

1. Mixed traffic with free agents and self-contained automation. Fully autonomous vehicles, with sufficient on-board sensors (e.g., "machine vision") and processing capability, would freely mix with manually operated automobiles. The roadside control system would augment the on-board control system for functions such as navigation and traffic management. As with the autonomous control RSC, the negotiation of the vehicle within the traffic stream would be the responsibility of the vehicle command and control system. Certain operational aspects could be programmed by the driver, with limits based on internal rules for maximum speed, car following distances, etc. It is not clear for this scenario, however, that the roadside control would be able to take over complete automated control within a mixed flow of automated and manual vehicles.

2. Shared highway with no barrier and individual vehicles. The same basic highway structure would be shared between automated and manual vehicles, however, the automated lanes would be separated from the manual lanes by a transition lane. The on-board control system will control navigation, lane keeping, longitudinal spacing and maximum speed with oversight (and possible override) by the roadside control system. Choice of lanes is made manually by the drivers, however lane-changes can be initiated by either the on-board or roadside control system to negotiate lane blockages or to move the vehicle into a breakdown area. Check-in and check-out occur in the transition lane with manual entry and exit.

3. Shared highway with no barriers and grouped vehicles. This scenario is the same as Scenario 2 above, except that vehicles travel in groups with individual vehicles spaced as close as 1 meter (3.2 feet) apart. It is assumed that the roadside control system would assist the formation and coordination of groups. The on-board control system would be responsible for basic communication with other vehicles in the group with oversight by the roadside system. Requests to join or form a group would be made manually with confirmation by both the roadside and on-board systems of all affected vehicles. Groups in different lanes may move at different speeds. Lane and group selection would be made first by manual control with possible override by the roadside system. Lane changes can be initiated by the either the on-board or roadside control system; in either case the entire groups will change lanes together. Individual vehicles would be moved into and out of a lane (or group) by the control system(s) upon driver request or to move vehicle into a breakdown area. Check-in and check-out occur in the transition lane with manual entry and exit.

4. Shared highway with barriers and individual vehicles. Barriers would separate the automated lanes from the manual and transition lanes. There may also be barriers between adjacent automated lanes. Entry and exit will be via "gates" in the barriers or via dedicated (automated) on and off-ramps. Entry and exit maneuvers, as well as all lane change maneuvers in the automated lanes, will be fully automated. Due to

the complexity involved with the barrier gates, it is assumed that the roadside control system will handle entry and exit. However, the vehicle control system is still responsible for negotiating all maneuvers and navigation within the automated lanes. Check-in and check-out occur in the transition lane or automated entry/exit ramp.

5. Shared highway with barriers and grouped vehicles. This scenario is similar to Scenario 4 above, except that vehicles travel in groups with individual vehicles spaced as close as 1 meter (3.2 feet) apart. The on-board control system is primarily responsible for all lateral and longitudi nal spacing, lane assignment and speed control with backup and/or override by the roadside system. Group formation will be negotiated through the roadside system and coordinated via the control systems of all group vehicles. As with Scenario 4, the negotiation of the barrier gates will require more active communication between the vehicles and the infrastructure. Check-in and check-out occur in the transition lane or automated entry/exit ramp.

6. Segregated highway with individual vehicles. This scenario is similar to Scenario 4 above in basic operational concept. The difference is that the highway structure is completely separate from any manual highway and entry and exit is only possible via rigorously enforced on and off-ramps. For this scenario, the roadside control system, in concert with the regional traffic management system, would have the capability to "meter" the entry of vehicles into the system as traffic conditions warrant. Entry and check-in to a segregated AHS facility would only be allowed if the vehicle were capable of fully automated travel. Once cleared for entry, the entry maneuver would be under the control of the roadside system. The vehicle and/or the roadside control system would then take over for mainline travel. Exits would be fully automated and controlled by the roadside system; check-out would occur on the ramp.

7. Segregated highway with grouped vehicles. This scenario is similar to Scenario 5 above in basic operational concept. The difference is that the highway structure is completely separate from any manual highway and entry and exit is only possible via rigorously enforced on and off-ramps. Also with this scenario, the roadside control system, in concert with the regional traffic management system, would have the capability to "meter" the entry of vehicles into the system as traffic conditions warrant. Check-in and check-out occur on the ramps. At the direction of the roadside control system, groups may be formed on the ramps prior to entry and would then enter as a group under the command and control of the roadside system. Depending on traffic flow conditions, individual vehicles that enter the automated lanes may be joined with a group.

SAMPLE INSTITUTIONAL AND SOCIETAL ISSUES SPECIFIC TO THIS CONFIGURATION:

Regulatory Issues:

- Who will be responsible for the regulation and inspection of AHS roadside systems?
- Who will decide when to initiate override control?
- What options will individual drivers have to being overridden by the roadside control systems?

Legal Issues:

- Shared liability exposure for both vehicle manufacturers and control system owner/operators.

Funding Alternatives for Implementation and Operation:

- Creates a "chicken or egg" situation. Until widespread roadside control systems are operational, there is little incentive for consumers to upgrade to an AHS vehicle.

Vehicle Priority Issues:

- Easier to implement override systems for use by police or public safety officers.

- Traffic management system has more direct control of the traffic flows.

Societal Aspects:
- With vehicle control subject to override, will this affect user acceptance?
- Roadside system maintenance now becomes more critical to overall system performance.

3. DISCUSSION OF STEPS IN THIS RESEARCH EFFORT

STRUCTURE AND PURPOSE OF EACH STEP

Task A - Inventory and Review of AHS System Configurations and Comparable Systems

As stated earlier, the purpose of this step was to develop a set of potential configurations for an AHS. In the early stages of this research effort there were a lot of very general concepts being promoted, with very few specifics. This is typical in most cases of engineering a new system. As the system studies and system definition progresses to a more detailed stage, the number of viable concepts will likely converge to only a few feasible and cost effective solutions. In order to conduct this study of potential institutional arrangements, however, some type of configuration must be assumed.

The development of the RSCs used in this effort was based on a need to cover, as much as possible, the range of potential AHS architectures. Another consideration was to provide a basis for determining whether one particular type of architecture had significantly different institutional issues than another. The hypothesis was that the type of command and control, in-vehicle versus in the infrastructure, would have different implications for legal, institutional and, perhaps, societal issues.

Task B - Institutional & Legal Issues Associated with each System Configuration

The identification of these issues was led by a team of legal experts with experience in the financing and deployment of transportation improvements. This team started with the list of issues presented in the BAA and included other issues based on their own experience. Some of the issues were deemed more important than others and were given more extensive review. The primary emphasis in this review was on overall cross-cutting issues. However, whenever apparent, the differences between the various RSCs were identified.

Due to the structure of the team (there were two law firms acting as consultants for this effort) the primary list of issues was developed by one firm with review and comment provided by the second. This process worked well to enhance the discussion of legal issues and interpretations of the law among the attorneys.

Task C - Identify the Societal and Behavioral Issues Associated with AHS

A concept like AHS has few comparable systems that the travelling public can relate to and understand. Thus, it is difficult to determine the potential level of user acceptance for a technology that is not well defined nor well understood. Therefore, the approached used in this study was to consider the user acceptance and other behavioral aspects related to an IVHS operational test. The TravTek operational field test held between 1992 and 1994 in Orlando, Florida was a test of an advanced in-vehicle navigation and traffic management system. The test involved 100 vehicles outfitted with an in-vehicle route guidance system with access to the Orlando traffic management center for up-to-date information on congestion. The test included a questionnaire study that gathered information about how people viewed the system.

Questionnaires given TravTek drivers were evaluated to extract information relevant to the study of an AHS. The questions of interest related to user, market and public acceptance. Relating these results to potential AHS concepts required some postulation and extrapolation.

Task D - Develop & Evaluate Candidate Institutional Frameworks for Implementation of AHS System Configurations

The first step in this task involved a review of existing institutional frameworks and an assessment of how well these frameworks could handle a new technology like AHS. This included a review of the funding structure for federal aid highway and transit improvements and the regulatory structure that currently has jurisdiction over highway construction and vehicle manufacture.

Next, any shortcomings identified in the review of existing frameworks would be identified and candidate solutions explored. This could take the form of changes in the existing institutions or new institutional frameworks to be established especially for AHS. Any significant differences between the RSCs will be highlighted. Financing options, such as the current matching federal aid process were compared with newer methods, such as tax district financing and public/private partnerships, and assessed for their potential to fund AHS implementation and operation.

Another important step in this evaluation process included a series of interviews conducted with key officials involved with transportation planning and implementation in two major metropolitan areas: Atlanta, Georgia and Washington, D.C. The resulting comments and concerns from these transportation officials were recorded.

Task E - Assessment of "Lessons Learned" and Recommended Next Steps

This step will extract the key lessons learned in this activity area. The process has included a collaborative discussion of major issues within the research team and other PSA contractors. A status review within the team highlighted those issues for which recommended solutions could be presented and those which will require further study to resolve.

MATERIALS COLLECTED AND REVIEWED

A literature review was conducted within two major subject headings: 1) research involving potential AHS system configurations and/or perceived AHS benefits; and 2) institutional and societal aspects of IVHS and/or AHS related technologies.

Prior to the beginning of this research effort there was not a tremendous amount of AHS research. However, much of what was available was of very high quality. The California Program for Advanced Transit and Highways (PATH) has had an on-going research initiative in the technical aspects of automated vehicles and highways since the late 1980's. The Institute of Electrical and Electronics Engineers (IEEE) and the Society of Automotive Engineers (SAE) have each sponsored specialty conferences related to vehicle automation systems and published several technical papers that examined potential configurations.

The U.S. DOT, first through FHWA and then through the Office of the Secretary, have had an ongoing program to examine the institutional and other non-technical barriers to the implementa tion of IVHS since the late 1980's. This effort has examined issues ranging from transportation policy and regulation to procurement reform and intellectual property rights resulting in a large number of published papers and reports on the subject.

Finally, the legal and financial reviews have referenced a large number of original source documents (public law, court opinions and legal interpretations) for the assessment of related issues. The work of the legal consultants is summarized below in a discussion the results and conclusions. However, original papers prepared by the legal consultants to this project are also included in the appendix.

An annotated bibliography is included as an appendix to this report. In addition to the references cited in footnotes to the text of this report, there are a number of documents that provide useful background material related to the study of institutional and societal aspects of AHS. A short description of each reference is included along with its relevance to this study.

KEY FINDINGS AND IMPORTANT ISSUES

This study has focused its efforts on a subset of the master list of institutional and societal issues. This subset is primarily centered around legal and regulatory issues with emphasis also placed on financing, organizational, and societal issues. This section presents the key findings and important issues for AHS as they relate to the following:

- Legal Issues
- Regulatory Issues
- Funding Alternatives
- Public-Private Partnerships
- Societal Aspects
- Environmental Issues and Concerns
- Organizational Issues

The findings related to these issues are summarized below. For further reference, the original papers prepared by the legal consultants to this effort are included in their entirety in an appendix to this report. Footnotes and an annotated bibliography also reference additional sources used as a basis for the findings presented here.

Legal Issues

Tort liability and sovereign immunity are among the most important legal issues addressed. These issues have been important to other IVHS technologies; however, the AHS concept will likely magnify these issues due to the higher level of control and responsibility assumed by the system.

Tort Liability

Tort liability has often been cited by manufacturers as a significant added cost and impediment to the development and sale of new products. The American tort liability structure essentially burdens manufactures with the cost of damages that are directly caused by their products. Personal injury claims have increased dramatically in number and award amount with manufactur ers liable for both compensatory and punitive damage claims. This is the case now that most product manufacturers are held to standard of strict liability. Generally, the strict liability standard holds the manufacturer liable for damages caused by a defective product even though the manufacturer exercised due care in the design, manufacture and sale of the product. This is in contrast to the traditional standard of negligence where manufacturers would only be liable for damages if they had not exercised a "reasonable" amount of care in preparing the product.

The theory of strict liability and its widespread application in product liability cases dates only from the early 1960's. Its application has evolved rapidly since then and different states have different rules for its application in tort claims cases. Due to the public perception that product liability awards have grown to excessive levels, tort reform has been proposed, in various forms and at both the state and federal level, since the early 1980's. Most efforts at serious tort reform have failed, however. Most recently, the U.S. Senate blocked consideration of a bill that would have limited damage awards. A particular point of contention with this bill was a provision that would have protected manufacturers from punitive damages involving products that had received approval from either the Food and Drug Administration or the Federal Aviation Administration[1].

Some form of strict liability doctrine has been adopted by some 46 states. Only 37 states, however, use the same rules (as set forth in Section 402A of the Restatement of the Law Torts[6]) for its application. This has led to considerable confusion and inconsistency.

Section 402 A raised certain important issues. First, liability is extended to the entire distribution chain: designers, manufacturers, wholesalers, and retailers. Second, Section 402A only applies to products that are defective when sold by the manufacturer. That is, the manufacturer will not be liable if the product is delivered in a safe condition and subsequent changes or modifications by the user or some third party cause the product to become dangerous. This exclusion is not absolute, however, and has not protected manufacturers from all liability in cases where a product was modified after sale and the modification was a contributing cause of the damages.

There are three primary public policy reasons, as stated by the courts, for the doctrine of strict liability:

- First, the harm caused by defective or dangerous products can best be born by manufac turers because manufacturers can price the product to include the cost of damages that may be caused by defective products. In a crude sense, an insurance premium is built into the price of each product.

- Second, manufacturers are best positioned to reduce damages caused by their products through better design, higher quality manufacturing, or warnings. This places a greater incentive on the manufacturer to produce products with a high degree of care.

- Third, the increasing complexity of product design today makes it difficult to prove negligence on the part of the manufacturer (as would be required under the more traditional legal standards). The theory is that manufacturers who were in fact negligent might escape liability because it was too difficult to prove simple negligence in the design or manufacturer of a complex product.

Should a defective AHS product result in physical harm then, without tort reform, it fall under the strict liability doctrine. In turn, the potential costs of litigation, compensatory and punitive damage awards would impose a significant burden on AHS product designers, manufacturers and distributors. The private sector must decide if the potential return on investment in AHS products would be worth these risks.

Experience with other new technologies suggests that the development of a specialty insurance market may be the key to AHS. Such an insurance market could cover the vehicles alone, in which case the cost to cover potential damages would be incorporated into the cost of owning and operating the vehicle. Government could cover the liability risks arising from the infrastructure elements of an AHS facility; this would be key to privately financed, owned and operated AHS facilities. In the case of a privately financed roadway in California, for example, the State agreed to absorb liability for damages caused by defective construction as long as the roadway was designed and built in accordance with State approved standards. In this particular case, however, state assumption of liability has been extended to the maintenance requirements of the conventional roadway elements, but not to the IVHS elements (toll collection and changeable message signs), which will remain the responsibility of the private operators. There is no reason, however, why state indemnification could not include liabilities for AHS technology designed, installed and operated in compliance with the state standards.

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6 Section 402A of the Restatement of the Law (Second) Torts; Berstein, A Model of Product Liability Reform, 27 Val. U.L. Rev. 637 n. 79 (1993).

While public consternation over the impact of large damage awards in product liability cases has generated a movement for tort reform to control the associated litigation and damage costs, some researchers have taken issue with the public perception and cite no clear evidence that large damage awards, particularly punitive damage awards, are either routine or unreasonable[3]. Thus, many legal experts question the need for extensive tort reform, especially for emerging technolo gies, where there is little experience in the potential for damages caused by the new products. The Office of the Secretary of the U.S. DOT, in its report to Congress[4], found that product liability did not "present significant barriers to the development and implementation of advanced highway technologies."

Nevertheless, should the AHS community feel that product liability causes an impediment to deployment and operation, there are a number of approaches which can be explored. Potential courses of action have been outlined in the legal papers included in the appendix to this report and are summarized in Section 4 which presents the conclusions and suggested next steps.

Regulatory Issues

The institutional framework in which AHS is deployed and operated will govern how AHS infrastructure and operators are licensed and/or certified. From the standpoint of the system operator, this issue has risen in other IVHS technologies. ATIS systems, for example have had to deal with how to regulate the flow of information, especially when a private enterprise is involved. With an AHS, regulation or licensing of the user, in addition to the operator, may be necessary to assure safety.

As a potential model for an AHS regulatory framework, this study looked at the current system established under the Federal Aviation Administration (FAA). The FAA regulatory system has already addressed some of the issues that will be faced by FHWA and or the states in the regulation of AHS, including manufacturing certification, maintenance and operation of a specialized infrastructure, user fees and traffic control.

To summarize the FAA regulatory roles, there are four basic areas in which the agency has certification responsibilities and authority:

- Aircraft Design - Type Certification
- Aircraft Production - Production Certificate
- Individual Aircraft - Airworthiness Certificate
- Pilot Certification

Aircraft design types are certified by the FAA upon a representation by the designers that the aircraft meets all minimum operation and safety standards for that type of aircraft. The designers must present all design drawings, test reports and engineering data and then must build and test a prototype. The type certification is valid for all aircraft which are constructed to the approved design specifications.

The type certification process can take several years for a new aircraft type. A similar process for an AHS vehicle can be expected to add significantly to the cost of product development. However, the benefits of such a process include a high degree of product reliability with, presumably, lower total liability insurance costs. Currently, NHTSA sets design standards for U.S. automobiles that are primarily crash-worthiness standards. A design certification process for AHS capable vehicles would have to extend design standards much more into the realm of performance standards.

Aircraft production certification is a review by the FAA of the manufacturer's capabilities for producing aircraft which meet the specifications of certified designs and must include a quality control process. With a type certification and production certification, the manufacturer can produce aircraft for sale. A similar type of certification for automobile manufacturers is currently conducted by NHTSA, but with a much less rigorous review of the manufacturers' facilities. The number of automobiles manufactured per year is several orders of magnitude greater than the number of aircraft. Even though the number of AHS vehicles manufactured each year will be small at first, the potential for growth to a very large number per year must be considered when contemplating potential regulatory structures.

Individual aircraft are required to maintain an airworthiness certificate. This certification is first issued upon inspection of each aircraft as it is manufactured. FAA specified maintenance and inspection must be conducted over the life of the aircraft to retain this airworthiness certificate. By comparison, safety inspections of automobiles after sale are the responsibility of the various states. Most states have such an inspection program, but the requirements and inspection practices vary considerable. Maintenance requirements are specified by the manufacturers, but there is generally no certification of maintenance quality or practices. An AHS vehicle would require a much more comprehensive inspection, to include performance capabilities in addition to basic safety requirements.

Another aspect of the FAA model that will be important is that of "delegation of authority." The FAA only employs about 400 engineers and could not complete all of the certification functions in a timely manner using only its own employees. The FAA delegates certain functions to employees of aircraft manufacturers involved in the review of type and production certificates.

Preliminary concepts for the automated check-in process, to be conducted as a vehicle enters an AHS lane, call for a check that all vehicle systems are in proper working order. An on-board diagnostic will likely perform this function at each check-in to an AHS lane. Prudent regulatory practice suggests that some periodic manual certification of these on-board systems would be required to check for malfunctions and assure that the user had not tampered with or bypassed the diagnostic functions.

In terms of regulatory practice, the functions now being performed by NHTSA in the certification of automotive safety features is not unlike much of what the FAA does for aircraft. A major difference is that the involvement of NHTSA does not extend to individual vehicles after their sale to the end use nor does it extend to drivers. The states have traditionally assumed the role of licensing drivers and inspecting vehicles for operational safety. It is possible that a regulatory framework for AHS can evolve from one or both of these existing institutional arrangements.

The type of AHS regulatory framework depends somewhat on the particular configuration selected for deployment. An autonomous control AHS, for example, would require that the regulatory framework be centered around the vehicle. A subordinate control system would require extensive infrastructure and operational regulation, but would also require a vehicle certification process that is more comprehensive than exists today.

The control that states now hold over vehicle registration, driver licensing, and safety inspection is one that not many states will be willing to give up to a federal entity. Roadway construction and traffic operations are areas that are even more firmly entrenched at the state and local level. Although the FAA model has worked well, in terms of public safety, for air travel, there are still issues of cost. There have been some pressures to privatize the FAA's air traffic control system, initiated, in part, by labor problems with controllers and cost overruns on contracts to upgrade the air traffic control computer systems. Nonetheless, experience has shown that as the potential risk for harm increases within a system intended for use by the general public, more and more users will look to the Federal government for the regulation of associated manufacturers and operators. This public perception of the role for the Federal government may have more of a say in the final regulatory framework than the merits of any competing alternatives.

These findings indicate that a cooperative arrangement between FHWA, NHTSA, the automobile manufacturers and state agencies (including departments of transportation, public safety and motor vehicle registration) is most likely to result in a safe and cost-effective regulatory model for AHS. The number of potential players in this type of arrangement makes administration and consensus more difficult, but should provide an evolutionary path that is acceptable to the largest number of stakeholders.

Funding Alternatives

Potential financial structures for an AHS must find a way to fit into a transportation funding supply that is already severely over subscribed. An AHS project could be proposed for inclusion in the transportation improvement program (TIP) of any state or local government. There are no specific exclusions in either ISTEA or the funding authorizations of any of the states that would prohibit the use of public funds for the construction of an AHS facility. However, the AHS project would have to compete for priority with many other transportation improvement projects. One of the key requirements of ISTEA is that the long range plans for transportation improve ments at both the state and local level must be financially feasible, that is, an identifiable source of funding stream must be available for all projects in the plan. This requirement has had an impact on the scope of project planning within metropolitan planning organizations (MPOs), but even before ISTEA, MPOs and the states were struggling to meet the funding needs of the transporta tion infrastructure.

Toll Road Financing

In many areas, the funding shortfall has been addressed, in part, with a more open attitude toward private financing and public/private partnerships. An example of this type of project funding is the private toll road. Private toll roads are under construction in California and Virginia and enabling legislation has been passed in Arizona.

In Virginia, the Dulles Toll Road Extension (also known as the Dulles Greenway) required state enabling legislation in 1987 to allow the private funding of an extension to a state-owned toll road in Northern Virginia. The private entity has acquired its own rights-of-way and is now construct ing this limited access toll road from a location near the Washington Dulles Airport to Leesburg, Virginia. The facility is being built in a new corridor and will serve a rapidly growing area. The private operating corporation projects profitable operations within 10 years after the project's opening. Under the Virginia Toll Road Act, the private owners must transfer the roadway to the state within 10 years after all permanent financing bonds have been paid off.

The experience of private toll roads has not all been positive, however. The Virginia Act does not extend the states right of eminent domain and condemnation to the private toll road developer. This resulted in an almost fatal obstacle for the Dulles Greenway project, since some landowners in the path of the project were holding out for more compensation for their property. In addition, the uniqueness of this type of project made private financing much more difficult. The traditional sources of private capital, the bond markets and venture capitalists, required extensive traffic analyses to determine if toll revenue would be sufficient to repay the acquisition and construction debt. Similar concerns over traffic demand have idled three of the four projects proposed under the California toll road enabling act, passed in 1989.

To encourage the expansion of such private ventures, ISTEA includes a provision7 which would allow the use of federal funds to assist in the development of private toll facilities. Utilization of these funds will in most cases require corresponding changes in state laws to permit privately financed and highway facilities. To date, ISTEA funds have not been utilized for private toll road financing.

Special Tax District Financing

A special tax district is a designated geographic area in which real property is assessed an incremental tax, over and above the normal tax rates. The proceeds of this incremental tax are used to finance public works or services which are of value to the whole district. Special tax districts have been used for centuries to finance public works projects, such as water and sewer projects. The use of special tax districts to build highway infrastructure is not new, but is still not a widespread funding method. It is perhaps better known as a popular method of financing transit system improvements, especially rail rapid transit projects.

Virginia's Transportation Service District Act, passed to enable and encourage tax district financing of highway improvements, added some novel concepts to this age old funding tech nique. Only commercial and industrial properties within the tax district may be assessed the incremental tax. Most importantly, however, the Virginia act allows the state's highway trust fund to be used as collateral for the debt, should there be insufficient incremental tax revenue. This greatly improves the credit worthiness of the bonds sold to finance the transportation improve ment. Combined with the tax exempt provisions of these bonds, financing costs are kept to a minimum. The commercial and industrial landowners of the district, who will be the subject of the incremental tax, have some say in the type and configuration of the transportation improvement to be constructed. The Virginia Commonwealth Transportation Board has jurisdiction over the improvements, including the power of eminent domain and condemnation, thus avoiding the problems with the Virginia Toll Road Act. Another feature of the Virginia special tax district legislation, one which is unique to this state, is a provision that requires a binding agreement between the landowners and the local government regarding the zoning and land use within the tax district. This creates a very close linkage between the transportation improvements and the affected land uses.

Even without some of the special features of the Virginia model, the underlying theory of the special tax district is that the improvements being financed, highways or other public works, have a direct and positive impact on the value of the land upon which the tax is levied. This has important implications for the use of this financing technique for AHS. An AHS project which could provide a measurable benefit, such as increased capacity or more direct access, would be a candidate for tax district financing. Based on the material reviewed to date, it is not clear that an exclusive AHS facility could provide the required level of benefits to justify the tax district method. However, a conventional highway with AHS features could more be acceptable as a package deal financed via a tax district.

A constraint to tax district financing faced by Virginia, and most other states, is that special tax district revenues may not be used to support private ventures. Thus, a privately operated AHS could not qualify for special tax district financing.

Trust Fund Financing

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[7] Section 1012 of the Intermodal Surface Transportation Efficiency Act of 1991. Public Law 102-240.

The aviation industry has imposed significant user fees on itself to finance the construction and operation of the airway infrastructure. The federally controlled Airport and Airway Trust Fund is the recipient of these fees and, in turn, serves as the source of funds for operation of the air traffic control system and the federal share for airport improvements.

A special "AHS Trust Fund" could be established and funded through excise taxes on AHS equipment and/or vehicles or via user fees for actual usage of an AHS facility. However, given the current political climate and unproven success of AHS, it seems unlikely that Congress would approve a special AHS trust fund, separate from the Highway Trust Fund. One additional problem is that even though both the Highway and Airway Trust Funds have consistently received more revenue than they have expended on projects, the balance of both of these funds is included in the total federal budget and gets counted against the deficit. To avoid this problem any new AHS Trust Fund should be established independent of the federal budget -- a process which would require a large and powerful constituency.

Public-Private Financing

Public-private ventures are a relatively new phenomenon and there are a great many issues to be resolved before this type of partnership can be widely used for implementing an AHS. Many of these issues are discussed in the following section on the public-private partnership arrangement. Specific issues related to financing are discussed separately here to highlight the potential for this type of funding for AHS.

The "Strategic Plan for IVHS,"[8] prepared by IVHS America, projected that 80 percent of IVHS user services would eventually be funded through the private sector. An excellent example of this is the in-vehicle equipment needed to facilitate an AHS. Depending on the configuration selected for AHS implementation, a majority of AHS costs might be encompassed in just the vehicle costs alone. Thus, some elements of public-private financing will be crucial for AHS in whatever form it eventually takes.

The IVHS operational test series, sponsored in part by FHWA and FTA, have provided more than technical data on the performance of IVHS technologies. They have also provided a real-world test of the feasibility of public-private ventures. One of the most important issues to arise in these tests has been that of financing and accounting rules and procedures. The operational test program is funded only in part by the U.S. DOT which has called for proposals from partnerships of private and local agencies. A recent study of the institutional issues affecting these operational tests was conducted by the Volpe National Transportation Systems Center[9]. This study found that many of the private sector participants had little experience in doing business, as either a partner or a contractor, for the Federal government. The financial issues included government accounting rules, requirements for full disclosure of internal costs and overhead, differing goals for cost sharing between the partners and uncertainty about the long term commitment of FHWA to the development of IVHS.

[8] "Strategic Plan for Intelligent Vehicle-Highway Systems in the United States," Report No. IVHS-Amer-92-3, Intelligent Vehicle-Highway Society of America, May, 1992.

[9] "IVHS Institutional Issues and Case Studies, Analysis and Lessons Learned," by Science Application International Corporation for the Volpe National Transportation Systems Center, Contract No. DTRS-57-89-D-00090, RA 3078, March 1994.

Accounting rules and procedures differ between federal government business and private business. The traditional federal government contracting process requires full disclosure of all elements of the costs being reimbursed by the government. Thus, internal cost factors such as product development costs, overhead costs and fees would normally be disclosed. This type of information is very central to the competitiveness of many private sector businesses. The Volpe Center study reports that this issue was a very serious one and almost resulted in the termination of the ADVANCE partnership and operational test. An arrangement was developed that allowed the federal matching funds to be handled under a federal regulation know as the "Common Rule" and not under the more restrictive FAR.

The goals for each partner also differ widely; the private sector is looking to develop a business market and the public sector is looking to improve services. This has lead to confusion in some operational tests about what the roles are for each partner. The central issue in the case studies is a lack of clear understanding about what costs are "enabling" for the technology, and thus the responsibility of the public sector, and what costs are "developmental" and thus the responsibility of the private sector.

Finally, the issue of long term commitment on the part of the public sector participants is central to the long term business planning of the private sector. In the operational test case studies, the private sector partners were not always expecting to show any profit as a direct outcome of the test. Instead, most saw the test as an opportunity to invest in a future market. With such an investment at risk, the private sector was concerned that the federal participation would be short-lived.

Public Private Partnerships

In addition to the issues related to public-private financing, there are a number of other issues related to these types of arrangements. An earlier section discussed the problems when the private sector did not have authority to use the state's right of eminent domain and condemnation. The culture or way of doing business is so different between the public and private partners that some very basic issues such as communication and leadership were found to be impediments within the operational test program.

An understanding that there are different goals for each of the partners is an obvious, but not always a guiding, principle. Many of the issues found in the operational test case studies centered around negative stereotyping and lack of trust between partners. The public-private partnership is much more than the typical owner-contractor relationship. In cases where the public-private arrangement worked best, a key factor was a high level of communication between and within all management levels of each side. This fostered a better understanding of what the roles and responsibilities were for each member of the partnership. Finally, there are still a lot of uncertainties with the development and deployment of new technologies such as IVHS. In the most successful operational tests, these uncertainties were a concern, but not an impediment, when strong leadership was present to make decisions and maintain progress.

Societal Aspects

The acceptance of a new technology is always based on each individual's assessment of cost (and risk) to perceived benefit. The purpose of this area of study is to define the main social and behavioral issues associated with the implementation of an AHS and to consider their probable impact on the feasibility of implementing candidate AHS configurations. The three main issues to be examined will be that of user acceptance, market acceptance, and public/political acceptance.

The TravTek test program is used as a source of information on user attitudes in an attempt to draw insights concerning the societal aspects of AHS issues. TravTek is a joint public and private sector operational field test of an advanced traveler information and traffic management system. The test involved 100 vehicles outfitted with an onboard route guidance system with access to the Orlando traffic management center for up-to-date information on congestion. The TravTek evaluation consists of several integrated studies including field studies and surveys designed to assess the benefits of driver information systems in reducing traffic congestion and increasing driver safety.

The RSC configurations are considered with regard to user, market, and public/political acceptance issues. The primary issue in user acceptance is driver willingness to relinquish control, whereas the issue considered in market acceptance is user willingness to pay. In public/political acceptance issue area, the issues of interest involve highway safety, energy conservation and environmental quality.

User Acceptance

Perhaps user acceptance is the most critical issue facing designers of an AHS because it is the users' perceptions of the system that ultimately drive all other acceptance issues. Just as Amtrak would cease to operate if it had no passengers, an AHS will not be effective if drivers are not willing to use it. If an AHS is to be accepted as a viable transportation system, its users must perceive that they are part of a reliable and safe system. Perceived reliability and safety will be dependent on many factors, central among them will be drivers' confidence in the onboard navigation system and willingness to relinquish some or all of the control of their vehicles.

The level of control issue is possibly the most critical impediment to the implementation of an AHS. We address this issue by using some preliminary results from the TravTek test as an indicator of driver acceptance of a CCS configuration. The TravTek system is comparable in some respects to a CCS configuration AHS in that it combines autonomous onboard navigation with subordinate system information updates from a central computer located within the roadway infrastructure. Although the TravTek is not directly equatable to the AHS configurations being analyzed in this report, enough "smart car" similarities exist to allow consideration of selected TravTek questionnaire data.

There were a number of measures collected during the TravTek evaluation, but were not directly analyzed. Specifically, these measures include: a comparison of the route taken vs. the route selected by drivers, number of times drivers accepted a new system proposed route and what they thought of the system's decision to generate a new route at that time (e.g., change of route due to traffic congestion or due to the driver or the system's being lost).

The data show that the TravTek system in some way or another was used in either planning or making a trip over 70 percent of the time. In the TravTek configuration with the most features, almost 80 percent of all trips included the use of a TravTek feature. These results suggest that drivers are willing to accept the navigation, trip planning, and congestion avoiding assistance from the TravTek ATIS system. The results suggest that drivers may be willing to accept a CCS configuration, providing that they perceive that the system is both reliable and safe.

Market Acceptance

The market acceptance of any AHS will obviously be driven by the basic economic force of demand. This report will examine perceived demand for a TravTek-type AHS through the willingness-to-pay issue explored by the TravTek evaluation. Within the willingness-to-pay issue lie two sub-issues: Who should pay? and How much?

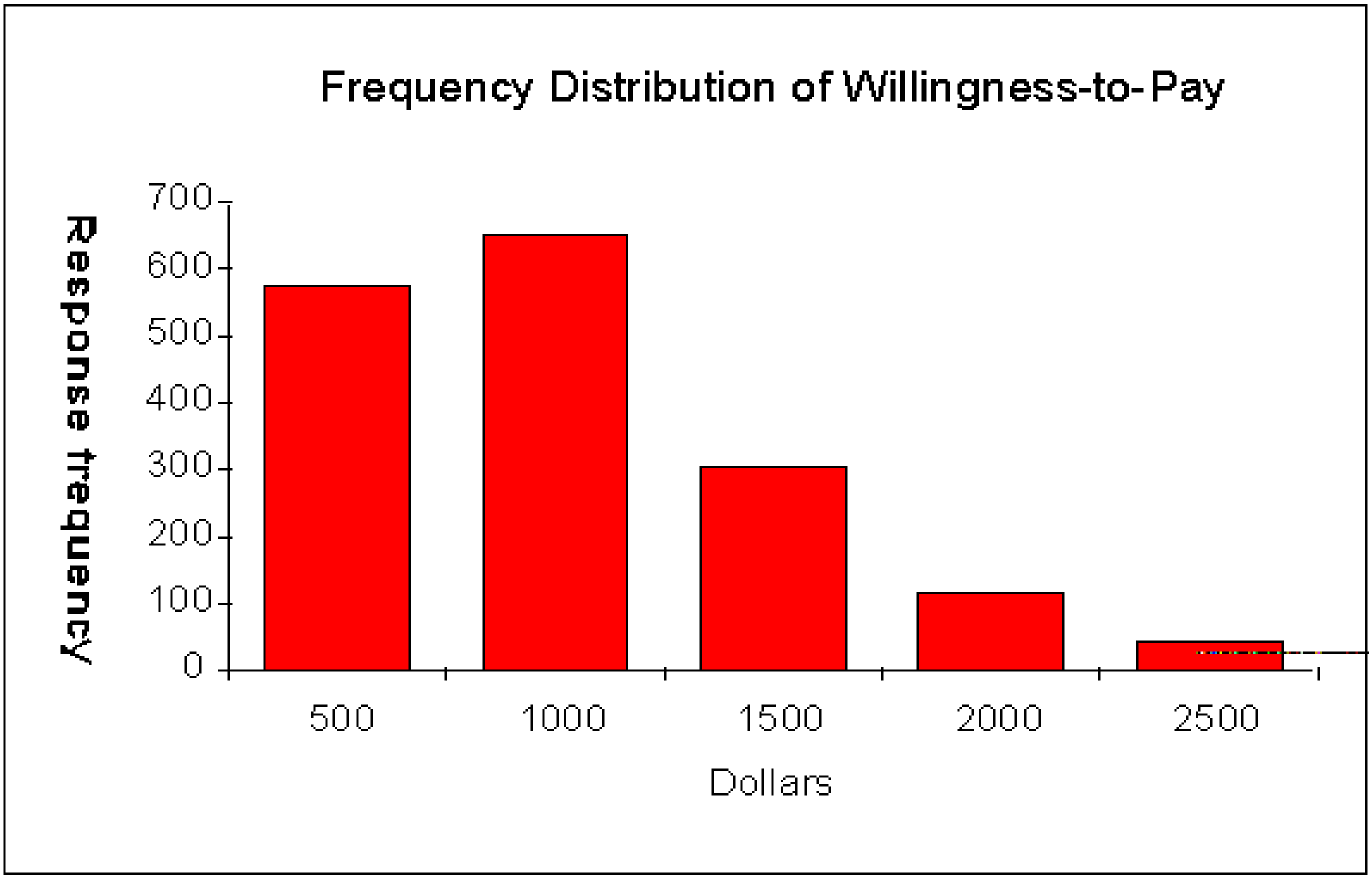
Willingness to pay: Who should pay?

A section of the questionnaire used in the TravTek Rental Users study asks users to indicate what entities should provide different aspects of the TravTek support infrastructure. Their choices were as follows: Government, Private enterprise, Manufacturers (Automobile manufacturers are implied here), and Auto clubs. The four different aspects of the TravTek system users were asked to consider were: the Services/Attractions directory, Navigation, Route guidance and Up-to-date traffic information. Of these, the results of only the last three aspects were deemed appropriate for the current analysis.

Survey responses suggested that, for the provision of navigation and route guidance information, the order of responsibility should be private enterprise, auto clubs, government and manufacturers. For the provision of up-to-date traffic information, the order was placed as follows: government, private enterprise, manufacturers and auto clubs. Overall the respondents distributed these responsibilities primarily to private enterprise with government and auto clubs sharing the next highest responsibility and manufacturers bearing the least overall responsibility for providing these informational services.

Willingness to pay: How much would you pay?

Two of the TravTek survey questions address the willingness to pay issue from the perspective of private citizens purchasing TravTek features as options on new cars or as upgrades to existing cars. The histogram in figure 1 was compiled from the TravTek Rental Users' Study questionnaire preliminary results. These responses are a composite of those subjects in the "Navigator" set of vehicles (almost all TravTek functionality enabled) and "Navigator Plus" set (all TravTek functionality enabled). The results in figure 1 are also a composite of all the questions that asked respondents how much they would be willing to pay for all TravTek features. As can be seen in the figure, the vast majority of respondents replied they would be willing to pay up to $1,000 for TravTek-like features on either a new car or to upgrade their existing cars. Starting at the $1000 mark, the distribution took on the shape of the expected price elasticity function for demand. That is, as price increased, the demand for the product (or the willingness-to-pay) decreased by some approximately proportional amount. Given the type of data reported, a true demand price elasticity graph could not be obtained, but the above data generally reflect expected behaviors and can provide a baseline from which to estimate the willingness of potential AHS users to pay for a full blown AHS equipped vehicle according to any particular configuration scheme.



Public and Political Acceptance
Figure 1. Response frequency indicating willingness of TravTek users to pay the indicated price range for the TravTek technology.

The public and political acceptance factors will be limited to those specifically investigated by the TravTek evaluation. The TravTek Rental Users Study questionnaire asked users to rank order the following factors in terms of their importance in the development of TravTek-like systems: energy conservation, environmental quality, highway/traffic safety, and relief of highway congestion. The analysis of questionnaire responses indicates that the TravTek users rank these items in the following order from most important to least important:

1) Highway/Traffic Safety;
2) Relief of Highway Congestion;
3) Energy conservation; and
4) Environmental quality.

Past experience with these types of questions indicates that people seem to rank these items egocentrically, that is, in order of most importance to themselves first and so on. In a way this ranking follows Maslow's need hierarchy. The results are also indicative of a general trend in public opinion that has been lamented by many in the environmental protection movement --namely that the general public is not aware of the air quality and other environmental consequences of many transportation improvement proposals. It is clear though, that if an AHS can demonstrate superior traffic safety and highway congestion mitigation, the public is going to support it.

Environmental Law Issues

Recent legislation, specifically the ISTEA and amendments to the Clean Air Act (CAAA), has outlined specific environmental requirements that must be addressed in the planning process for surface transportation projects. The CAAA, requires the Environmental Protection Agency (EPA) to set ambient air quality standards for several airborne pollutants. When passed in 1990, the CAAA noted that a majority of Americans live in areas which do not meet one or more these standards. This includes most of the large metropolitan areas in the country. All areas of the country must be classified by EPA as being either in "attainment", "non-attainment," or "unclassifiable" as to each of the ambient air quality standards. The CAAA also tied the achievement of these standards to the metropolitan planning process. Subsequent passage of ISTEA formalized the linkage between air quality planning and surface transportation funding.

The CAAA and ISTEA require states to submit state implementation plans (SIPs) that include a process, for all metropolitan areas which are non-attainment areas, for achieving and maintaining attainment with the air quality standards. Rule-making at both EPA and the U.S. DOT has recently laid out the process by which the states and MPOs must perform these duties. The U.S. DOT has published final rules[10] for metropolitan and statewide planning that outlines the planning process required for the development of a TIP and the criteria for individual project selection. The EPA has published a final rule[11] that establish the criteria for determining whether the plans and/or individual projects conform to the requirements of the CAAA. A key element of the CAAA and this final rule, known as the conformity, is that all projects must meet these criteria, regardless of whether or not federal funds are involved. The rule even applies to privately financed improvements.

Clearly, these issues must be addressed before an operational deployment of an AHS can be approved in any metropolitan area in non-attainment. An important criteria for AHS to meet is that it will not only have no significant impact on air quality, but it must be a integral part of an overall process that will <u>improve</u> air quality.

An additional element of the CAAA and the conformity rule is that transportation improvements must not have the effect of increasing automobile vehicle miles of travel (VMT) within a non-attainment area. On the surface this is a logical requirement, since additional vehicle miles of travel usually mean additional vehicle emissions. However, it is generally understood that this requirement of the CAAA will apply even if an AHS project were proposed that consisted entirely of zero emission vehicles. An underlying rational for this EPA requirement is that projects which allow an increase in VMT tend to encourage suburban sprawl. Suburban sprawl has many other environmental impacts (e.g., water supply and wastewater treatment, wetlands, depletion of wilderness) that EPA would like to avoid as well.

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[10] "Final Rules, Statewide Planning; Metropolitan Planning," FHWA, 23 CFR Part 450, FTA, 49 CFR Part 813, published in the Federal Register, October 28, 1993.

[11] "Final Rule, Criteria and Procedures for Determining Conformity to State of Federal Implementation Plans of Transportation Plans, Programs, and Projects ...," EPA, 40 CFR Parts 51 and 93, published in the Federal Register, November, 1993.

These environmental requirements will have significant implications for the role of AHS as a potential mobility solution in non-attainment areas. For example, if the AHS facility is open to all vehicles, regardless of the number of persons in each, the route of the AHS would likely have to serve travel demand that otherwise has to take a circuitous (i.e., longer) and more congested route in order to show a positive impact on area VMT and/or air quality. However, an AHS that was designed for transit or other high occupancy vehicles could more easily be shown as having a positive impact on both VMT and air quality.

The impacts and benefits of AHS are being studied in parallel activity areas and are just beginning to assess the potential impact of an AHS on the environment. These impact assessments will suggest the potential for AHS to provide a solution to the environmental concerns as well as mobility needs.

Organizational Issues

An important finding of the Volpe Center's case studies of IVHS operational tests was that the human resource requirements of these test were often under-estimated or were unavailable due to timing or budget constraints. Each of the operational tests studied were sufficiently large to justify a full time program office with appropriate staffing. In most cases, the program office was not set up in advance of the program's start date; resulting in significant delay in the program's progress. The unique skills required for IVHS technologies represent a dramatic departure for most state DOTs. This often resulted in a lack of qualified personnel within the public sector partners to these operational tests. The predominant skill areas that were noted as being lacking were systems integration and test management, systems evaluation, and systems maintenance. In the operational tests, most of these skill areas were filled by private sector personnel. As far as the developmental aspects of the operational tests, this arrangement worked very well. It became clear, however, that when materials were submitted to state and local agencies for review, there were no qualified engineers or systems analysts that could evaluate them.
The implications of these findings for AHS include the need for a clear understanding of the role of the public sector. Even with much of the systems development and integration performed by the private sector, the public sector will require its own unbiased experts in the appropriate technologies to oversee and regulate AHS facilities and vehicles. Some of the issues mentioned in the operational test program, will be mitigated as IVHS and AHS reaches the full deployment stage. For example, many states and some localities are establishing dedicated offices or divisions to handle intelligent transportation system technologies. It is important to note, that the obstacles are more "structural" than cultural. The existing state and local DOTs are not currently set up very well to plan, design, deploy and operate IVHS technologies and/or AHS. The consensus is, however, that these structural changes are being planned and implemented for the future.

In order to gain an understanding of current stakeholders understanding and concerns about AHS, a series of informal interviews were held with transportation officials in two major urban areas: Atlanta and Washington, D.C. In Atlanta, discussions were held with senior engineers at Georgia DOT and with planners from the Atlanta Regional Council, the local MPO. Prior to the visit, a strawman description of an AHS was sent to each of the participants for their review.

The Georgia DOT engineers were very familiar with many IVHS technologies, especially those related to advanced traffic management systems (ATMS). Georgia DOT is currently installing a large scale ATMS in and around Atlanta with the goal of being operational in time for the 1996 Olympics. The Georgia DOT representatives reiterated many of the same concerns found in the operational test case studies. Even though the ATMS is a large scale integration of electronic equipment there is only one Electronics Engineer position within the Georgia DOT. Even with the automation features of the system, two full time positions were needed in the City of Atlanta's traffic management center. The city had some difficulty in committing to these personnel requirements. The DOT will operate a central information distribution center using data entry personnel to transcribe information from cellular calls and radio reports into a traffic information database. The DOT did not have an applicable personnel category for "data entry" and suggested using the same qualifications as "equipment operator" to fill these positions.

The Georgia DOT representatives' reaction to the AHS description and proposal was generally favorable. As traffic engineers, there was some concern over the details of the entry and exit functions and how such a high volume of traffic could be absorbed at the terminus of an AHS. Given a feasible and cost effective solution to all of the AHS technical hurdles, it was felt that an AHS could offer a viable solution to certain needs facing Georgia DOT. The shortcomings related to personnel and training were seen as only a short term problem. The Georgia DOT is committed to building and maintaining one of the most advanced ATMS installations in the country. The department does seem to understand what is ultimately required, in terms of support resources, to accomplish this.

Representatives of the Atlanta Regional Council (ARC) were transportation planners by training. They too had many technical concerns about integrating an AHS into conventional traffic lanes. Some of the preliminary concepts were discussed, such as a transition lane or a dedicated facility. It was thought that transition lanes would defeat any benefit gained from the additional capacity of an AHS. A dedicated AHS facility might require large amounts of right-of-way -- something not in abundant supply around Atlanta. The ARC is in the planning stages of an HOV lane installation on I-75 in Cobb County. Current plans call for the taking of an existing conventional lane for the peak period use by HOVs with two or more people. Given the strong public and political resistance to this HOV plan, the ARC planners questioned the feasibility of dedicating an existing conventional lane exclusively to automated vehicles.

An AHS for Atlanta was also discussed in light of urban planning considerations. Atlanta is now considering an "Outer Perimeter," or outer beltway, to handle widespread growth of suburbs. An AHS which made travel to and from Atlanta employment center easier from further out would tend to intensify this suburban sprawl. Like many MPOs in non-attainment areas, Atlanta is struggling to meet the requirements of the CAAA and ISTEA. These new constraints have not seemed to have a significant affect on road project planning, however. Unlike the Washington, D.C. area, where there have been several real or threatened lawsuits over planned highway improvements and compliance with the CAAA, the Atlanta area is still planning and building roads and freeways. A Cobb County Transit Alternatives Study, concluded that further planning for the extension of rail transit (MARTA) into the county should be postponed for two years. Still, these ARC planners could foresee the use of AHS as one of many possible transportation solutions once convinced that the technical and cost issues were sufficiently addressed.

Discussions with Washington, D.C. area officials about AHS potential were conducted even more informally. At the time of these discussions, there were several more pressing concerns related to the transportation planning process in the Northern Virginia jurisdictions of the Metropolitan Washington Council of Governments (COG) -- the area's MPO. These other concerns are discussed here because they are quite relevant to any planning for an AHS deployment. First, COG has had a very difficult time coming up with a politically acceptable air quality improvement plan. As a severe non-attainment area, the plan must include a 15 percent reduction in emissions by 1996. This is in addition to the mitigation of all growth related gains in emissions during that time. Key issues centered around mandates for employer-based transportation control measures (TCMs) that would reduce low-occupancy vehicle travel to employment centers. Second, the Virginia SIP was deemed non-compliant by the EPA and the state is facing a possible cut-off of federal highway funds if an acceptable plan is not submitted. Finally, several highway improvements were being proposed as additions to the region's TIP in order to support a bid by a major entertainment company to build a large theme park in one of the outer jurisdictions. There are several threats of lawsuits to stop these improvements, since they were seen as promoting suburban and ex-urban growth and contributing to a growth in VMT.

The discussions of a potential AHS facility took place in the context of these events. There are several issues with these events that have implications for evaluating the benefit-cost comparisons of an AHS. It was suggested that an AHS could possibly offer transit-like service, via carpools or vanpools, with a wider range of origins and destinations than conventional rail and bus transit can offer. This type of AHS could fit into regional air quality improvement plan. One of the primary reasons that the major highway improvements were opposed was that it was seen as mainly benefiting one corporation. A proposed AHS must have a broad-based appeal and a recognizable benefit to a large number of people.

4. CONCLUSIONS

SUMMARY OF ISSUES ADDRESSED

Legal Issues

The issue of tort liability has been researched at length, both in the context of IVHS technologies and, as a focus of this effort, for AHS products and infrastructure. The potential for tort liability to severely impact development of AHS is very real, primarily due to the additional costs it will impose on AHS products. The risk of this becoming a "show stopper" for AHS, however, can be classified as only medium in nature. This is due the relevant experience to date within the automotive industry and the somewhat related experience of ATMS and ATIS technology deployment.

Suggested approaches to mitigating the issue of tort liability have centered around tort reform, that is placing caps on damage awards, limiting the terms under which punitive damages may be sought and special exemptions from liability for protected products. The history of tort reform measures has shown that federal legislation is difficult to pass. The Systems Definition phase of the AHS program should seek to minimize the risk of failure (and the coincident cost of liability) through a comprehensive and iterative design process. This should be a pro-active approach, which seeks to prevent injuries due to product failure, and not a defensive approach against possible litigation. This pro-active approach will compliment any possible tort reform or special protection that may be found politically feasible.

Regulatory

The FAA model of aviation regulation offers many insights into the types and extent of regulation that will be required for AHS designers, manufacturers, and operators. There is little probability that state DOTs and DMVs will allow some new or expanded federal agency to completely assume their current powers of licensing, regulation, and operation of the highway system. However, since the level of control of an AHS over each individual's vehicle is so complete and the potential harm in case of failure is relatively large, the federal government will be expected (by a majority of the public) to play a strong role in AHS regulation.

The FAA regulatory model is recommended as a potential AHS regulatory model. The AHS vehicle designs, infrastructure design and operation, and driver certification will need to be uniformly safe across all manufacturers and within all states. However, this does not mean that the AHS regulatory process has to be solely vested in the federal government. The path that leads to an AHS regulatory model must start with the existing regulatory framework. As AHS matures and is deployed , the regulatory framework will have to evolve toward one which is inclusive of all the current stakeholders (NHTSA, FHWA, FTA, state DOTs and state DMVs, state and local public safety agencies) and capable of regulatory functions similar to those used in the airline industry.
The following table lists potential stakeholders in an AHS and some preliminary assignment of roles in the regulatory framework. Note that some roles will be familiar, but will take on added importance within the context of AHS. Some of the recommended roles are different in ways not as subtle as the table entries suggest. For example, FHWA has never been in the business of setting standards. Roadway design criteria have been the responsibility of the American Association of State Highway and Transportation Officials (AASHTO), with support from FHWA. An AHS will require much more stringent design criteria. For some AHS configurations (e.g., subordinate control), these criteria will approach the level of formal standards.

TABLE 2.
Participants and Roles in AHS Regulation

Participant	Role	Comments
Congress	Establishment of federal standards for preemption of state tort laws for AHS.	Airline and drug industries are precedents. Will require strong case to make politically feasible.
NHTSA	Establishment of technical standards for vehicles.	Requires expansion of existing role into performance standards.
FHWA AASHTO	Establishment of recommended design criteria and operational standards for AHS infrastructure.	Requires strengthening of existing criteria. Real standards must be set.
State Legislatures	Clarify AHS insurance program standards. Establish traffic ordinances and laws regarding AHS operations.	May require expansion of existing roles into vehicle and roadway inspection for evidence of insurability.
State & Local Transportation and Motor Vehicle Agencies	Design/Conduct or Review/Inspect AHS roadway construction and maintenance. Testing and certification of AHS drivers. Inspection and certification of AHS vehicles.	Existing roles greatly expanded in technical scope and logistical requirements.
State & Local Public Safety Agencies	Enforce AHS traffic laws and vehicle inspection requirements.	Existing role expanded in technical scope.
Private Insurance Companies	Establish insurance program for AHS users.	Expansion of existing programs into area with unknown risks may require initial underwriting by public sector.
Automotive Manufacturers	Provide and train personnel to assist in the certification process under the direction of public sector agencies.	Requires new and significantly expanded roles.

Funding Alternatives

The funding of an AHS facility will likely be undertaken much like any other transportation system improvement. This issue was examined in light of ISTEA and CAAA requirements and emerging trends in public/private and wholly private financing of transportation projects. The good news is that all existing forms of funding for conventional roadway and transit projects are available for AHS projects. Even with the completion of the interstate program, however there is still a shortfall in funding for all transportation infrastructure improvements.

This means that AHS projects will have to provide benefits that exceed those offered by conventional projects. Funding alternatives available will depend on how much better the AHS project is than competing alternatives. This includes the null or “do nothing” alternative where the cost of the improvement must be weighed against the cost of continued congestion and poor mobility. Given a benefit/cost ratio only slightly greater than the competing alternative, an AHS project will be too great a risk for private financing (including toll financing) and would require public funds to implement the project. With a greater improvement in the benefit/cost ratio, public-private partnerships or toll financing allow the leveraging of public funds with reduced risk to private investment. Only AHS projects with a significant advantage in terms of benefits and costs will be attractive enough to be considered for wholly private financing.

Public Private Partnerships

A number of structural and organizational issues were examined concerning public-private partnerships. These include the issue of differing roles, private use of public funds and authority, mistrust between partners and apportionment of liability. The most important issues within this list can be mostly solved through better communications between the partners. This means taking the time to explain what each partner_s roles are and what the expectations will be for the project.

Other issues, such as the apportionment of liability between partners, are best resolved as part of a comprehensive approach to legal issues rather than a piecemeal solution just to accommodate the public-private arrangement. In contrast, attention is very much needed on just how public-private ventures are expected to operate as a business venture. Some private sector participants in the operational test program have complained that the public sector does not adequately understand business plans and profit and loss analysis. Some of these concerns may be the result of lack of experience with the concept, however these issues cannot be expected to resolve themselves.

It is recommended therefore, that standards of practice be established for public-private partnerships. These would include model ordinances spelling out the “rules of engagement” and the general requirements of all parties. These standards should be developed by FHWA or some other third-party entity. These standards of practice could then be used by the state or local agency to serve as a basis for contracts or enabling legislation.

Societal Aspects

The potential public acceptance of AHS vehicles and services was projected by studying the results of the evaluation of the TravTek operational field test. Specifically, user acceptance was related to several parameters reported from the TravTek results: level of control, quality of life, perceived safety, and driver privacy. Market acceptance parameters included willingness to pay and who should pay issues. Public and political acceptance measures were limited to a ranking of social needs that the technology (TravTek in this case) should address.

In summary, the TravTek results showed a high enthusiasm for the IVHS user services offered. The level of control that the guidance system had over the drivers_ route choice was not reported as a concern. Perceived safety and other benefits contributed to a reported positive influence on the quality of life by the technology. The mean response from TravTek users was that they would spend up to $1,000 for the equipment and services offered by the system. Most users felt that continuing operation of the system should be funded by whomever is receiving the benefit, including both public highway agencies and private advertisers on the system. The needs of the individual drivers (improvement in mobility and/or safety) were ranked ahead of reduced energy and environmental impacts as a desired used of the TravTek technology.

A recommended approach to developing and maintaining public acceptance and support of AHS must include highly visible demonstration projects like TravTek. This should include a series of public tests of various elements of an AHS (e.g., intelligent cruise control, collision avoidance, etc.). Coordinated with the planned 1997 demonstration of a full AHS prototype, this campaign will make the public aware of the capabilities and potential for all elements of an AHS. This will stimulate market demand and allow a more natural evolution and deployment of AHS enabling technologies in both the automobile industry and the transportation infrastructure.

The TravTek results that showed a higher regard for personal mobility and safety over environmental concerns should be reviewed in light of the fact that these were private responses. Public sentiment will include these personal desires, but tempered with a desire to protect the environment as well. Therefore, any public relations campaign must be able to show positive energy and environmental benefits attributable to AHS.

Environmental Law Issues

The environmental requirements laid out by ISTEA and CAAA for surface transportation projects will also apply to AHS projects. These requirements will apply to any AHS project that is located in a metropolitan area that is in non-attainment with the ambient air quality standards. A particular requirement in these non-attainment areas is that any new project must past a conformity test that proves the project makes a positive impact (not just no impact) on the air quality of the region. This requirement applies to all projects in a non-attainment area regardless of whether the funding is public or private. Furthermore, no project in a non-attainment area may contribute to a region-wide increase in VMT. This is both an attempt to control growth in vehicle emissions and growth in suburban sprawl.

The approach to dealing with these environmental requirements in urban areas centers on two aspects of how an AHS might be planned and developed. One aspect is the type of vehicle to be used. The mobility needs of most urban areas cannot be met by conventional mass transit because of low development densities. Nor can these needs be met with additional conventional highway lanes. An AHS for transit and/or HOVs would provide an enhanced speed and capacity mode that could better serve less dense areas and link suburban areas to rail rapid transit systems. A second aspect is the type of corridor served. A highly developed corridor with excess demand and too little room for expansion could increase peak period through-put via an AHS. Vehicle miles of travel would not increase, but levels of service would improve during peak periods. Finally, the projected benefits of AHS must offer real solutions to both mobility and the environment.

Organizational Issues

It has become clear, even given the brief history of the IVHS program, that the institutional framework which builds and operates conventional highway and transit systems cannot continue to do "business as usual" and expect to efficiently deploy and operate high technology transportation systems. This finding is supported by studies of the IVHS operational test program and interviews conducted as a part of this PSA study.

An earlier section suggested a potential framework for handling regulatory functions. Much of that framework will be involved with AHS development and deployment as well. Depending on the AHS configuration, the level of involvement will vary. A subordinate control AHS will require a relatively large organization of system operators to handle the infrastructure command and control system. An autonomous control AHS would require less of an infrastructure based organization and greater reliance on vehicle manufacturers.

As the required skills and duties of those involved in delivering transportation services change with more and more highway and transit automation, the organizational structure of state and local DOTs will have to adapt. A recommended way for local governments to approach this change is through a coordinated program of in-house training and privatization. This approach builds a base of knowledge within the organization while encouraging the wide spread dissemination of methods and procedures within the private sector. The operational framework for an AHS should be an outgrowth of that now emerging for IVHS technologies.

Findings Critical to the Success of AHS

The following are three key findings that should be included as some of the most important non-technical issues to be resolved for the future success of AHS.

Tort Liability

- Product liability presents a potential impediment to the deployment of AHS since the cost to settle tort claims could make the cost of the system prohibitive.

- Product liability costs can be controlled or transferred, but not eliminated.

    - The primary way to control tort liability costs is through careful design of AHS products and careful operation of AHS facilities. Such due care and diligence will reduce the probability and/or severity of injury due to product failure, malfunction or misuse.

    - Federal or state legislation which limits damage awards or grants a special "exemption" from product liability for the AHS industry (as for the airline and pharmaceutical industries) transfers some of the cost of product caused injuries from manufacturers or operators to the injured parties.

    - Product liability costs are transferred to all users of the AHS service through incremental costs added to products and services. This type of "cost transfer" is currently practiced by the automobile industry to cover damage awards and settlements in product liability cases.

Financing & Deployment

- All financing options open to conventional highway or transit construction modes are available to potential builders of an AHS.

- All deployment criteria (e.g., ISTEA and CAAA) that apply to conventional transportation improvements will apply to AHS products. CAAA conformity determinations will apply to both public and privately financed projects.

- All financing options will be heavily dependent on the ability of AHS to provide expected benefits. For public financing, the AHS must satisfy a major investment analysis for the use of public funds. For private financing, property values and/or user fees must be able to provide a profit motive.

Organizational Frameworks

- Most State and local DOTs are ill-equipped to handle the complex tasks associated with deployment and operation of an AHS. This is a structural shortcoming that will likely require a revamping of state and local personnel and organizational frameworks.

- Even with the private development and operation of AHS, a public supervisory bureaucracy will be required to support public acceptance of AHS. NHTSA not withstanding, this bureaucracy does not now exist and must be created.

Issues and Risks that will have Significant Impact on AHS

The issues surrounding tort liability represent a moderate level of risk to further development of AHS. This risk is not seen as a potential showstopper unless total costs cannot be contained or if safety is less than a sure thing. Either of these events may result in a total product cost that is financially infeasible once the product liability costs are built in.

The resolution of regulatory issues will shape the ultimate mode of deployment and operation of AHS. At the federal level, a design and production certification process that quickly processes manufacturer AHS design submittals will enable the quickest most cost effective deployment of AHS ready vehicles. Whether this federal involvement is from NHTSA or some other agency depends on the evolving mission of FHWA . Ideally, all state and local regulation of AHS will be similar from state to state. Most likely, this will not be the case. Differing state and local regulations will result in differences in AHS deployment. These differences will likely affect public perceptions and market acceptance.

Issues and Concerns for Further Study and Resolution

Compliance with environmental laws will be required of any operational deployment of AHS. The ability of AHS to meet these requirements will depend heavily on the primary and secondary benefits of this user service. Transportation planning for conventional highway and transit projects is still a less than precise science. Projections for travel and ridership demand are often only educated guesses. The underlying relationships between transportation improvements and changing land use is only now being well understood. The role of AHS as a potential tool for transportation planners to use in solving mobility problems will depend on ongoing and future studies of the benefits and impacts of transportation system improvements. This must also include the demonstration of projected AHS benefits.

Market acceptance of AHS is an area where there is still too little data to make a projection regarding future demand for this user service. The results of the TravTek study are very encouraging for the development of traveler information and traffic management services. An AHS may be considered a logical extension of these services and some valuable information is extrapolated from the apparent market acceptance of TravTek like services. The concept of fully automated travel is still a far fetched one for many consumers, however. Future market acceptance studies should not only measure the consumer's desire for AHS user service, but should correlate this desire with their understanding of the concept and willingness to pay for the service.

APPENDIX A: ANNOTATED BIBLIOGRAPHY

Project Memorandum, IVHS Institutional Issues: Identification and Definition of Institutional Issues (PM-42-93-AD1), November 1992, U.S. Department of Transportation.

This document lists and defines institutional issues found during an extensive review of publications (government, commercial and academic) by Volpe Center analysts, which might affect the deployment of IVHS products and services. Topics covered encompass a broad range of issues to include: coordination among participants, legal issues, financing and product management/development among others.

"Supplementary Description of Automated Highway Systems (AHS)", Supplement to "Broad Agency Announcement for Precursor Systems Analyses for the Automated Highway System (AHS) Program", U.S. Department of Transportation, November 1992.

A high-level overview of AHS operations and general program goals. Delineation of intended societal benefits and system operational concepts serve to underscore the broad range of institutional issues likely to mark deployment of AHS. Institutional issues not addressed directly.

National Highway Traffic Safety Administration (NHSTA) IVHS Plan (Attachment 2), DTFH61-93-R-00047, June 12, 1992, Department of Transportation.

NHTSA's role in IVHS program, comparative role with commercial industry in product safety assessment/development and the agency's vision of its role in the implementation of safety-effective commercialization of IVHS by industry. Implicit in this article are issues involving commercial sector and government relationships and interactions in AHS product development and program management.

"National Intelligent Vehicle-Highway Systems Program": Transcript of Testimony Before the House Appropriations Committee, Subcommittee on Transportation and Related Agencies, April 15, 1993, Thomas A. Horan, Ph.D., April 15, 1993, George Mason University.

Briefly addresses quality of information available to the Congress and the nation on how and where IVHS can most beneficially be applied. Lists several institutional issues that could affect the overall course of IVHS.

" Toward Adaptive IVHS: The Role of Impact Assessments in Guiding the Development of Advanced Transportation Technologies",Thomas A. Horan, Ph.D., Proceedings of a National Workshop on IVHS Benefits, Evaluations, and Costs, Washington D.C. : IVHS America, Spring 1993.

An overview of IVHS within the current transportation policy context followed by a brief review of expected IVHS impacts and requirements for sound evaluation information. Two potential institutional impacts are identified and receive a few lines each: public/private cooperation and the role of IVHS within the context of regional governance. Author devotes more space to Army Corps of Engineers' long experience with introducing major change to communities.

"A Sociotechnological Perspective on Public-Private Partnership for IVHS Infrastructures": IVHS Technical Report: 92-01 (Draft), Kan Chen, Frank P. Stafford, The University of Michigan.

A detailed treatment of issues surrounding private-public partnerships and potential partnership arrangements and opportunities. Report cites specific examples, followed by possible solutions to current barriers. Issues addressed include regulatory policies, financing and legal liabilities. Highly supportive of private sector involvement in IVHS product and service development and deployment.

"Status Report on the Automated Highway System Program", J. Richard Bishop, Jr, FHWA IVHS Research Division, and Elizabeth Alicandri, FHWA Information and Behavioral Systems Division, Presented at the Autonomous Unmanned Vehicle Society Annual Meeting, Washington D.C., June 28-30, 1993.

This paper summarizes the FHWA vision of an Automated Highway System within the context of the Intelligent Vehicle Highway System. It provides the FHWA program approach and status of current major activities. It identifies, but does not elaborate on, a number of issues pertaining to each RSC including institutional and societal aspects which FHWA believes will affect operation and deployment of AHS systems.

"Highway Automation: Regional Mobility Impacts Assessment", Mark A. Miller, et al., Presented at the Transportation Research Board 72nd Annual Meeting, Washington D.C., January 10-14, 1993.

This paper focuses on the evaluation of mobility impacts of automation technologies applied to portions of the Southern California freeway network in 2025. It summarizes the findings of a projected application of AHS technologies to non-desert portions of Los Angeles, Riverside, San Bernadino, Orange and Ventura counties. Results indicated potential for sizable mobility benefits and significant congestion relief.

"Human Factors Design of Automated Highway Systems (AHS)": Task A.5 First Generation Scenarios: H.S. Jacob Tsao et al., PATH Program Institute for Transportation Studies University of California, Berkley and Thomas A. Plocher et al., Honeywell Inc., California Department of Transportation, April 8, 1993.

Describes results of an effort to develop AHS operational scenarios that will exercise a broad range of potential AHS functions so as to define the driver-system interfaces for the AHS system. Human factors and infrastructure were the primary issues under consideration for this analysis.

"An Overview of Systems Studies of Automated Highway Systems", James G. Bender, IEEE Transactions on Vehicular Technology, Vol.40, NO.1, IEEE Log NO. 9040759, February, 1991.

This paper summarizes a comprehensive systems study of the factors influencing the design, development and deployment of an AHS. The primary emphasis of the article is on developing a recommended RSC for deployment. Liability, environmental impact, community impact and financial concerns as they relate to the selected RSC are summarized. The author was with the Allison Transmission Division, GM Corp., at the time the article was written.

Nontechnical Report to Congress Public Docket Submissions, Thomas E. Marchessault, Facsimile, Industry Economics & Finance Division, U.S. Department of Transportation, Washington D.C., July 8,1993.

A seven page fax listing people (by organization) who had submitted comments to the Public Docket on nontechnical IVHS issues as of June 15, 1993. Information also includes a useful matrix that tracks IVHS topics by the organizations which expressed interest in them. The document also includes copy of the Wednesday, February 3,1993 issue of the Federal Register containing comments addressing potential nontechnical constraints to IVHS deployment.

Intelligent Vehicle Highway Systems Institutional and Legal Issues Program - Project Updates, Federal Highway Administration's Office of Traffic Management and IVHS et al., U.S. Department of Transportation, Washington D.C., April 7, 1993.

This document provides an update of Federal IVHS programs addressing institutional and legal issues. The document provides the subject area/product (e.g., Nontechnical Constraints Report-fiscal years 92-94), program objectives, progress to date, the DOT lead, the off-site lead and total cost for each program. Data presented in tabular format.

Intelligent Vehicle highway-Systems Public and Private Partnerships: Managing the Legal Issues - A Summary of Conference Proceedings January 25-26, 1993, Dallas, Texas, IVHS America Legal Issues Committee and Federal Highway Administration, TRESP Associates, Inc., Alexandria, Virginia.

Proceedings from conference sponsored by IVHS-America and FHWA in Dallas, Texas on the legal issues involved in IVHS. Examines unique aspects of the various agreements and contracts now in force and highlights some of the many pitfalls involved in a relatively new area of contract law.

IVHS and Social Policy, Patricia Waller, IVHS Review, Winter/Spring 1994, Washington D.C.

This article presents IVHS as a project with potentially broad social ramifications using development of the interstate highway system and subsequent suburban development as an example. This article cites the need to integrate IVHS development and public policy goals and identifies the U.S. Human Genome Project as an analogous effort in terms of size and potential social impact.

Public and Private Sector Roles in Intelligent Vehicle-Highway Systems (IVHS) Deployment: Final Report - Summary of Seminar Proceedings, April 8-9, 1992, Rockville, Maryland, Federal Highway Administration Offices of Policy Development and Traffic Management, Walcoff & Associates, Washington D.C.

This report provides a useful overview of the complexities of determining the nature of the relationship between the public and private sector that will be required for successful deployment of IVHS technologies and services. The report summarizes the proceedings of a Federal Highways Administration workshop held in cooperation with IVHS America. Twelve discussion topics were selected and papers were prepared prior to the seminar. Authors or coauthors of the papers presented summaries of the their findings to seminar participants who responded to the issues raised by the authors. This report records reactions to and comments made by the participants (to include authors) the issues raised and any conclusions drawn during the sessions. Topics addressed include: public/private sector ventures and roles in IVHS deployment, procurement issues, operational tests, and design and deployment issues.

Safety and Human Factors in IVHS, Thomas Sheridan, IVHS Review, Winter/Spring 1994, Washington D.C.

Article provides brief overview of safety factors and emphasizes their importance in IVHS development using examples from the aviation and nuclear power industries. The three broad levels of man-machine interface in terms of automation (e.g., machine evaluates data and takes action independently) described in the article are noteworthy due to their implications in regard to liability issues.

Institutional and Policy Assessment of IVHS, Thomas Horan, Arnold Howitt, IVHS Review, Winter/Spring 1994, Washington D.C.

This article describes key institutional and policy challenges that could affect the success of near-term deployment of IVHS products and services. It focuses on three issues: the need to assess IVHS within a regional approach; the need to assess stakeholder support for IVHS deployment; and the need to assess organizational capabilities for adopting and managing IVHS.

Seminar on Key Issues in Public-Private Partnerships for Highway Development: Draft Report - Summary of Seminar Proceedings, November 21, 1991, Washington D.C., Federal Highway

Administration U.S. Department of Transportation, Walcoff & Associates, May 5, 1992, Washington D.C.

This report summarizes a FHWA seminar on key issues in public/private partnerships for highway transportation. Primary focus of this report is on the critical issues facing highway agencies in any transfer of traditional public functions to a partnership involving the private sector. Report includes case studies describing the experiences and issues faced by the public and private sector during development of the California demonstration projects and on Virginia's Dulles toll road extension. Report provides perspectives of public and private sector representatives on public-private partnerships.

IVHS Legal Issues, Vol.2, No.2, IVHS Legal Issues Committee et al., IVHS America, Spring 1994, Washington D.C.

This edition of IVHS Legal Issues focuses on the laws that govern public/private partnerships and the forms these arrangements have taken in the IVHS arena. Of particular note in this edition are articles discussing the Department of Justice's new focus on the antitrust implications of technology developments (Gena E. Cadieux of Davis, Graham & Stubbs); the personal perspectives of John A. Milano (Asst. Chief Counsel of IDOT) and William T. Wilson (Counsel, Siemens Corp.) on public/private cooperation, respectively; and an article by Sol Glasner, General Counsel, MITRE Corporation on policy and law concerning public/private partnerships.

"Smart Cars and Highways Go Global", Ronald K. Jurgen, IEEE Spectrum, May, 1991.

This article appeared as a special report in the May 91' edition of IEEE Spectrum as a special report IVHS. Although somewhat dated, the article provides a clear overview of some of the institutional issues that have yet to be resolved and could potentially slow or arrest IVHS deployment. That section of the article dealing with institutional issues focuses on questions concerning liability and financing. Other issues such as safety, privacy or the implications of multijurisdictional deployment on technological integration are receive cursory attention.

"IVHS: The Invisible Revolution", John Pendergast, Civil Engineering, Vol. 63, No. 4, April 1993.

Article addresses a number of non-technical constraints in addition to those typically listed such as issues affecting the construction and design communities, which are discussed the manager for federal programs of the Bechtel Group, Inc. Other issues such as data availability are discussed briefly.

IVHS Legal Issues, Vol.2, No.1, IVHS Legal Issues Committee et al., IVHS America, Winter 1994, Washington D.C.

This edition of IVHS Legal Issues focuses on intellectual property aspects of IVHS. Of particular note in this edition is the article excerpted from a paper entitled "Intellectual Property Rights and the National IVHS Program" that was prepared for FHWA (Contract DTFH61-93-C-00087). The article addresses potential constraints related to patents, trade secrets, and state intellectual property law. The paper suggests that while the complexity and ambiguity inherent in the laws and policies governing intellectual property rights may discourage some potential private developers, current law and policy are flexible enough to permit private developers to participate in public/private consortia without giving up rights in pre-existing and independently-developed technologies. Also of note is an article prepared by Beverly Russell, a transportation specialist in FHWA's Office of Traffic Management and IVHS, entitled "The Government License Under Federal Funding Agreements". This article addresses government license provisions of the Bayh-Dole act of 1980 and the 1983 Presidential Memorandum. According to the article, these measures were designed to increase the probability of commercial development of inventions developed with federal assistance. The intent of the Bayh-Dole Act, according to Edward C. Walterscheid, author of "The Need for a Uniform Government Patent Policy: The DOE Example", is that the government is " .... not as successful as the private sector in delivering new products/inventions to the marketplace ...." and that therefore ".... the public is not receiving the full benefits of the research and development efforts that it is supporting". Followed to its conclusion, the article suggests that the private sector should not view federal licensing provisions as an impediment to public/private product (i.e., IVHS) development.

"Big Brother is Clocking You", The Economist, August 7, 1993.

This article raises questions regarding the potential effects of IVHS technologies on civil liberties in the areas where they would be deployed " .... technology that promises fewer traffic jams may damage your civil liberties". The emphasis of the article is on technologies that would probably be components of ATIS systems or automated toll systems. The article suggests that systems designed to identify specific motorists for billing purposes (e.g., electronic toll booths) or that transmit a car's location to an ATIS control center would create a database that could be used to track the location of a specific motorist is at any given time. The central theme of this article is that while these technologies offer benefits, there are also privacy considerations that will have to be addressed before they are deployed.

APPENDIX B: LEGAL PAPERS AND REVIEWS

LEGAL AND INSTITUTIONAL ISSUES ARISING FROM THE DEVELOPMENT OF AUTOMATED HIGHWAY SYSTEMS

Prepared for the Federal Highway Administration

by

Curtis M. Coward, Esq.
Thomas K. McGowan, Esq.
McGuire, Woods, Battle & Boothe
8280 Greensboro Drive, Suite 900
McLean, Virginia 22102

EXECUTIVE SUMMARY

The challenge of developing automated highway system ("AHS") technology in the United States inherently includes significant institutional and legal issues. However, the available technology and its costs and benefits, not these institutional and legal issues, should be the controlling factors in creating an automated highway system. The legal issues raised by the design, manufacture and operation of an AHS do not vary significantly between the three proposed representative configuration systems ("RCS"): Subordinate Control (Smart Highway); Autonomous Control (Smart Car); and Combined Control (Average Concept). This paper addresses four issues which must be resolved in order to create an AHS in the United States: Financial Structures; Tort Liability; Environmental Law; and Federal Regulation.

The recent private toll road legislation in Virginia and the Federal Aviation Airport and Airway Trust Fund are helpful models in financing the development of an AHS. If adopted with certain modifications, both programs could be used to contribute towards the creation of an AHS in the United States. Additionally, Virginia's special tax district legislation may also provide a mechanism for financing the costs of constructing and operating an AHS. However, because special tax districts depend upon indirect economic incentives in the private sector, any proposed AHS which is dependent upon such financing must provide a tangible economic benefit to local landowners to encourage the substantial investment which will be required.

The product liability laws in the United States have created the most comprehensive and complex risk allocation system in the world. Despite recent efforts to standardize liability, tort reform is a controversial issue. While allegations by manufacturers that irresponsible damage awards have become routine, legislators at both the state and federal levels have resisted implementing wholesale reforms for many years. Nonetheless, numerous options to reduce product liability expenses exist if the federal government desires to reduce the cost of developing and manufacturing new AHS products. Principally, the federal government could preempt state tort law to the extent state laws might be different from federal AHS safety standards, prohibit tort claims for heavily regulated AHS products, and/or require that plaintiffs show intentional malicious behavior by the defendant by clear and convincing evidence before awarding punitive damages in product liability cases.

The potential increase in traffic and air pollution resulting from AHS will raise significant air pollution control issues for urban areas. In the Clean Air Act as amended in 1990[12] (the "CAA"), Congress has mandated that areas not meeting minimum air quality standards must adopt strict plans to reduce air pollution. Potential increases in pollution produced by AHS programs in those areas will create two important conflicts with the CAA. First, to account for any additional air pollution from AHS in their implementation plan, states will have to reduce air pollution from other sources. It will be politically difficult to require others in regions not served by the new system to reduce their air pollution to accommodate an AHS. Second, Congress has expressly stated that one objective of the CAA is to reduce air pollution by reducing "vehicle miles travelled" and encouraging the use of mass transportation. However, creating additional highway capacity by building an AHS may encourage more automobile use and reduce incentives to use mass transportation. Accordingly, the Environmental Protection Agency, which has enforcement authority under the CAA, may not wish to approve modifications to pollution reduction implementation plans to accommodate an AHS program.

Finally, due to the special safety concerns associated with AHS technology and the substantial inherent risks in operation, the federal government may wish to supervise and regulate the design, construction and operation of AHS. The Federal Aviation Administration_s regulation of the

[12] 42 U.S.C.S. § 7401 et seq.

air transportation industry is discussed as a model for safety regulation of the AHS transportation industry.

INTRODUCTION

The purpose of this paper is to identify various institutional and legal issues that may arise from the development, construction and operation of an AHS and to discuss what effect several different RCSs may have on those issues. Science Applications International Corporation ("SAIC") previously recommended the following three basic RCSs for further evaluation[13]:

Subordinate Control System - Also known as the Smart Highway/Dumb Car, this configuration places most (if not all) of the processing, communications, command and control functions within the roadway infrastructure. AHS vehicles would be required to have actuators to control vehicle operations (steering, accelerator, braking, etc.) and some type of communication transponder to receive instructions from the roadside controllers and transmit acknowledgments. Sensors to determine vehicle position and whether potential roadway obstructions are within the roadway infrastructure.

Autonomous Control System - Also known as the Smart Car/Dumb Highway, this configuration requires that, in addition to control actuators, each vehicle must have on-board sensors to determine lane position and relationship with other vehicles and obstructions and an on-board information processing capability to determine control actions for navigation and to respond to changing conditions. The roadway would provide passive guidance and perhaps some regional information on traffic and weather conditions.

Combined Control System - Also known as the Average or Distributed Concept, this configuration would allow a more widely distributed level of command and control. Both vehicles and the roadside would have some elements of the sensor, communications, processing and control systems. The roadside based command and control system could provide a backup system to the vehicle based system or could take over to provide more tightly controlled platoons as congestion increased.

This paper focuses on four issues arising from the development and operation of an AHS: alternative public/private methods of financing AHS; the need to reform tort liability law to insure appropriate burdens on potential manufacturers of AHS products; environmental law and how the Clean Air Act will affect the development of AHS; and the Federal Aviation Administration's regulation of air travel as a model for regulating an AHS.

DISCUSSION

I. FINANCING STRUCTURES

A. Introduction

In an era of insufficient public funding for transportation improvements, the development of AHS may well depend upon identifying innovative public/private financing mechanisms. The

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[13] Technical Memorandum No. 1 Representative System Configurations to be Evaluated for Institutional and Societal Issues prepared by Science Applications International Corporation ("Technical Memorandum No. 1").

Commonwealth of Virginia has recently adopted several different methods to promote private financing for public highways which might prove useful as models for AHS development.

One such method is privately owned toll roads. Under the Virginia statute, a private corporation purchases the land for the highway and contracts with the State to build the highway and issue bonds to finance the construction of the highway. The private entity collects tolls until the financing has been paid off and then transfers the highway to the state, all for a fixed rate of return. Another method recently enacted provides for the creation of special tax districts to finance improvements. In a special tax district, commercial property owners are taxed an incremental amount to pay a portion of the cost of the project. This type of financing is appropriate for projects with substantial local benefits that serve as an incentive to commercial landowners to organize a special tax district.

Another important financing model at the federal level for AHS transportation projects is the Airport and Airways Trust Fund Act. Congress adopted this legislation to provide a dedicated source to pay for airport and airway capital improvements. However, if a trust fund is used to finance AHS projects, the trust fund must be kept separate from the federal budget to avoid the problems confronting the Airport and Airways Trust Fund.

B. Private Toll Roads

In response to the near gridlock on Northern Virginia's highways, Virginia adopted legislation in 1987 which allows private corporations to build and finance private toll highways (the "Toll Road Act").[14] The Toll Road Act was enacted to tap existing public demand for immediate relief from traffic congestion as a source to finance new road construction. As a toll road, travellers are assured that their user fees go directly to construction of improvements that benefit them, unlike gasoline taxes or other general statewide taxes which may be fragmented for a variety of public purposes. Accordingly, tolls have proven to be a politically feasible method to finance new highway construction.

Under the Toll Road Act, private parties may apply to the Virginia State Corporation Commission (the "SCC") for a certificate of authority to construct a public roadway which may be financed by tolls. The SCC must grant the application if it finds, after a public hearing, that the application is complete, approval of the application is in the public interest, and that the applicant has complied with the provisions of the Toll Road Act. The design and construction of the proposed roadway must be approved by the Commonwealth Transportation Board, and the road alignment must conform to the comprehensive plan for each county or locality through which the road will pass.

The Toll Road Act provides that the petitioner may correct a fixed rate of return on his investment through State regulation of the tolls that may be collected. The State may issue bonds to finance the construction of the roadway; however, it may only pledge the proceeds from tolls to repay these bonds. After the owner has paid back the financing for the roadway, it must donate the roadway back to the state within ten years from the end of the term of the original permanent financing.

Virginia's Toll Road Act has two important limitations which make it difficult to construct a private roadway. First, the petitioner building the highway does not have the power of eminent domain. Therefore, the petitioner must obtain the voluntary consent of each landowner through whose property the roadway will pass in order to build the road. This proved especially difficult in the case of the 16 mile private roadway being constructed in Northern Virginia between the Dulles Toll Road and Leesburg. It took several years more than expected to obtain the consent of each

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[14] Va. Code § 56-535 et seq.

landowner along the proposed alignment as there were several holdouts. Accordingly, if privately owned toll roads are considered for developing AHS systems, some entity, whether the private owner or existing highway commissions, should be authorized to condemn the necessary property.

Second, the success of a private toll road will depend upon achieving and maintaining a minimum amount of use of the road in order to provide a reliable stream of revenues. Therefore, using the private toll road financing option may only be appropriate for an AHS when sufficient traffic demand already exists, as a private owner would likely not be able to bear the risk that demand would rise to a profitable level after the AHS is built. After AHS technology has matured and been accepted by the public, private toll roads may be a useful alternative for creating or financing additional AHS routes.

C. Special Tax Districts

The Commonwealth of Virginia has recently rejuvenated the use of special taxing or assessment districts to finance the construction of transportation facilities. Special assessment districts are not new. In fact, the British Parliament created the first recorded special assessment district in 1427 when a group of riparian landowners in the Cambridge area were subjected to a special assessment to pay for the draining of some marshes. Since that time, such districts have been used to fund every conceivable type of infrastructure improvement from sewers, sidewalks and highways to trash collection. Nonetheless, while Virginia's Transportation Service District Act[15] did not invent the notion of special taxes for financing public service, the legislation has incorporated several novel concepts to provide public and private incentives to create tax districts to finance new public services.

Under companion legislation, the Commonwealth Transportation Board is authorized to issue Contract Revenue Bonds which are repaid from the proceeds of the contract payments (i.e. the special tax proceeds) from the tax district. Importantly, the statute authorizes a call against the state's highway trust fund in the case of a deficiency. It is this credit support which makes the bonds so attractive to the public market, thus reducing the cost of debt and the amount of special taxes required to repay that debt.

1. Objectives of Tax District

The objectives of Virginia's Transportation Service District Act are: (a) to target the special tax burden exclusively on commercial and industrial properties; (b) to provide indirect access to Virginia's superior public credit; and (c) to establish direct linkage between the planned transportation improvements and land use within the district.

The special tax applies only to commercial and industrial properties in order to minimize political controversy, to avoid referenda, and to provide commercial landowners with the leverage to negotiate a balanced transaction with local government. By targeting commercial landowners with the special tax and by using the existing taxing powers of the county in lieu of creating new ones within these new districts, a number of difficult legal issues are avoided or resolved. Furthermore, on a political level, this targeting serves to enhance the attractiveness of the program substantially, by allowing local governments to provide important new improvements to the public on an accelerated basis without the imposition of any new general county-wide taxes. In exchange, the commercial

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Va. Code § 15.1-791.1 et seq.

landowners are given appropriate leverage in negotiating the terms and conditions of the proposed program due to the requirement that such districts could only be created upon the petition of a requisite number of commercial and industrial landowners within a proposed district.

The procedure set forth in the Transportation Service District Act involves only one public hearing, thus allowing the process to move forward expeditiously. This methodology allows commercial and industrial landowners to propose a project on terms which serve their economic interests. However, the power to approve and implement the project is reserved exclusively in the local governing body. The resulting balance provides for effective negotiations between the public and private sectors, and insures that no district is formed unless the interests of each are protected and advanced.

The second legislative objective is access to public credit. This element distinguishes Virginia's special tax districts very notably from the overwhelming majority of special taxing or assessment districts across the country. In the typical special district program, the public's sole contribution to project financing is the extension of tax exempt status to the district's debt instruments. Typically, such districts are empowered to issue bonds and the sole source of the repayment of those bonds is the special tax or assessment. Further, the security for such debt instruments is typically the real estate within the special district. Because of these factors, interest rates on special district debt are substantially higher than that of the debt of the relevant state or local government, and the default rate and complications of liquidating collateral are substantial.

The Transportation Service District Act, and the companion Contract Revenue Bond program, interpose the very substantial financial strength of the Commonwealth of Virginia, the locality, or both between the tax district and the bondholders. This end is achieved by proscribing the issuance of debt by the tax district, and by requiring instead that the district purchase the improvements under contract. This empowers the district to contract with the Commonwealth Transportation Board, which then pledges the proceeds of that contract, together with specified public revenues as either a supplement or credit enhancement to the holders of its debt instruments. Because the public agency participates in this way, the debt paper commands a very competitive interest rate, thus reducing the effective cost to the commercial landowners and minimizing the risk of default. As an example, in the case of the 14.3 mile Route 28 project in Fairfax and Loudoun Counties, the $138 Million project was financed in 1988 at an effective interest rate of 7.2 %, well below the cost of funds available at that time through conventional taxing district financings. In addition, because the Commonwealth Transportation Board has the power of eminent domain, the right-of-way acquisition problem which arises under the Toll Road Act is avoided.

Perhaps the most unique aspect of Virginia's special taxing district scheme relates to land use, the third element of the legislation. The legislation provides that the board of supervisors shall describe with specific terms all zoning classifications which shall be in force in the tax district for a term of up to 20 years (except for changes required by superseding state law or regulation, such as environmental legislation). This long term “contract zoning" is exclusive in Virginia to such districts, thus providing a powerful inducement to commercial landowners to initiate the formation of tax districts so that they may lock in their permissible uses and densities for the entire term of their buildout and financing. It is equally attractive to local governments in that it provides the power to land use provisions and transportation improvements in critical transportation corridors in such a way as to insure adequate levels of service over a prolonged period of time.

2. Application of Special Taxing Districts to RCSs

The prerequisite of the consent of the commercial landowners in the district limits the application of special taxing districts to projects which offer substantial economic benefits to adjacent commercial landowners. In order for landowners to agree to pay a special tax to support an AHS project, they must receive a direct and clearly definable benefit from the project. Any AHS project that can provide such a benefit is a candidate for serving as the basis for a special tax district. For example, landowners in a high density commercial area plagued with traffic congestion may wish to create tax districts to encourage a particular AHS project to be built near their property to improve access and enhance land values.

Historically, tax districts have been used to finance either local projects or regional projects that have an important local benefit. However, the role of special tax districts to finance AHS projects would not necessarily be limited to local AHS projects. Special tax districts may also be used to finance specified portions of a multijurisdictional AHS project with significant local importance. In this way, a regional AHS project may be supported in part by several local tax districts that collectively could provide an important portion of the financing necessary to build a regional AHS project.

It is important to note that under the Virginia model, special tax districts could be used to support only the publicly owned components of the three RCSs. Virginia's Constitution expressly prohibits the use of public revenues to provide a private benefit. Therefore, the proceeds of the special tax must be used to finance governmental, as opposed to private, costs of an AHS. Accordingly, special tax districts may be especially appropriate for a RCS that requires substantial publicly financed infrastructure, such as the Smart Highway RCS.

To encourage the creation of special tax districts to finance AHS projects, the FHWA could draft model state legislation similar to Virginia's establishing the proper balances and incentives for both commercial landowners and local governments. This model legislation would expedite local governments' consideration of this financing alternative as well as provide comfort to government and private participants that this method of public/private financing is feasible.

D. Airport and Airway Trust Fund

The federal aviation industry has imposed significant user fees to finance the construction and maintenance of airway infrastructure, including airports and the air traffic control system. Congress created the Airport and Airway Trust Fund[16] (the "Trust Fund") to provide a dedicated source of funding to pay for this infrastructure. The Trust Fund is financed by excise taxes on the aviation industry, including an eight percent ticket tax on commercial air transportation in the United States and aviation fuel taxes. However, despite a broad consensus that the current aviation system is congested and obsolete, the Trust Fund consistently takes in more taxes each year than is withdrawn to fund capital projects. The reason for this surplus is that the balance in the Trust Fund is counted against the federal deficit. Accordingly, the purpose of the Trust Fund has been lost in the overall domestic budget deficit debate, and the FAA has been deprived of the steady revenue stream needed to finance the long term capital projects necessary to improve the air transportation system. The National Commission to Ensure a Strong Competitive Airline Industry has recently recommended that the FAA be reorganized as an independent federal corporate entity in part so that the Trust Fund may be managed separately from the federal budget.[17]

[16] 49 U.S. C. S. § 2201 et seq.
[17] The National Commission To Ensure A Strong Competitive Airline Industry, A Report to the President and Congress, August 1993.

We strongly recommend that if a national trust fund is created to collect AHS user fees, such funds should be placed outside the federal budget. Otherwise, expenditures for AHS projects will be subjected to the same external forces which have frustrated the Trust Fund program.

II. TORT LIABILITY

A. Introduction

Product manufacturers often cite the American tort liability system as a significant cost and impediment to the design, manufacture and sale of new products. The American tort liability structure essentially burdens manufacturers with the cost of damages proximately caused by their products. Manufacturers routinely absorb this risk through insurance premiums which become a part of the cost of the product. Manufacturers claim that the tort liability system allows too many personal injury claims and that excessive amounts are often awarded to plaintiffs by sympathetic juries. As a result, they allege, insurance premiums soar, fewer products are developed and the price of products that are sold to the public is inflated to cover the high cost of potential product liability awards.

Toll reform for products liability has recently attracted special attention due to the strict liability standard to which product manufacturers are held and the threat of large and unpredictable punitive damage awards. As described more fully below, a strict liability standard generally means that a designer, manufacturer or seller is liable for damages to a user caused by a defective product even though the manufacturer has exercised all possible care in the preparation and sale of the product. In contrast, under the more traditional negligence standard, a manufacturer generally would only be liable to the user of a product if the manufacturer had failed to exercise a "reasonable" amount of care in preparing the product.

The theory of holding manufacturers strictly liability for harm caused by defective products is relatively new[18] and continues to evolve through periodic state legislative reforms and through case law. For years manufacturers have complained of the substantial costs associated with carrying the resulting economic risk of the American product liability system. However, despite the widely held perception that grossly excessive product liability verdicts are frequently given, efforts to significantly change U.S. tort law have failed. For example, federal tort reform proposals, such as the still pending Product Liability Fairness Act[19], have been defeated in Congress regularly since 1983.

Provided below is a brief summary of the current product liability system and a description of several possible methods for modifying that system to encourage the design, manufacture and sale of AHS products.

B. CURRENT PRODUCT LIABILITY SYSTEM

In general, persons who design, manufacture or sell products may be liable for two types of damages: compensatory damages and punitive damages. Compensatory damages are intended to reimburse the victim for the harm caused by the product and may consist of medical costs, monetary payments for pain and suffering, and reimbursement for lost wages. Punitive damages are not intended to compensate the victim but are imposed to punish the defendant and to deter others from acting in the same manner. Towards that end, punitive damages are often a multiple of compensatory damages. Both compensatory and punitive damages can be awarded to the same plaintiff. Accordingly, a manufacturer may be required to fully compensate a victim through a compensatory damage award and then be required to pay additional punitive damages to the same person.

Tort law, including products liability, is generally determined by state law. A manufacturer's potential liability therefore varies from state-to-state, creating considerable confusion and inconsistency. However, approximately 46 states have adopted the doctrine of strict liability, and

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[18] Henningsen v. Bloomfield Motors, Inc., 32 N.J. 358, 161 A.2d 69 (1960).
[19] Senate Bill 687 version 2 , 103rd Cong., 1st Sess. (1993).

about 37 states generally follow the strict liability rule as described in Section 402A of the Restatement of the law (Second) Torts[20]. Section 402A of the Restatement provides:

§ 402A. Special Liability of Seller of Product for Physical Harm to User or Consumer

(1) One who sells any product in a defective condition unreasonably dangerous to the user or consumer or to his property is subject to liability for physical harm thereby caused to the ultimate user or consumer, or to his property, if

(a) the seller is engaged in the business of selling such a product, and

(b) it is expected to and does reach the user or consumer without substantial change in the condition in which it is sold.

(2) The rule stated in Subsection (1) applies although

(a) the seller has exercised all possible care in the preparation and sale of his product, and

(b) the user or consumer has not bought the product from or entered into any contractual relation with the seller.

Note that Section 402A provides that a manufacturer is subject to liability for harm caused by a defective product even though he has exercised all possible care in its design and construction. Further, the strict liability rule makes any person in the product distribution chain liable, including designers, manufacturers, wholesalers and retailers. In addition, where a manufacturer has reason to anticipate that harm may result from a particular use of the product, it will also be liable if it failed to give an adequate warning of the risk associated with the product.

Under Section 402A, the strict liability rule applies only to products that are unreasonably dangerous to the user. A product would be unreasonably dangerous for the purposes of Section 402A if the product, if defective, may be expected to cause physical harm to the user or his property. In the case of AHS, almost any product could be expected to cause serious harm if defective, so the strict liability rule would clearly apply to manufacturers and sellers of such products.

Section 402A only subjects a manufacturer to liability for products that are defective when sold by the manufacturer. The manufacturer should not be liable if the product is delivered in a safe condition and, subsequently, the user modifies or mishandles the product to make it unreasonably dangerous. However, this rule has not prevented liability by manufacturers if, for example, an employer removes a safety shield from a conveyor and then a worker becomes injured by the conveyor.[21]

One consequence of adopting a strict liability rule is that fault by the injured user of the product is not a bar to a successful claim. Many states have a negligence rule which provides that if an in injured plaintiff's negligence was a contributing cause to his injury, he cannot claim damages from another party. However, where strict liability is applied, a manufacturer cannot use the consumer's negligence as a defense.

[20] Bernstein, A Model of Products liability Reform, 27 Val. U. L. Rev. 637 n.79 (1993).
[21] Clements v. Barber Green Co., Cir. Ct. St. Louis, Mo. (1987).

An exception to strict liability generally applies to some products which are unavoidably unsafe even for their intended and ordinary use. An example of this type of product would be a life-saving drug that also has a significant risk of serious side effects. While the risk of using such a drug is great, the benefits may still outweigh the risks. These types of products would not be considered unreasonably dangerous, assuming they are properly prepared and adequate warnings are given.

Clearly, the strict liability standard, the cost of litigation and the cost of punitive damage awards impose a significant burden on product manufacturers. This burden is sometimes too high for product manufacturers and can result in insolvency, or more likely in a decision not to manufacture what might otherwise become an important new product.

C. The Public Policy Behind Strict Liability

While courts have given many explanations for the theory of strict liability, at least three general public policy reasons exist for the doctrine of strict liability.[22]

First, the courts believe that the cost of harm from defective and dangerous products can be born best by manufacturers because manufacturers can price the product to include the cost of damages that may be caused by defective products. The manufacturer may then spread the cost of these damages across all users of the product, acting essentially as an insurer with a risk premium included in the cost of the product.

A second reason often stated for the strict liability rule is that manufacturers are best positioned to reduce accidents caused by their products, either through better design, improved manufacturing operations or warnings. With a threat of physical harm, consumers already have an incentive to act carefully. By placing the cost of accidents on manufacturers, they are given an equally strong incentive to exercise a responsible amount of care in the design, manufacture and production of the product.

A third rationale asserts that with the increasing complexity of products available today, it has become extremely difficult for plaintiffs to prove that a manufacturer was negligent, even by the mere preponderance of the evidence. This theory holds that if a simple negligence test was applied, manufacturers who were negligent would often escape liability. Accordingly, based upon these public policy objectives, the doctrine of strict liability was developed to create an effective mechanism to ensure that products would be developed safely.

D. Debate over Tort Reform

The movement for tort reform has gained momentum in recent years as the perception has grown that product liability law, as well as tort law in general, is inefficient and produces inconsistent judgements that can be extremely disproportionate to the harm caused. In response, many states have adopted limited product liability tort reforms. But some researchers have challenged the public's perception, and to date, proposed fundamental changes to the strict liability system have generally not been adopted.

Punitive damages in product liability cases are often cited as the worst example of excessive awards that are too often granted against manufacturers. However, a recent survey of empirical studies on punitive damage awards concluded that punitive damages are neither routine nor staggering.[23] That review of published and unpublished product liability cases nationwide from 1965

[22] Prosser and Keeton, Prosser and Keeton on Torts, 5th ed., § 98.
[23] Rustad and Koenig, The Historical Continuity of Punitive Damage Awards: Reforming the Tort Reformers, 42 Am. L. Rev. 1269 (1993).

to 1990 found only 355 punitive damage verdicts (from more than 161,000 product liability cases). It found that the largest and most numerous punitive damage awards were in business/contract lawsuits, not in the product liability area. The study reviewed other empirical studies on punitive damage awards that also concluded that punitive damage awards were not being misused. One such earlier study of federal product liability trials decided from 1982 through November 1984 found only ten punitive damage awards out of 172 reported product liability cases.[24]

In addition, a report by the U.S. General Accounting Office found, among other things, that generally (i) plaintiffs were awarded an amount of compensatory damages consistent with the degree of injury suffered; (ii) appeals and post-trial settlement negotiations resulted in final payments substantially less that initial awards; (iii) punitive damage awards were frequently reversed on appeal; (iv) negligence, not strict liability, was the basis of liability in approximately two-thirds of the product liability cases and strict liability was the basis in about 27% of the time; and (v) most proposed reforms would affect only a minority of product liability cases.[25]

Notwithstanding these studies, manufacturers clearly fear the prospect of large damage awards, and this fear can impede the expeditious development of AHS technology. Accordingly, it is important to review specific facets of product liability law and possible remedial actions which might mitigate inappropriate disincentives to AHS development.

E. Specific Liability Issues

1. Establishment of Clear Standards for Calculating Punitive Damage Awards

Due to their large size and because they are often greater than the underlying compensatory damages, punitive damage awards have received a great deal of attention from tort reformers. Since any compensatory damages that may be awarded to a plaintiff are supposed to fully compensate the plaintiff for harm he or she may have suffered, efforts to reduce such compensation attract more criticism than efforts to reform punitive damage awards. In addition, most tort reformers do not go so far as to suggest that punitive damages should be eliminated entirely, but offer less drastic reforms.

The Supreme Court recently held that the U.S. Constitution provides few limitations on punitive damage awards.[26] In that case, the Supreme Court upheld a $10,000,000 punitive damage award where compensatory damages were only $19,000. In reviewing the facts of the case, the Court found that the punitive damages awarded were not unreasonable given the potential harm that the defendant's actions could have caused. Given that potential harm and the wealth of the defendant (a subsidiary of USX Corporation, a Fortune 500 company), the Supreme Court found that the $10,000,000 punitive damage award was not so large as to be prohibited under the U.S. Constitution despite the relatively minor damage caused by the product. Given such recent case law, it is clear that fundamental reform of punitive damage awards will require legislation.

Limiting jurors' discretion on the size of punitive damage awards is a popular suggested area for tort reform. In the absence of legislation, strict liability law has been developed by judicial decisions. Two recent Supreme Court cases regarding punitive damages, TXO Production Corp. v. Alliance Resources Corp. and Pacific Mutual Life Insurance Co. v. Haslip, have established more specific standards for determining an appropriate amount of punitive damages.[27] The factors outlined

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[24] Id.

[25] General Accounting Office Report, Product Liability Verdicts and Case Resolution in Five States, GAO/HRD-89-99 (September 1989).

[26] TXO Production Corp. v. Alliance Resources Corp., 113 S.Ct. 2711 (1993).

[27] TXO Production Corp. v. Alliance Resources Corp., 113 S.Ct. 2711 (1993), and Pacific Mutual Life

in Haslip which determine whether a punitive damage award is reasonably related to the goals of deterrence and punishment include:

(1) whether there is a reasonable relationship between the punitive damage award and the harm likely to result from the defendant's conduct as well as the harm that actually has occurred;

(2) the degree of reprehensibility of the defendant's conduct, the duration of that conduct, the defendant's awareness, any concealment, and the existence of and frequency of similar past conduct; and

(3) the existence of criminal sanctions and other civil awards against the defendant for the same conduct.

In the context of AHS, the FHWA may wish to support federal legislation, similar to the proposed Product Liability Fairness Act[28], which provides similar so that juries and appellate courts will be able to determine with better consistency what amount of punitive damages, if any, are appropriate in a particular case.

2. Clarifying When Punitive Damages Should be Awarded

Punitive damage awards have existed in the United States for over 200 years to punish and deter intentional, deliberate, and malicious misconduct.[29] However, over the past 20 years, courts have begun to allow punitive damage awards in a wider variety of circumstances. Examples include simple reckless conduct or criminal indifference to civil obligations affecting the rights of others.[30] In these cases, punitive damages are awarded to punish excessive profit-seeking actions or extreme carelessness with respect to public safety.[31]

In response to this expansion of the use of punitive damages, one popular element of tort reform is to return to the former standard which provided that punitive damages were only appropriate to punish intentional misbehavior. For example, the pending Product Liability Fairness Act provides that punitive damages may only be awarded against a manufacturer if the harm is the result of the manufacturer's conscious, flagrant indifference to the safety of those persons who might

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Insurance Co. v. Haslip, 111 S. Ct. 1032 (1991).

[28] Senate Bill 687 § 203(e) version 2, 103rd Cong., 1st Sess. (1993).

[29] Rustad and Koenig, 42 Am. U. L. Rev. 1269 (1993); and Keeton, Prosser and Keeton on Torts, 5th ed. § 10 (1984).

[30] TXO Production Corp. v. Alliance Resources Corp., 187 W.Va. 457, 419 S.E.2d 870, 887-888 (1992) ("We have examined all of the punitive damages opinions issued since Haslip was decided in an attempt to find some pattern in what courts find reasonable. Generally, the cases fall into three categories: (1) really stupid defendants; (2) really mean defendants; and (3) really stupid defendants who could have caused a great deal of harm by their actions but who actually caused minimal harm. ") See also Rustad and Koenig.

[31] Rustad and Koenig.

be harmed by the product. A failure to exercise reasonable care in choosing among alternative product designs, formulations, instruction, or warnings is not of itself such conduct.[32]

3. Establishment of a Higher Evidence Standard

Another possible method to reduce punitive damage awards is to require that a plaintiff meet a greater burden of evidence. For example, it could be required that the plaintiff establish that the defendant acted intentionally by "clear and convincing evidence."[33] A clear and convincing evidence burden of proof standard would occupy a middle ground between the "preponderance of the evidence" standard (50% plus) which is the ordinary standard of proof in civil cases, and the "beyond a reasonable doubt" standard (about 95 % of certainty) used in criminal proceedings. In the past 10 years, approximately half of the States appear to have adopted this intermediate standard.[34]

The "clear and convincing" standard is attractive because it provides a certain amount of protection to defendants for an award that both punishes and stigmatizes the defendants in much the same way as a criminal conviction. It could also lessen the chance of arbitrary awards without impairing the State's interest in deterring similar conduct in the future.

4. Exemption of Regulated Products

Another possible method of reducing a manufacturer's product liability is to prohibit punitive damage awards against manufacturers of heavily regulated products. The proposed Product Liability Fairness Act includes a provision that, absent fraud, prohibits punitive damages in cases involving drugs, medical devices, and aircraft products due to the extensive regulation of those products by federal government agencies.[35]

This type of defense could also be made applicable to AHS products if the federal government determines that a similar comprehensive level of regulation of the AHS industry is necessary. The basis for this limitation on liability is that courts and juries are not as qualified as experts in the federal agencies to determine whether the product is safe. Furthermore, the federal safety regulation should preempt any attempt to impose stricter safety standards under state law.

However, the proposal to exclude manufacturers of heavily regulated products from punitive damages has also been criticized because too many flaws exist in the federal regulatory system to grant such a broad based protection from liability.[36] Such flaws arise from inadequate agency resources to effectively supervise or regulate their respective industries and from significant time lags that exist between the time that regulations should be and are revised or updated. In addition, those oversight agencies may also be unduly influenced by industry groups. The need for this exemption

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[32] Senate Bill 687 version 2, 103rd Cong., lst Sess. § 203 (1993).

[33] Schwartz and Behrens, Following the Spirit of Haslip: Virginia Should Adopt a "Middle" Burden of Proof in Punitive Damage Cases, XX VBA J. 4 (1994).

[34] Id.

[35] Senate Bill 687 § 203.

[36] Schwartz, Punitive Damages and Regulated Products, 42 Am. U. L. Rev. 1335 (1993) (citing S. Rep. No. 215, 102d Cong., lst Sess. 13 (1991).

was also questioned in the Senate committee reporting on the proposed Product Liability Fairness Act which found only one case (which was later overturned) in which a punitive damage award had been improper or excessive.[37]

5. Establishing a Cap on Damages

Another liability limitation method being adopted by legislative action in many states is a specific monetary cap on punitive damages. For example, Virginia has recently adopted a $350,000 cap on punitive damages.[38]

One difficulty in adopting this standard is that it also caps the effectiveness of awarding punitive damages. For a large corporation, the risk of bearing a punitive damage award of $350,000 may not be sufficient to insure that the manufacturer will adequately consider the potential harm of its developmental products.

F. Protection Under Governmental Immunity

The doctrine of governmental immunity generally protects the federal government, its agencies and their employees from liability arising out of their actions. This limited governmental immunity would allow the FHWA, or any other federal agency, to assume an active role in the development of AHS without undue risk of liability. Furthermore, to the extent that the FHWA assumes responsibility for selecting the standards for AHS products, AHS product manufacturers who meet those standards might avoid liability for their products.[39]

However, the federal government has waived a significant portion of its governmental immunity under the Federal Tort Claims Act (the "FTCA").[40] Under Section 2680(a) of the FTCA, the federal government and its employees are now only immune from

Any claim based upon an act or omission of an employee of the Government, exercising due care, in the execution of a statute or regulation, whether or not such statute or regulation be valid, or based upon the exercise or performance of the failure to exercise or perform a discretionary function or duty on the part of a federal agency or an employee of the Government, whether or not the discretion involved be abused.

Interestingly, the FTCA also expressly provides that claims arising from the activities of the Tennessee Valley Authority and the Panama Canal Company may not be brought against the United States.[41]

The FICA has created some uncertainty regarding what specific governmental actions are "discretionary" and therefore protected. The Supreme Court has interpreted "discretionary" to mean acts that involve an element of judgment or choice as opposed to actions controlled by mandatory

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[37] Id.

[38] Va. Code § 8.01-38.1 (1993).

[39] See Section G Federal Preemption of State Tort Law.

[40] 28 U.S.C.S. § 2671 et seq. (1993).

[41] 28 U.S.C.S. § 2680(l) and (m) (1993).

statutes or regulations.[42] A discretionary decision will be protected, but an employee's actions will not be protected if the employee failed to follow a federal statute, regulation or policy prescribing a specific course of action because the employee has no rightful option but to adhere to the directive.[43]

For example, the Army Corps of Engineers was recently held not liable under the FTCA for the negligent operation of a navigational dam which created an ice jam on the Ohio River[44]. In that case, the Corps previously determined that its first priority would be to maintain water flow to a hydroelectric plant and that navigation on the river would be a secondary priority. The Court found that the Corps' decision to maintain water flow to the plant at the risk of creating an ice jam was protected because the Corps had made a policy decision in creating a priority list among the different groups relying on the river.

In the context of regulating the airline industry, the U.S Supreme Court has found that the decision of the FAA to use a "spot check" plan to inspect aircraft was protected by the discretionary function protection.[45] In that case, the FAA was sued by an owner of an aircraft that allegedly burned due to the improper flame retardant materials used in the aircraft's construction. The Supreme Court wrote that the FAA was delegated authority to issue regulations regarding the certification and inspection of aircraft and that the FAA had discretion in determining how to conduct that inspection.[46] Therefore, the choice to use a spot check plan of inspection for aircraft was a protected discretionary decision. The FAA did comply with its own spot check regulations, but did not discover the improper use of non-fire retardant materials in the aircraft lavatory. The Court found that the FAA was not liable for the oversight, although it would have been liable if the FAA had not complied with its own spot checking program.

Accordingly, the FTCA would protect the FHWA with respect to the exercise of its discretionary authority in regulating AHS products. However, the doctrine of governmental immunity does not extend to discretionary decisions by non-governmental entities, and therefore would not provide any protection for the discretionary decisions of AHS manufacturers.[47]

The limited governmental immunity available for discretionary actions by government agencies does not favor any particular RCS. Assuming federal regulation of the AHS industry, the FHWA could review or make these discretionary policy level decisions for any of the three RCSs. In any case, the FHWA will be protected from liability for discretionary policy decisions, not from liability arising from operational errors in managing an AHS system.

G. Federal Preemption of State Tort Law

If the federal government becomes actively involved in the design and safety standards of

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[42] U.S. v. Gaubert, 111 S.Ct. 1267 (1991).

[43] Id., at 1273.

[44] Re Ohio River Disaster Litigation, 862 F.2d 1237 (6th Cir. 1988). See also Graves v. U.S., 872 F.2d 133 (6th Cir. 1989).

[45] U.S. v. Varig Airlines, 104 S.Ct. 2755 (1984).

[46] Id., at 2766.

[47] Cleveland v. Piper Aircraft Corp., 985 F.2d 1438 (10th Cir. 1993).

AHS technology, Congress may elect to preempt state tort liability law with respect to AHS design and safety standards. If state tort law is preempted by Congress and a particular product meets the FHWA's standards, the manufacturer may not be liable for damages if a person is harmed while using that product. Congress has already set several precedents for preempting state law when regulating transportation, including the Federal Aviation Act of 1958[48], and the National Traffic and Motor Vehicle Safety Act of 1966[49]. In addition to federal statutes, regulations promulgated by a federal agency may also preempt state law.[50]

For example, in Pokorny v. Ford Motor Co., the court held that an automobile built by Ford was not defectively designed because the car met federal safety standards.[51] At the time Ford built the car used by Pokorny, federal Motor Vehicle Safety Standard 208 required automobile manufacturers to install one of three types of passenger restraint systems. Ford chose the option of installing combined lap and shoulder safety belts with a warning light and buzzer. After the accident, Pokorny claimed that the automobile design was defective because Ford had not installed air bags or automatic seat belts, the other two options under Standard 208. The court held that Ford was not liable because the National Traffic Motor Vehicle Safety Act and Standard 208 preempted Pokorny_s state common law tort claim that the car was defectively designed.[52]

However, the intent to preempt state common law tort claims must be explicit. In Cleveland v. Piper Aircraft Corporation, the court found that state common law claims were not preempted in the absence of clear legislative intent.[53] In that case, an aircraft pilot claimed that his Piper aircraft was defectively designed even though the Federal Aviation Administration (the "FAA") had certified the aircraft design as meeting minimum safety standards. The court held that Congress had not indicated a "clear and manifest" intent to preempt state law and that the use of the term "minimum standards" by the FAA implied that states were free to impose more strict safety standards.[54]

Accordingly, if Congress adopts special legislation for the development and operation of AHS technology, it should include a provision expressly stating that state common law tort claims are preempted by federal statute. The extent of the preemption should correlate with the extent of the federal regulation of AHS products and manufacturers. The more extensive the federal regulation of AHS, the less proper it would be for judges and juries to second guess those regulations and impose liability for allegedly defective AHS product designs.

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[48] 49 U.S.C.S. App. § 1305.

[49] 15 U.S.C.S. §1392(d).

[50] Pokorny v. Ford Motor Co., 902 F.2d 1116 (3rd. Cir. 1990).

[51] 902 F.2d 1116 (3rd Cir. 1990).

[52] Id. at 1119.

[53] 985 F.2d 1438 (10th Cir. 1993).

[54] Id. at 1444.

III. ENVIRONMENTAL LAW

The development, construction and operation of AHS projects must be coordinated with the Clean Air Act, as amended in 1990 (the "CAA")[55]. In 1990, Congress amended the CAA to require that the Department of Transportation's planning process take into account air quality planning.[56] Transportation sources are generally acknowledged to be the source of approximately 50% of urban ozone and 90% of urban carbon monoxide pollution, and average nationwide motor vehicle exhaust emissions are projected to increase by the year 2000.[57] The Environmental Protection Agency (the "EPA") has established ambient standards for six pollutants: ozone, lead, sulfur dioxide, particulates, nitrogen dioxide and carbon monoxide. In the 1990 amendments to the CAA, Congress recognized that the majority of Americans do not breathe air which meets these air quality standards.

One of the primary goals of the 1990 Amendments to the CAA is to reduce motor vehicle emissions by reducing vehicle miles traveled ("VMT") or improving traffic flow. Traffic control measures are needed because VMT nationwide are projected to increase two to three percent per year from 1990 through 2005. While average motor vehicle exhaust emissions are projected to decline, the overall level of emissions is projected to increase due to the increase in VMT.

The CAA requires that all sections of the country be designated as either attainment, non-attainment or unclassifiable areas.[58] An area that either does not meet the air quality standards set by the EPA, or contributes pollution to another area that does not meet those standards, is to be designated "non-attainment." An area that meets the air quality standards and does not contribute to another area that exceeds these standards is to be designated "attainment." An area that cannot be classified on the basis of available information as meeting the air quality standards is "unclassifiable."

The 1990 Amendments to the CAA require states to submit state implementation plans ("SIPs") within 24 months after the promulgation of a national ambient air quality standard.[59] For a non-attainment area, the SIP must show how the state will achieve compliance with those air quality standards and maintain its compliance once those standards have been met. If a non-attainment area fails to submit or implement its SIP or achieve interim standards, Section 176 of the CAA provides that federal transportation funds designated for that area must be shifted to mass transportation programs designed to provide alternatives to single occupancy vehicles.

The CAA also requires that before participating in any new transportation project, a federal agency must find that the activity does not cause or contribute to violations of an ambient standard, does not increase the severity or frequency of existing violations, and does not delay progress in achieving ambient standards in any non-attainment area (i.e. the project must "conform" to the SIP).[60] Furthermore, no transportation plan can be adopted or found in conformity with a SIP until a

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[55] U.S. C. S. § 7401 et seq.

[56] Clean Air Act § 174(b).

[57] S. Rep. No. 101-549, 101st Cong., 2nd Sess. 27 (1990), reprinted in 1990 U.S. Code Cong. & Ad. News 3412.

[58] CAA, § 107(f)(1).

[59] Senate Report No. 101-549 at 19.

[60] Id., at 28.

determination is made that (i) emissions expected from the projects in the plan are consistent with estimates of motor vehicle emissions and emissions reductions included in the SIP; and (2) the projects will not lead to new violations of ambient air quality standards or exacerbate existing violations.[61] The impact of the plan should be considered on a region-wide basis over a long-term period to ensure that the plan will not stimulate VMT greater than that contemplated by the percentage reduction requirements of the SIP.

Before adding a new project such as an AHS, the project must be found to conform to the SIP before funding. The program may be evaluated independently for "hot spot" pollutants such as carbon monoxide, but the program must be evaluated region-wide for ozone and other pollutants.[62] If the overall impact results in non-conformity, the program may not be federally funded unless the regional plan is modified to achieve overall emission levels.

In addition to general conformity requirements, conformity determinations for transportation programs must also involve a demonstration of consistency with the SIP_s motor vehicle emissions budget. Motor vehicle emissions budgets may be revised at any time and the state may reallocate emissions from one source to another. For example, a state may decide to reduce emissions from stationary sources and reallocate those reductions to motor vehicle emissions. However, when reallocating emissions, those revisions cannot threaten attainment and maintenance of applicable standards or milestones in the required time frame, and the reallocation in the SIP must be approved by the EPA.

The implications of the conformity requirements of the CAA are especially important for AHS projects. First, in order to generate a sufficient level of use of an AHS project, the AHS project will likely be located between major urban areas. However, the vast majority of urban areas throughout the country are in severe non-attainment areas and must therefore adopt a SIP that includes significant and difficult reductions in emissions. To amend a SIP to include an AHS project, those areas will be forced to adopt even more stringent reductions in other types of emissions to compensate for the emissions arising from the AHS project. Furthermore, AHS projects may also promote other types of development which will also increase pollution, and the SIP will also need to address how it will achieve the applicable air quality standards with this additional development. Accordingly, unless the CAA is amended to provide a special provision to encourage the construction of AHS projects, AHS projects that are presented to localities will need to bring clear definable benefits to the public to convince local jurisdictions to reallocate their already tight emissions budget.

Furthermore, there appears to be a direct conflict between the development of AHS facilities and the goals of the CAA. One effect of the development of AHS projects will be to encourage the use of single occupancy vehicles while one of the primary goals of the CAA is to reduce the use of single occupancy vehicles. Therefore, if a local jurisdiction elects to amend its SIP to include AHS, the EPA may be disinclined to approve those amendments because they may lead to increased use of single occupancy motor vehicles.

As with tort liability reform, the Clean Air Act will impact the development of any of the three proposed RCSs for AHS. Nonetheless, to the extent that the Smart Highway RCS will increase the efficiency of automobiles through central AHS control of the vehicles and the use of more efficient automobile platoons, the Smart Highway RCS would appear to be more consistent with the goals of the CAA than the other alternatives.

IV. FAA Regulatory Model

The reliance on automation and new technologies for implementing AHS facilities raise special concerns about the safety of AHS technology. To address these concerns, the federal government will likely provide some level of safety-related regulation and oversight of the AHS industry. Reviewing the FAA's regulation of the air transportation industry may provide helpful guidance to the FHWA because the FAA's regulatory system already confronts several important issues that the FHWA will face when regulating AHS, including regulation of the manufacture, maintenance and operation of specialized transportation products, user fees and traffic control systems. Accordingly, the FAA regulatory model provides lessons for the FHWA in regulating a nationwide, automated transportation system.

The extent of regulation and supervision by the FHWA that may be appropriate is likely to depend upon the complexity of the AHS technology and the severity of harm which may result if the system failed. The more risk associated with using an AHS, the more the that the public will look to the federal government to oversee AHS manufacturers and operators to ensure that they did not compromise safety for profits.

A. Aircraft

1. Aircraft Design - Type Certification

The first stage of the FAA's regulation of air travel in the United States is aircraft type certification. Each aircraft type manufactured for sale in the U.S. must receive a Type Certificate from the FAA.[63] To receive a Type Certificate, the designer of the aircraft must show to the FAA that its aircraft design will meet the FAA's minimum operational and safety standards for that type of aircraft. The FAA's engineers first review the designs, drawings, test reports and other engineering data relating to the aircraft, and then the designer must build a prototype aircraft and conduct additional ground and flight tests. If the aircraft meets the FAA's standards, the FAA issues a Type Certificate for the aircraft. Each aircraft which is later built must conform exactly to the specifications contained in its Type Certificate. If significant changes are made to the aircraft design, the FAA must review those changes prior to being implemented.

Similarly elaborate design certification procedures would impose substantial costs on the AHS industry. For example, depending upon the complexity of the aircraft, the FAA's review process before awarding a Type Certificate can last several years. In 1980, one aircraft manufacturer of commercial aircraft estimated that in the course of obtaining a Type Certificate it would submit to the FAA approximately 300,000 engineering drawings and changes, 2,000 engineering reports, and 200 other reports.[64] In addition, the aircraft would undergo 80 major ground tests and 1,600 hours of flight tests.[65] A cost/benefit analysis should therefore be conducted before a determination is made as to the extent of design certification procedures relating to AHS.

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[63] 14 C. F. R. Part 2 1.

[64] See U.S. v. Varig Airlines, 104 S.Ct. 2755 (1984)(citing National Research Council, Committee on FAA Airworthiness Certification Procedures, Improving Aircraft Safety 29 (1980)).

[65] Id.

2. Aircraft Construction- Production Certificate

Once a Type Certificate has been issued, the FAA then conducts a review of the aircraft manufacturer to determine whether the manufacturer will be able to consistently build aircraft that will meet the specifications in the Type Certificate.[66] Therefore, the FAA also conducts a thorough review of the aircraft manufacturer to assure that the manufacturer has established and can maintain a quality control system that insures that each aircraft will conform to the Type Certificate. Once that review has been completed, the manufacturer receives a Production Certificate and can begin producing aircraft for sale.

3. Individual Aircraft - Airworthiness Certificate

After an aircraft design has received a Type Certificate and its manufacturer has received a Production Certificate, the FAA also performs a safety inspection of each individual aircraft that is built. If a particular aircraft conforms to the Type Certificate and is in a safe condition to operate, the aircraft receives an Airworthiness Certificate. After construction, the aircraft must also be maintained and inspected in accordance with FAA regulations by certified mechanics and inspectors in order for the aircraft to retain its Airworthiness Certificate.

Detailed maintenance and inspection logbooks are required to be kept with the aircraft at all times, and the FAA regulates how entries must be made and whether a pilot or mechanic must sign off on maintenance work.

B. Pilot Certification

The FAA also certifies the pilots operating the aircraft.[67] The level of training required depends upon what type of service the pilot will be operating. Private pilots who do not operate aircraft for compensation are required to have the least training while pilots for commercial carriers must have the greatest amount of training. A pilot must receive general training as well as specific training for each type of aircraft that he or she will be operating. In addition, pilots are required to have minimum recurrent training to maintain their license. The FAA also requires pilots to pass periodic medical examinations.

C. Delegation of Authority

With approximately 400 engineers, the FAA cannot complete the necessary design and operational compliance program itself. Instead, the FAA delegates much of this responsibility to qualified private persons.[68] In the case of Type and Production Certification, the FAA designates certain employees of the manufacturers with detailed knowledge about the aircraft's design as FAA representatives. Those designated representatives perform the necessary review and oversight work to insure FAA standards are met.

The FAA model of regulation and supervision of the design and construction of aircraft may provide a useful model that the FHWA may use in designing its own regulatory scheme for the AHS industry. Furthermore, to the extent that the FHWA does assume additional regulation and

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[66] 14 C. F. R. Part 21.

[67] 14 C.F.R. Part 61.

[68] 14 C.F.R. Part 183.

supervision of the AHS industry, it might well be appropriate for Congress to provide limited product liability protection for the manufacturers and sellers of AHS products.

D. Summary

The FAA model of regulation has served to develop a competitive yet safe system of air transportation. While the structure of the FAA has come under recent scrutiny, the issue of whether the FAA should be a separate public corporation as opposed to continuing as a government agency is an economic one. The FAA's performance in regulating the safety of the air transportation system has not been criticized.

The FAA model of regulation can serve as a model of regulation of the AHS industry. The greater the degree of safety of passengers depends upon the safety and reliability of automation, the greater regulatory role the FHWA should perform.

Accordingly, the FAA regulatory model would be most appropriate for the Smart Highway RCS. If it elects to move towards such a regime, the FHWA should also consider adopting similar regulatory systems for AHS products as soon as possible in order to prevent delays arising from exhaustive engineering safety reviews of those products immediately prior to their scheduled introduction.

McDermott, Will & Emery
Washington D.C.

M E M 0 R A N D U M

TO: Science Applications International Corporation

DATE: March 25, 1994

FROM: McDermott, Will & Emery

RE: Input to Task B/Additional Considerations on Legal and Institutional Issues

This memorandum presents some additional considerations relating to the legal and institutional aspects of an Automated Highway System AHS as discussed in the McGuire, Woods, Battle & Boothe ("MWB&B") draft memorandum dated 2/2/94.

Attached to this memorandum as Exhibit A is a preliminary framework identifying key organizations involved in implementing the Representative System Configurations described in the SAIC paper dated October 8, 1993.

In addition to our comments regarding implementation of AHS, thought should be given to how the market for the in-vehicle equipment necessary to function on an AHS might evolve. This evolution would likely begin during earlier stages of IVHS in which transportation improvements are effected primarily through improved information availability. Annexed as Attachment B are some thoughts on the context in which initial implementation of IVHS is most likely to occur and a description of two "preliminary RSCs" in which the potential effects of automated highway systems could be studied.

COMMENTS-ON LEGAL AND INSTITUTIONAL ISSUES

A. Financing Structures

Toll Financing. We agree that with the suggestion of the MWB&B memo that toll roads, including private toll roads, may well be an appropriate method for financing some AHS projects. It is important, however, not to overestimate the current political acceptability of toll facilities, especially when they are privately owned and operated. Although public acceptance of user charges for highway facilities seems to be increasing, many Americans, especially in the western states, cling to the belief that highway facilities should be free of user charges; this was the reaction of many California citizens to the enactment in 1989 of private toll road legislation. Similarly, political debate over whether new transportation facilities should be financed by general taxation or by tolls was a major obstacle to the implementation of the Arizona toll road program.

Private development and operation of roads, as well as the imposition of tolls, often generates initial public resistance. The California privatization law was also challenged, ultimately unsuccessfully, by state engineering employees threatened by loss of work. In 1991, the California legislature passed a resolution calling on Congress to bar use of Federal funds to assist construction of private toll facilities; however, this approach was rejected by Congress when it enacted Section 1012 of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991.

We agree with the comment that the availability of the eminent domain power is central to the success of any privatized toll road program. The Arizona experience bears this out. The Arizona privatization statute (A.R.S. § 28-3051 et seq.) consists of two parallel enactments, one modeled after the California statute (California Streets and Highways Code § 143) and the other after the Virginia Highway Corporation Act (Va. Code § 56535 et seq.). The California model made eminent domain powers available through the Arizona Department of Transportation, whereas the Virginia model did not. The Arizona Department of Transportation was authorized to solicit proposals from prospective developers of privately financed toll facilities and to select for franchising and development two projects under the California model and two projects under the Virginia model. However, the availability of eminent domain assistance was so crucial that the vast majority of proposals received from prospective developers were structured to fit the California model. Although the Virginia toll road statute does not expressly provide for the power of eminent domain, developers of the Dulles-Leesburg road have stated that the perceived threat of state use of its eminent domain power was critical to their ultimate success in land assemblage.

A related question is the extent to which a private highway developer must provide the funds needed to pay the state's condemnation costs (or pay ongoing rents which compensate the state over time for its condemnation expenditures), or whether the state instead could absorb the cost of acquiring right of way and lease the condemned right of way to the private developer at nominal rents. Leaving land acquisition costs with the state substantially reduces the total financing that must be obtained and lowers the tolls which must be charged in order to amortize the financing, thus increasing the feasibility of private participation in development, with private funds covering the non-real-estate portion of the project.

We agree with the statement of the MWB&B memo to the effect that feasibility of a financing structure based on the pledge of future toll revenues will depend on the assurance of adequate future traffic demand. Uncertainty about this issue has significantly deterred the development of privatized facilities. In recent California experience, for example, of the four franchises executed for private toll facilities, to date only one has completed financing and commenced construction. This is the SR 91 project, which is being built in the median strip of a highly congested existing freeway within an urbanized area; thus there was visible assurance of adequate traffic demand to support the financing of the facility. Even in that case elaborate traffic projections were a prerequisite to financing. In the case of the other franchised California projects, toll revenue uncertainties have slowed development efforts to a crawl. Those Mexican toll road projects which have been financed have been supported by favorable traffic projections.

Feasibility of toll financing may also depend on assurance of reasonable protection against toll violators. State laws must exist or be enacted which criminalize toll evasion on private as well as public facilities, and adequate enforcement mechanisms must be in place. The climate must be such that drivers do not view toll evasion as a viable option.

Special Tax Districts. The prerequisite for public acceptance of a special taxing district is that the proposed improvement is expected to bring to adjacent properties an increase in value which exceeds the additional real estate taxes which must be imposed to support repayment of the bonds issued by the special tax district. As the MWB&B memo points out, it is often the case that owners of land, especially in relatively undeveloped areas, can expect a rapid increase in property values as a result of the construction of improved access roads. It is not clear, however, that adding AHS technology to an existing roadway will cause a similar major increase in property values and therefore will have the same suitability for financing by special taxing districts. In the case of a proposed project which involves installing AHS equipment on an existing roadway, it seems unlikely that the perception of increased property values resulting from AHS would achieve sufficient political support for a special taxing district to finance the installation of AHS. On the other hand, installation of AHS technology might be financed by a special tax district where the technology is to be incorporated as part of a new roadway included within the same financing package and where the perceived benefit to adjoining landowners of the new access is sufficient to make the entire financing package politically acceptable.

The Trust Fund Financing Model. Several potential obstacles should be considered in evaluating prospects for a segregated AHS trust fund.

It may be hard to justify the need for a special trust fund. It does not appear that current federal law bars the use of highway trust fund moneys for projects which include AHS or other IVHS elements. Federal law also permits these funds to be applied toward the construction or major rehabilitation of publicly or privately owned toll facilities.

It also seems unlikely, especially in the current political climate of competing urgent needs and large federal deficits, that installation of AHS technology will be considered of such pressing importance as to justify creation of its own trust fund, separate from the Highway Trust Fund, or that any such trust fund would be treated as outside the national budget and deficit limitation constraints.

The idea of using toll revenues to fund a trust for future development is attractive, but will provide near-term funds only when the tolls are imposed on a facility financed with federal and state grants, with no repayment obligation. Historically such facilities have been toll free, although under ISTEA it would now be permissible to impose tolls and apply revenues to the development of additional facilities. 23 U.S.C. § 129(a)(3). With respect to tolled AHS facilities financed privately or with public revenue bonds, user fees collected in the form of tolls will be needed, at least for the first ten to twenty years, to repay the financing costs of those facilities, and will not be available to finance the development of new facilities. While user fees imposed in the form of sales or other taxes on the sale of AHS equipment could provide a fund for the financing of additional AHS facilities, the price increase resulting from the imposition of the sales tax could slow consumer acceptance of the technology.

If a trust fund is established, consideration should be given to leveraging available moneys by utilizing them for credit support rather than for direct expenditure. Under this financial structure, available funds are made available to be pledged as security for the repayment of revenue bonds issued to finance new facilities. This technique increases the number of projects which can be assisted with any given amount of money.

B. Tort Liability.

The development of an insurance market may be the key to whether major AHS facilities (e.g. an entire limited access roadway equipped with AHS) can be privately financed, owned and operated. Alternatively, a substantial portion of the potential liability for accidental injuries arising from AHS usage must be absorbed by government, either by statute or by contractual negotiation, on a case by case basis. For example, in the case of the privatized facility now under construction in California, the state has agreed to absorb tort liabilities arising from construction defects if construction was carried out in accordance with designs and construction procedures which the State approved or mandated. In addition, the State Department of Transportation has contracted to provided highway maintenance services, and is liable for injuries resulting from faulty maintenance; the private owner, however, is responsible for maintenance of the IVHS components of the facility (consisting primarily of an automated toll collection system and changeable electronic signage) and for tort liability arising from faulty maintenance of those components. If the government cannot absorb a substantial share of potential liability, and if insurance is not available at a premium that can be covered by user charges, then ownership and operation of these heavily used facilities must remain with the government.

The potential for tort liability, while by no means a trivial consideration, may be no greater deterrent to prospective manufacturers and vendors of AHS-related technology and equipment than it is to dealers in numerous other types of goods which also carry a potentially high risk of tort liability. The risk of liability will of course exert upward pressure on the price of products. If the risk is too great, obviously the products cannot then be marketed. As is suggested by the MWB&B memo, explicit federal pre-emption of state negligence law by federal regulatory standards would be helpful to the development of the AHS industry, in that it would decrease vendors, tort exposure and increase predictability, thus making it more feasible to establish an appropriate price for a product which takes liability risk into account.

Exhibit A

OUTLINE OF POTENTIAL FRAMEWORK FOR IMPLEMENTING THE REPRESENTATIVE SYSTEM CONFIGURATIONS

Participant	Role
Federal	
Department of Transportation (NHTSA) (FHWA)	Establishment of technical standards for vehicles and in-road equipment. (Need to coordinate vehicle and highway standards) Provide guidance and funds for state and local planning Provide federal funding for construction and reconstruction of highways incorporating AHS technology. Facilitate coordination of AHS development program and MPO planning
Congress	Centralized tort reform Establish preemption of state tort law by federal standards Provide incentives/priority fund distribution to states supporting AHS. Provide for tax exempt financing for AHS
State and Local	
State legislatures	Tort reform Clarify legality of AHS Clarification of AHS insurance program standards.
State Transportation Departments	Testing and licensing of AHS drivers. Maintenance of driver records. Design, construction, operation and maintenance of AHS roads. Inspection and certification of AHS vehicles. Evaluation of efficacy and cost/benefit of AHS.
State police/highway patrol	Enforcement against barrier crossing by non-AHS vehicles and against toll evasion on tolled facilities.

Special Purpose state entities	Act as financing vehicle for ownership (and operation) of major dedicated facilities Facilitate permitting and sitting of AHS.
County/local planning agencies	Planning and coordination; fostering public acceptance.
Special Purpose Districts	Serve as financing vehicle for ownership and operation of AHS facilities having substantial local benefit.
Schools	AHS driver training
Private	
Equipment suppliers - vehicle mounted equipment	Provide factory-installed and/or retrofit equipment - must coordinate with producer of in-road equipment
Equipment suppliers - road mounted equipment	Supply in-road equipment
Road Builders	Financing of major tollable projects
Developers	Financing of major tollable projects
Financial institutions	Financing of major public and private tollable construction projects. Lease purchase financing of government-owned equipment. Development of criteria for AHS finance.
Automobile suppliers	Installation of technology as standard or available option Seek favorable insurance treatment for AHS use
Private training facilities	Driver training - commercial and non-commercial drivers
Trucking firms and Bus Lines	Purchase and use of in-vehicle equipment, as new vehicle option or as retrofit. Payment of tolls and other user charges.
Non-commercial users	Purchase and use of in-vehicle equipment, as new vehicle option or as retrofit. Payment of tolls and other user charges.
Insurance Carriers	Develop program for AHS users. Develop program to cover state liability.

Exhibit B

SUGGESTED PRELIMINARY RSCS

In Task A, SAIC developed three Representative System Configurations ("RSCs"). All three of these RSCs would be implemented in the context of major highway settings, and would realize their optimum potential when used for long distance, high speed travel, or possibly for main corridor commutation. The essence of these RSC's is the shifting of certain control functions from the driver to the technology, involving major changes in technology and attitudes. How individual vehicles will come to be AHS-equipped is likely to evolve earlier and in a wider variety of settings than an AHS. Accordingly, this exhibit presents several scenarios of early implementation of IVHS technology that would prefigure the existence of a fully AHS-capable vehicle fleet.

Identifying these configurations permits us to focus discussion of legal, regulatory, political and institutional issues in a more immediate time frame. These "precursor" RSCs ("PRSC") would be focused around providing more information to drivers than is now available. The PRSCs outlined below describe ways in which current IVHS technology can be integrated into the existing transportation system and economy and the resulting problems examined "in person".

The PRSCs are defined for several transportation settings including urban core (downtown CBD and urban access corridors), current commuting (both highway and major arterial), and commercial services (freight and passenger transport). These PRSCs could be implemented in the near future from products currently available in the marketplace.

Study of these PRSCs could highlight the benefits, problems and further opportunities of IVHS and focus the legal, institutional, regulatory, political and funding discussion around questions of immediate urgency. At the same time, discussion of these information-oriented PRSCs can help to identify ways in which markets and political arenas can be shaped to help develop the more complex "control" RSCs posited by SAIC.

As the market for more sophisticated versions of IVHS opens up, commercial and political pressure will grow to exploit the new opportunities. The regulatory, legal and institutional infrastructure that grows around the implementation of the PRSCs will serve as foundation for development of the Subordinate Control (Smart highway/dumb car or "SH/DC") RSC, when public acceptance, political appetite and a private market for the in-vehicle technology will be more mature.

Accordingly, we suggest that two preliminary PRSCs should be considered before looking at the Autonomous Control RSC (which involves the most private and least public ownership of three RSCs.)

PRSC 1 posits near term implementation of an array of off-the-shelf technologies in settings where the benefits of IVHS can most quickly be realized: urban core, commercial vehicle, freight or passenger, commuting, and highway travel.

For example, an urban core congestion reduction PRSC would consist primarily of enhanced information about travel conditions and increased responsiveness of the traffic control system. The TravTek model is an example of increased information which provides roadway and place locators in a street-level format. To that, two more information layers could be added: longer term road condition information (street closings, utility repairs, construction lane narrowing, etc.) and hourly traffic conditions (either audio or visual representation of traffic flows). In-flow chart representing densities of traffic on major arterials; this could be coupled with up-to-the-minute news of accidents and other obstructions.

Drivers would access the information system at any point during a trip and could then plan and modify a trip to use the fastest corridor. The information could be disseminated by radio and be received either or both audially or visually. The equipment and information could be marketed to commercial vehicle fleets and commuters as well as occasional drivers.

Fully computerized local traffic control systems could be made responsive to individual vehicles. For example, and in-vehicle transponder signal could be received by intersection controls to respond to a request for a green light.

A commercial vehicle (passenger and freight) PRSC example could add to the urban core PRSC described above, in-vehicle communications, central company dispatch and public information technology systems to provide information on long distance routes, road conditions, travel amenities, etc. These would be predominantly navigation and information systems to enhance travel time, safety and comfort. Given the importance of improvements in any of those three categories should provide the impetus for necessary investments (whether public, private or a combination). Again, the legal and institutional questions -- ownership, regulation, control, financing, multiparty collaboration -- raised by these PRSCs would anticipate those that will be raised for the RSCs.

Introduction and use of these first PRSC technologies will likely be highly consumer driven, relatively inexpensive, easily financed, will fit comfortably within the confines of existing liability law, and will impose few demands on environmental, land use, local transportation, zoning, or policing plans and resources. For both the individual and the locale, these first PRSCs should begin to help reduce traffic congestion and travel time and educate drivers to using and relying on much enhanced information systems.

Implementation of these PRSCs will require relatively minor legal, legislative, funding or institutional innovations. The major institutional effort would be to develop a publicly available, centralized transportation information system. Gathering necessary information would require existing government agencies and private entities to report activities that impact the transportation network, such as street openings for utility repairs, parades, construction projects, and short term emergencies. Traffic flow information would also be funneled in. A central transportation information agency or entity might need to be created. Initial funding and an ongoing payment system would be required.

PRSC 2 posits a next generation of technology that would grow naturally from the first, although not yet achieving the full vehicle control/highway positional information of the Autonomous Control RSC. PRSC 2 posits in-vehicle technology from PRSC 1 that is sufficiently widespread to create confidence in its usefulness and to justify, politically and economically, public investment in some greater information dissemination, bringing society-wide benefits in travel time, safety, congestion and air pollution reduction. PRSC 2 technologies could include early "dumb highway" RSC technologies such as lane and locational indicators and "smart car" technologies such as certain automated guidance systems or in-road travel information that would relieve the individual driver of certain present tasks. These could include position/distance monitors, lane position monitors and preprogrammed exit advisory systems. Highway audio signage could announce exits, distances to major destinations, weather and traffic conditions over pre-set, noncommercial radio stations.

Implementation of various aspects of PRSC 2 will most likely take place on the basis of societal acceptance of a number of elements in the first PRSC. That is, private and commercial vehicle owners will already have purchased, and will be familiar with" in-vehicle information systems. Liability, privacy and ergonometric problems will be accommodated, resolved or under advanced study. Franchises for dissemination of traffic and, trip planning information will have been awarded in major cities.[69] Cruise control and an automatic vehicle spacing warning system or braking system will have become standard vehicle equipment. Automatic toll collection, whether in connection with congestion pricing, new roadways or upgrades of existing facilities, will be commonplace. Costs of the individual automobile equipment will have been brought down to a level to achieve consumer acceptance.

Amplification of these suggested PRSCs could provide a more structured way of building up to evaluating the legal and institutional needs of the full blown IVHS RSCs developed by SAIC. Basic institutional questions -- e.g., how will public/private partnerships be structured to develop complex traffic information systems (in-vehicle receivers and transmitters; information gathering; single or multiple source information dissemination) -- and legal questions --intellectual property rights, ownership, rate regulation, radio and TV communications regulation -- will have solutions.

Moving from the two PRSCs posited above, which consist primarily of enhanced information availability, to the Autonomous Control RSC, which begins the shift of vehicle control away from the driver over to the vehicle and highway, represents a further evolution of the technology and its integration into the economy.

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[69] It appears likely that states will adopt, within the next few years, legislation permitting localities to franchise traffic information systems, and that regional governmental organizations will have resolved problems in providing uniform traffic information to a multi-jurisdictional area, on the same wavelength, with the same or similar driver licensing regulations, as necessary