Precursor Systems Analyses of Automated Highway Systems

RESOURCE MATERIALS

Institutional and Societal Aspects

U.S. Department of Transportation
Federal Highway Administration

Publication No. FHWA-RD-95-045
November 1995

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.

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Technical Report Documentation Page

1. Report No. FHWA-RD-95-045	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle: Activity Area O--Institutional and Societal Aspects		5. Report Date: November 1995
		6. Performing Organization Code
7. Author(s): Chris Cluett, Fred Morris, Brett Baden, Stan Nealey, Kristi Branch		8. Performing Organization Report No.
9. Performing Organization Name and Address: Battelle, Transportation Systems, 505 King Avenue, Columbus, OH 43201		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. DTFH61-93-C-00195
12. Sponsoring Agency Name and Address: Federal Highway Administration, Finance Division, Room 4314, 400 Seventh Street, S.W., Washington, DC 20590		13. Type of Report and Period Covered: Resource Materials 8/17/93 - 11/94
		14. Sponsoring Agency Code: FHWA

15. Supplementary Notes

Contracting Officer's Technical Representative (COTR): Dick Bishop (HSR-12)

16. Abstract

To be successful, an AHS-engineered system must be compatible with the institutional and social environment in which it is expected to operate. Institutional aspects include such dimensions as relevant organizations and their interactions, the legal and regulatory framework, and the role of politics in the shaping of policy. Societal aspects include such dimensions as the factors that will govern public acceptability, the process by which interested parties are included in decision-making, the potential for beneficial or adverse social and economic consequences, and public perceptions of potential risks and benefits associated with AHS. Appropriately addressing the social and instituional aspects is likely to be at least as important for ultimate program success as successfully addressing the technical and engineering aspects. Because people are an integral part of the proposed systems, "people issues" must be anticipated, identified, evaluated, and accounted for at each stage of conceptualization, design, construction, and operations. For these reasons, we believe that institutional and societal analyses should be considered among the highest-priority activity areas. This task identifies and analyzes the institutional aspects of AHS systems, the societal aspects of AHS systems, and, for each institutional and societal aspect identified, describe potential courses of action for dealing with resulting issues.

This document type is resource materials.

17. Key Words: Automated Highway Systems, AHS	18. Distribution Statement: Document available to the public through National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	175	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

EXECUTIVE SUMMARY

Objective and Scope

The overall objective of the Area "O" efforts was to develop an understanding of the institutional and societal issues likely to be important in achieving sufficient public acceptance to allow for successful AHS deployment. A secondary objective of this work was to identify courses of action to address the institutional and societal issues identified.

The scope of the Area "O" activities is described by the following definitions and descriptions. For the purpose of this program, the term *institutional analysis* refers to the set of meanings, norms, and rules of conduct that shape the behavior of organizations, with particular attention to the patterns of interaction within and among organizations, and the causes and consequences of these patterns. The institutional issues of particular relevance to AHS acceptance include:

1. The **perspective of environmental organizations** and their role in shaping state and local decision making regarding AHS deployment.

2. The **state and local decision process** (including organizational structure, and roles and responsibilities) that influences how an AHS proposal might work its way through the system to a "go" or "no-go" decision.

3. The **role of the print media** in communicating information about AHS and in shaping how the public perceives AHS.

4. The **legal liability risks** from vehicle accidents potentially facing AHS participants and arrangements for managing those risks.

The term *societal analysis* refers to similar issues but at both an individual and collective level. The societal issues that are important for public acceptance of AHS that this study has focused upon include:

5. The **public perceptions of the potential safety risks** associated with AHS systems, factors that influence how those perceptions are formed, and how risk perceptions are likely to interact with technical information disseminated about the program.

6. The extent to which AHS is perceived to help move us in the direction of more **sustainable transportation** systems and livable urban environments.

7. A process for encouraging **public involvement** in the program that can serve to engender public understanding and acceptance.

8. An examination of **equity issues** that may be raised by AHS systems, and their relationship to public involvement.

Because of (1) the very broad scope just described, and (2) the very limited exposure to date of the various stakeholders, the focus of these analyses was on AHSs in general—not on specific RSCs. Nonetheless the results encompass and provide insight on a range of RSCs. For example, the section on state and local decision procedures addresses the different perspectives expressed in interviews and meetings regarding perceived tradeoffs associated with programmatic emphasis on vehicles or on infrastructure. Decisions regarding RSC type also raise important liability considerations as discussed in the section on legal liability risks. The pervasiveness of the institutional and societal issues is such that of the eight activity areas pursued by this program team, this team's Area "O" effort had the broadest need to keep abreast of the activities and findings of other activity area teams—both internally (other Activity Areas within this program team) and externally (Activity Area "O" teams amongst other contractors).

Methodology

Exploring the broad scope outlined above required a multi-pronged attack and involved a wide variety of sources. The approach utilized involved elements tailored to the particular needs of each of the issue areas addressed. The links between the approach and the analyses of the issues is probably best communicated through the condensed table that follows.

Institutional Issues Addressed	Steps in the Analytic Approach
Perspective of environmental organizations	• Literature review • In-person interviews with regional/local representatives of environmental organizations
State and local decision process	• Literature review • In-person interviews with selected state and local transportation officials, academic experts, and others knowledgeable about transportation issues in Washington State • Conducted a workshop with members of a Washington State ITS Resource Group • Prepared a set of questions to be included in a meeting with Arizona DOT members
Role of the print media	• Literature review • Search of several national computerized databases • Content analysis of selected articles on AHS

Legal liability risks	• Reviewed literature on legal liability for vehicle accidents • Examined case law that could apply to AHS • Applied the framework to three categories of AHS participants: drivers, vehicle manufacturers, and roadway authorities • Identified options for managing legal liability risks

Societal Issues Addressed	Steps in the Analytic Approach
Public risk perceptions	• Reviewed the literature on perceived risk • Examined AHS in terms of factors (attributes of AHS technology) known to influence how people perceive and interpret the riskiness of technology
Sustainable transportation	• Reviewed literature on sustainable development, focusing on the emerging literature on sustainable transportation • Developed a working definition of sustainable transportation, and a general framework for understanding this concept in terms of resource use, environmental impact, and societal implications • Discussed how AHS might be evaluated against a sustainability yardstick
Public involvement approaches	• Reviewed the literature on public involvement strategies that have been used successfully in high-technology programs • Developed a set of recommended approaches to the conduct of public involvement that can be applied to the AHS program
Equity	• Reviewed the literature on equity • Discussed equity issues with stakeholders • Assessed the particular equity issues that are likely to be pertinent to AHS, particularly as a factor in designing public involvement strategies

The concluding Area "O" task involved synthesizing the extensive observations and study results into a cohesive set of findings and recommendations for each of the critical eight issue areas referred to above.

Results

Findings from the eight issue areas are summarized below. Where appropriate, implications for public acceptability of AHS are noted and strategies are suggested for addressing issues raised by these findings. Additional findings and supporting material are presented in the accompanying Activity Area "O" report.

Perspective of Environmental Organizations

The regional/local representatives of environmental organizations interviewed in this study are predominantly hostile toward any proposed system that may increase ease of transportation, VMT, or enhance the attractiveness of the automobile. There was some interest in AHS applications to mass transit, but substantial, positive results would need to be demonstrated. Likewise, alternative propulsion AHS vehicles, such as electric power derived through roadway power strips was of interest to some of the environmentalists. Most of the environmentalists interviewed remain skeptical, awaiting further study and some verifiable research tests and data. Any environmental improvements that are claimed by AHS will have to be very thoroughly tested and modeled to withstand the latent skepticism that environmentalists have toward AHS.

Most environmentalists see sustainable transportation as a long-term process that would change land use patterns toward more higher density living and different (and reduced) transportation patterns. They would be willing to consider an AHS approach that is modeled in this context and integrated into a comprehensive urban plan to reduce VMT overall. For example, AHS could be used to link dense urban areas, and maximize the efficiency and safety of highway travel between these areas.

While these environmentalists are skeptical of AHS technology, their current perspective is based upon limited knowledge, and further research will be needed to understand the views of the larger environment community. Additional research that can demonstrate environmental benefits and allay fears about induced demand effects may change their perspective. Inclusion of AHS into regional growth planning models, and demonstration that AHS can support growth management objectives may persuade environmentalists to be more supportive. Demonstration of economic benefit accruing from environmentally sound AHS also may help to convince some environmentalists.

State and Local Decision Processes

The key AHS deployment decisions are likely to be made at a state DOT and local MPO level. Though transportation organizations and transportation planning traditionally occur quite separately from urban development and growth management planning, many state and regional planning agencies are coming to recognize the importance of institutionally integrating major planning programs in such areas as growth management, energy, and transportation. Regional deployment of AHS will need to take account of this kind of integrated development planning process.

State DOTs and MPOs vary substantially with regard to the institutional structure of their decision making about transportation innovations. Differences include: degree of coordination among state and local agencies; existence and content of State Implementation Plans (SIPs) and Transportation Improvement Programs (TIPs) and associated proposed project evaluation criteria; existence and clarity of procedures for how an AHS proposal will be considered; existence of or desire to include ITS elements in state transportation plans; and the like. In sum, state DOTs and MPOs often are not well prepared to evaluate innovative, non-traditional transportation programs like AHS. A single blanket AHS template is not likely to lead to acceptance and a deployment decision. In addition, many states face serious organizational constraints on their capacity to operate and maintain an AHS with regard to such things as staffing, training, command and control capabilities, integrated facilities, and financial resources.

FHWA and the Consortium should be prepared to reach out to potentially interested state DOTs and MPOs to understand their unique circumstances and transportation needs and tailor AHS to meet those needs. The discussion under “public involvement process” in this report offers suggestions about what elements of such an outreach effort to emphasize, such as incorporating state DOT and MPO representations as participants in AHS design and deployment decisions early on, and enlisting their suggestions about how to structure an effective involvement process. Flexibility and involvement of local jurisdictions are critical for AHS success.

Role of the Print Media

A role of the media is to interpret AHS technology for the public. In this way, the media can exert a significant impact on shaping public opinion and public acceptance.

AHS is currently most often represented in the print media as a far-in-the-future technology (at least 25-30 years away), the apparent end point of the long list of ITS technologies being applied to our transportation systems. While media treatment of AHS specifically has been limited, science fiction terminology like “Buck Rogers” and “The Jetsons” is not uncommon. The media often present an image of a platoon of vehicles traveling at very high speeds (80 to 100 mph) with very close gaps (“1 yard).

Some benefits of AHS as represented by the media include: congestion relief; driver safety; reduced air pollution; economic stimulus; improved public transit; enforcement of traffic rules; and, aid to older drivers. While the majority of media articles appear to represent AHS in a positive or neutral light, some are decidedly negative. Some potential drawbacks in media reports include fear of major accidents, high cost, unwillingness of drivers to relinquish control, loss of privacy, competition with public transit, urban sprawl, liability risks, impacts on secondary roadways, complexity, and lack of demand.

In sum, while the media are supportive of the AHS concept at this early period in the conceptualization of AHS, their representation of AHS is neither accurate nor complete. As AHS becomes more visible, the risk is that its complexity will lead to misunderstandings and misrepresentations that may jeopardize public acceptance. National and regional transportation managers should establish early and close working relationships with the various pertinent journalists to assure that a balanced, accurate picture of AHS is presented to the public and that media errors or misinformation are corrected without delay. The media should be viewed as an ally and updated frequently as the program evolves.

Legal Liability Risks

To succeed, AHS will have to secure the participation of the corporate and individual driving public, who purchase, operate, and maintain fleets and vehicles; motor vehicle manufacturers (and their suppliers and dealers), who design, manufacture, sell, and service vehicles; and state and local transportation agencies (and their contractors), who plan, finance, design, build, and operate roadways. One important factor in obtaining the necessary level of acceptance by these participants will be their assessment of the impact of AHS on their risks of legal liability for damages resulting from vehicle accidents. In evaluating these risks, participants will take into account not only the risks of actually being held liable for alleged AHS-related accidents, but also the "litigation risks" of incurring the transactions costs and reputational damage that can result from merely being named in lawsuits.

To the extent AHS results in an overall improvement in highway safety, it should reduce the costs of motor vehicle accidents, and thus decrease liability risk in the aggregate. However, vehicle manufacturers and roadway authorities who fear they may experience disproportionate risks or costs may be reluctant to participate in AHS.

Whether these risks will be unacceptable will depend on the potential participants' evaluation of specific system configurations in light of the offsetting benefits. The underlying safety of the system and the allocation of control among the driver, vehicle manufacturer, and the roadway authority will be fundamental to this evaluation. In principle, it should be possible to manage the legal risks of AHS accidents to overcome disincentives to participation. To the extent AHS increases highway safety and thus reduces liability for accidents in the aggregate, it creates a windfall for the liability "winners", which can be tapped if necessary to create institutional arrangements that compensate the liability "losers" so that all participants would be as well or better off as in the absence of AHS. These arrangements need not be direct payments, but rather could take a variety of forms, including vehicle industry or roadway association standards for AHS systems, regulatory standards, government indemnification, or insurance pools.

Public Perception of Potential Safety Risks

The nature of public concerns, particularly about potential safety risks associated with prospective AHS features, is speculative in the absence of specific measures of such concern. It is important to assess public concern because the political viability of AHS will be affected by the way it is perceived by the public. Some assessment of public perceptions is possible based on an examination of the extensive literature on perceived risk, coupled with interviews with various AHS stakeholders. A number of technologies have been measured in a two-dimensional risk space. The first dimension contrasts technologies perceived as uncontrollable, involuntarily imposed, and having fatal and potentially catastrophic consequences with those seen as controllable, voluntary, and having only individual consequences. The second dimension contrasts known risks like handguns and motor vehicles with those where the effects are less well understood (by the public) such as DNA research and solar electric power. Technologies perceived to be high on both dimensions (unknown and feared) face great challenges in winning public acceptance. Informal interviews and literature review of AHS descriptions suggests that AHS technology may be located somewhere in the middle of both dimensions. AHS is, at this early stage, not well known by the public, and it is perceived by some to have potentially fatal or catastrophic consequences (an image represented in the media).

Literature review shows that most people hold a positive attitude toward advanced technology and automated systems as long as human control is possible as a back-up; automatic elevators and airport terminal trains are examples. While the public has learned that human error is ubiquitous, knowledge about and familiarity with the technology can help reduce concerns. This is a difficult challenge for AHS, since the technology is not yet deployed. Several features of new technologies can contribute to or prevent their successful introduction: uncertainty about its safety, being out of control, and involuntary exposure to risk. All are concerns voiced by the public about AHS. Yet these concerns may be overcome if AHS addresses them in the development process, avoids early disasters, and most of all, if AHS really does provide clear benefits that overwhelm the inevitable public concerns about new technology.

In sum: (1) The public will have substantial safety concerns about AHS. These will have to be carefully predicted and taken into account in design and initial deployment. (2) Phased deployment that does not require the public to place blind faith in unproved technology will be essential. (3) Technologists and developers must be careful not to oversell AHS, and they must be careful that they are not perceived as claiming that “nothing can go wrong”. Either error will provoke public distrust and lead to anger when problems do occur.

Sustainable Transportation

Environmentalists and other citizens concerned with how public policy can help shape the relationships between technology, the environment, energy use, development, and quality of life, are increasingly applying sustainability as a yard stick to measure success. Sustainability in the transportation sector raises particular questions about the use of non-renewable energy resources, pollution of urban air, and impacts on human communities and settlement patterns. The acceptability of AHS as a new transportation technology is likely to be increasingly judged in terms of its contribution to helping meet sustainability goals. Politically influential stakeholders, such as environmental organizations, along with selected federal and state agencies, are pressing for greater attention to sustainability, and transportation managers can expect to be held to similar performance standards.

AHS can demonstrate responsiveness to these emergent concerns by incorporating into its mission and goals a balanced focus on both mobility enhancement (flow, congestion relief) and sustainability (VMT reduction, demand management, congestion pricing, alternative non-vehicle modes of access, less pollution, and use of alternative fuels).

In sum, AHS should be positioned as much more than a stop-gap measure designed to address current congestion. Rather, couple AHS with Transportation Demand Management (TDM) and Transportation Systems Management (TSM) measures, as well as selected capacity enhancement measures, that serve to manage congestion problems over the long-term without inducing demand that spirals into worse congestion in the future.

Public Involvement Process

The overall goal of public involvement (PI) can be framed in terms of improving the quality of decision making and the influence that members of the public can have on that process. Within this overall perspective are the supportive objectives of developing a shared understanding of the nature of the problem among stakeholders and the project proponents, developing a PI process that is viewed by stakeholders as equitable, and reaching a decision that is acceptable and implementable. A review of studies of the implementation of technologies comparable to AHS reveal important lessons for this program.

There is a lack of consensus on key societal goals and priorities and increased concern about the environment and public health and safety. In addition, there is increasing lack of trust of managers of those technologies perceived to embody risk. This lack of trust is manifest in a rise in the number of public interest groups and activist organizations. The deployment of AHS must be able to work with this diverse collection of stakeholder groups and individuals.

PI offers a process for bringing together AHS proponents and disparate stakeholder groups that hold a wide range of opinions and concerns about this technology and its potential deployment consequences. AHS developers and managers should be prepared to work from the outset with stakeholders who best understand the institutional and societal context within which AHS will be sited, and be prepared to negotiate approaches and decisions about AHS conceptual development and deployment with them. AHS management must be prepared to alter decision making based in input from the PI process.

With a relatively unknown technology like AHS, members of the public and stakeholder groups are more likely to find AHS acceptable if (1) they are invited in as active participants in design and deployment decisions; (2) they are invited into the process early on, before key decisions have already pretty much been made; (3) they actively help shape the PI process itself; (4) they feel they have some ownership in the outcome of the participative process and thereby can see how AHS really helps meet their needs.

- Establish stakeholder identification and interaction processes very early in the program conceptualization and definition phase. Don't wait until deployment. This is especially important for AHS technology that carries with it higher levels of perceived safety risks.

- Make PI specialists members of the AHS design and deployment team.
- Involve upper management in the PI enterprise and be sure they fully subscribe to and support the goals of PI.

Equity

Concerns have been expressed by various stakeholder groups that ITS technologies may impact minority (race, age, physical handicap) and low-income populations differentially. More specifically, questions have been raised about AHS in terms of the ability of various segments of the population to be able to afford AHS equipment (low income), to have adequate access to AHS (people without personal automobiles), or to have the requisite operating skills (elderly, disabled). Questions also have been raised about the fairness of dedicating existing lanes to AHS, thereby restricting those who choose not to acquire AHS capabilities, or increasing the tax burden for everyone when only some will benefit. Finally, open and fair access to AHS decision making processes is a measure of program equity that ties in with the public involvement challenges discussed in this report.

The perceived equity of AHS will be a critical factor in its ultimate acceptability and implementability. AHS management should set equity-related goals for the program, and monitor progress towards the achievement of these goals. The AHS public involvement process needs to be sensitive to equity concerns, and make particular efforts to include low-income, minority, elderly, and disabled interests in the PI process.

Conclusions and Research Needs

Without a sufficient degree of key stakeholder and general public acceptance for AHS, state legislatures, state DOTs, local MPOs, and other AHS proponents are not likely to be able to successfully win the measure of support needed to proceed with deployment. Our interaction with a number of State DOTs, including findings from a public meeting at the Transportation Research Board (TRB) meeting in January 1993, further suggest a large amount of skepticism about whether AHS is even worth pursuing, so there are large hurdles ahead for this program. Environmental groups are likely to be especially reluctant to endorse AHS, unless its benefits can be clearly demonstrated. We have found that acceptance of AHS is likely to depend on the resolution of an interrelated set of institutional and societal issues. The findings summarized in this document reflect those issue areas and suggest some strategies for addressing the issues. We also find some additional validation of these findings, given a measure of comparability of findings across the variety of different issue areas investigated here.

Much remains to be done to better understand how these and other institutional and societal issues will interweave with the AHS program as it unfolds. A few research suggestions include the following:

- We need to better understand how AHS may influence VMT and potentially induce additional demand for travel.

- For candidate deployment sites, we need to research how state and local organizations are structured with regard to decision making on innovative transportation technologies like AHS, what their selection criteria are, and what processes are used to identify and engage stakeholders in a productive dialogue.

- Research is needed to identify the kinds of information that the public would like to know about AHS so that informational materials can be made responsive to identified needs.

- We need to learn more about how members of the public perceive the riskiness of AHS technologies and what the preferred configurations look like. Focus groups, survey research, and deliberative polling approaches with a national sample of the public are useful ways to gather critical data.

- With regard to better understanding liability risks, research needs include: (1) validating and refining the legal liability concerns of the corporate and individual driving public, who purchase, operate, and maintain fleets and vehicles; motor vehicle manufacturers (and their suppliers and dealers), who design, manufacture, sell, and service vehicles; and state and local transportation agencies (and their contractors), who plan, finance, design, build, and operate roadways, applying the framework developed in this chapter; (2) identifying legal risk management models from other domains and analysis of their applicability to the management of the risks identified in this report.

- The media analysis should be expanded to include television coverage, since a large portion of the population gets their news from that source.

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INTRODUCTION

Description of Activity Area "O"

This activity area focused on a subset of institutional and societal issues that are expected to be critical for the success of the AHS program. The broad activity area falls in the so-called non-technical issues arena which has been acknowledged by many participants in the ITS program to constitute perhaps the most critical dimension of the entire program.

- **Institutional aspects** of the AHS program include the roles and responsibilities of the many organizations that are likely to be connected with AHS (e.g., conceptualization, development, manufacturing, marketing, deployment, insurance, regulation, and use of AHS), the interactions among these players, and the political climate within which they operate and make decisions that affect the future of the AHS program.

- **Societal aspects** include the factors that will govern public acceptability of AHS, the process by which interested stakeholders and members of the public are included in decision making, the potential for beneficial or adverse social, economic, or environmental effects, and public perceptions of the potential risks and benefits associated with AHS.

Purpose

The specific focus of this effort has been on understanding factors that are expected to influence the public acceptability of AHS. To be successful in the longrun and to have an opportunity to initiate deployment of AHS in the shortrun, the concept and its various systems configurations and operations must establish a measure of stakeholder acceptance in order to be able to move forward. This analysis has examined what we believe to be some of the more significant institutional and societal components of the program with regard to their potential impact on public and stakeholder acceptance. Recommendations and suggestions are made where appropriate, given the limitations of the research performed in this precursor study.

Issues Addressed

Table 1 lists in the left hand column those issue categories that were contained in the PSA Compendium of issues and that have been included within the scope of the analysis in this activity report. The right hand column provides a brief description of the particular aspect of the issue category that was examined. As indicated earlier, the overall integrating issue focus for this study has been the public acceptability of AHS. Each of the separate issue category analyses that we have conducted is ultimately directed to gaining a better understanding of the social and institutional factors and conditions that can serve to create a more successful AHS program. At the same time, the analysis

Table 1. PSA issues covered in this study.

Issue (From PSA Compendium)	Aspects of the Issue Category Examined in This Study
Legal	Potential impacts of AHS on the risks of legal liability for damages resulting from vehicle accidents.
Environmental	Interviews with members of the environmental community in the Seattle, WA area to explore issues and concerns that they would have about an AHS as a candidate for deployment.
Societal aspects	Assessment of stakeholder issues, public acceptance, equity concerns, public perceptions of risk.
Public acceptance/education	The overall organizing focus of this analysis has been on public acceptance in terms of identifying the issues that AHS must address in order to gain a level of acceptability such that AHS can be successfully deployed. This has included an analysis of the factors anticipated to influence public acceptability, including equity. The need for information, education, and communication in this regard has been addressed as a two-way process; that is, stakeholders learning about AHS and transportation engineers and program managers learning about the public's point of view on AHS.
Organizational	Organizational issues that arise at the state DOT and local MPO levels as AHS is considered for deployment. Issues examined include which organizations must work together to make AHS a reality, and how decision making is structured.
Public health, safety & welfare	Principle factors that are known to contribute to public perceptions of the safety risks of technology with application of this perspective to AHS.
Other issues	• Print media coverage of AHS and how media can influence public acceptance of AHS. • The concept of sustainable transportation and how AHS might be viewed by the public, and in particular environmental groups, in terms of its relationship to sustainability.

points out issues, concerns, and risks that need to be addressed and resolved in order to achieve this success.

At this early stage of the program AHS researchers can't expect to have all the answers to resolve the issues addressed. But we do believe that resolution of these issues is both feasible and essential for public acceptance, upon which the success of the program ultimately depends. We have offered suggestions about how to position AHS to be successful in terms of these issues. We believe that the successful approach will involve a willingness to address these so-called non-technical issues on an equal footing with the full range of technical issues, to look at their interactions, and to accept the implications that may emerge for changing or redirecting the technology or reconsidering deployment strategies to better take this integrated perspective into account.

Overall Approach

Our approach has included several elements tailored to the particular needs of each of the issue areas addressed. The links between our approach and the analyses of the issues are summarized in Table 2.

Table 2. Steps in the analytic approach.

Issue Addressed	Steps in the Analytic Approach
Perspectives of environmental organizations	• Reviewed literature on environmental groups and their roles and perspective in transportation matters. • Participated in and helped facilitate a national meeting on ITS and the Environment. • Interviewed more than a dozen representatives of environmental organizations that are actively involved in transportation issues in the Seattle area, guided by a set of discussion topics prepared ahead of time. (See Appendix E) • Summarized findings from these sources.

Table 2. Steps in the analytic approach (Cont.)

Issue Addressed	Steps in the Analytic Approach
State and local decision process	• Reviewed literature on experience with transportation decision making at the state and local level. • Interviewed selected state and local transportation officials, academic experts, and others knowledgeable about transportation issues in Washington State. • Examined the institutional structure of transportation decision making in Washington State. • Conducted a workshop with members of a Washington State ITS Resource Group. • Prepared a set of questions to be included in a meeting with Arizona DOT members. (See Appendix D) • Participated in several regional and national transportation meetings and workshops where these issues were discussed. • Summarized key findings from each of these sources.
Role of the print media	• Reviewed literature on comparable examples of media analyses. • Conducted a comprehensive search of several national computerized database systems. • Analyzed each article from the search according to a content analysis strategy. • Summarized findings from this analysis, and drew inferences about the role of the media in the future success of AHS.
Legal liability risks	• Reviewed literature on legal liability for vehicle accidents. • Examined case law that could apply. • Developed a conceptual framework for analyzing legal risks of AHS. • Applied the framework to three categories of AHS participants: drivers, vehicle manufacturers, and roadway authorities. • Identified options for managing legal liability risks.

Table 2. Steps in the analytic approach (Cont.)

Issue Addressed	Steps in the Analytic Approach
Public risk perceptions	• Reviewed the literature on perceived risk. • Examined AHS in terms of factors (attributes of AHS technology) known to influence how people perceive and interpret the riskiness of technology. • Inferred strategies from this analysis that may help the Consortium avoid having the driving public view AHS as much riskier than the transportation engineers.
Sustainable transportation	• Reviewed the general literature on sustainable development and particularly focused on the emerging literature on sustainable transportation. • Developed a working definition of sustainable transportation, and a general framework for understanding this concept in terms of resource use, environmental impact, and societal implications. • Discussed how AHS might be evaluated against a sustainability yardstick.
Public involvement approaches	• Reviewed the literature on public involvement strategies that have been used successfully in high-technology programs. • Drew on first hand experience in conducting training for federal and state officials in how to set up a successful public involvement process and program. • Developed a set of recommended approaches to the conduct of public involvement that can be applied to the AHS program.
Equity	• Reviewed the literature on equity, and societal and institutional transportation literature for perspectives on equity in this context. • Discussed equity issues with the various stakeholders interviewed in the course of this study. • Assessed the particular equity issues that are likely to be pertinent to AHS, particularly as a factor in designing public involvement strategies.

Guiding Assumptions

The assumptions that underlie this analysis are guided by the Representative System Configurations (RSC) that are contained in Volume 9 of this set of PSA reports. A condensed version of the RSCs is contained in Appendix F. Other assumptions are derived from our sense of how AHS is being represented to the outside world at this time by FHWA, assumptions that have been made implicit in AHS project meetings, assumptions that underlie current AHS literature, and our own professional sense about the social and policy context within which AHS is now being developed. We want to stress that many of these assumptions cannot be verified or proven correct, at least at this point in time. Only the future will tell us how reasonable the assumption is. Also, some of these assumptions are currently facing the test of empirical data that derive from further analysis of the subject, interviews with people about AHS, and studies currently underway. Generally, in the non-technical aspects of the PSA analyses of AHS, there seems to be a wider margin for the kinds of assumptions that are needed in order to proceed with these analyses, compared with the more technical aspects of the program. Some of the key assumptions that underlie this research include the following:

- AHS will be phased in gradually (incrementally) over time.
- Many people (general public) know little or nothing about ITS or AHS at this time.
- We cannot expect to identify all the stakeholders at the outset of this program. Some will emerge as the program unfolds.
- The level of acceptability of an AHS system will vary between regional/local areas, and the national level.
- The introduction, adaptation, and acceptance of AHS technology will follow patterns similar to those experienced by other comparable technology introductions.
- The public and private sectors will be required to work together to successfully manage and operate AHS.
- Successful deployment of AHS technology will depend substantially on the resolution of non-technical issues.
- The human factors aspects of user interfaces in the car will make the systems relatively simple and user friendly.
- The AHS program will continue to receive political and financial support from Congress and DOE/FHWA.

- A 100 percent level of public acceptance is not expected to be achieved for AHS, nor is it considered necessary for success.
- High consequence accidents, though low in probability of occurrence, are assumed to be possible, and the public will perceive this to be the case.
- AHS may operate on either dedicated (AHS-only) or mixed traffic lanes.
- AHS operations will not be 100 percent automated; rather, they will be monitored and controlled as necessary by human operators.
- No assumption is made regarding whether AHS drivers will be charged a user fee.
- AHS will cause some institutional and societal impacts that cannot be anticipated at the outset.
- AHS deployment decisions are anticipated to be made predominantly at the state and local level.
- When operating in an AHS mode, the vehicle will be controlled by some combination of vehicle technology, infrastructure technology, and the driver.

ANALYTICAL APPROACH

Introduction

This chapter summarizes the analytical approach used in conducting the various analyses that are described in detail in the following chapter. The initial effort on this PSA activity was to conduct an extensive literature review of institutional and societal issues that have been raised in the broader context of the entire ITS program. The non-technical literature on AHS is understandably limited at this early stage of the development of the program, though research that will be relevant for AHS has been initiated within the last few years under the auspices of ITS America's several working committees with responsibilities for institutional and societal matters.

For the print media analysis we conducted a thorough computer-generated search for appropriate articles on AHS, and this procedure has been described in detail in the following sections. The general approach for much of our analysis has been a set of key informant interviews, coupled with a workshop that we organized in collaboration with the Washington State DOT.

An alternative approach of a national public survey research strategy for eliciting information from a broader, representative population of drivers across the country was explored earlier in this project. This approach was rejected after discussion with the FHWA that it is perhaps too early in the development of the AHS concept to approach the general public with a national survey approach. This is especially difficult when the concept is still evolving, has not yet been demonstrated, and is not at all well known or understood by the general public. Better approaches at this stage are methods such as focus groups,[1] in which particular aspects of AHS could be described and discussed with the help of a facilitator, or deliberative polling,[2,3] in which a sample of people can be selected and brought together for a day or two to discuss AHS in some detail, after which their opinions can more reliably be solicited.

There are, of course, a number of other data gathering strategies that could be used. The approaches we chose for each of the different components of our activity scope were selected on the basis of scientific appropriateness, convenience within the time and resources available, and ability to derive insights that may be helpful to the Consortium in planning the next steps of the analysis of AHS options and deployment strategies.

Literature Review

The acquisition of literature began with a list of ITS-related documents provided by the Battelle Columbus Office (BCO). BCO had identified a subset of documents from a comprehensive computer search of various electronic databases that appeared to be of potential relevance to this Activity. We reviewed the entire list and requested selected items, initially through the BCO library, and subsequently, for those items not readily available through BCO, through the Battelle Seattle Research Center (BSRC) and University of Washington library systems. Throughout the process of requesting and receiving reference materials, we reviewed the bibliographies of useful documents as they came in and requested additional reference materials based on citations in those documents. We also had been identifying and assembling relevant documents during the proposal development stage.

Much of our search involved investigation of the holdings of the University of Washington libraries, through the on-line catalog, law library database catalog and searches conducted at the library itself. Other potentially useful articles were identified based upon our review of related research materials, through collaboration with the institutional/societal teams from other contractors, through the ITS America Clearinghouse, through investigation of national computer archives, and from attendance at conferences and seminars by various members of the Activity Area "O" Team.

As we have focused more closely on the history of ITS planning and implementation in the State of Washington and particularly in the Seattle metropolitan area, we have included in our working bibliography references that pertain to this particular area. Also, we have included materials that relate to such broad issues as public acceptance, transportation growth management planning, transportation and the environment, sustainable transportation, and other materials that help contribute to an understanding of how the major stakeholders in developing our transportation systems might view AHS, and what that may tell us about public acceptability issues.

We have set up our bibliography on ProCite™, a computerized bibliographic database system that resides on our network and is directly accessible to members of the research team. This allows for efficient searching and sorting of the reference list, as well as printing the bibliography in a variety of standard or customized formats for reporting purposes.

Because we have opted for inclusiveness, at least during the early research portion of this project, the reference list has grown quite large. Upon more careful analysis, some documents and reference materials that we had at first thought might be useful have subsequently proved to not be particularly useful. These have been removed from our list. Because AHS is such a new concept, there are relatively few references exclusively focused on this topic, while there are many that address institutional and societal issues associated with ITS. As work on this Activity has progressed, the reference list has been further refined and condensed down to the most relevant source materials for inclusion in the bibliography.

Media Analysis Methods

<u>Introduction</u>

We made an early decision to limit our media analysis to print media, primarily due to the relative ease with which we could achieve wide coverage of the range of articles that have been published. We conducted an extensive computer search for print media articles that provided coverage of AHS over the six year period from 1988 to about mid-1994. The print media have provided extensive exposure for the ITS program nation-wide, but with substantially less exposure to AHS in particular, primarily because AHS is a fairly new concept and will be implemented later than most of the other ITS technologies. We canvassed national, regional, and city newspapers, the national wire service, national news magazines, and selected “car” magazines published during this period. Because AHS is a very new concept, we decided that the time period covered would capture most of the available information on this subject.

Search Process

In the past, Battelle has conducted media analyses by sampling specific time periods of a select few representative newspapers or magazines and then generalizing from that sample.[(4)] Basing a media analysis on a sample is appropriate if the universe of articles is large and a sampling procedure can be applied that will allow for valid generalizations to be made. For the purposes of analyzing the U.S. print media treatment of Automated Highway Systems, however, we decided to collect a 100 percent sample.

Two electronic, computer-based search services were used to provide source materials for the search: the *Dialog Information Retrieval Service* (from Dialog Information Service, Inc.)[1] and the *Expanded Academic Index* at the University of Washington. The Expanded Academic Index was used to corroborate the Dialog search and update the period March through June, 1994. Investigation of other sources, such as the ITS America on-line (Reach) news-clippings files, yielded no new information beyond what the other search services had provided. On-site library searches and browsing also was used to supplement and verify the electronic servers’ findings.

The Dialog search process examined the titles and first two paragraphs of articles in several databases. The Expanded Academic Index search examined the titles and abstracts of articles in its database. These analyses include:

- National newspapers: the *Wall Street Journal*, the *New York Times*, the *Washington Post*, *Christian Science Monitor*,
- Regional newspapers: *Los Angeles Times*, *Atlanta Constitution*, *Rocky Mountain News*, *Detroit Free Press*.
- National magazines: *US News and World Report*, *Newsweek*, *Business Week*.

[1] This system is purported to be more comprehensive than Nexis. Their self-description states: "The DIALOG information collection contains references to millions of documents, compiled from more sources than those in any other commercial online database service." It is also less expensive than Nexis.

- "Specialized magazines" that cater to select audiences, such as: Omni; World Watch; and American Town and Country. Also, "science consumer" magazines which are non-technical journals that deal with science for a lay audience, such as: New Scientist; Science; Environmental Science and Technology. Also, the automotive media, such as: Automotive News; Car and Driver.

Professional journals were not included because they are not readily available, and they tend not to be read by the general public.

The searches conducted on Dialog found several newswire articles from direct wire sources such as UPI, AP, Reuters, and PR Newswire. These articles constitute a resource made available to the media around the country, but it is uncertain when and where newswire articles actually will be used.[2] Due to this uncertainty, we only used articles that actually showed up in print somewhere, and did not include articles culled directly from the newswire source.

Neither Dialog nor the Expanded Academic Index searches revealed any articles in publications such as *Road and Track* or *Car and Driver.* Further investigation revealed that these magazines tend to be less concerned with possible future transportation developments; rather, their focus is on current automobiles and systems.[3] *Automotive News* did, however, discuss AHS several times, and these data are included in the analysis.

The electronic search process involved the use of "search strings", words and combinations of words, or acronyms, such as "automated highway system", or "AVCS".[4] Initial searching quickly revealed that there is considerable disagreement over terms and concepts in the media. Searches for "intelligent vehicles", "IVHS", "smart cars", "smart highways", and many others yielded articles that discussed ITS and all its components extensively, referred to an AHS as ITS, or contained no mention of any form of an AHS. Appendix A details the "search strings" used. Over 300 articles were identified, collected, and read.

Of over 300 articles collected, 117 were identified as pertinent to AHS. Of these, 29 were reprints of other articles. There were 88 distinct articles that dealt with AHS. Reprints either were passed along through news-wires, were reprints of op eds., or were syndicated articles.

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[2] A UPI representative described the system thus: UPI (or another newswire service) generates multiple articles which they send electronically to their clients. They have no records or way of knowing which

articles are actually published, how they might be published, or if they are used as source material in other articles.

[3] The Engineering Editor of *Road and Track* said that AHS was beyond the scope of that magazine. A systematic library search of the 1993 and 1994 issues of *Car and Driver* confirmed this.

[4] The acronym AHS was not searched for; the potential for finding references to Auburn High School, Atlanta Health Service, etc. was overwhelming.

The main criterion for inclusion into our sample was that AHS was recognized holistically as an automated system composed of several key components, such as automated cruise control or lane keeping technology. Discussions of the independent parts of AHS was not sufficient to allow that article to be included in the sample. Also, the article did not have to be wholly devoted to AHS; in fact, very few articles did so. Mention of "car trains", "automatic chauffeurs", and "snooze control" are all examples of different ways that the press conceptualize automated highway systems. Many discussed an evolutionary, step-wise approach to AHS, such as that described by Jerry Ward.(5) However, to consider the article as a part of the analysis, there had to be some mention of highway linkage, and the components had to be treated as part of a functioning, automated system. Articles that described component technologies of AHS were included only when they described a "picture" of an AHS that employed a "hands-off, feet-off" technology an agent other than the human driver in control of driving functions and entailed interaction with the roadway.

This media analysis is a very qualitative, subjective kind of assessment. We took great care in laying out a logical, structured approach to the analysis of issues covered in the articles under review. We also attempted to measure inter-rater reliability by having several team members read and analyze a subsample of the articles. But in the final analysis, there is a lot of room for judgment in this kind of exercise. We believe that the overall observations and the insights to be derived from them, can offer valuable guidance to the FHWA and the Consortium, both in understanding how public opinion is being shaped by the media, and in framing strategies for interacting successfully with the media as the program moves toward deployment. Further details on the analytic methodology and a description of procedures employed to verify the findings of this analysis are presented in Appendix B.

State and Local Methods

AHS deployment decisions ultimately will be made at the state Department of Transportation (DOT) and local Municipal Planning Organization (MPO) levels, and will require the support of state and local elected officials, agency representatives, and other regional stakeholders and members of the public. It is critically important at this early stage in the program to better understand how AHS is viewed from this regional perspective, and to discuss the issues as the DOTs, MPOs, and other regional stakeholders see them. A premise of this analysis is that successful development and deployment of AHS will depend on regional and local recognition of its benefits, extensive stakeholder involvement, and acceptance by the driving public.

For this portion of our analysis under Activity Area "O" we relied on several sources of information, as follows:

- Literature reviews of both national and regional source materials.
- Interviews with key informants, including persons knowledgeable about transportation issues, selected state and local officials in the Seattle[5] and Phoenix[6] areas, and representatives of environmental groups in the Seattle area.
- Findings from a meeting with members of the Washington State DOT Resource Group,[7] including responses to a mail-out set of questions that were sent to all members of the Resource Group after the workshop.
- Discussions on these issues in several national AHS meetings, and membership on the Environment Committee and the Social Issues Task Force of ITS America.

We have reviewed these various sources of information in order to try to better understand how AHS is likely to be interpreted and received at the State and local levels, and to be able to draw inferences that may be helpful to the Consortium about how best to proceed with plans for deployment of AHS.

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[5] A list of all the persons interviewed in person and their respective positions is included in Appendix C. Also included is an informal, general protocol of questions that were used to guide discussions.

[6] We provided Mr. Dave Bruggeman of BRW in Phoenix with a set of questions to pose in a meeting he held with the Arizona State DOT in April 1994. These questions are provided in Appendix D.

[7] The WSDOT Resource Group has about 50 members and is composed of WSDOT members from across the state, county and city traffic engineers, academic representatives, and selected other transportation experts in the State of Washington who were convened to support the development of the State's IVHS Strategic Plan. Appendix E contains a list of all the attendees, including selected members of the Resource Group, at a meeting held in Seattle on August 30, 1994 to discuss AHS. Also included is the question form that was mailed out to all members of the Resource Group after the workshop.

INSTITUTIONAL/SOCIETAL ANALYSES

Introduction

7Institutional analyses address the set of meanings, norms, and rules of conduct that shape the behavior of organizations, with particular attention to the patterns of interaction within and among organizations, and the causes and consequences of these patterns. Institutions should not be confused with the organization itself. Of interest here is how and why organizations, their management, and their workers do what they do, how they think about their role (in this case with regard to the development and deployment of an AHS), and how they interact (or fail to do so effectively) with other organizations and actors to accomplish their missions. Societal analyses address similar issues (meanings, norms, roles, behavior, perceptions, patterns of interaction) but at both an individual and collective level, not constrained to organizations.

We have already noted that the unifying focus of this activity's work has been on the factors and conditions that bear on the eventual level of public acceptance of AHS. We have not tried to analyze every possible issue in this regard, a task that would be neither feasible nor particularly informative. Rather, we have narrowed the focus to an analysis of eight key institutional/societal issue areas. These include:

- The perspective of environmental organizations.
- State and local decision process.
- The role of the print media.
- Legal liability risk.
- Public perceptions of potential safety risks.
- Sustainable transportation.
- Public involvement.
- Equity issues.

Perspective of Environmental Organizations

Interviews with Environmental Groups

During June and July, 1994, we conducted in-person interviews with 13 members of the environmental community in the Seattle area. Their names and organizational affiliations are contained in Appendix C along with an interview protocol that was used only as a general guideline for the discussions. A brief background writeup on AHS was provided in advance to each person interviewed. The purpose of these interviews was to sample a cross-section of views, about transportation in general and AHS in particular, from the environmental community in the Pacific Northwest. We believe that environmental organizations constitute a significant public interest group for AHS, and that they represent an even broader constituency of members of the public who are likely to be sympathetic with environmental perspectives on transportation systems and technologies.

> "Environmental organizations constitute a significant public interest group for AHS."

We have organized our record of these interviews around a subset of common themes that emerged from the discussions. Each theme is summarized, and paraphrased statements from the interviewees are included as illustrations of the range of perspectives expressed by this particular group of environmental organization representatives. The themes are not at all mutually exclusive; that is, the ideas expressed overlap the different theme areas. These findings are based on a small, non-representative sample of all environmental groups and individuals in the Seattle, WA area; therefore, the messages contained herein should be viewed as suggestive of an environmental perspective on AHS but not representative either of all environmental groups in this area or of a national environmental perspective. The discussion that weaves through these thematic topics covers a broad range of views and perspective on transportation, on human behavior, on policy preferences, and on the potential for AHS. Some overarching observations from out of all these discussions include some of the following:

- AHS should be deployed in a way that serves to reduce the demand for vehicles, not increase it.
- Creating the behavioral changes that will lead to reduced numbers of and use of vehicles is much preferred over technology strategies to increase system capacity, but such behavior changes will not be easily achieved, if at all.
- Cars, at least as currently configured, tend to have damaging effects on the environment. We need to encourage people to drive less, and to seek automotive technologies that are more environmentally friendly.
- Environmental groups are looking for good research evidence, based on solid modeling, that AHS will work as advertised without causing the same old set of problems that they have been criticizing our transportation system for in the past.

<u>Role Of The Automobile In Society</u>

> "Many environmental organizations are encouraging policies that will limit automobile use."

A pervasive theme among this sample of respondents is that the automobile has done and will continue to do damage to our environment and to the fabric of our society. There is concern that vehicles damage the environment, threaten health and safety, and are generally noisy and disruptive. Many environmental organizations that are focused on transportation are encouraging policies that will limit automobile use and provide incentives to curb the rising trend in vehicle miles traveled. Notwithstanding this theme that is generally negative on the automobile, these environmentalists appear to be willing to learn how the technology might be able to help meet their broader environmental goals.

Respondent Comments

- Environmental organizations tend to believe that automobiles are not good investments in our society at this time. They note that inordinately large resources go into supporting transportation, and this should be moderated. The automobile should be deemphasized in the US. SOV use and sprawl is a poor outcome of the transportation system. Externalities and hidden costs make for uneconomic land use.
- Respondents are concerned what role AHS might play in this regard. Would AHS simply prolong the use of the internal combustion engine and the automobile? Other forms of transport should be investigated and pursued. People should use cars less in the future.
- AHS funding should be used to get people out of cars, to find alternate means of transportation, or to reduce the need to use transportation. This is much more important as a goal than AHS and would have much larger impacts than the marginal 10 to 15 percent improvement claimed by AHS.
- Key issues for transportation include increases in vehicle miles travelled (VMT) caused by population growth and car ownership and resulting in air, water, and noise pollution, lost habitat, and urban sprawl. Any plan, such as AHS, that makes it easier for car owners to drive contributes to these problems. These increases in VMT have greatly increased our reliance upon petroleum. We should promote least cost planning approaches to transportation decision making, zero emission vehicles, and traffic calming strategies.
- Even if zero emissions were achieved, there would still be too many negative impacts of the automobile. Automobile driving should be reduced and the share of non-auto trips should be increased.
- There are too may deleterious effects of the automobile. These include oil spills, destruction of community, over allocation of resources to the automobile, over devotion of land to car related uses, and too many people dying in car wrecks. Once off the freeway, cars continue to cause a variety of impacts. This must be remembered when considering AHS.
- Any definition of AHS should include pedestrians as travelers on the road. Intelligent roadways have actually hurt the pedestrian. We need more balance.

We have marooned the pedestrian. Roadways have become more unsafe and unpleasant for bicyclists. Also crucial for transit riders. People want traffic to slow down in their neighborhoods. AHS should be putting high priority on balancing the excesses of the use of technology to date.

- Defining AHS to just have to do with freeway systems is too limiting. We have an opportunity to make systems more multimodal, balanced, and sustainable. We keep trying to make the urban area "fit" the automobile. The focus has been too much on making it easier for vehicles to move. AHS would continue the use of the "infernal combustion engine" which should not persist. An electric AHS system would be more palatable, but technically difficult.
- Even though there are too many cars now, people will continue to use cars until there is an alternative that is as convenient as the automobile. Thus it makes sense to improve car/highway efficiency as much as possible with options such as AHS. People should be able to keep their cars, but be encouraged to drive less. Telecommuting more would be helpful, as would working at home.
- A transportation system with vehicles that do not have the size and danger of the current automobile will be preferable. Modified AHS vehicles could fill this demand with smaller, electric powered cars.

General Environmental Perspectives

As part of the general view of the environmentalists we interviewed, addressing the question of how transportation systems can be made more environmentally friendly is important to them. Some believe that transportation managers are wedded to an outdated view of our social condition that maintains that more roads, more vehicles, and technologically sophisticated systems will surely improve our well-being. Several respondents commented that we need to be thinking in terms of behavioral changes relative to how we think about and use our transportation systems, rather than relying on technology alone to solve our problems. These interviewees see the current system as being seriously flawed, and think that new approaches are called for. AHS may be a part of such an approach, if it is introduced and managed in the right way.

> "We need to be thinking in terms of behavioral changes rather than relying on technology to solve problems."

Respondent Comments

- National transportation policy prescriptions that apply to everyone, such as rezoning, CAFE standards, or other lifestyle changes are very problematic. They involve setting a policy prescription that will hold constant across all places, people, and situations. Such policies tend not to fit well with all people in all places. The potential for rural-urban conflicts, for example, are immense. AHS seems to be a low-conflict plan, since it is voluntary and does not prescribe changes for everyone, but offers an option that may be acceptable and workable for some and not for others.

- People will probably accept AHS more and more over time. A strong generational influence will take place, as more technology accepting generations grow older.
- A recent local survey found that 68 percent of those surveyed said that traffic was the worst problem they had to deal with and the biggest motivation for them to live elsewhere.
- The goal of transportation should be to move people and not cars, so it is important to consider how AHS may fit in with this goal. Any technological “fix” such as AHS should have reduction of VMT as a primary goal.
- Behavioral changes effected through incentives and disincentives (often market oriented) are much better than technological fixes. Half the money spent on an AHS spent instead on parking allowances would be much better at congestion relief and reduction of VMT. This includes investment in rail systems. Programmatic TDM is much better than either light or heavy rail.
- Transportation departments tend to want to build new lanes rather than close and refit existing lanes due to the hassles and inconveniences that it causes. This must be remembered in any highway expansion plan. This is the highway construction department bias. AHS sounds something like trying to squeeze the last gasp out of a poor system. Given limited transportation funding, AHS is a poor choice of disposition of those funds. Radical programs like AHS should not be pursued. Instead transportation should get radical by changing peoples’ behaviors.
- There is to date no environmental assessment or environmental impact statement on AHS. This should be pursued ASAP. We need to study the cumulative effects and uses of irretrievable resources.
- An AHS is not an inherently bad system. Lane-keeping embedded nails sound very complex, however. The worst problem is that AHS would increase capacity. Any potential of an AHS to create additional roadway capacity is unattractive. There is too much traffic currently. Constructing new roadway won’t ever solve congestion problems. We need to get away from the notion that having a car is every one’s right. “What if everyone in China had to have a car?”
- AHS doesn’t address two vital goals of sound environmental transportation policy: the reduction of VMT and the increase of the modal share of non-automobile trips.
- Policies that appear more desirable than AHS include: better urban planning and land use that would not force people to jump in the car to shop, and put people closer to work; better equity in transportation access; fuel efficiency standards; alternate fuels; and electric vehicles.

Growth Management And Land Use Planning

Environmentalists think of growth management and land use planning as tools for addressing the serious problems outlined above regarding our current transportation systems. Transportation is seen as inextricably tied in with land use patterns, particularly in and around our urban areas. Regional growth management planning in the Pacific Northwest and elsewhere in the country is examining ways to break the trend toward increasing suburban sprawl and roadway building to service these low density settlement areas. These trends have fueled the growth in VMT, number of vehicles, and number of trips that result in greater fuel consumption, worse urban air quality problems, and generally exacerbate the concerns of environmental organizations. While policy strategies such as zoning restrictions and the creation of urban villages are under serious consideration in many urban areas in the country, they imply a level of public acceptance that even environmentalists are not convinced is possible. These issues emerged in our discussions with these Seattle environmentalists, and they thought about AHS in this context.

"Regional growth management planning is examining ways to break the trend toward increasing suburban sprawl."

Respondent Comments

- The ITS technology should be used to restrain and regulate automobile use, rather than to encourage its further growth. In this regard, AHS should be introduced in a way that is consistent with the objectives of growth management and land use planning.
- We should keep in mind the European model that uses growth management strategies to keep vehicles out of the inner cities and encourage non-vehicular modes. The Europeans have considered the demand side better than we have in the U.S. We need to integrate several transportation systems, including AHS, into simulation models and simulate/troubleshoot possible consequences. Computer simulation should be used to project travel plans in the context of growth patterns and transportation. AHS should be considered in the context of such models.
- Locational architecture predisposes our condition of relying on the automobile. Current land use patterns force people into a lifestyle they would not otherwise choose. They are forced to live further from work and shopping. AHS doesn't really address this fundamental problem with our transportation system.
- Current zoning that separates residential from commercial areas is an accurate reflection of what people want today, and this increases the need for cars to get around. While rezoning may be possible and desirable as a way to reduce dependence on the automobile, people are not likely to change their land use and

residential preferences very readily. It will be a very gradual process. We need to work with the system that we have now. Forcing people to live with higher density land uses will be hard to sell, and raises equity issues.

- It may not be appropriate to assume that vehicles will continue to increase as in the past because we may be approaching a level of saturation. But in areas of rapid population growth, VMT will continue to grow, and AHS has the potential to further augment that growth.
- Would AHS transfer points (entry and exit) attract more development and increase sprawl, thus furthering the harmful impacts of urban growth? Would AHS push congestion onto off-ramps, thereby creating endpoint congestion?

Induced Demand

Environmental groups in particular, but others as well, are concerned that any transportation technology that has as an objective improving the capacity and throughput of existing roadways will create additional demand on those roadways. AHS is expected to free up the available non-AHS lanes either by creating a new dedicated lane, or by increasing the traffic flow on an existing lane. This, it is feared, will have the effect of encouraging more drivers onto those roadways. Evidence from various parts of the country suggests that this induced demand is not just a relocation effect of existing traffic patterns, but rather leads to a larger number and volume of vehicles in the aggregate. That is, more people drive, and people drive more than they did before the capacity was created. Some believe that traffic congestion is a good thing because it discourages this latent demand from becoming manifest. Our discussions with these interviewees echoed these kinds of sentiments.

> "AHS may lead to a larger number and volume of vehicles in the aggregate."

Respondent Comments

- Appeals to non-AHS users that AHS will lessen congestion by drawing off other drivers is unconvincing. It may not lessen congestion for them; it may just encourage further use of AHS lanes by other cars that would not otherwise be driving. AHS will need to convince these people that the system is beneficial to them personally, rather than indirectly beneficial to them.
- VMT increases due to induced demand from an AHS system would overwhelm any air quality improvements. Puget Sound people would not accept that. Latent demand will overwhelm any extra capacity made available by AHS.
- AHS could increase air pollution by drawing more cars onto the highway. This happened in Europe where smaller cars on the highway led to more cars being present, hence more air pollution.

- If AHS encourages more driving, that is acceptable because it reflects people's needs and preferences. Improving transportation is a worthwhile goal in and of itself. If people consider themselves better off through better transportation, they will be better able to take care of the environment. Environmental protection follows affluence.

Sustainability

Environmental groups are the principle spokespersons for the importance of a sustainability perspective in our nation's transportation planning (see Sustainable Transportation Section for a more detailed treatment of this concept and its potential relevance to AHS). Sustainable transportation has to do with fuel consumption, air emissions, and quality-of-life effects. It raises questions about whether AHS is more than a short-term solution to long-run, systemic transportation problems.

> "Sustainability raises questions about whether AHS is more than a short-term solution."

Respondent Comments

- Transportation agencies still see themselves as growth agencies, and there is not enough focus on using scarce resources more wisely and sustainably. AHS may find itself in the middle of this issue. AHS should be judged on the basis of whether it makes resource use more efficient. It would be best if AHS were to be based on alternative, more efficient, less polluting fuels. If AHS continues the use of non-renewable resources, this will be neither sustainable nor desirable.
- Sustainability is actually hampered by people looking at the world and wishing that it were different. We should deal with the world in terms of how it actually is. Utopian communities, though desirable to some, are not desirable to many, and programs that push for them will engender great opposition. Programs that coincide with the way people want to live are more likely to succeed and be sustainable. People have reasons that they like and use cars. AHS should support the reality of drivers' needs.
- Transportation priorities for many environmental organizations include: setting up cities that can be operated without cars, e.g. the urban village; building better bicycle routes and improving existing bicycle access; making the streets more pedestrian friendly; changing to alternate, less polluting fuels; and changing peoples' lifestyles such that they perform their activities close to home and do not need to drive, such as shopping near home instead of at a mall. Our transportation improvement goal should focus on access rather than mobility. "That is the sustainable answer."
- AHS promises of increased efficiency is the same solution as creating new highway capacity by building new roads. This is only a short-term solution and

keeps us away from other alternatives. AHS looks like a short-term improvement solution that will be overwhelmed in the long run by population growth.

- Individual car ownership is an inefficient use of resources. It is not sustainable and leads to waste. Mass transit is a much better method of transportation. Electrified AHS also would be a good approach, and would increase the attraction of the program from a sustainability standpoint. AHS supported use of smaller, electric cars would be a very positive move.
- To achieve sustainable transportation, resource consumption should be reduced. Part of this means the reduction of accidents and vehicle replacement. AHS could help achieve this last goal.
- A Caltrans study points out that ramp meters are not sustainable in the long run. They are causing backups in the neighborhoods and creating opposition. So in the long run, they may be doomed. Perhaps AHS could help reduce these backups. We also need to be careful that AHS doesn't cause similar backups at entry and exit points.
- Putting more vehicles on the road will only exacerbate the current road maintenance problems. It is not the way to achieve sustainable transportation.
- AHS sounds like a "last gasp" toward trying to keep the highway system intact and maintaining the use of cars. Instead we should move toward more sustainable transportation alternatives. AHS sounds like an American high-tech toy. A sustainable development point of view would suggest that the money be spent on other things.
- Congestion may change radically in the future and not be a problem. In such a case, would the need for an AHS vanish as well?
- If an AHS can reduce exhaust emissions through speed maintenance, then this will be a good thing. However, the air pollution mitigation value of increasing highway speeds may be over-stated. This needs to be modeled better. The models should be reevaluated. The possibility is there that more cars on the road will offset all transportation gains.
- Automobile dependency is not sustainable. Walking, bussing, and rail are sustainable alternatives. Rezoning and growth management will make this possible. To get toward this goal, driving should be made closer to its true cost. The cost of driving must go up because even the best rail system in the world can't compete with free driving.

Life-Cycle Perspective

This perspective is closely related to a sustainability perspective. It reflects a perspective of the automobile that takes account of the resources that go into making it, its useful life span, the side effects of its use, and its ultimate disposition and the environmental effects that accompany each stage of its natural life cycle. Respondents in our interviews were asking that AHS be examined in this comprehensive way.

> "AHS should stress its contribution to lowering non-renewable resource use."

Respondent Comments

- AHS should incorporate a pollution prevention approach to better protect the environment. It should include a plan for disposal of the usual by-products of vehicle use (oil, batteries, tires, etc.) and the recycling of components.
- Today we treat cars as a throw-away product. New AHS vehicles should be built with life-cycle production in mind. The manufacturer should take the automobile back for reproduction, reengineering, and recycling, rather than entering the vehicle into the waste stream. New AHS vehicles should be designed for the long-term and built with recycling and reengineering in mind. Life-cycle production would make transportation sustainable. Perhaps manufacturers should be mandated by regulation to take/buy back the vehicle once it is through its useful life span. Design might differ if this were the case toward favoring life-cycle production.
- Surcharges or other charges (possibly even up-front waste disposal insurance/deposits) might be a good way to reduce the pollution that comes from buying a throw-away car.
- Increased safety means fewer accidents which means fewer wrecks entering the waste stream. It probably also means less car damage leading to longer automobile retention rates which also benefit the environment. If AHS could increase the longevity and operating life of cars and thus result in lower resource use, this would be a large environmental benefit as seen from the resource use and waste stream perspective. AHS should stress its contribution to lowering non-renewable resource use.
- Use of pallets could offer more workable solutions for life-cycle design and maintenance. If one organization (like an MPO) owned the pallets, then it could maintain, repair, and control the waste flow resulting from the AHS cars (the pallets) much more effectively than separate, individual owners could. Many UPS trucks are over 30 years old, but the company keeps rebuilding and refurbishing them. Like things could happen for AHS pallets that would result in

extended life-times for the vehicles and less uncontrolled entry into the waste stream, as well as more effective recycling efforts.

- Will AHS soon be dated and become obsolescent? Will changes in technology such as telecommunications render it useless? Will other forms of transportation replace it soon? This would make an extremely expensive investment a large waste of money.

AHS System Configuration

Part of the difficulty in conducting interviews like these, with environmentalists or any other respondents, is that AHS is not yet well conceptualized or understood. In these interviews, the respondents had a variety of notions about how an AHS system might be configured, questions about what this would mean, and concerns about the consequences of various assumed configurations. Until the AHS concept is further developed, this will be a common communication problem. But in the meantime, these questions about system configuration offer clues about the kinds of issues that a more fully developed AHS system will face. They also offer an opportunity to consider how best to configure the AHS system at the outset to be more acceptable in the long run.

> "AHS should be positioned to benefit the entire transportation system of an area."

Respondent Comments

- Conversion of underutilized HOV lanes is a good idea, but adding more lanes to the highway is not the best solution because it causes more people to drive. HOV to AHS conversion would allow for properly equipped busses on AHS. New lanes should only be built where land already has been set aside for that purpose.
- You should be able to achieve environmental goals while keeping traffic flowing. Using AHS on HOV lanes may be a good idea, but those lanes need to extend longer distances to make them more effective.
- Electric powered AHS vehicles or lanes would be a good idea, but the costs should be considered in such a plan.
- Having separate, dedicated AHS lanes could have the benefit of increasing acceptability. Those stuck in traffic in the normal lanes would see AHS lanes moving faster and be motivated to try AHS, even despite their fears. The comparison factor could help market the benefit of AHS. Mixed use lanes might raise safety concerns among the driving public.
- AHS is a technologically interesting idea, but it should not be thought of in isolation. Rather, AHS should be considered in terms of the whole transportation system. The potential for impacts on side streets must be remembered. AHS

should be positioned to benefit the entire transportation system of an area, not just a part.

- A system of small, low powered city cars as well as bicycles and mass transit for urban use and larger freeway cruisers (similar to the cars that we now have) for hub to hub transport would be a much better system. AHS could facilitate this in many ways, by making distance transit safer, and perhaps shuttling city cars safely between cities.
- What happens at exit areas? Would downtown side streets back up onto the freeways? Tolls on AHS SOVs entering the downtown area help might address this problem.
- Electrically powered AHS vehicles would be a good idea, but at present such systems are very expensive. Busses that run on electricity and diesel are very costly (though perhaps due to the presence of only one supplier). The concept should be explored further.
- A mixed traffic AHS scenario seems very problematic. Any system that puts an innocent driver in the path of being harmed by another, culpable driver creates a grave situation. Massive litigation may result if a blameless person is hurt by a reckless person through no action of their own. A mixed lane scenario would be very difficult to defend legally. There are too many bad automobile drivers on the road, too great a lack of good automobile standards and safety enforcement, and a general assumption that there will be a safe system for automotive control.
- An HOV AHS only in rush hour would discourage SOVs and not dismantle the incentive to car pool.
- Palleting might be more cost-effective to pursue on railroad trains. Trains have similar access restrictions to an AHS and already exist. The transformation might be much easier.
- An electrified lane is mildly positive. What is the efficiency of electric locomotion versus other fuels? What kinds of changes would be necessary to hook an AHS into a local power grid?
- The most important issue for highways is their impact on wetlands and endangered species, and this is particularly related to the impact of new highway construction. In what areas would AHS require additional lanes, or additional entry and exit facilities? Highways are often located in the natural waterways, where topographical changes are gradual and curves not abrupt. This means that any highway expansion tends to particularly impact wetlands.
- Building new lanes will be a major deterrent to acceptance by the environmental community. The use of existing lanes (HOV included) is better than adding lanes.

Safety

As with most of the other thematic issues that are of interest to these environmental respondents, the potential safety implications of an AHS elicited a range of perspectives, from presumed safety benefits of AHS to potential drawbacks. Distinctions were drawn between the increased safety of drivers on an AHS controlled roadway, and the safety of pedestrians and others who might be adversely impacted by the indirect consequences of AHS. Because the concept of AHS is not very clear yet to people, we can only take these comments as suggestive of the kind of safety issues that environmental groups can be expected to raise as the program proceeds.

> "Distinctions need to be made between the safety of drivers on an AHS and the safety of pedestrians."

Respondent Comments

- The potential for safety concerns and problems seems particularly high without the use of dedicated lanes for AHS.
- AHS lane-keeping and automatic breaking capabilities would provide a big safety benefit as lane-changing in heavy traffic and tail-gating cause many accidents. A further positive benefit of AHS could be better automated emergency response management (Mayday-type systems).
- One very positive contribution of AHS technology would be to keep uninsured or unlicensed vehicles off the road. Such computer lock-outs could contribute to a substantial marginal improvement in roadway safety. Another positive contribution would be to regulate speed on side-streets by the use of a computer lock-out of high speeds on selected roads. However, such a traffic calming strategy may engender substantial driver opposition.
- AHS can't guarantee safety improvements; it may only make new, expensive cars safer, and this raises equity questions. AHS should be configured to provide access to everyone.
- Consider non-construction alternatives. People are even safer if they do not have to drive at all. Safety is a poor reason for highway building. Whose safety is being improved? Pedestrian safety should be improved first. Busses and trains are safer than cars. Telecommuting might have a revolutionary impact.
- There is a certain amount of noise, pollution, and danger associated with any kind of trip. Any AHS system will degrade safety, not on the highway, but because of the additional trips that the AHS makes possible, overloading existing streets. AHS will increase mileage on city streets and will cause an increase in accidents there that will outweigh reduced accidents on the system. If AHS stimulates

more vehicles, then there will be more bicycle and pedestrian accidents on the feeder streets. Regarding safety and congestion, the number of cars on the road contributes to the safety problem, so we need more emphasis on public transportation, walking, and bicycles.

- Regarding increasing safety by deploying AHS, public resistance will be strong. Seat belt use illustrates the difficulty of trying to change people's actions to accomplish safety.

Cost

> "Environmentalists are concerned with the high potential costs associated with AHS."

As with safety, environmentalists are concerned with the high potential costs associated with AHS. In our interviews, they discussed the need for a careful cost analysis of AHS along with other alternatives so that a least-cost approach to planning our transportation future can be applied. They also talked about system costs and pricing as a tool to address problems of peak traffic congestion and to gain a measure of control over rising VMT. Equity issues also were identified in discussions of who could afford AHS and who might experience restricted access due to cost.

Respondent Comments

- The highway system is over-utilized beyond an optimum level because driving is so highly subsidized. People should be made to pay more of the costs of driving. Fuel prices could be raised, automatic toll collection and congestion pricing could help, and parking allowances could also be used to ration traffic, which has been shown to be very effective.
- While AHS components may be expensive in the short term, regulations mandating their inclusion on all new cars might help bring some of these costs down.
- AHS sounds like it will be very expensive. If the goal is to reduce pollution, for example, then perhaps the money should be spent on other projects that meet that objective directly.
- The environmental community will need solid cost analysis for AHS; current cost estimates are too vague.
- While the costs of AHS might be daunting, the opportunity costs and current and projected environmental costs of congestion also should be kept in mind.
- Taking a lane for AHS represents an opportunity cost for transit right of way.
- Congestion pricing or other fiscal strategies could have a major effect on how AHS would work in our transportation systems.

- Owning a car is very expensive. Poor people will not be able to afford AHS and this raises an equity issue.
- A better use of funds for inter-city corridors would be to build rail, because the costs for AHS might be very high. How does AHS compare to mass transit that would do essentially the same thing? It may be cheaper to improve busses so that they are competitive with cars (better amenities, more versatile in routing and schedules, perhaps smaller busses). AHS should focus on longer distance corridors, and leave bus/rail for city trips. What is the least-cost alternative?
- The implementation costs and the opportunity costs of AHS appear to be significant.
- CVO is causing the highway to fall apart. Too little is charged for the impact created. There is not enough money in the freight sector to devote AHS to CVO.
- Overall, the AHS inquiry is a useful line of inquiry, if for no other reason than looking to get more out of our highway investment.
- If lanes are dedicated, then this will require dedicated ramps. This represents a major infrastructure investment at substantial cost.
- Will some parts of an AHS system only be useful when the entire AHS system is complete? Will cars essentially carry useless technical systems that only are good in certain areas under certain conditions? Will people be willing to accept and pay for this? Implementation of AHS on busses may help solve some of this by installing a substantial amount of technology at once.
- Would retro-fitting for AHS be feasible or would it be very costly? Subsidization of retro-fits would have significant costs.
- Rationing is better than congestion pricing. Pricing issues bring up equity concerns about the poor not being able to drive. Parking is an effective rationing system. If much parking is eliminated, driving should decrease.

Relationship to Public Transportation

Our interviews elicited a wide range of opinions and perspectives on the merits of automobile applications of AHS versus public transportation versus applying AHS to public transportation. Environmental groups generally favor public transportation over the private automobile, and they see that AHS can be applied in a variety of ways that support their underlying preference for moving people versus facilitating the mobility of vehicles.

"Environmental groups generally favor public transportation over the private automobile."

Respondent Comments

- AHS may prove to be a viable substitute for Seattle's underutilized bus transit system. The bus system of mass transit in Seattle is not worth further investment because it is difficult to make the system attractive to everyone. Some routes work, but most go empty. Mass transportation has to be extremely convenient to substitute for the automobile. Busses would need to run very close together to eliminate waiting times. Funding should be reallocated to other uses, such as paratransit, shuttles, subways, or AHS.
- The use of AHS on busses is a very good idea. Mass transit would be more attractive if it moved faster than the cars that are immobilized by congestion. Also, since bus-car interactions are often hazardous, AHS could reduce bus driver error and minimize car-bus accidents.
- Environmentalists tend to be more supportive of public transit solutions to transportation problems, so AHS would be well advised to position itself in support of transit rather than SOVs. Transit applications of AHS should be emphasized to reduce VMT.
- Park and ride, or other inter-modal transportation methods are bad ideas from a time, convenience and personal safety perspective. Sitting in traffic takes less time than shifting transit modes, and people feel safer waiting in their own cars than at a transfer point.
- AHS is a much better idea than light rail. People want to move themselves <u>and</u> their belongings conveniently, and automobiles are useful for doing that.
- The use of AHS for professional drivers of trucks and busses are the most attractive application for AHS
- Current government policy is presently automobile focused. This severely limits other transportation options. Mass transit and other forms are clearly peripheral to the government. Improve mass transit significantly by making connections between neighborhoods easier, increasing the frequency of busses, and improving the safety and amenities of bus stops. Traffic congestion is not a serious problem for automobiles but is for busses and commercial vehicles, and AHS applications for mass transit might be able to help.
- AHS sounds more appropriate to rural areas, such as driving across Nebraska. Urban areas should use a train as rapid transit. We need to think of the investment alternatives. What improvements would AHS offer an urban area over mass transit?

Public Perception of AHS

Our interviewees offered some observations about how they thought the general public might react to AHS. They commented on public fears, misconceptions, and preferences in a way that suggests that such issues as equity, perceived risk, and views about technology applications to societal problems will be particularly relevant for AHS. How these issues are handled in the process of developing and deploying AHS will influence public acceptance.

> "People will not want to surrender control of their vehicles."

Respondent Comments

- People behave irrationally concerning risks, and fears of malfunction and computer crashes with AHS may be significant. Human system errors are common, and lead to dangerous situations.
- The equity issue will be prominent. Eight percent of the population is disabled or vision impaired; how will AHS help these people?
- Unless the vehicles are tested every time they enter the system, there will be significant liability questions.
- People will not want to surrender control of their vehicles to an AHS technology system. For example, the Denver airport baggage system (automatic control) does not inspire confidence about the viability of a computer controlled AHS system. People are unlikely to be willing to turn manual controls over to automatic control. Urban areas are places where people especially like to retain manual control of the vehicle.
- AHS sounds like Star Wars weapons technology looking for a new home and more money (solution looking for a problem).

Marketing Strategies for AHS

The interviewees in this group of environmentalists had a range of suggestions about how AHS could be effectively marketed, both to the environmental community and to the public at large. The same themes that have been noted earlier enter into the consideration of marketing strategies, such as a need for modeled results that support an AHS deployment decision, the need to resolve perceived equity imbalances, the merits of using a least cost planning approach to deployment decision making, and the importance of knowing your audience when marketing AHS.

> "There is a need for modeled results that can support an AHS deployment decision."

Respondent Comments

- In order to effectively market AHS (to the environmental community at least), include it among a full range of transportation options in a least cost planning model. Show with a model how AHS interacts with these other options. Such modelling is crucial to the environmental community. It will make it much more readily acceptable to them if there are extensive, modeled results that can show how an AHS would work, how it would interact with other programs, and why it is a good option to choose.
- Environmentalists are concerned that AHS represents an example of technology driving change, rather than AHS emerging as a preferred choice based on careful planning. An evaluation process weighing problems and benefits needs to be established. Unanticipated results are likely when new technology is introduced without first having carefully modelled the effects.
- At the least, AHS should be coupled with other alternatives, such as: least cost planning, TDM, congestion pricing, parking allowances, and increased transit. The problem needs a comprehensive analysis.
- Mass transit is too choked; private companies and entrepreneurs just can't get into the mass transit business because the system is so politically constrained. Emergency service is the only area with any room for growth. Public/private partnership approaches for AHS need to consider these circumstances.
- Would AHS compete for funding with mass transit and other transportation programs?
- AHS will likely be viewed differently by different generations. Younger generations may be more comfortable with automatic control. There should be some way to distinguish between willing users and unwilling users, also between users and nonusers.
- To make an AHS a worthwhile system, it must reduce air emissions, increase the cost of driving (which is assumed to lead to a decrease in the demand for driving), institute some sort of non-VMT-increasing policy such as congestion pricing, and address the equity issue of giving rich drivers the benefits while ignoring poorer drivers.
- Equity is probably one of the key issues to environmental groups. Transportation focus is traditionally on the vehicle and people in the vehicle. What about all the other people? Disabled, pedestrians, etc. Deaf and blind persons have real problems. AHS needs to address these issues to be widely acceptable.

State and Local Decision Process

Interviews With State And Local Officials

In addition to the interviews with members of the Pacific Northwest environmental community, we also interviewed various state and local officials, including representatives of the academic community in the Seattle area. Our objective was to gain a better understanding of how transportation activities are managed in this region and how decisions might be made with respect to a proposal to deploy AHS in this area.

AHS was described to us as a long range policy issue for the Washington State Transportation Commission. It clearly is not a front burner issue. The Commission would need to support a decision to move forward with AHS, and they are interested mainly in short term issues, in part because of Commission membership turnover, and in part because they are focused on helping to prepare for the next legislative session.

We discussed the State's experience with the Western States Transparent Borders Project that may reflect how AHS might be handled.(6) The project produced several summary reports on institutional barriers to CVO and recommended actions, plus separate reports on each of the western states. There was broad agreement on the merits of the CVO concept, and it was technically easy to implement. However, no one could agree on what actually should be done, what the intent or goal of CVO should be, or who should pay for the system. Each of the players came to this with very different views, and consensus could not be achieved. AHS can expect to encounter similar institutional problems.

"Achieving consensus among institutional stakeholders in support of AHS is likely to be a real problem."

Part of the problem was that the participant groups seemed to change frequently, so it was hard to reach agreement, and there always seemed to be a new group coming forward demanding a seat at the table. Proponents soon discovered, for example, that there was no such thing as "the trucking industry;" rather, there were many different trucking companies, each with a different set of concerns. One of the important things they were not able to do was reach agreement on how to prioritize the problems that needed to be solved.

One of the big issues of concern with the computerized information systems associated with CVO was the subsequent audit processes they would face. Trucking companies felt they would need to maintain duplicate records, in case the electronic system lost data. The smaller companies were reluctant to expose themselves to the disclosure and scrutiny implied by the system. The larger companies generally welcomed the system as a way to police the behavior of all companies and "level the playing field."

Washington State DOT was characterized as more progressive than most from a national perspective. The State has developed an IVHS Strategic Plan and has many ITS funded projects underway in the State,[7] though different cities throughout the state vary a lot on how they are willing to prioritize ITS programs. The dominant perspective among State traffic managers and engineers is focused on building new roadway and rehabilitating pavement, rather than pursuing advanced technologies. This suggests that many state DOTs, where much less interest in ITS currently exists, are likely to be more conservative, traditional, and parochial, and by inference less likely to view AHS favorably.

> "Most of the focus in Washington State is on high occupancy vehicles and public transportation."

Most of the focus in Washington State is on high occupancy vehicles and support for public transportation, and transportation planners are actively trying to discourage SOVs. There have been studies of intermodal linkages, such as roadways to ferries, but these have not yet looked at how an AHS might fit in. Some of the institutional issues that are being looked at include access (equity), congestion pricing schemes, and interjurisdictional cooperation. The equity of access issue includes fairness (ability to pay or concern for some people experiencing delayed access to the system). AHS, as one of the more exotic and visible components of the ITS program, is apparently viewed by members of the public as synonymous with it.

A big issue for AHS is who is going to run the system and pay for it. There is a general sense that if it is a private sector, money making kind of system, then the private operator can set rates and decide how to run the system. While this may not be viewed as fair by everyone, it is what is expected when the private sector is running it. If the public sector is to run system, then perceived fairness and political correctness become more important.

Some of those interviewed echoed sentiments expressed by members of the environmental groups, namely, that increasing roadway capacity and making it easier for people to drive will inevitably have negative side effects that should be avoided. These include the familiar transportation consequences such as suburban sprawl, air pollution, energy consumption, and increased congestion. Likewise, these more experienced transportation respondents also wanted to see more research findings that could provide assurance that catastrophic accidents caused by systemic failures could be avoided. AHS was seen as inconsistent with a need for urban structural reform that will help reduce the need to drive, rather than facilitating mobility.

> "Because state DOTs are likely to be conservative, traditional, and parochial, they are less likely to view AHS favorably."

We attempted to identify a process or procedure by which new transportation initiatives are evaluated, selected, and deployed. While there was a relatively clear path to follow for the traditional transportation construction projects, is not so clear with regard to the newer, more innovative project proposals, such as AHS. Part of the problem is that the transportation picture is changing fairly rapidly, and as a result the way the State and lower tiered agencies deal with these issues is changing. WSDOT, for example, doesn't have a current mission statement; rather, they operate with functional statements for their various offices. Another part of the problem is that transportation initiatives of various types, scopes, and origins are each handled quite differently. Finally, the traditional roles and functions of the WSDOT, which centered on highway construction and maintenance are giving way to new and more innovative approaches to addressing such problems as increased VMT, congestion, population growth and redistribution, and a range of traffic demand management approaches. These new approaches and technologies include, among other things, the full range of ITS components, including AHS.

If AHS, or any other large scale transportation project were initiated through WSDOT, the agency would presumably want assurance of the availability of significant funding before proceeding. The state legislature is deliberating on a budget for ITS, which needs to be matched at a ratio of about four to one. That is, if the state puts up 20 percent, all other non-state sources, including the federal government, must come up with 80 percent. The Assistant Secretary for Program Development makes the final spending decision. But there are no codified procedures for how alternative uses for these funds would be evaluated, or who would have to be involved in funding allocation decisions. There would be some general sorts of constraints dictated by the customary ways of addressing these activities, and the larger the dollar size and work scope, the wider the circle of stakeholders who would have to be involved in order to get final approval. But just how this works is unclear and apparently quite idiosyncratic. This kind of institutional uncertainty in the decision process is likely to be common to many transportation agencies around the country. AHS proponents will need to seek to understand how the process does work in an area being viewed as a candidate for AHS deployment.

"Institutional uncertainty in the decision process is likely to be common to many transportation agencies around the country."

"AHS is seen as inconsistent with a need for urban structural reform."

Several interviewees told us that it is important it to have a systems perspective and to get past the old "we just do state highways" mentality. The state set up about two years ago and funds an Office of Urban Mobility (OUM) with a mission to link WSDOT with all the other transportation-related organizations in the State. The intent was to introduce more teamwork, better coordination,

"No formal, structured process currently exists to address new, innovative transportation technology applications such as AHS."

and better communications to the task of managing the state's transportation systems. But OUM is still not yet dealing with particularly evolutionary transportation applications, such as AHS. DOT created OUM to deal with a perceived existing problem of lack of coordination, and is not likely to create a process for something that does not yet exist. Thus, no formal, structured process currently exists in the State of Washington to address new and innovative transportation technology applications such as AHS, other than the planning structures imposed by ISTEA guidelines.

WSDOT Resource Group Meeting

An invitation was sent out by the Washington State Department of Transportation (WSDOT) to about 60 persons, including members of the WSDOT Resource Group and others in the Washington State transportation community, to participate in a meeting to discuss Automated Highway Systems (AHS) and their potential role in Washington State. Attendance at the meeting from the northwest included members of WSDOT from Seattle, Olympia, and eastern Washington, representatives of FHWA in Washington and Portland, Oregon, city and county transportation experts, and Seattle Metro Transit. Two representatives of Mitre Corp. from Washington, DC attended, along with staff from the Battelle Seattle Research Center and a member of Battelle's Pacific Northwest Laboratory in Richland, WA. A complete list of attendees and their affiliations is contained in Appendix E. WSDOT's ITS Program Manager opened the meeting and provided an update on selected WSDOT ITS activities. A member of the AHS Area "O" study team then provided a background presentation on AHS. The remainder of the meeting was taken up with a discussion of AHS issues (see the list of questions contained in Appendix E). The participants broke into smaller groups to continue discussions of the issues over lunch, and then reconvened to further discuss the range of issues raised by AHS and its potential applicability in Washington State.

The purpose of this meeting was to hold an exploratory, open-ended discussion of issues and perspectives on AHS at this early stage of the national program. There was no intent to either arrive at a consensus viewpoint on AHS or to move toward any decisions about the concept. The discussions covered a number of issues and concerns. The meeting provided constructive observations about the AHS program and concept, and what might need to be done if AHS is to become a viable, acceptable concept for future serious consideration in WA State.

The following record of the discussions reflects both the formal meeting discussions and informal conversations with some of the participants, and it is organized around a number of central observations that arose during the course of these discussions.

- It appears that AHS will be very costly to deploy, perhaps costing in the billions of dollars for WA State. It is difficult to estimate what these costs might actually be, because they depend on the particular configuration and size of the system. Also, as the technology evolves, the costs are likely to go down. There also may be life-cycle operational cost reduction benefits that would make AHS more attractive over time. The anticipated scenario is that AHS will be cost shared under some agreed upon public/private partnership arrangement. The comment was made that public/private partnerships can be very controversial among the public, raising ethical questions. Public acceptance and public involvement are critically important if AHS is to succeed. This includes both local governments and the general public. There is tangible evidence in WA State that the public does accept new technologies; ramp metering is a good example of a transportation technology that was rapidly accepted among drivers in this area. HOV lanes are another example of a transportation management strategy that is well accepted, but not completely so. The comment was made that about 90 percent of the drivers in this region accept both the opportunities and the constraints that HOVs represent. One of the key factors supporting acceptance is that anyone can have access to the HOV lanes if they have the required number of persons in their vehicle, or if they use public transportation (i.e., an equity consideration). If AHS were to operate on dedicated lanes, this would likely be viewed as unfairly restrictive of drivers who could not afford the AHS technologies, thereby raising an equity issue that would result in lower public acceptance. AHS lanes should be made accessible to everyone.

> "Public acceptance and public involvement are very important, and perceived cost and system equity are critical AHS success factors."

- Drivers, all of whom believe they have above-average driving skills, will be reluctant to turn over "control" of their vehicle to a technological, automated system. This suggests that it will not be sufficient to rely upon arguments that automated systems can respond more rapidly and reliably than humans in emergency situations. People are more willing to vest control of an airplane they are flying in to a trained, professional pilot than they are to turn control of their automobile over to machines and computers that are perceived to be likely to fail. Individuals tend to believe that they can safely avoid accident situations with their driving skills alone. It was noted that current conceptualizations of AHS operations assume some measure of continuous driver involvement and alertness, similar to the airline pilot remaining attentive while the flight is on auto pilot. There was some discussion of data that suggest run-off-the-road accidents in rural areas may be linked to the use of cruise control. The issue is whether the driving public would be confident that AHS could prevent these kinds of events, given the likelihood that drivers will be bored and distracted while their vehicle is under automated control. Some of the meeting participants commented that, based on their personal experiences with electronic transportation systems, they would prefer that the driver retain greater control and

> "Drivers will be reluctant to turn over control of their vehicles to an automated system that they believe is less reliable than their own driving skills."

the infrastructure be more passive. It is difficult to obtain either the funds or the commitment to maintain complex electronic systems in reliable, fail-safe working order. Others felt that the main AHS effort should go into passive assistance that helps drivers do their job better, with technology such as proximity sensors and alarms, while keeping the driver more involved in driving, and also keeping the costs down.

- AHS on highways must address the "network effects," i.e., congestion on arterials and city streets at AHS entrances and exits. This will require both analysis and input from local jurisdictions, and therefore raises an important institutional issue dealing with jurisdictional coordination and participation in planning and operation of AHS systems. Some of the concerns raised include congestion on these secondary roadways, parking availability, and safety considerations. These side roadways already experience higher accident rates compared to the freeways to which AHS might be applied, and AHS would not reduce these accidents. Perhaps for this reason, it would be better to focus AHS on Metro transit bus systems in this area. It may be better to automate buses or commercial vehicles, but not SOVs. The potential for safety applications of AHS to the commercial sector, along with more attention to AHS's role in an intermodal transportation system, were viewed more favorably than private automobile applications.

> "Participants were concerned about the "network effects" of an AHS on non-AHS arterials and city streets. Local jurisdiction in-volvement is crucial."

- From a liability standpoint, infrastructure-based AHS systems appear to present real impediments for highway authorities who will be concerned that they would be stuck with legal responsibility for claims related to system failures. On the other hand, the vehicle manufacturers will be equally concerned about liability risks for an individual vehicle-based AHS system. Participants in these systems are fearful that the liability burden will shift towards the locus of control; however, if the system in the aggregate can be made safer and less costly by AHS, then total liability in the system should decline. If that occurs, then those who actually experience liability losses could be compensated through various mechanisms by those who did not, and everyone would end up better off than they would in the absence of an AHS system. One participant commented that the vehicle manufacturers are the key to acceptance of AHS, yet are the least likely to work toward it due to liability concerns.

> "Liability risks are perceived to vary by whether the AHS system is infrastructure-based or vehicle-based."

> "In a recent Northwest survey, convenience and speed were jud-ged more important than safety."

- In a rail marketing survey in Western Washington, convenience and speed were the key concerns for the I-5 Seattle to Portland corridor; everything else, including safety, was a much lower priority to these survey respondents. This suggested to the participants that AHS would be compared with alternative transportation technologies based on convenience and speed enhancements, rather than on safety considerations. The convenience afforded by having a private vehicle at both ends of the AHS controlled right of way was thought to be a very important attribute. Another thought here was that people like to keep moving in their vehicles, even if travel time actually increases. That is, some drivers apparently prefer to take a roundabout route to their destination that might actually take longer than waiting in congested traffic on a more direct route; at least they would be moving and feeling that they are getting somewhere. This suggests that a route that includes a section of AHS-controlled roadway may be preferable, even when it is understood that may involve a longer overall travel time to the destination. Alternatively, it may be possible to travel a longer distance in a shorter overall time with part of the route involving AHS. The perception of greater efficiency and reliability may be the key here.

- There was further discussion of the need to involve local jurisdictions in specific projects such as AHS, and that a good way to do this is to build upon local experiences with current systems and demonstrate how the new technology is an extension of something that traffic managers and the driving public are already familiar with. For example, Seattle Metro is currently developing systems and strategies for controlling the speeds, schedules, and reliability of their bus system. AHS could be integrated into existing traffic control systems, rather than be presented as a new, essentially unknown and unproved stand-alone system. Having AHS integrally associated with familiar systems will enhance the likelihood of acceptance. The comment was made that AHS should try to be responsive to existing needs. The potential for automation of the public bus system in the Lincoln Tunnel in New York was discussed as an example of how AHS could meet a clear need and provide a measurable improvement on the order of 20 percent in passenger throughput. There is real value in the idea of pushing for incremental AHS developments because this can produce visible results that make it possible to achieve a full-blown AHS.

> "Linking AHS with existing systems and involving local jurisdictions in the deployment process should enhance public acceptance."

- To be accepted, AHS needs to provide a demonstrable safety benefit on urban arterials and rural roads, not just highways. Safety is the best incentive for state and local governments to support AHS. Infrastructure investment

> "A criterion for judging the success of AHS should be how many <u>people</u> we can move, not how many vehicles."

will be made only if there is such a clear societal benefit. In this meeting, there was more skepticism about the benefits of AHS than about its feasibility. Some of this skepticism was based on the perception that AHS may only impact a very small portion of regional traffic flow; namely, that traveling on those few roadways that have AHS capability installed. This was seen as providing relatively little benefit in the aggregate. The predominant image of AHS with regional planners and the driving public is in terms of very large vehicle capacity and throughput. The criterion for judging the success of AHS should be how many people we can move, not how many vehicles. That is the way WSDOT assesses the success of HOV lanes today. While automation allows for a scenario that includes more vehicles moving at higher speeds, greater focus needs to be placed on how to provide better, more convenient access for more people to the places and things they desire to be connected with.

- State and local transportation authorities lack the manpower and technical expertise to operate and maintain an advanced AHS system with a lot of control in the infrastructure. They have enough trouble maintaining current transportation technologies, such as draw bridges and ramp meters. But a vehicle-based system may actually reduce capacity by gearing traffic speed to the slowest vehicle. In spite of this, some felt that the only realistic scenario for adoption of AHS is an evolutionary, vehicle-based system, in which vehicle manufacturers take the lead. Furthermore, it was suggested that the private sector needed to play a much larger role in marketing AHS. It is apparent that there remains both controversy and uncertainty about how the relative merits and disadvantages of AHS emphasis on the vehicle or on the infrastructure will play out. It was suggested that infrastructure benefits will sway public investment only if those benefits are substantial. Safety benefits are very important to be able to demonstrate, congestion relief is much less important, and other possible benefits are likely to be even less important. An AHS demonstration should be helpful in showing how this is likely to play out in reality.

> "There is both controversy and uncertainty about how the relative merits and disadvantages of AHS emphasis on the vehicle or on the infrastructure will play out."

- Equity is a major issue. The public will not accept devoting public dollars to make commuting easier for luxury car drivers, and it will not be acceptable to dedicate a lane or lanes to AHS that restricts access to those who may not be able to afford the price of entry. While recovering the costs through user fees could reduce this concern, from a transportation agency decision making standpoint, AHS will be different from and more difficult than most other technologies if you have to dedicate lane space to it. It will be much easier to get

> "It will be easier to get started with AHS on mixed-use lanes because dedicated lanes are difficult to implement and raise equity concerns."

started with mixed lanes, which implies autonomous, vehicle-based systems. Dedicated AHS lanes would be much more difficult to implement than ordinary HOV lanes, which are already hard enough. On the other hand, the Washington, D.C. Dulles private toll road has proven to be an effective arrangement that benefits both the users and the non-users. Still the participants thought that experience shows that it is very difficult to sell the indirect benefits of less traffic on some lanes due to dedicating other lanes to restricted-use vehicles.

- The question of how WSDOT would approach a decision on AHS was raised: Who would need to be involved in the decisions? How would AHS be evaluated? Are there decision making procedures in place to do this? The difficulty with AHS is that it is unclear what the decision is at this point, and AHS itself is not well enough defined or understood. Whether the approach would be vehicle-based or infrastructure-based, a concrete proposal and plan are needed from which to work. WSDOT is not prepared to decide on concepts; proponents of AHS need to build a constituency of support for the program. A new concept and technology like AHS will need to establish support in the state legislature, because that is where resource-allocating decisions are made. The legislative process determines how WSDOT will operate. First, an analysis would be needed of the rationale, costs, and benefits of an AHS. The decision processes for established kinds of transportation programs that are fairly well understood and accepted (e.g. repair of roadway damage or maintenance of bridges) are pretty straightforward. AHS is very new and different, and the decision process is not clear cut. One potentially workable approach would be to get the driving public on board with AHS through a gradual, evolutionary diffusion of new vehicle technologies. Then a basis of acceptance will have been laid that will allow the state to move forward with infrastructure investments that could further support AHS.

> "AHS is a very new and different technology, and the deployment decision process is not clear cut. State legislatures need to be sold on the concept."

Summary: WSDOT feels ambivalent at this time about investing resources and energy in the development, testing, and deployment of AHS for Washington State. While Seattle might be a good location for further research and testing of AHS applications, it is first necessary to have a clear understanding of the benefits of AHS over the other alternatives, and to have a measure of public understanding and support for the concept before moving aggressively ahead. Much more public involvement and education is essential to success in this regard. It is so early in the AHS program that the concept is beyond the vision of most state highway organizations and planners. Another key is the availability of seed money to support research and development on these ideas, and one potential source of additional funds would be increased state gas taxes; another source is federal seed money. Demonstration projects can help show people what AHS can do and what its benefits can be, and these should be undertaken incrementally. These would need to be tailored to the needs of each area, and they must come before any deployment

decisions can be made. Some of these participants are concerned that AHS studies to date are not much more than academic exercises, and that a real AHS will not occur in our lifetimes. But on balance, the participants in this meeting, who constituted a limited representation of the WSDOT Resource Group, were generally positive and constructive in their discussion of AHS and willing to consider how it might serve the needs of Washington State to improve the functioning of our transportation systems.

ADOT Workshop

A workshop was held on April 15, 1994 in Phoenix, Arizona with nine members of the Arizona Department of Transportation (ADOT). A portion of these discussions were specifically directed to institutional and societal issues. Appendix D provides a list of the members of ADOT who participated in the workshop discussions, along with a set of questions that had been prepared for guiding the discussion topics.

The participants were asked how interested ADOT might be in hosting an AHS demonstration project, and how acceptable the AHS concept appeared to them and to their management. Their response was quite favorable toward the idea. They noted that Arizona is very forward-looking in their transportation planning, and both the State, the county, and local municipalities would be interested. They have developed their freeway management and communications systems with an eye to being able to accommodate future ITS-type technologies, so they feel that they are well-prepared to handle an AHS system from that standpoint.

The ADOT representatives indicated that they have good relationships with their county and city governments, and they feel that they have more mobile and progressive communities compared with other cities in the country. While they experience traffic congestion, it is not nearly as severe as in other major cities, such as Los Angeles. They feel that the organized grid-like structure of their local city streets compliments the freeway system, and that would make it easier to adapt AHS to their particular setting. They said that over the coming years they will be building the rest of their planned freeway systems in the Phoenix valley, which would make it easier to adapt an AHS into their construction plan, compared with trying to retrofit a system.

The workshop discussion shifted from the perceived benefits to potential drawbacks of AHS. The participants thought that one of the biggest problems from a systems management point of view centers on a lack of adequate personnel to operate an AHS. They characterized their personnel system as relatively unresponsive to the expressed staffing needs of transportation management.

Another issue identified is the problem of maintenance. One participant commented that it would be nice to have the federal funding up front to build an AHS, but then ADOT inherits the responsibility for maintaining it, and that would be a major cost and manpower consideration.

Another concern expressed was the importance on not diverting, or appearing to divert, funds from existing approved freeway construction plans to AHS, because many would feel that AHS was taking away something that people wanted and had agreed upon.

The comment was made that "AHS is a move more vehicles, not a move more people and less vehicles system." This participant was concerned that AHS might actually encourage more vehicles on the road. That, plus the higher speeds of an AHS would translate into more air pollution.

Another participant said that "AHS requires a tremendous infrastructure investment, such as connections to local street systems, and it is a major clean air issue. It will be a challenge trying to get some of those things programmed and funded, and coordinating with local agencies in terms of how far this goes off the freeway system to make it useful to the community."

It was noted that Phoenix is a non-attainment area from an air quality standpoint, so the air pollution implications would have to be addressed. One participant said, "This AHS system would have to improve the air quality or we couldn't put it in. We are at a point where we cannot add capacity, unless it is HOV-type that encourages a decrease in traffic. If we don't meet their [EPA] standards for air quality, it can effect our future funding for existing facilities."

The participants acknowledged that "there are a lot of political issues to doing something like this. People will be concerned that you are doing this for the elite. It will have a pretty good cost to it. You are eliminating people who can't afford it, and people with older vehicles. This is a discrimination-type action waiting to be filed, politically at least." There was the additional concern that AHS will be subject to environmental challenge, and challenge from citizens who are concerned that their taxes are being diverted from something else they wanted to fund AHS.

Some potential opposition to AHS was thought likely to the extent that AHS is viewed as reducing the need for transit or as competing with the need for transit. Transit would have to be one of the institutional players in the decision process.

Finally, it was acknowledged that "public perception is going to be critical. If the public or the legislature ends up opposing AHS, then it is probably going to be an insurmountable barrier. What is done on the front end is probably going to be as critical as everything else that is done downstream."

Role of the Print Media

Introduction

> "The media will have a significant impact on shaping the opinions that people form about AHS."

The media already have begun to play a role in communicating information about AHS to the general public, and as AHS gets closer to deployment, media attention can be expected to increase well above current levels. For most members of the public, the media may be the only way in which they are able to learn about this new set of technologies, and, depending on how the media tell the story, the media will have a significant impact on shaping the opinions that people form about AHS. We have to be interested, therefore, in both the informational content of media articles and the perspective or interpretation that the media bring to bear on that content. It also is well recognized that the media gravitate toward the more sensational side of news stories. Because AHS is a technology that has the potential to be treated from this kind of perspective, it is important for AHS management to be particularly attentive to the media.

As discussed in the Media Analysis Methods Section, our analysis of the media has focused on the print media coverage of AHS since 1988. In assessing the 88 articles that we identified as covering AHS during this recent period, we have the following kinds of questions in mind:

- What is the breadth and extent of the coverage of AHS (in terms of subject matter and geography)?
- What media are addressing AHS, and who is their likely audience?
- From where do the media appear to be deriving their information about AHS?
- What is the image of AHS that the media are conveying, and is that accurate?
- What is the overall tone of the representation of AHS (positive, neutral, negative)?

After identifying and reviewing the articles that fit our inclusion criteria, we address these questions, identify issues, and offer some suggestions to FHWA about how to effectively work with the media.

Media Analysis

The majority of articles that mentioned an AHS discussed it in the context of other ITS technologies, other transportation issues, or technology forecasting. Of the 88 distinct (non-reprint) articles, only 11 focused exclusively (or almost so) on AHS. Of these only three were longer than one page in length.[1] Given the small number of articles exclusively devoted to AHS and the difficulty of trying to unambiguously attribute particular issues to AHS from an article that covers ITS technologies more broadly, this analysis will draw inferences about AHS based on the best judgment of several reviewers. This analysis examines the context in which AHS has been discussed, along with the benefits, disadvantages, and obstacles to implementation that considered to be associated with AHS.

[1] These three articles are: Goldman, Jay, "Automated Roads Called 'Inevitable' Cars May Drive Us to Work Someday", *San Jose Mercury News*, 1/7/86, p. 1C; Horine, Don, "Cars on Autopilot Likely by 2002", *Palm Beach Post*, 10/19/92, p. 1A; Zygmont, Jeffrey, "Automobility: Cars that Drive Themselves" *Omni*, April 1993, p. 38. These three discuss AHS in depth and are useful for seeing what the few most knowledgeable journalists think about AHS.

Year of appearance: The following figure 1 shows the number of original articles identified through our search procedures that were written concerning AHS each year, the numbers of reprints of those articles, and the totals of both originals and reprints. Reprints are articles by the same authors that have appeared in another publication dated after the original. Reprint content is contained in the original. A shortened version of the original article is considered a reprint. The data for 1994 are through June only. AHS became more frequently written about in the media in 1990, perhaps due to the preparation for and passage of ISTEA.

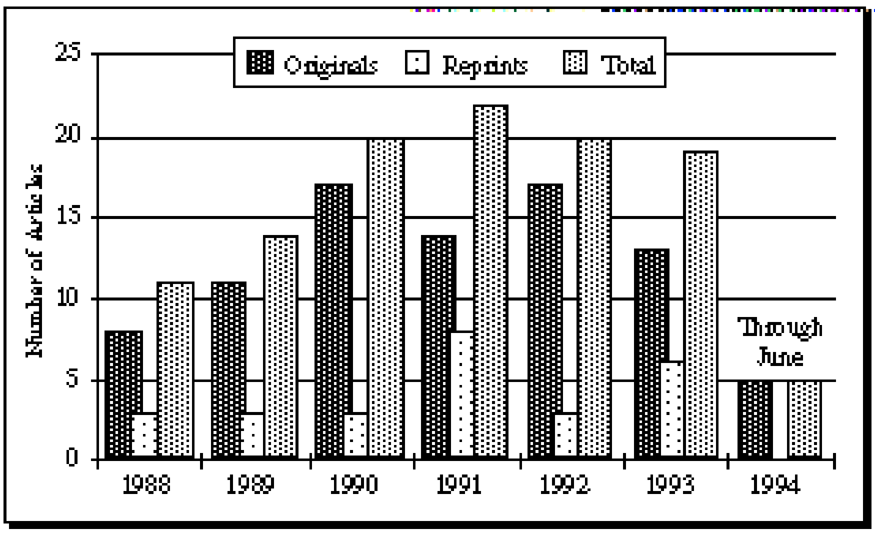

Figure 1. Number of articles by year of appearance.

Source of appearance: Figure 2 shows the sources of articles. The majority of articles mentioning AHS were in regional newspapers such as the *Sacramento Bee*, *Rocky Mountain News*, and the *Los Angeles Times*. Of the 50 articles occurring in regional papers, eight were news stories (in the first or "A" section of the paper), 35 were features (in other paper sections), and seven were editorials (on the editorial pages). The next most frequent source of articles was magazines. Only two articles were in national magazines: an article in *Newsweek* and an article in *Businessweek*. The rest (24) were in specialized magazines (applied scientific journals were not considered in this review) such as *Omni*, *Popular Science*, and *American City and Country*. The fewest articles were in national newspapers such as the *Christian Science Monitor*, the *Wall Street Journal*, and the *Washington Post*. Of these 12 articles, seven were features, two were news stories, and three were editorials.

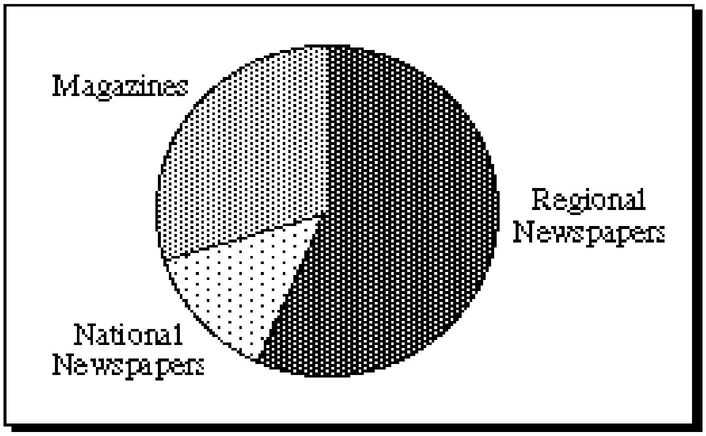

Figure 2. Sources of articles.

The prevalence of articles concerning AHS in city newspapers is explained in part by the large number of such papers in the United States. However, the lack of articles in national magazines, coupled with the small number of newspaper articles, suggests that AHS is not yet acknowledged as a significant national topic.

Influential individuals: Several journalists or other individuals authored more than one article, and many of them appeared in several publications with reprints. The following table lists these individuals, their affiliation,[2] the number of original articles written on AHS, and the total number of times articles by that author appeared. The last category includes both original articles and reprints. This information suggests who has been prominent in print media reporting on AHS.

Table 3 offers potentially useful information for FHWA's efforts to promote public understanding of AHS through closer interaction with the media.[2]

Another very influential group of individuals in newspaper and magazine articles covering AHS are the experts cited or used as references. These are the people to whom the media are turning for information on AHS. 18 individuals were referred to two or more times. The table 4 below lists their names, last known affiliation,[4] and the number of times they appeared in original articles (not reprints).

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[2] As judged by the by-line of the article.

[3] Perhaps subscriptions to ITS America's REACH network should be encouraged.

[4] As listed in the article.

Table 3. Authors of selected AHS media articles.

Name	Affiliation	# of Original Articles	# of Reprints
Frances Dinkelspiel	Knight-Ridder Newspapers	1	2
Paul Eisenstein	Christian Science Monitor	2	3
David Everett	Knight-Ridder Newspapers	1	4
J.E. Ferrell	Los Angeles Times	2	2
Al Fleming	Automotive News	3	3
Donald J. Frederick	National Geographic	1	4
Dan Gillmor	Detroit Free Press	3	3
Jay Goldman	Knight-Ridder Newspapers	1	2
Don Horine	Cox News Service	1	3
Jack Keebler	Automotive News	3	3
Marcía Lowe	Worldwatch Institute	2	5
Arden Moore	Fort Lauderdale Sun-Sentinel	1	4
Tom Nadeau	Sacramento Bee	1	3
Ronald Rosenberg	Boston Globe	1	2
Curt Suplee	Washington Post	1	3
Ken Western	Arizona Republic	1	2
Jeffrey Zygmont	Omni Magazine	2	2

Table 4. Individuals cited as media resources.

Name	Last Known Affiliation	# of Appearances
Robert Ervin	University of Michigan	8
Samuel K. Skinner	United States Department of Transportation	7
Lyle Saxton	Federal Highway Administration	5
Richard Morgan	Federal Highway Administration	4
James Constantino	ITS America	3
Harry Mathews	Arthur D. Little Consulting	3
Stephen Shladover	California PATH	3
Robert Arnold	Motor Vehicle Manufacturers Association	2
Paul Bouchard	VORAD	2
Kan Chen	University of Michigan	2
Thomas Deen	Transportation Research Board	2
Don Orne	California PATH	2
Daniel Raviv	Florida Atlantic University	2
Howard Ross	University of California at Berkeley	2
Edwin Rowe	Los Angeles Department of Transportation	2
Louis Schmitt	Arizona Department of Transportation	2
William Spreitzer	General Motors	2
John Vostrez	California Department of Transportation	2

Knowing who is being referenced frequently is a good indicator of the public visibility of selected individuals, and offers some sense of whose point of view is likely to be conveyed to a public readership. If these are some of the individuals who are particularly likely to emerge as spokespersons for AHS, than FHWA may want to be sure that these persons are fully informed about current plans and perspectives on this rapidly evolving program.

> "It will be useful to keep those cited in media articles about AHS fully informed."

Media treatment of AHS: Media treatment of the idea of an automated highway system was predominantly positive. 54 of the original articles portrayed AHS in a positive manner, 23 in neutral terms, and 11 in negative terms. Judgments about the author's treatment of the subject are based upon tone, choice of words, balancing of merits and disadvantages, and conclusions reached about AHS. The title of the article often provided an indicator of how the subject matter was going to be treated. For example, Marcía Lowe's *World Watch* article entitled "Road to Nowhere" is, not surprisingly, a negative portrayal of AHS. Initial descriptions also were important. A positive initial description, followed by a balanced discussion of advantages, barriers to implementation, and disadvantages that ended with the assurance that AHS could probably be successfully implemented, was considered positive in nature. Positive articles varied in support of AHS from unquestioning advocacy to lukewarm assessments that it was the best of imperfect solutions. Articles that gave balanced treatment to the issues, and neither advocated nor denigrated AHS, were considered neutral. Most of the articles classified as negative were quite clearly against implementation of an AHS, and the majority of those articles were in the form of newspaper editorials. Figure 3 illustrates the predominance of neutral or positive affect toward AHS at this time, which is suggestive of an opportunity that exists at this stage of the development of the AHS concept and program to build strong, positive relationships with the media. This should include discussions of how the most current information on AHS can be provided to the media, along with mechanisms for addressing misinformation when it does show up.

"Current media response to AHS offers an opportunity to build strong, positive media relationships."

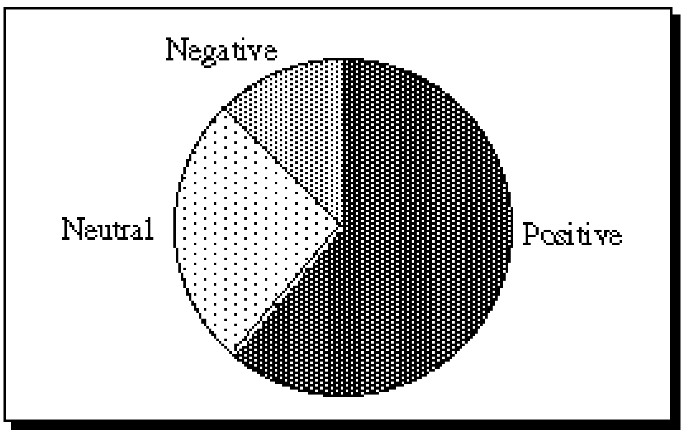

Figure 3. Tone of print media articles on AHS.

Time of deployment: Many (34) of the original articles envisioned the deployment of an AHS as a distant future event, well into the twenty-first century. This was indicated by either a span of years cited as an indication of when deployment could take place or by such phrases as "distant applications" or "far future events". Most of the articles that referenced a time of deployment or operation, however, envisioned deployment of an AHS within the next 30 years. These articles (48)

"Many articles on AHS envision deployment as a distant future event."

indicated that AHS deployment was likely to occur “25 to 30 years from now”, “within my lifetime”, that test-bed deployment could occur within a few years, or they provided descriptions that advocated the technology and thought there were no significant barriers to implementation.

Descriptions of AHS: Journalists envision an AHS in many different ways. While a small number mentioned the term “automated highway systems” and discussed the concept without providing a definition of what they meant, most provided some kind of definition. The simplest, and most common, was the description of a “hands-off/feet-off” driving experience, which was often implied by the ability of drivers to sleep or read the newspaper while the vehicle took them to their destination. Many journalists included high speed (above normal highways speeds of 50 to 65 mph) as a component of an AHS. The concept, though not the actual term, of platooning also was frequently mentioned. Often writers combined the two concepts when describing “trains of cars shooting down highways at 100 mph”. “Car trains” of closely spaced vehicles is how most of the media understand platooning. Figure 4 displays the frequency with which certain terminology was used to describe automated highway systems. Media articles frequently included several of these descriptive terms when describing AHS.

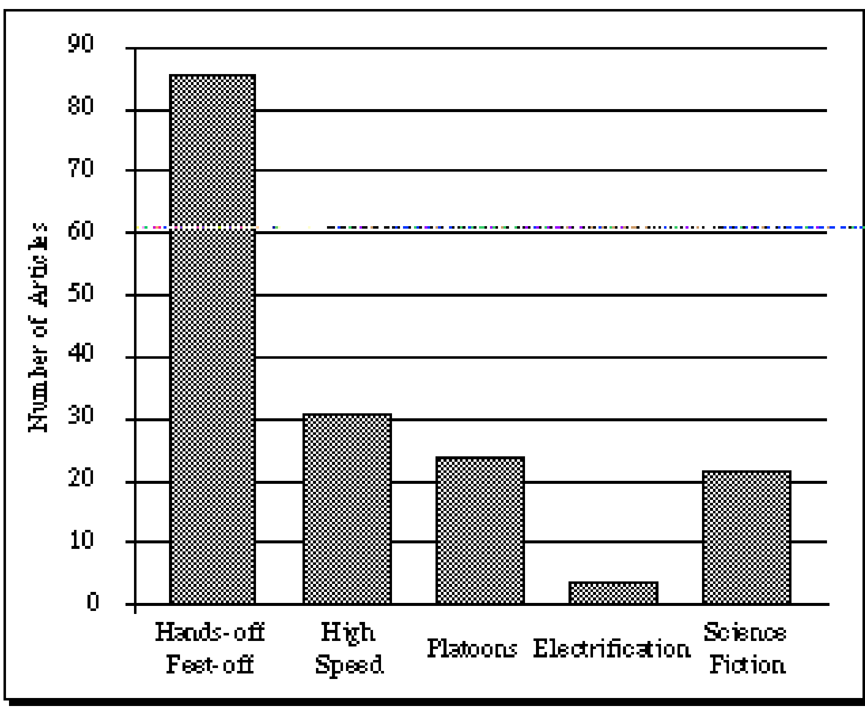

Figure 4. Media characterization of AHS.

A significant number of articles described an AHS as having both higher than normal legal speeds as part of the system design, and as platooning cars together closely (very short gaps between vehicles). A few (four) articles described electrification (vehicles powered by electrical conduits in the pavement) as part of AHS. A number of writers also described AHS in terms of science fiction concepts, such as “Buck Rogers”, the “Jetsons”, or “Star Wars”. Use of science fiction concepts usually seemed to be intended as illustrative or attention-getting, rather than disparaging. Only four of the 22 articles that used science fiction terminology to describe AHS were negative in tone.

Benefits: Most articles mentioned a set of potential benefits likely to be derived from the deployment of AHS. Figure 5 shows the frequency of appearances of these types of benefits for the original/non-reprint articles. Mention of potential benefits does not necessarily mean that the article was positive in tone. Some articles mentioned benefits within the context of an overall negative tone. Typically, more than one benefit was mentioned in an article, and many articles discussed both benefits and disadvantages.

> “Increased safety was the most frequently mentioned potential benefit of AHS.”

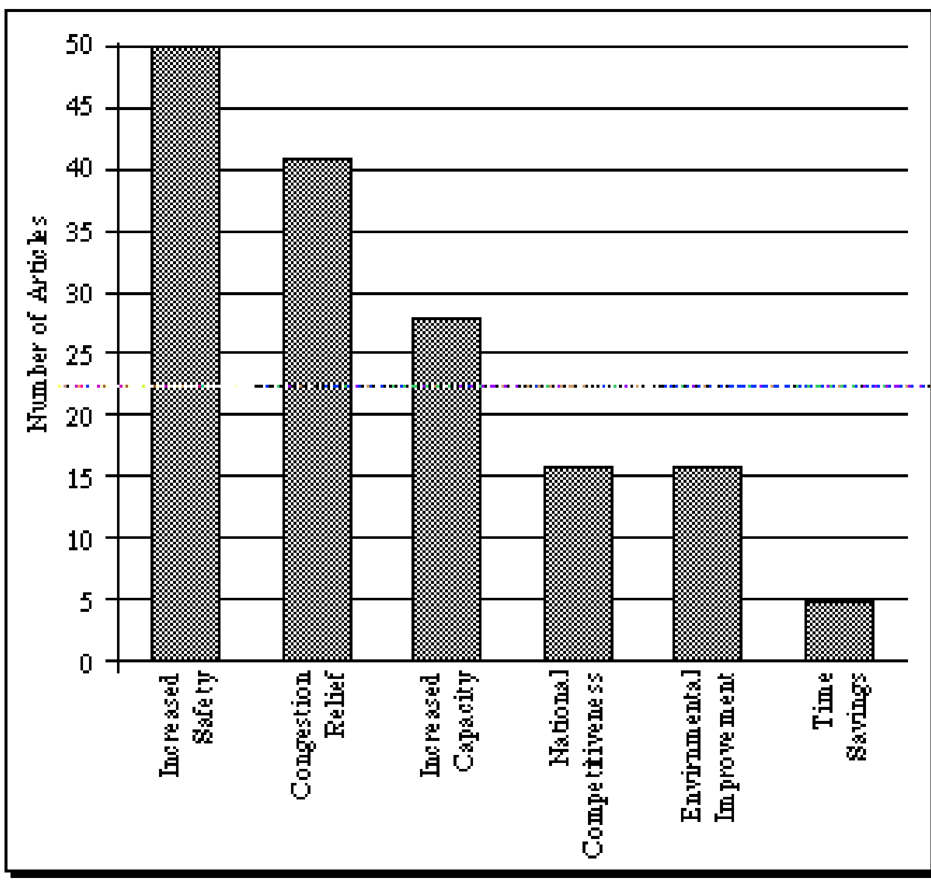

Figure 5. Benefits of AHS identified in print media.

Increased safety was the most frequently mentioned potential benefit of AHS, usually represented in terms of the driver’s ability to avoid an accident. Other safety improvements were described as the ability to travel much faster and closer to other vehicles with enhanced capacity to respond or without the need to respond (the car would avoid danger). Congestion relief is another benefit, presented in terms of having less tightly jammed traffic, thereby avoiding unsafe situations. Often rising accident statistics were quoted, and AHS was described as a solution. Increased roadway capacity differs from congestion relief by its emphasis on enhancement of the ability of a roadway to carry more vehicles. This benefit often accompanied statistics regarding a need for greater capacity and a discussion of the need to expand capability. Many articles insisted that it was vital that the U.S. develop an AHS to maintain (or enhance) national competitiveness. Accounts of Japanese or German ITS advances often accompanied talk of this benefit, as well as warnings that if AHS were not developed, U.S. consumers would have to import yet another high technology good. Some journalists associated AHS with environmental improvement through reduced emissions of noxious air pollutants, reduced wrecked cars in the waste stream, and reduced fuel consumption. A few articles predicted a substantial time savings associated with AHS. This time savings could be used for productive work in the car or at the workplace instead of being wasted in traffic.

There also was some discussion of cost savings associated with AHS, but it was difficult to attribute this as a benefit clearly distinct from many of the others noted. Other benefits were mentioned with less frequency. Three AHS articles mentioned a significant potential to improve mass transit. Two articles said that AHS might provide assistance for older drivers who could be enabled, they reasoned, to drive on longer trips more safely, to drive for more years, and to have judgment failures compensated for through automation. This was emphasized as very important for an aging population. One article mentioned that improved opportunities for regulation and policing of the highways would result, and one envisioned an economic stimulus deriving from AHS through technological spin-offs.

Disadvantages: The disadvantages of AHS identified in the print media are very similar to the barriers to implementation (following section). What makes them different, however, is that they could be experienced even if an AHS were built after surmounting all of the identified obstacles. The articles that were negative in treatment toward AHS contain descriptions of many different disadvantageous outcomes of an AHS. Some positive and neutral articles also contained negative consequences, but in those cases the disadvantages were judged to be outweighed or balanced by the benefits associated with AHS. Figure 6 shows the number of media articles on AHS that contained discussion of selected specific disadvantages.

Environmental degradation characterizes a general worsening of the environment, most often due to increased air pollution accompanying increased automobile use and vehicle miles traveled (VMT). The disadvantage of increased complexity is that it may confuse the driver and lead to accidents or the inability of some drivers to cope with a new, more technically demanding driving environment. Fears of a catastrophic accident are described in terms of “a new meaning of computer crash,” where the automatic system fails and there is a multi-car pile-up, similar to a plane wreck in terms of the scope of damage and loss of life. This is exacerbated by the lack of control that drivers are likely to experience. Increased sprawl includes a set of concerns that AHS would encourage unwanted growth, and might even accelerate the spread of low density suburban settlement patterns. This is most often a fear that AHS will conflict with regional or local urban development plans. Side road impacts involve a similar effect. They reflect the

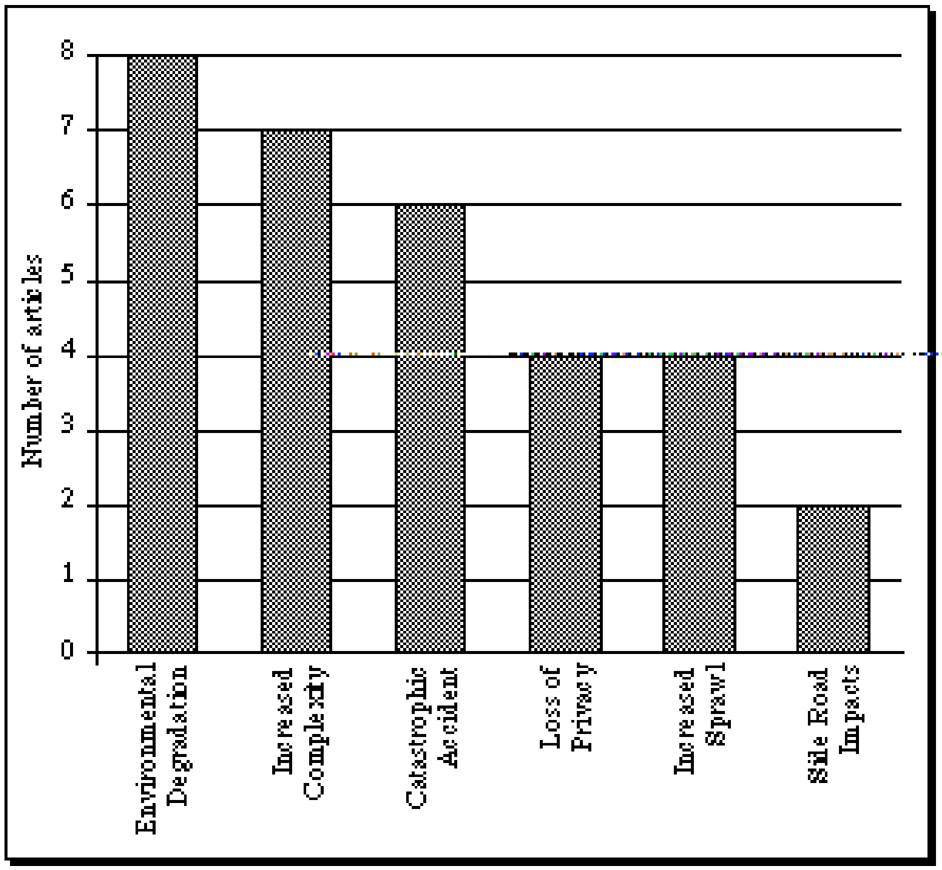

Figure 6. Disadvantages of AHS identified in print media.

concern that AHS would overwhelm feeder roads and highway exit areas with new, larger volumes of traffic, thereby contributing to excessive noise, congestion, and safety problems in those adjacent neighborhoods.

The mention of these disadvantages at this time in the media underscores the need for AHS management to come up with a strategy for addressing and answering the questions that are raised by the concerns. Informational and educational materials descriptive of AHS will need to address these concerns as well.

Barriers to implementation: Like the disadvantages of AHS noted above, barriers to implementation are problematic issues to assess, and the distinction between barriers and disadvantages is somewhat fuzzy. The implications of these issues for the conceptualization and eventual deployment of an AHS are important, and their presence in recent print media articles underscores the importance of addressing them soon, before they can have an adverse influence on the public readership. Figure 7 shows the incidence in these articles of some of the main obstacles to AHS.

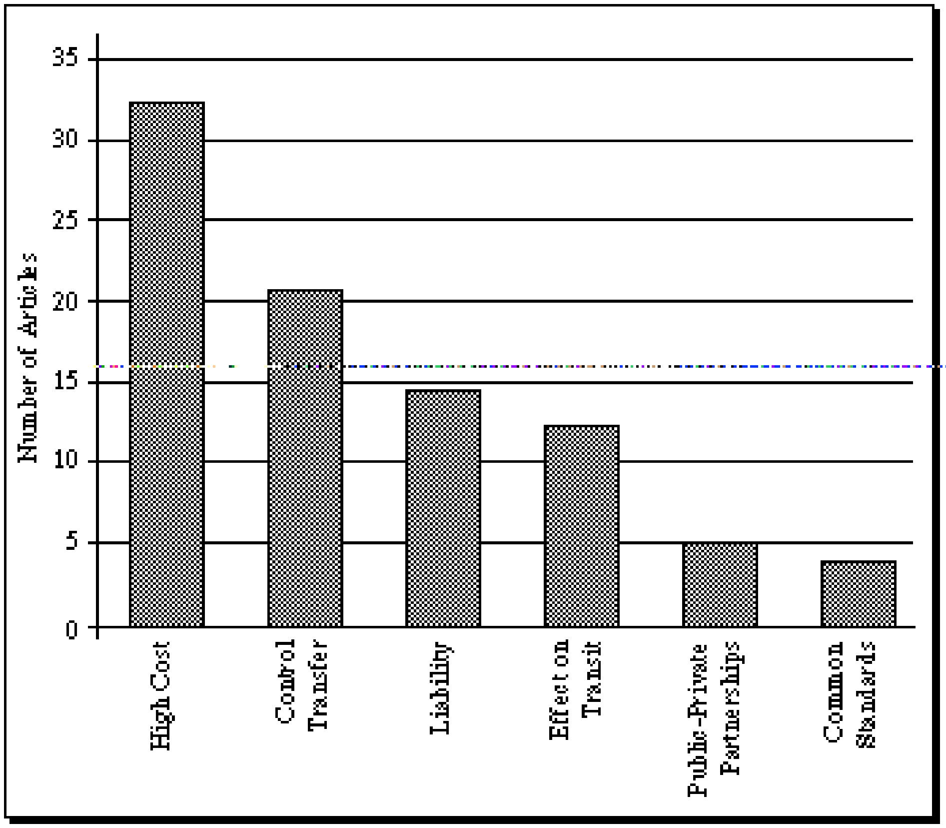

Figure 7. Barriers to implementation of AHS identified in print media.

> "The high cost of implementation was cited often as a problematic issue."

The high cost of implementation was cited often as a problematic issue in the deployment of AHS. However, it was not typically represented as an overwhelming barrier. Many articles suggested that it would be even more costly not to deploy an AHS. Authors of these articles were very concerned about the persistence of automobile culture and driver concern about transferring control to an automated system. One article did mention that non-automated driving allows no greater control for drivers who spend most of their time stuck in traffic at a standstill anyway. Liability concerns were raised in many articles. This persistent issue focuses on who is responsible in the event of an accident. Many articles suggest that the authors and transportation officials are concerned that AHS might have a deleterious effect on transit. Some other improvements in transportation, such as rail, have drawn riders from other forms of mass transit. The fear is that AHS will draw riders away from mass transit. Many people believe that mass transit should be encouraged more than single occupancy vehicles. This is an issue that AHS will want to address. Another concern regarding development and deployment of AHS is a need for public-private partnerships. There are many institutional problems associated with such partnerships, such as public funding of patentable innovations. Common standards also will have to be developed and instituted. Some articles have suggested a standard government infrastructure plan that all regional AHS implementations would have to conform to.

Other, less frequently mentioned issues include achieving a critical mass of consumers willing to try AHS, addressing equity issues, and fear of political manipulation. The critical mass concern involves the difficulty in interesting a large enough section of the driving population in using an AHS and buying AHS technology. This is seen as necessary for creating a system that will develop fully, and three articles mentioned this issue. Two articles mentioned equity as a concern. Journalists expressed their concern that it would be inequitable if only the very wealthy were to benefit from an AHS project that used public funds. One article mentioned a concern that local politicians would ruin scientific development of AHS by battling over pork-barrel appropriations for their home states.

Conclusion: Coverage of print media articles on AHS peaked in 1992. Since then, media attention has declined slightly, although complete data for 1994 are not yet available. Some authors were responsible for multiple articles containing information about AHS. Most original articles that mentioned AHS were positive in nature. A minority (only one in eight) were negative. The majority of the articles that made reference to a time for AHS deployment or operation, saw it roughly within the next thirty years.

This research did not uncover any unanticipated or surprising new issues. But the analysis of these articles is very suggestive of ways that FHWA and other AHS managers might want to proceed. This includes establishing positive working relationships with members of the media, providing the media with consistent, comprehensive information that reflects current plans and thinking about the AHS program, and responding quickly to misinterpretation or misinformation about AHS represented in the media. Given the powerful role that the media play in shaping public opinion, it is clearly not too early to commit to working closely with the media, and treating them as an ally rather than an adversary. Given that most of the media articles reviewed herein are neutral to positive about the future of AHS, the time is right to build on this favorable foundation to help forge a constituency of support for this program.

Legal Liability Risks

<u>Introduction</u>

In order to succeed, AHS will have to attract the involvement of several essential categories of participants whose willingness to participate may depend in part on their assessment of the impact of AHS on their risks of legal liability for damages resulting from vehicle accidents. These participants include the corporate and individual driving public, who purchase, operate, and maintain fleets and vehicles; motor vehicle manufacturers (and their suppliers and dealers), who design, manufacture, sell, and service vehicles; and state and local transportation agencies (and their contractors), who plan, finance, design, build, and operate roadways. This chapter examines the legal risks facing these parties and options for managing them. It is organized in four parts. First, the chapter describes an analytic framework for identifying and evaluating legal risks. Second, it applies this framework to AHS. Third, it discusses options for managing the significant legal risks identified. Fourth, it provides a summary and conclusions.

Analyzing The Legal Risks Of Accidents

For purposes of this analysis, liability is the legal obligation to pay monetary compensation for property damage, personal injury, death, or economic loss resulting from an accident involving one or more motor vehicles. Liability is established through a judgment in a lawsuit among the parties alleged to have had a role in causing the accident (or exacerbating the resulting damage or injury). Depending on the circumstances of the accident, these parties will generally be some combination of the driver, the vehicle manufacturer, and the roadway authority. They may also include other associated parties, such as the driver's employer or parents, the manufacturer's suppliers or dealer, or the roadway authority's contractors or employees.

Theories of liability: Whether a given party is held wholly or partially liable for the accident will depend on the facts of the particular case and the legal principles applicable to establishing liability, which vary somewhat among the three main categories of participants.

Drivers: Drivers generally incur liability for vehicle accidents only when they are at fault -- that is, under the legal theory of negligence. Establishing liability for negligence requires a showing (1) that the defendant failed to conform to a legally recognized standard of conduct for the protection of others against unreasonable risks, (2) that there was a reasonably close causal connection between this conduct and the injury, and (3) that actual loss or damage resulted. The standard of conduct which must be met in order to avoid liability for negligence is that of the "reasonable person." This is a fairly stringent standard because it refers not just to an ordinary individual (who might occasionally do unreasonable things), but rather to the community ideal of a prudent, careful person.[8]

A driver's negligence in causing an accident can come into play in either of two ways. If Driver A's negligence causes an accident, injuring Driver B, then Driver A is liable to Driver B for the resulting damages. If Driver B was also negligent, then his or her recovery is limited by the doctrine of contributory negligence. At one time, contributory negligence could preclude Driver B from recovering any damages at all. Under the modern doctrine of comparative fault, Driver B's contributory negligence will limit his or her recovery in proportion to the relative role played by Driver B's negligence in causing the accident.

Drivers have been held negligent for committing a variety of errors, including: failing to keep a proper lookout for persons or objects in the roadway, failing to drive at a speed that will enable them to stop within the assured clear distance ahead, failing to keep the vehicle under control at all times (for example by taking their hands from the steering wheel), failing to take account of adverse road conditions (such a slippery pavement), violating a statute or ordinance governing vehicle operations (such as a speed limit), violating a statute or ordinance governing vehicle maintenance (such as a requirement to keep brakes in good working order), and failure to exercise increased diligence in the presence of children.

Vehicle manufacturers: Vehicle manufacturers can also be held liable if their negligence in designing or producing vehicles causes an accident. Increasingly, however, plaintiffs rely on the theory "strict liability," because it is easier to establish than negligence. Under the theory of strict liability, manufacturers of products (such as vehicles) are liable when a "defect" in their product causes an accident resulting in personal injury or property damage. A product is defective if it is unreasonably dangerous by virtue of (1) a production flaw (that is, an unintended abnormality), (2) the manufacturer's failure to adequately warn of a risk related to the way the product was designed, or (3) a defective design.

Defective designs are the most significant source of potential liability for vehicle manufacturers. Courts have adopted two different approaches in evaluating design defects: (1) a "consumer-contemplation" test, and (2) a "danger-utility" test. Under the consumer-contemplation test, a product is defectively designed if it is more dangerous than would be contemplated by the ordinary user. Under the danger-utility test, a product is defectively designed if a reasonable person would conclude that the danger associated with a particular design feature outweighs its utility. Under a variation of the danger-utility test, a design can be held defective even where the harmful consequences did not outweigh the benefits, if it is determined that a feasible alternative design would have less harmful consequences. "Most of the products liability litigation related to design hazards has been concerned with the feasibility of an alternative safer design."(9)

Motor vehicle manufacturers have been held liable for defects in accelerators, axles, brakes, gas tanks, steering apparatus, tires, trailer hitches, transmissions, lighting, and wheels.

Roadway authorities: Roadway authorities can be held liable for damages for accidents resulting from defective roads under negligence, strict liability, or "nuisance" theories, or a combination of these, depending on the statutory and common law of the particular state. Because state agencies roadway authorities generally have "governmental immunity" for tort liability, state law must create an exception to such immunity in order for liability to attach. The states differ as to the applicable statute of limitations, the range of injuries for which damages are recoverable (e.g., personal injury, property damage, economic loss), whether the highway authority must have had notice of the defect, what parties can be liable, and whether a negligence or strict liability standard applies.[(10)]

Examples of roadway defects for which roadway authorities have been held liable include: insufficient pavement markings, faulty traffic signals, obstructions placed on or above the roadway or shoulder, accumulations of water on the roadway, roadways subject to unusually slippery conditions when wet, placing or leaving slippery substances (such as asphalt, oil, tar, or paint) in the roadway, and insufficient barriers, guards, lights, signals, or warnings on drawbridges.

Multiple parties: In many cases, more than one party is negligent or strictly liable: accidents are caused by "a combination of bad drivers, bad vehicles, and bad roads."[(11)] While the specific rules for apportioning liability in such cases vary from state to state, the dominant approach is some form of comparative fault: one or more drivers, the vehicle manufacturer, the roadway authority, and any other responsible party share liability for total damages in proportion to the relative role of their negligence or strict liability in causing the accident.[(12)]

Punitive damages: Historically, the purpose of awarding damages in a negligence or products liability case is to make the defendant "whole" -- that is, to compensate those injured or their survivors for the death, personal injury, or property damage that occurred as a result of the accident. Compensatory damages generally reflect this purpose and are calculated with reference to the harm suffered by the plaintiff. However, when their behavior is particularly egregious and rises to the level of "willful," "wanton," or "reckless" misconduct, defendants are becoming increasingly subject to liability for punitive damages, which can involve much larger amounts judged necessary to punish the defendant for that conduct and deter further misbehavior in the future.

Legal risk analysis: In evaluating the legal risks of liability for accidents involving a system such as AHS, potential participants must consider three separate tiers of risk:

- safety risks
- litigation risks
- liability risks

Safety risk refers to the probability and immediate consequences of vehicle accidents -- that is, the overall safety of the system or the particular aspect of it under consideration. In the case of AHS itself, a design goal is that the system afford a higher degree of safety than driving on conventional highways.

Litigation risk refers to the probability and consequences of being named in a lawsuit for damages resulting from vehicle accidents. The probability is conditional on an accident having occurred, and thus depends in part on safety risk. It also depends on the likelihood that a case can be made that the participant's conduct (or in the case of a manufacturer, its design) played a role in causing the accident and that one or more injured parties will bring such a claim. The consequences include transactions costs (the monetary costs and annoyance of defending the lawsuit) and reputational costs (the damage to one's good name by virtue of being the object of litigation).

The distinction between safety risk and litigation risk is illustrated by figure 8, which compares injury rates (a determinant of safety risk) with lawsuits brought (a determinant of litigation risk) in the field of products liability.(13) As the figure shows, while the injury rate remained fairly steady from 1970 through 1986, suits in state courts increased somewhat and suits in federal court increased dramatically within the same period.

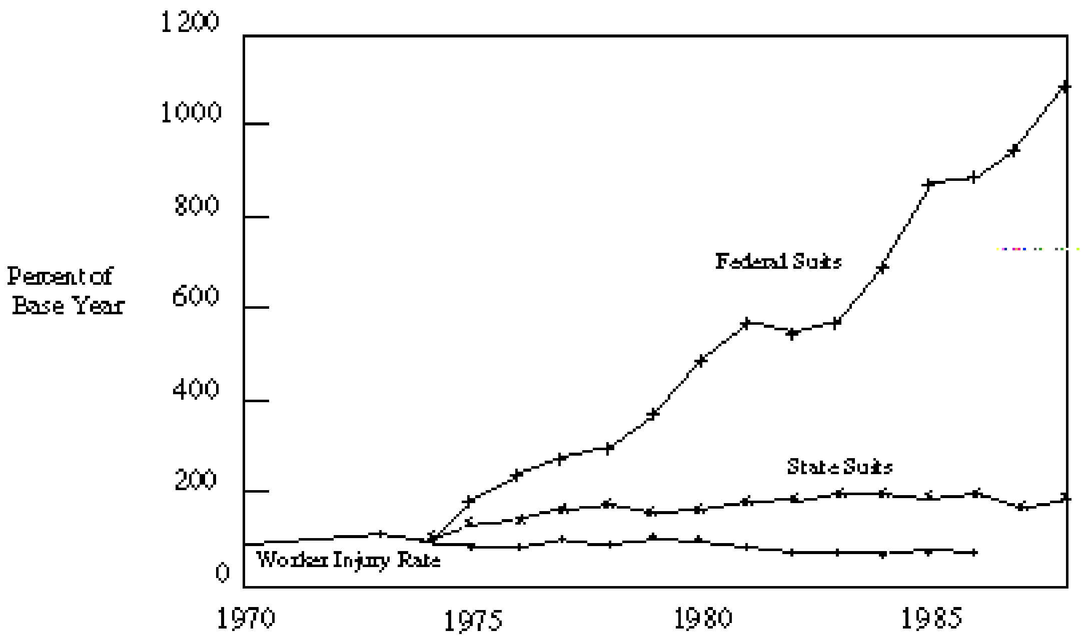

Figure 8. Products liability: Injury rates and claims made.
(Source: Priest.)

For the defendant, liability risk refers to the probability and consequences of losing the lawsuit. The probability is again conditional, on both an accident having occurred and the participant having been named in the lawsuit. It also depends on the likelihood that the participant can be proved to have played a role in causing the accident in light of the available legal theories, evidentiary rules, and jury sympathies. The consequences include additional transactions costs and reputational impacts, as well as the monetary costs of entering into a settlement or paying a final judgment.

The distinction between safety risk and liability risk is suggested by figure 9, which compares the accident rate in the general aviation industry with claims dollars paid, in both litigated judgments and settlements.(14) As the figure indicates, accident rates decreased modestly from 1972 through 1987, while claims payouts increased significantly.

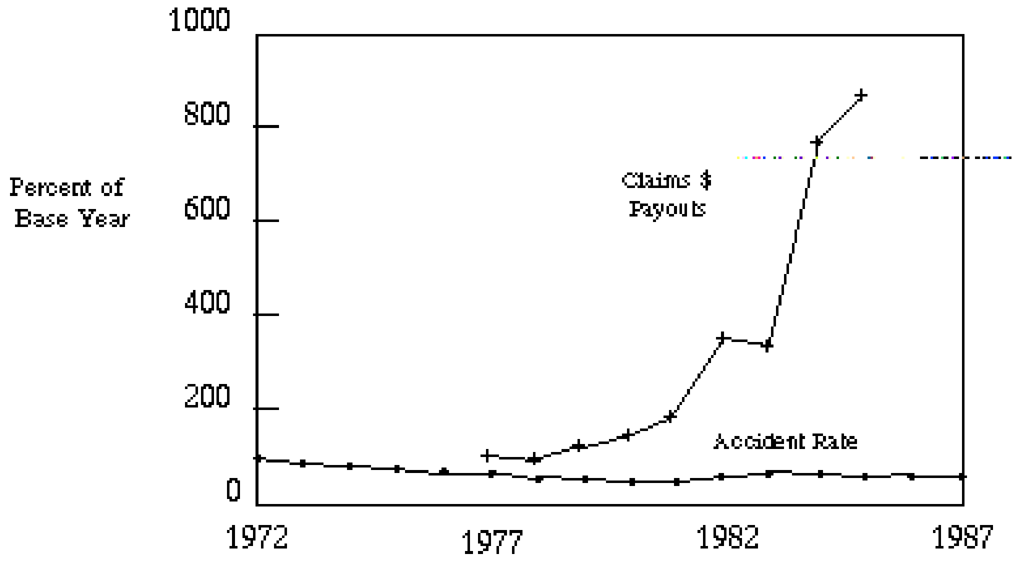

Figure 9: Accident rates and claims payouts.
(Source: Priest.)

In making decisions in their respective domains, each of the three categories of participants is likely to analyze safety, litigation, and liability risks in a somewhat different way.

Drivers: The individual driver seems unlikely to look beyond safety or perceived safety, an issue of growing importance to the driving public. While there was once a conventional wisdom in the auto industry that "safety doesn't sell," dating from Ford's experience with an optional safety package in the 1950s, car buyers are apparently becoming increasingly safety conscious. In a recent survey, more than two out of three consumers ranked safety ahead of price, maintenance costs, and fuel economy, behind only quality as a purchasing consideration.[15] And safety reputation may also be a surrogate for overall quality.[16] As a result, safety is now viewed as a positive marketing feature.[17]

For an individual driver, safety seems likely to completely dominate consideration of litigation or liability risk. The monetary aspects of those risks are assumed by the driver's automobile insurance carrier and thus are "felt" by the driver in insurance rates, if at all. Both these and the non-monetary aspects (the annoyance and potential reputational damage of participating in or losing a lawsuit) seem likely to pale in importance relative to the risk of death or personal injury.

For corporate vehicle fleets and the operators of commercial vehicles such as buses and trucks, litigation and liability risk may be more of a consideration than for individuals, but primarily as reflected in their liability insurance premiums or coverages (unless they "self-insure"), rather than as something they evaluate directly.

Under liability policies, the insurance carrier is required to pay both the costs of defending a lawsuit against the insured (whether or not the claim is meritorious) and the monetary damages if the insured is actually held liable or enters into a settlement approved by the insurer. Accordingly, carriers will evaluate both litigation risks and liability risks, in terms of the probabilities of claims and judgments (or settlements) and the consequent monetary costs. Insurance carriers to some degree take into account the presence or absence of certain safety features in setting insurance rates for vehicle liability coverage. For example, insurers offer substantial discounts on personal injury coverage for vehicles equipped with air bags, automatic seat belts, or antilock brakes.[18, 19, 20] The presence or absence of certain AHS features may similarly affect insurance premiums. In turn, the resulting rates will be evaluated as a cost of doing business by corporate vehicle fleets and the operators of commercial vehicles such as buses and trucks.

Vehicle manufacturers: Vehicle manufacturers and their suppliers are likely to analyze very carefully the full range of safety, liability, and litigation risks associated with contemplated vehicle features. The bedrock of this analysis will address safety itself: the impact of the design feature on the probability and consequences of vehicle accidents. But “actual safety,” to the extent it can be predicted, is far from the only consideration. Litigation and liability risk are only partially determined by safety and must be analyzed separately.

In terms of probabilities, for example, features that improve safety can actually raise litigation risk by increasing the probability that when there is an accident, certain types of claims will be brought against the manufacturer. Thus air bags can give rise to claims for injuries resulting from failure to deploy, inadvertent deployment, and the impact of the air bag itself. One court has even suggested that a manufacturer could be liable for injuries resulting from failure to wear a seat belt if induced by faith in the air bag.[21] Nor does the probability that a particular design feature caused an accident uniquely determine the probability that liability will be established against the manufacturer. For reasons unrelated to the merits of the plaintiff’s technical case, manufacturer lawyers sometimes settle claims based on defective design that engineers believe are preposterous (for example, because the plaintiff will look sympathetic to the jury).[22] The argument that driver error and not design is the cause of accidents may be difficult to sustain--e.g., AMC’s claim that Jeep CJs were safe when driven intelligently.[23]

The degree of legal or factual uncertainty about who is liable may also affect litigation risk. For a variety of legal and practical reasons, plaintiffs’ lawyers will err on the side of naming all parties who could conceivably be held liable for an accident, especially “deep pockets” such as vehicle manufacturers. Similarly, they will also err on the side of including all remotely plausible theories for establishing liability against the parties they do name. As a result, if the addition of a safety feature provides a new basis for suing the vehicle manufacturer, litigation risk will increase to the extent of participating in the lawsuit and disproving the theory -- even if it is highly unlikely that the safety feature will in fact cause accidents.

Similarly, the consequences of lawsuits do not equate with the consequences of accidents. For example, the reputational damage resulting from litigation, whether or not the claims are ultimately successful, can have more impact on manufacturers than the monetary costs of defending the lawsuit or paying damages if liability is established.[(24)] As a result, the risk of litigation -- which can do substantial reputational damage whether or not liability is ultimately established -- can figure more prominently in a manufacturer's calculations than one might expect.

Many of these points are illustrated by the explosion of "sudden acceleration" litigation against the Audi 5000.[5] Spurred by a segment on "60 Minutes," owners of 1978-1986 Audi 5000s brought products liability claims against the manufacturer, alleging that design defects cause the car to suddenly and mysteriously accelerate from a standing start, even as the driver is furiously attempting to apply the brakes. The plaintiffs did not allege a single cause of the phenomenon, but pointed generally to the electronic systems that maintain idle, regulate emissions, and operate cruise controls. As of 1989, the number of lawsuits was over 100 and rising and the dollar value of theses claims was reported to total $5 billion. While not all of these suits were successful, Audi paid millions of dollars in settlements and judgments. Sales declined from a peak of 73,000 cars in 1985 to 23,000 in 1988. Meanwhile, the matter was investigated by NHTSA, Transport Canada, and the Japanese Ministry of Transportation. None could find defects in the Audi's electronic systems. Instead, all concluded that "sudden acceleration" results from the driver's misapplication of the accelerator rather than the brake.

A further complexity for the manufacturer is that its analysis is not necessarily confined to the particular design feature under consideration, but may also extend to the litigation and liability risk associated with vehicles that do not incorporate the feature. If, for example, safety improvements might be construed as admissions that previous designs were defective, the increased litigation and liability risks associated with older vehicles might outweigh any reduced risks for new vehicles and thus discourage the manufacturer from making the improvement.[(25)] This concern arose in connection with the phase-in period for the introduction of air bags, which would be necessarily long as the technology and production capabilities geared up. Manufacturers feared claims based on the theory that an injury occurred because the driver's car lacked an air bag, even though it was technologically and economically feasible. In retrospect, this situation may have increased litigation risk, but apparently not liability risk: the courts have tended to rule that the federal air bag standard preempts this liability theory and that the absence of an air bag is not a design defect.[(26)]

One factor that can increase both litigation and liability risks is the prospect of "catastrophic accidents," accidents which entail extremely large losses of human life, health, or property.[(27)] While there is no single accepted definition of a catastrophic

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[5] This account relies on Chapter 4, "Sudden Acceleration," in Huber, Peter W., *Galileo's Revenge*, 1991.

accident, it seems to connote death and serious injury to system operators, users or passengers, innocent bystanders, and even future generations, through long-lived contamination or genetic effects.[28] Chernobyl and Bhopal would qualify as catastrophic accidents in this sense. The closest motor vehicle accidents come to this level of severity would seem to be chain reaction pile-ups of the sort caused by dense fog or a bridge collapse. These accidents are more analogous to a commercial airplane crash than a Bhopal -- tragic for the victims, harrowing for the survivors, and worthy of widespread news coverage, but unlikely to threaten the continued viability of the organizations involved. Nonetheless, the prospect of catastrophic accidents even in this more limited sense is apt to be evaluated very carefully. From the standpoint of litigation risk, the ensuing large and complex lawsuits are likely to be burdensome to defend and damaging to the reputations of defendants. From the standpoint of liability risk, there is a higher than usual likelihood that the "system" (rather than bad luck or driver error will be found at fault) and punitive damages imposed (failure to anticipate and prevent a chain of events this calamitous is inherently reckless).

Roadway authorities: Roadway authorities probably represent an intermediate case between drivers and vehicle manufacturers in terms of their approach to evaluating litigation and liability risks. Like drivers, roadway authorities most likely are primarily concerned with safety itself, in this case of particular roadway features, highway design, and operating systems in design and practice. Indeed, safe travel is one of their primary missions. Like vehicle manufacturers, however, roadway authorities cannot be indifferent to litigation and liability risks. In the case of roadway authorities, the direct monetary costs of defending a lawsuit and paying a settlement or judgment are probably less of a consideration in evaluating such risks than are reputational effects. Because they are not profit-making or (to any significant degree) revenue-generating, roadway authorities are largely insulated from the out-of-pocket costs of litigation and liability. The bills are paid through legislative appropriations. However, they can expect to pay indirectly for litigation resulting from accidents in such coin as future budgets, degree of executive and legislative oversight and second guessing, freedom to innovate, press scrutiny, management's reputation and career prospects, staff morale, ability to recruit new staff, and public confidence. The prospect of catastrophic accidents are likely to seem particularly threatening in these regards. Like most government organizations, roadway authorities are risk-averse and generally wedded to their mainline mission, which has been identified by one close observer as "pouring concrete." To the extent roadway features, highway designs, or operating systems depart from established approaches, the prospect of litigation and liability risks (as well as safety) will be predictably advanced as an argument against the innovation in internal agency deliberations.

<u>The Legal Risks Of AHS</u>

Potential participants in each of the three categories (drivers, vehicle manufacturers, and roadway authorities) can be expected to include liability considerations in determining whether and how to participate in AHS. As discussed above, each category of potential participants is likely to evaluate these risks in a somewhat different fashion. In addition, their evaluations will likely depend on the particular system configuration under consideration and the particular phase of the AHS program.

In developing Representative System Configurations (RSC), the contractors for the Precursor Systems Analyses have identified a number of dimensions in which AHS systems could vary. Three of these dimensions are particularly relevant to litigation and liability risk: Roadway Infrastructure, Command, Control, and Communications (C^3), and Types of Vehicles to Be Served. Options for Roadway Infrastructure include: (I1) use of existing freeways with minimal modification and change in use patterns, (I2) creation of specialized AHS lanes similar to HOV lanes, and (I3) establishment of dedicated AHS roadways. Options for C^3 include: (C1) AHS vehicles operate independently, (C2) AHS vehicles and the roadway share decision making, and (C3) a central control entity makes all decisions about speed, spacing, and lane maneuvers. Types of Vehicles to Be Served include: (V1) only passenger cars, vans, and small trucks -- collectively known as single vehicle equivalents (SVEs), (V2) segregated SVEs and large trucks and buses -- the latter known as multiple vehicle equivalents (MVEs), (V3) mixed traffic for SVEs and MVEs, and (V4) SVEs powered by roadway electrification. Table 5 organizes these different RSC dimensions that are relevant to legal liability risk.

Table 5: RSC dimensions relevant to legal liability risk.

Roadway Infrastructure	
I1:	Existing freeways with minimal modification
I2:	Specialized AHS lanes
I3:	Dedicated AHS roadways
Command, Control, and Communications (C^3)	
C1:	AHS vehicles operating independently
C2:	Shared AHS vehicle/roadway decision making
C3:	Centralized decision making
Types of Vehicles to Be Served	
V1:	SVEs only
V2:	Segregated SVEs and MVEs
V3:	Mixed SVE and MVE traffic
V4:	SVEs powered by roadway electrification

The implementation of AHS is anticipated to proceed through several phases, including Preliminary Analysis, Systems Definition, Operational Evaluation, and Operations. Because the current Preliminary Analysis phase is intended to develop concepts and identify issues and risks, it will not involve the operation of AHS vehicles and thus the risk of accidents that could trigger liability. Accordingly, it will not be addressed here. The Systems Definition phase will include the operational testing and demonstration, probably of several AHS concepts. The Operational Evaluation phase will involve limited early deployment and evaluation of a smaller number of selected AHS concepts. The Operational phase will result in adoption of AHS by state and local transportation authorities and full-scale deployment. Each of these three phases has the potential to raise distinct liability issues.

Drivers: As discussed above, litigation and liability risk seem at most minor considerations to individual drivers in evaluating driving and vehicle options. There is no reason to believe their evaluation of AHS would be unusually sensitive to these considerations.

Corporate vehicle fleets and the operators of commercial vehicles such as buses and trucks may be more concerned with litigation and liability risk, especially to the extent these factors are reflected in their insurance rates. If so, the acceptability of AHS system configurations that include MVEs (V3 and V4) could depend in part on addressing the liability concerns of these potential participants. AHS should be attractive to these participants to the extent it improves overall safety, and thus reduces litigation and liability risks (without degradation in other important vehicle characteristics, such as cost, reliability, and speed). AHS should also be attractive to them to the extent it tends to shift liability to the vehicle or the roadway authority. This characteristic should be inherent in all AHS configurations because to at least some degree they take control from the driver and give it to the vehicle or the roadway. From a liability standpoint, these participants may prefer configurations that place decision making with the roadway (C3), since they may more clearly shift decision making responsibility away from the driver than those configurations in which some or all of the decision making is retained by the vehicle (C1 and C2).

Vehicle manufacturers: Vehicle manufacturers face complex tradeoffs in evaluating AHS. To the extent AHS improves safety by reducing the probability or consequences of accidents or both, the aggregate liability risk for all parties (drivers, vehicle manufacturers, and roadway authorities) should go down. However, for a particular party, this potential gain could be more than offset by a shift in the incidence of liability away from the driver to the vehicle manufacturer or roadway authority. Other auto safety advances appear to have had this effect. Addition of such features can be a source of increased litigation and liability risk, because they give plaintiffs an extra “hook” on which to hang claims. As noted above, the introduction of air bags triggered a host of claims involving such matters as failure to deploy, inadvertent deployment, the impact of the air bag itself, and failure to adequately warn of the air bag’s limitations .[29]

That the prospect of such claims can affect the willingness of vehicle manufactures to make safety innovations is illustrated by the example of adjustable seat belt anchorages, which have mounting points, which can be adjusted to suit the driver and the seat position. Saab introduced this design in the early 1980s and it is now common in Europe and Japan. Several U.S. manufacturers indicate that it has been deliberately withheld here because of products liability risks. The manufacturers’ concern is drivers’ erroneous belief that seat belts should prevent all injuries, even in severe accidents: if someone wearing a seat belt is injured, the seat belt must be defective.[30] Thus manufacturers may reason that an accident involving any vehicle in which AHS was or could have been operating will trigger a lawsuit in which the vehicle manufacturer will effectively have the burden of showing that AHS was not the cause.

Exactly how these concerns will play relative to alternative system configurations is difficult to predict. Vehicle manufacturers may prefer systems in which decision making resides exclusively with the roadway authority (C3), to minimize allegations that the cause of an accident was a defect in the design of vehicle-based components. However, if some control remains with the vehicle, manufacturers may prefer that vehicles have exclusive control (C1), because showing that on-board systems were not responsible for the accident in such instances may be easier than attempting to disentangle the relative roles of the vehicle and the roadway authority in causing the accident in configurations where they share control (C2).

Liability concerns may also complicate comparative evaluation of different approaches to AHS in the Systems Definition and Operational Evaluation phases. Historically, the threat of products liability has tended to encourage uniformity in design. Since one way of proving defective design is identifying an alternative design used by another manufacturer, no one wants to be the oddball by diverging from a de facto industry standard.[(31)] An example of such a fear concerns the passive seat belt. This technology was launched by Volkswagen in 1974. But until forced to adopt it by the promulgation by the NHTSA of FMVSS 208 (the passive restraint standard) in 1987, other manufacturers shied away from it because of the liability risk associated with a non-standard technology that was different from ordinary, "active" seat belts.[(32)]

Roadway authorities: Roadway authorities face tradeoffs analogous to those confronting the vehicle manufacturers: AHS may increase the overall safety of highway travel, but increase the litigation and liability risk to roadway authorities by shifting the responsibility for avoiding accidents away from the driver. Under some configurations (C2 and C3), roadway authorities will take on responsibility for actively operating the AHS system, much as the FAA operates the air traffic control system or regional transit authorities such as BART and DC Metro operate subway systems. While roadway authorities may have some experience in operating their highways (as when they raise or lower draw bridges, or open, close, or reverse HOV lanes), this experience is limited and at most provides a taste of what operating an AHS system might be like. The pressures on the system to maintain both production (keep traffic moving) and safety (avoid accidents) are apt to be immense.[(33)] While human operators will try to err on the side of safety, there is always the possibility that they will make a mistake that causes an accident. To the extent technology substitutes for human operators, this source of error is eliminated but so is the operator's contribution to recovery from system design flaws or unanticipated environmental conditions.[(34)]

In terms of the C^3 dimension of systems configurations, the analysis of roadway authorities is therefore likely to approximate the mirror image of vehicle manufacturers' analysis: placing control entirely in the vehicle (C1) is preferable because it minimizes the roadway authority's litigation and liability risk, but if that is not possible, the roadway authority may prefer to assume all decision making responsibility (C3) than to be forced into the complexities of sorting out whether they or the vehicle manufacturer were at fault in a jointly controlled system (C2).

<u>Conclusions</u>

To the extent AHS results in an overall improvement in highway safety, damages and injuries from motor vehicle accidents, and thus liability risk in the aggregate should be lower than would be the case in the absence of AHS. However, this reduction in overall liability may be accompanied by three changes in the nature of the liability risks and who bears those risks that could create disincentives for vehicle manufacturers and roadway authorities to participate in AHS.

First, to the extent AHS transfers control from the driver to the vehicle, the roadway authority, or a combination, the liability for the fewer and/or less severe accidents that do occur may shift to these parties. From their standpoint, the increased proportionate share of liability may more than offset the reduction in total liability and thus increase their net liability risk.

Second, to the extent AHS increases uncertainty about the causes of accidents and who is responsible, it may increase the number, complexity, and parties to lawsuits, thereby raising transactions costs and potential for reputational damage, and thus increase litigation risks. In contrast to the shift in liability risks discussed under point 1 above, this involves a net increase and not a shifting of risk. Vehicle manufacturers and roadway authorities are likely to bear the brunt of it. System configurations that divide control among the driver, the vehicle, and the roadway could add further complexity to determining responsibility for accidents and thus exacerbate this problem.

Third, to the extent AHS creates the possibility of accidents involving large numbers of vehicles, it likewise creates the possibility for "catastrophic liability" that could severely damage or destroy individual participants, especially private firms.

<u>Managing The Legal Risks</u>

In principle, it should be possible to manage the legal risks of AHS accidents to overcome the disincentives to participation by vehicle manufacturers and roadway authorities. To the extent AHS increases highway safety and thus reduces liability for accidents in the aggregate, it creates a windfall for the liability "winners" (the driving public), which can be tapped if necessary to create institutional arrangements that compensate the liability "losers" (vehicle manufacturers and roadway authorities) so that all participants would be as well or better off as in the absence of AHS. These arrangements need not be direct payments, but rather could take a variety of forms.

Vehicle industry or roadway association standards: One approach to reducing (but not eliminating) the increased liability and litigation risks to vehicle manufacturers and suppliers would be for them to adopt an industry standard for the AHS features they provide. Such standards would tend to counter products liability claims based on the theory that another alternative approach to the technology is safer. The disadvantage of such an approach is that it would tend to stifle experimentation with alternative approaches in the Systems Definition and Operational Evaluation and inhibit innovation in the Operational phase.

An analogous step for roadway authorities would be to adopt similar national standards for AHS features that reside in the highway. Over the past several decades, the American Association of State Highway and Transportation Officials (formerly the American Association of State Highway Officials) have developed well-established national standards for safe road design and construction, including the Red, Yellow, and Blue Books.[35] Incorporating standards for AHS roadways in one or more of these would tend to counter claims of defective highway design. As with vehicle standards, however, this approach would tend to limit the scope for diversity and innovation in AHS approaches.

Regulatory standards/preemption: As an alternative to voluntary industry or roadway authority association standards, NHSTA or another federal regulatory authority could adapt AHS vehicle and/or highway design standards as regulatory requirements, perhaps with a phase-in period. This was approach followed with the federal air bag standard, which mandated air bags and provided for a phase-in period. In litigation to date, the courts have tended to rule that the federal air bag standard preempts this liability theory and that the absence of an air bag is not a design defect.[36] In the case of AHS, such a standard could expressly provide for alternative approaches, so as to encourage innovation, at least within the range of options contemplated by the standard.

Immunity, damage limitations, or indemnification: The federal government could make vehicle manufacturers and roadway authorities immune from certain types of lawsuits stemming from AHS, limit the damages recoverable, or indemnify (promise to reimburse) them for some or all of the damages recovered. In the early 1970s, the vehicle manufacturers, who feared that the introduction of air bags would expose them to unacceptable liability risks, proposed that the industry should be given immunity from liability resulting from passive restraints or that the federal government agree to indemnify them. Neither proposal was accepted.[37]

The problems with this approach are significant. Immunity or damage limitations seem particularly vulnerable because they in effect ask accident victims to bear the risks if AHS fails and causes accidents. Indemnification does not have this problem, but it and the other two approaches suffer from the problem of “moral hazard:” reducing or eliminating the incentives for safe design and operation of AHS. A partial indemnification scheme, in which the federal government shared but did not completely assume the liability risk is more promising. That is the approach of the Price-Anderson Act by which the government partially underwrites the risks of nuclear power. The Price-Anderson Act itself is highly controversial, however, and the challenges of adopting a similar scheme for AHS should not be underestimated.

Insurance pool: A final approach to managing AHS liability risks is the most traditional: insurance. In the case of AHS, the problem is that at least in the early phases of AHS, the uncertainty about the actual risks is apt to make insurance extremely costly or unavailable. An organization such as ITS America or a consortium of AHS participants could band together to create their own insurance pool, as has been done at various times for other difficult-to-insure activities, such as medicine or law. If necessary to induce participation, this insurance pool could be guaranteed by the federal government.

Summary

To the extent AHS improves highway safety, it should reduce the costs of motor vehicle accidents, and thus decrease liability risk in the aggregate. However, three legal liability considerations could discourage vehicle manufacturers and roadway authorities from participating in AHS.

- First, to the extent AHS transfers control from the driver to the vehicle, the roadway authority, or a combination, the liability for the accidents that do occur may shift to these parties and thus increase their net liability risk.
- Second, to the extent AHS increases uncertainty about the causes of accidents and who is responsible, it may increase the number, complexity, and parties to lawsuits, thereby raising transactions costs and the potential for reputational damage to parties who must defend themselves.
- Third, to the extent AHS gives rise to accident scenarios involving large numbers of vehicles, it raises the specter of "catastrophic liability" that could have major financial impacts on individual participants, especially smaller private firms.

In principle, it should be possible to manage these legal liability risks by establishing institutional arrangements that tap the benefit stream created by improved safety to compensate or insure those affected.

In considering how to focus research efforts in this area from here on out, the following suggestions are offered:

- Validate and refine the legal liability concerns of the corporate and individual driving public, who purchase, operate, and maintain fleets and vehicles; motor vehicle manufacturers (and their suppliers and dealers), who design, manufacture, sell, and service vehicles; and state and local transportation agencies (and their contractors), who plan, finance, design, build, and operate roadways, applying the framework developed in this chapter.
- Identify legal risk management models from other domains and analysis of their applicability to management of the risks identified in this chapter and further research.

Public Perceptions of the Potential Safety Risks

Public perceptions of the safety of automated highway systems need to be assessed in order to design and implement system features that will meet with public acceptance. Yet, the role that public risk perceptions should play in technology development has been controversial. Many technologists hold the view that assessing risk associated with new technology is a demanding technical exercise that should be the responsibility of specially trained experts. The resulting risk assessments are of great importance because they help determine the features of the technical systems designed to mitigate risks. Further, this view holds that attempts to measure perceived risks only get us bogged down in subjective exercises that divert our attention from the real risks.

Several arguments attempt to rebut this point of view.[38] For one thing it is contended that expert risk estimates are after all estimates. Data limitations, especially in newly developing technologies preclude precise risk measures. Lacking such measures, experts make judgments that may be subject to various biases, just as public perceptions may be biased by lack of knowledge. Technologists have values that can affect their risk estimates just as does the public. In other words, it is not accurate to characterize risk estimates by lay persons as subjective and those by experts as objective--both are perceptions based on available data; although the data available to the experts is presumably more quantitative and gathered within the conventions of scientific practice.

Without attempting to settle the question of the role that public perceptions of risk ought to play in the design and implementation of AHS, this section will review several aspects of the risk perception literature that appear of relevance. The objective is to offer what guidance this literature might provide in the development of automated highway systems. It does seem clear that the political viability of AHS will be affected by the way it is perceived by the public; will its perceived benefits outweigh its perceived costs and risks?

To date the supersonic transport has not passed this test, while automobiles and commercial aircraft have largely replaced trains as publicly preferred modes of travel. Regardless of the prospective “real” merits of AHS, people act largely on their perceptions. If AHS is widely perceived to pose unacceptable (as defined by each potential user) safety risks, its deployment will be greatly hampered. If, on the other hand, public perceptions can be factored successfully into its design and deployment, it is much more likely to find public acceptance and become widely useful.

Absent the careful collection and analysis of data on public perceptions and concerns about AHS we must rely on the risk perception literature to make some speculative inferences about how the public will react. However, some incidental information about public risk perception about AHS comes from interviews with various stakeholders.

“Regardless of the prospective “real” merits of AHS, people act largely on their perceptions.”

The most common of such findings is prompted by descriptions of AHS deployment that involve “hands off, feet off” driving with close following gaps and high speeds. This portrayal is common in media accounts directed at the general public. Such descriptions of AHS usually prompt expressions of concern about safety. Some involve visions of catastrophic system failure. If roadside control is assumed, concerns involve power failure, controller error, or some system glitch that causes a massive accident. Literature on acceptance of new technology shows that most people are positive about automatic controls as long as human control is possible as a back-up; automatic elevators and airport terminal trains are examples. Systems with obvious fail safe or fail soft characteristics are also appealing. Running the gas gauge to “empty” is a sport for many motorists but few (surviving) pilots.

Human error is widely understood to be a frequent cause of catastrophic accidents. Errors by both pilots and air traffic controllers are highly visible as causes of aircraft accidents. Errors by maintenance personnel and terminal ground crews are less frequently singled out, but still widely understood by the public. Public concern is also substantial regarding controller errors in nuclear power plants and chemical processing plants. The Three Mile Island accident and the Bopal disaster provide memorable examples. The sinister possibilities of advanced technology are exploited in science fiction and “disaster” themes for the mass media. These often feature technology that has escaped automatic and human control, and runs out of control. Everyone knows of Murphy’s Law--“If anything can go wrong, it will!” These themes are evidence of public skepticism in a time when public concerns about safety--of everything--is higher than in the past and still increasing.[39] There is no question that the safety of automated highway systems will be the subject of intense public scrutiny and media attention. Any new technology in the current climate of public distrust of institutions and public skepticism about safety can expect to be very closely examined by a wide array of stakeholders.

“The safety of automated highway systems will be the subject of intense public scrutiny and media attention.”

Several other public concerns about AHS are frequently voiced when it is described as “hands off, feet off” driving with on-board control:

- Can control be resumed in the event of an emergency? Nearly all drivers are more confident in their own control abilities than those of others. Yet there is concern that there would not be adequate response time or even warning if something goes wrong, especially with close following distances. Some also note that the attraction of AHS as a concept would decrease, if it would require constant vigilance.

- If constant attention is not required (as most scenarios suggest), what activities would be possible? Can one read? Can one sleep? If not, how will drivers keep awake?

- How can one be protected against mistakes or rogue actions by other drivers? Again, human error is perceived to be ubiquitous. We have all been urged to drive defensively.

- What about the capability of the technology to cope with unusual environmental events such as ice, fog, cross winds, or animals on the roadway?

A common theme that runs through many of the concerns voiced by the lay public when considering AHS is uncertainty. Of course, new technologies are by definition unfamiliar and thus pose uncertainties. Faced with uncertainty over safety there is a tendency to make worst case assumptions.[40] In other words, not knowing how safe a system is, will cause many people to treat it as highly unsafe. Studies of risk perception also reveal a public tendency to overestimate the incidence of rare but catastrophic events--nuclear plant accidents, mass murder--and to underestimate the incidence of common but non-catastrophic events--deaths from air pollution or bicycle accidents.[41] One reason is that catastrophic accidents are the focus of heavy media attention. As such they are easily remembered, a feature risk perception experts refer to as the "availability heuristic"; that is, they are available as examples to prompt ones memory.[42] The mass media tend to focus on new technologies and approach them with a somewhat skeptical perspective. Any failure of a new technology (consider the Denver airport baggage-handling system) will draw heavy media attention. This serves to increase the availability of the incident in public perception. Consider also the status of computers in our society during the several decades it took for their public image to evolve from arcane tools for scientists to that of invaluable tools for school, business and home.

Another theme that runs through expressed public concerns about AHS as it is generally described is control. A common finding in studies of risk perception is that activities over which we exercise personal control are perceived as less risky and thus more acceptable than are activities over which we do not exercise personal control.[43] This perceptual tendency modifies the risk estimates we might make based strictly on actuarial data. Travel by automobile vs. airplane is an example. Most people, regardless of relative driving skill, feel safer driving than riding as a passenger.

> "Activities over which we exercise personal control are perceived as less risky and thus more acceptable."

When lack of personal control over risk exposure is paired with involuntary exposure to risk, perceived risk is likely to be very high and public acceptance is likely to be very low.[44] An automated highway system would, of course, not require motorists to use it and would not be involuntary in this sense, but if its deployment precludes other uses of the roadway--for instance as an HOV lane--it could prompt public opposition.

Such opposition may only partly be based on safety concerns. However, in the politics of opposing public projects, safety is often used as a proxy issue. Safety concerns are readily communicated and by definition legitimate to those who express them. So, if I oppose the siting of some facility in my neighborhood because I think it will change the "tone" of the area, I might, for strategic reasons, base my protest on safety concerns. The point is that AHS opposition may be expressed as perceptions of safety risk, while in fact some ideological reason for opposition may be accounting for the resistance. This is one reason why the introduction of new technology proceeds more smoothly if it can avoid triggering opposition based on some ideological principle.

In the case of AHS, such a scenario may be the result of general opposition to the automobile on the part of some environmentalists. An important element in winning public acceptance, even in the face of ideologically based opposition, is for the new technology to present such clear and widespread benefits that public judgments of benefits vs. costs and risks is positive.(45) The public judgment about the benefits of using saccharine is one example. Despite government warnings about the possible risks, most members of the public voted at the check-out counter to continue its use. Automated highway systems can win similar public acceptance if they present clear benefits that overwhelm risk concerns.

> "AHS can win public acceptance if it presents clear benefits that overwhelm risk concerns."

Yet another important requirement for the successful introduction of a new technology is that there be no early disasters.(46) The crash of the Hindenburg brought a halt to the development of dirigibles for passenger travel. Introduction of AHS on a test basis under circumstances carefully designed to prevent major accidents is recommended. The objective is to enable the development of some public familiarity which can reduce perceived uncertainties about the new technology (which as we have noted will likely reduce the tendency to make worst case assumptions about safety risks). It would be helpful if there could be a phased introduction of elements of AHS that can build on public familiarity with known technologies such as cruise control.

A primary reason for why it is so important to avoid a catastrophic accident is the fact that a technology that causes a large number of deaths in one event will be perceived as much more risky than one that causes a similar number of deaths spread out in a number of smaller events over the same time period. Risk is often defined in the expert literature as the product of event probability and event consequence. Yet, we know that large consequence–small probability accidents are much more feared than small consequence–large probability accidents.

A final important requirement that affects public acceptance of a new technology is that the technology control mechanisms be well developed.(47) Automobiles did not win wide acceptance in the twentieth century until the development of reliable braking mechanisms. The relation between personal control and perceived risks, previously noted, is the psychological basis of this effect. Perceptions that one will be "out of control" when using an automated highway system need to be carefully explored. Worse yet is a perception that the technology itself is out of control--as some perceive nuclear power technology to be beyond our power to control. Demonstrations of AHS that feature its controllability will be important to public acceptance.

Risk perception research aimed at measuring the reasons why some technologies are perceived as risky while others with comparable safety records are seen as much safer have resulted in the identification of a two-dimensional perceptual space.[(48)] Respondents in risk perception studies rate existing technologies on these dimensions. Figure 10 is based on this research and displays only a few of the hazards that were studied in terms of their location with respect to these two dimensions. The first dimension, Dread Risk, contrasts technologies perceived as uncontrollable, involuntarily imposed, and having fatal and potentially catastrophic consequences with those seen as controllable, voluntary, and having only individual consequences. Nerve gas and nuclear weapons are high on this dimension, while home appliances, bicycles and sunbathing are low. The second dimension, Unknown Risk, contrasts known risks like handguns and motor vehicles with those where the effects are less well understood (by the public) such as DNA research and solar electric power. Technologies perceived to be high on both dimensions face great challenges in winning public acceptance--nuclear power is a prime example. While AHS has not been rated in these studies, informal interviews and examination of AHS descriptions by the media suggest that it may be located somewhere in the middle of both dimensions. The challenge in AHS technology design, public information, and deployment will be to consider how it can avoid being perceived as high on the Dread Risk and Unknown Risk perceptual dimensions.

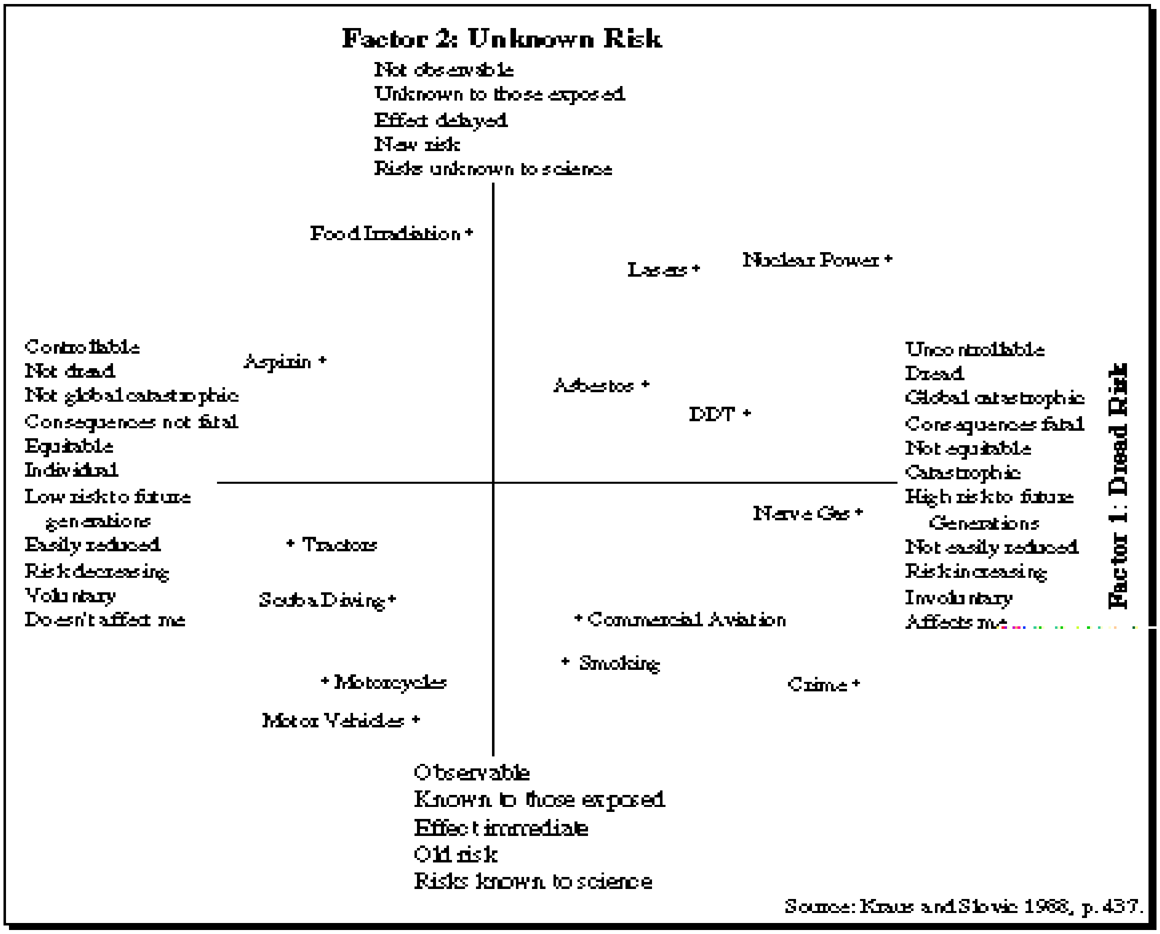

Figure 10. Hazard location in a risk factor space.

Research on public acceptance of technology shows that the process of technology introduction is as important as the actual features of the technology.[(49)] This often means early and continuous involvement of a wide array of stakeholders in the design and implementation phases. Of course, the practice of involving potential customers is standard in the marketing phase for new products and services in the commercial world. This is what customer orientation and being "market driven" means. This principle is especially important (but often overlooked) in the development of public sector projects where issues of equity are of great importance and therefore capable of generating intense political pressure that can work for or against the new technology. In the public participation process, public perceptions of the safety risks of AHS will need to be squarely faced. Stakeholders will wish to be heard, and to have their concerns treated as issues to be resolved.

Since to date we have only sketchy data about public risk perceptions of AHS, the discussion here should not convey the impression that the public is spring loaded to reject AHS as too risky to pursue. For one thing, "the public" is an abstraction that involves an array of differences. Tolerance of risk is known to vary substantially across people, and so does the inclination to accept new technology. Age is one demographic variable that should be considered. To a first approximation, individuals born before 1890 were never as comfortable with automobiles as were those born after 1930. Similarly, individuals born after 1970 are likely to be more comfortable with computers than those born before 1950. As more and more features of the driving experience are going hi-tech, from cruise control to ABS, successive generations of drivers gain more familiarity with, and confidence in, automotive technology. These younger drivers, used to capable brakes, responsive steering, and reliable instruments and controls may well have less difficulty placing their faith in a technology that may strike older generations as somewhat far fetched.

> "*The public* is an abstraction that involves an array of differences. Tolerance of risk is known to vary substantially across people, and so does the inclination to accept new technology."

Research Strategies for Understanding Perceived Risk

In order to collect the relevant data that will permit more than informed speculation about how risky the public may feel AHS is, attention will need to be given to methodology. It seems clear that public attitude surveys as they are commonly applied will not be very useful in this situation.[(50)] Surveys are based on the premise that people have an attitude that can be revealed by asking a question. With new technologies, most members of the public have little or no knowledge on which an attitude could be based. Therefore they have no attitude that can be extracted. More useful are techniques that provide carefully considered information about the new technology coupled with careful listening to the range of responses the information stimulates. It is important not to characterize the new (and unknown) technology as useful, effective, or attractive. In other words, it is important not to provide evaluative information about it, lest the feedback simply reflect what was fed in.

One useful technique, often used by private industry, to gauge the interest of potential customers to new product ideas is the focus group. Briefly, a small group of people meet under the guidance of a facilitator to talk about the prospective product or technology and respond to information provided about it. Often the technology developers are somewhat surprised at the range of reactions. This is, of course, evidence that public views are providing new information to the technologists. As the technology develops, presumably responding to public input along the way, more and more information can be provided to these test groups. The objective is to avoid surprises that could result if some feature of the technology that seemed quite unimportant to the experts turns out to be of high importance to consumers.

Another set of techniques for collecting useful data about public perceptions of prospective technologies is referred to a complex judgment tasks.[(51)] Briefly, characteristics of the technology are abstracted out of the whole and presented for respondent reaction. The objective is to learn what particular features of the technology trigger positive or negative reactions. How do the wind, the lightening, and the thunder contribute to the fear of a storm? Complex judgment tasks can collect more quantitative data than focus groups, which result in mostly qualitative data. However, careful judgment is required in interpreting both types of data.

Yet another technique involves working with respondents to develop a "mental model" of the way a prospective technology is perceived.(52) Researchers, puzzled why most people did not take the hazard of radon gas in homes very seriously, worked patiently with respondents to understand what they knew and how they thought about what they knew and how that was linked to their behavior in responding to the potential radon risk. A similar process would involve working interactively with representatives of the public, providing information as requested, to develop a model of how AHS is perceived, how information changes the perceptions, and how people are likely to behave toward the new technology.

Sustainable Transportation

Given wide-spread evidence of a high degree of concern throughout the world with the quality of the environment,(53) sustainability, more specifically sustainable development, has recently emerged as a related public, as well as government, concern. Attention to sustainability, particularly with regard to human activities that have consequences for the environment or technologies that have consequences for the human condition, reflects a growing concern for the importance of conducting our affairs in a way that reduces harm to the environment, reduces threats to non-renewable resources, and allows future generations the opportunity to enjoy access to undiminished natural and economic capital--a kind of intergenerational equity.(54)
The 1987 report of the Brundtland Commission provides the most widely agreed upon definition of sustainable development.(55) They suggest that "sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technical development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations... [Sustainable development] meets the needs of the present without compromising the ability of future generations to meet their own needs." The objective of this section of our report is to explore the notion of sustainable transportation, its relation to sustainable development, and the role of AHS in contributing to sustainable transportation. If AHS can be shown to support sustainability, then its acceptance in the marketplace and with the driving public is likely to be enhanced.

"If AHS can be shown to support sustainability, then its acceptance in the marketplace and with the driving public is likely to be enhanced."

In order to better understand how automation of segments of our transportation systems will help solve transportation related problems and be attractive enough to states and local agencies that they will decide to deploy AHS, we need to understand the context in which these choices will be made. This includes understanding how the various stakeholder groups view AHS, and for our purposes in this section, how sustainability fits into the calculus. When we talk about sustainability, we have to ask what it is that we are trying to sustain. We suggest that we are trying to achieve sustainable transportation in three areas that each may be relevant to AHS technologies and deployment effects. These include:

- a reduced, sustainable level of consumption of non-renewable resources, particularly petroleum;
- a reduction of impacts on the environment to levels that do not exceed absorptive capacity, especially with regard to air pollution; and,
- a reduction of impacts on society, culture, and the economy that are perceived as undesirable and/or unmanageable.

We offer the following definition of sustainable transportation:

> Sustainable transportation may be defined as an anticipative and adaptive system for meeting the mobility and access needs of all segments of society over the long-term, without compromising the ability of future generations to meet their own transportation needs, and without jeopardizing the energy resource base, the quality of the environment, or the quality of social life with which these systems interact.

With this definition in mind, the AHS Consortium might want to consider the following kinds of questions in an effort to come to grips with the potential relationships between AHS and sustainability of our transportation systems:

- How can AHS help provide a level of personal mobility and an exchange of goods and services that are consistent with the needs of our economy, our desire for quality living and work environments, and the ability of the natural environment to support these needs?
- How can AHS help reduce traffic congestion and its adverse effects in the face of continuing growth in Vehicle Miles Traveled (VMT) and number of trips, very high portions of the population preferring to travel in Single Occupancy Vehicles (SOVs), and sprawling suburban settlement patterns that do not efficiently support public transportation systems and require more and longer trips, all in a context of population and economic growth pressures?
- What impact might AHS have in contributing to the creation of induced demand for more vehicles and further increases in VMT on our highways?
- Can the judicious application of AHS technologies support a stabilization of or even a reduction in VMT, SOV use, and other demand-side problems?

- What role might AHS play in the range of strategies available to manage the energy requirements of the transportation sector to minimize our national dependence on petroleum and our vulnerability to international oil politics?
- How can AHS help reduce the adverse impacts of transportation systems on society and the environment such that the health of our natural ecosystems and human populations can be protected and sustained?
- Are the transportation requirements for our economy and our growing population's mobility needs consistent with the achievement of a sustainable relationship with the global resource base and natural environment? How can AHS help us move in the direction of bringing them in line with each other?

Is it important to try to address these kinds of questions? We think so. Does this imply that AHS is expected to shoulder the full burden for achieving the sustainability objectives of ITS or of our transportation system? Certainly not. We believe that sustainability is a criterion that increasingly will be held up to major technology proposals, and that AHS clearly qualifies as such a candidate proposal. Environmental groups, for whom sustainability is emerging as a central tenet, are already looking very closely at ITS technologies and evaluating them on grounds that include whether they will contribute to sustainability of our environment, including both natural and human systems. AHS will be judged independently from the rest of the tools in the ITS tool box in terms of the kinds of evaluative questions posed above. Thinking about how to answer these questions early on in the program, and engaging in an open and searching dialog with those who are concerned with sustainability issues, will greatly enhance the likelihood that joint strategies will be discovered that can lead to better, more acceptable configurations of AHS, and position the technology for more successful deployments throughout the country.

> "Environmental groups are already evaluating ITS technologies on the basis of their contribution to sustainability."

Current Situation and Trends

The U.S. transportation sector has played a vital role in the development and sustenance of our nation and will continue to do so into the foreseeable future. But all is not well with this system that is so intimately tied to our energy, environmental, economic, and social well-being. The numbers of vehicles and miles traveled continue to increase at a rate that has substantially outpaced population growth, resulting in more instances and longer periods of severe traffic congestion, increased numbers of air quality non-attainment days in our cities, significant safety issues, increased demands for imported non-renewable fuel resources, threats to fragile ecosystems, increased uncertainty regarding our national energy security, difficulty in providing equitable access to all segments of the population, extensive suburban sprawl, and related social consequences such as isolation and stress.

Advances over the past two decades in emission control technologies and automotive fuels and their rapid diffusion into the marketplace has had a major beneficial impact on reducing adverse air quality impacts. Improvements in engine efficiency also has helped increase fuel consumption efficiency. In spite of these positive developments, we continue to experience increasing energy consumption, serious urban air quality impairments, and persistent growth in VMT. Urban traffic congestion continues to worsen nationally, even in the face of capital investments to increase roadway capacity, create new right of way, and improve elements of the infrastructure through measures such as ramp metering, HOV lanes, and coordinated traffic signalization. It would appear that at best we find ourselves barely able to keep up, and at worse we are loosing ground. In their 1994 forecast, EIA suggests that “efficiency gains from new technology are more than offset by increases in driving, automobile ownership, freight truck vehicle-miles traveled, airline travel, and waterborne and rail ton-miles traveled. Passenger vehicle highway travel continues to increase faster than the driving-age population over the forecast period as a result of relatively stable fuel prices and growth in real per capita income.[56]

In sum, we have a transportation system that may be increasingly unsustainable in terms of demands for non-renewable petroleum resources, impacts on the environment and urban quality of life, and its ability to continue to meet the economic and social needs of the nation. How can we effectively address these problems of sustainability, and what role might AHS play? First, it is important to recognize the systemic nature of the problems raised by the challenge of sustainable transportation. This is not just an energy problem, and it is not just a science and technology problem; it also is a very complex matter of value tradeoffs (mobility as economic necessity; the need to link people, goods and services together; transportation as a key factor in economic competitiveness; a way to achieve individual autonomy and independence; mobility vs. access, etc.) It involves more than a focus on the development of advanced transportation technologies, or the application of those technologies to a selected subset of our highway system. Even if AHS can enhance safety and increase throughput on one urban highway segment, for example, people will be judging that AHS system from a holistic perspective. They will be considering safety and congestion-reduction benefits system-wide. And they will be judging AHS against alternative investments for their scarce transportation dollars. They will want to know whether and how AHS fits in with a broader vision for making improvements in urban/rural transportation, rather than evaluating it in isolation from a broad regional transportation and growth management plan. This suggests the need for a comprehensive strategic approach to surface transportation, a clearer understanding of what we mean by sustainability in this context, and an approach to moving toward sustainable transportation that is multi-faceted in terms of the several dimensions of the problem. AHS can then be evaluated appropriately in this context. The following summarizes some of the trends that illustrate the context within which transportation sustainability issues are being raised.

From a transportation sustainability perspective, key trends include large increases in vehicle fuel efficiency, reductions in noxious air emissions (due to the catalytic converter and related technologies), rising vehicle ownership, increasing numbers of vehicle trips, and continuing increases in total vehicle miles traveled. The forces that are pushing VMT up include continued population growth and the changing structure of the American family (more two income households, more female drivers, and more single parent households), somewhat higher rates of automobile ownership, and the further geographic dispersion of people and the places they need to access and the construction of more miles of roadway to support this pattern. Another major factor in growth of VMT has been the continuing decline in the use of alternatives (transit, walking, working at home) coupled with a decline in average vehicle occupancies.(57) Most work-related travel now occurs in SOVs. Strategies designed to achieve sustainability in transportation will need to take account of these factors and trends and focus on those areas where there is opportunity to make a difference.

Transportation constitutes the backbone of our economy, providing for the efficient, cost effective exchange of goods and services across the nation. Transportation systems provide for the mobility of our population that is closely linked to our ability to live and work where we choose or where the best opportunities are perceived to exist. Unrestricted access to transportation is viewed as a national birth right, an attribute of our democracy, and it serves as the principal means of exercising our freedom to go when and where we wish. It is estimated that about 20 percent of our national GDP is directly or indirectly dependent on the transportation sector. In a very real sense, transportation *sustains* our economy. But there is a down side to this intimate relationship between transportation and society. Just as our current transportation system can bring people closer together who otherwise are remotely located from one another, its effect on urban settlement patterns has been to contribute to and support a pattern of low density sprawling development. Both jobs and residences are increasingly located in the suburbs, far from our urban centers, and this pattern has been made possible by our current transportation infrastructure. In addition, there is increased separation of work place from residence, lengthening the daily commute, and much of this commuting is now taking place between suburbs, rather than between suburb and central city as has predominated in the past. About one-third of total average annual VMT are for the purpose of commuting to and from work, and this proportion has remained relatively stable over the past 25 years.(58) The adverse consequences of this pattern can be severe: increasing vehicle miles traveled by individuals who need to access goods and services that are widely separated in geographic space; more individual trips in single occupancy vehicles; a continuing decline in the use and economic viability of public transportation that depends on higher population densities to operate efficiently; increasing traffic congestion and social dislocations; increased energy use; increased air pollution; and so on. AHS has the potential to help address many of these problematic aspects of our current transportation situation. It can also further support the positive aspects. That is, it can improve safety and reduce congestion on the highway segments where it is implemented, and it can contribute to the more efficient, economic movement of people and goods along those highways.

"AHS has the potential to help address many of these problematic aspects of our current transportation situation."

Rising VMT and the potential for induced demand effects of AHS, along with its secondary impacts on adjacent, non-AHS roadways, are particularly salient issues with environmental groups, urban transportation and growth management planners, and other members of the public. It is because of these kinds of concerns that some environmental groups suggest that AHS be relegated to a low priority on the list of ITS programs under consideration.[59] The following are factors that effect VMT growth, followed by how AHS might be more effectively positioned within this picture.

Figure 11 illustrates the factors that contribute to changes in VMT, along with recent trends in each of the factor components.[60] Between 1983 and 1990, VMT grew by 40 percent where VMT is a measure of vehicle travel made by private vehicles in which each mile traveled is counted as one vehicle mile regardless of the number of persons in the vehicle. Person miles of travel (PMT) on the other hand account for the miles traveled by an individual such that if two people travel five miles in the same vehicle, a total of 10 PMT and 5 VMT results. PMT increased about 19 percent between 1983 and 1990, about equally influenced by population growth, increases in per capita tripmaking, and increases in average trip length. Because the geographic distribution of population is much more important in creating changes in travel behavior in particular locations, the experience with and perception of sustainability of transportation systems can be expected to vary a lot from place to place. This suggests the need to target AHS technologies to the needs and conditions that are found in different locations. Another major factor in growth of VMT has been the continuing decline in the use of alternatives (transit, walking, working at home) coupled with a decline in average vehicle occupancies. Transit's share of all national travel (annual person trips) has declined to 2.2 percent in 1990 from 3.4 percent in 1969, though transit has tended to decline less than other alternative modes to the personal automobile.[61] The percent of workers who walked to work declined to 3.9% in 1990 from 10.4% in 1960. Correspondingly, the percent who worked at home declined from 7.5% in 1960 to 2.3% in 1980, then rose to 3.0% in 1990.[62] More research is needed to understand the factors related to working at home.[5] An important factor in understanding congestion in urban areas is occupancy levels of vehicles, particularly those related to work travel during peak driving periods. Average occupancy in 1990 for all travel purposes was 1.6 person miles per vehicle mile, down from 1.9 in 1977.[63] Most work related travel occurs in SOVs while longer distance recreational and vacation travel has the highest numbers of persons per vehicle. Factors influencing these trends include declining household size and increasing numbers of household vehicles, leaving fewer persons available as passengers in either private vehicles or for public transit. Strategies designed to achieve sustainability in transportation will need to take account of these factors and trends and focus on those areas where there is opportunity to make a difference.

"This suggests the need to target AHS technologies to the needs and conditions that are found in different locations."

[5] The recent emergence of attention to the information superhighway, the role of computers in the home, and the potential for telecommuting to substitute for work trips for one or more days of the week are major new developments that will impact the journey to work data. They also suggest strategic approaches for reducing VMT and moving toward sustainability in the transportation sector.

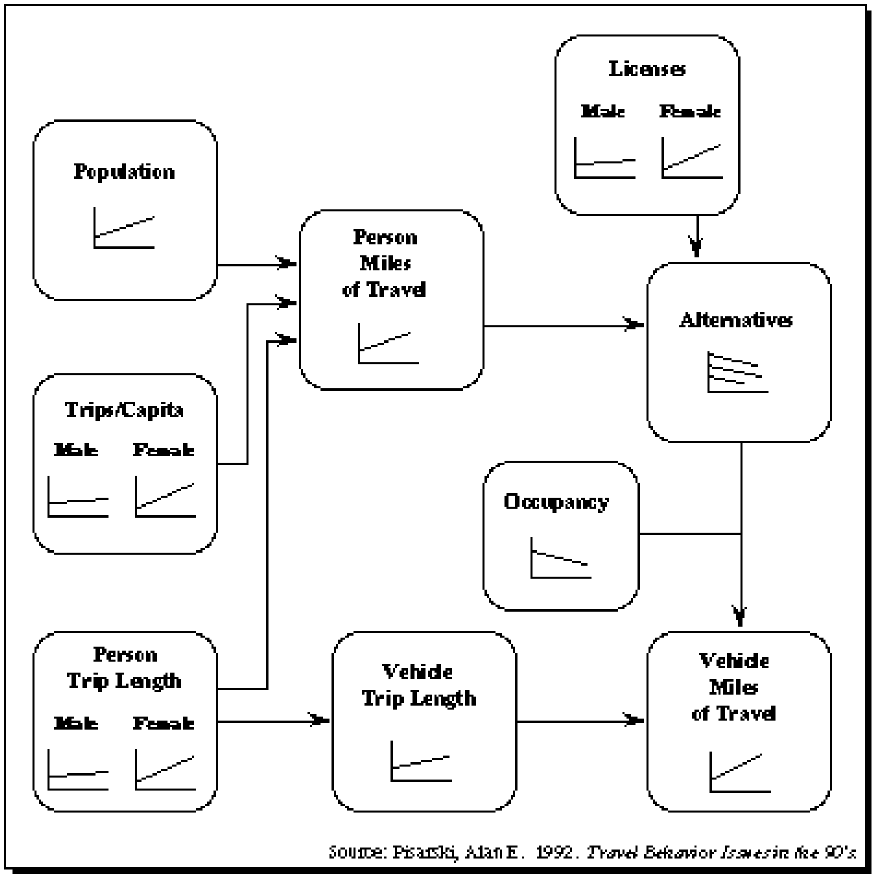

Figure 11. Factors influencing growth in personal travel.

The end use consumption of petroleum by the transportation sector constituted almost 64 percent of all petroleum use in the U.S. in 1990. At this time there were about 1.5 cars for every working American, and over half of all U.S. households owned two or more vehicles. The number of households owning three or more vehicles has increased from 2.5% in 1960 to 17.3% in 1990.[(64)] An increasing portion of those vehicles are light trucks or vans which achieve lower energy efficiency and higher air emissions than the standard automobile. The number of SOVs on the highway is increasing, and VMT continues to increase at about three percent a year. The increase, based on the most current preliminary data, was 3.1% from June 1993 to June 1994, reflecting a range of 0.4% in the Northeast to 5.3% in the West.[(65)] Congestion on our highways, in our cities and suburbs, and at our airports continues to worsen, increasing air pollution, wasting scarce and costly fuel resources, and costing the nation billions of dollars every year, estimated at $73 billion a year or two percent of GNP for the private and commercial sectors.[(66)] Transportation also is costly to families. Average annual expenditures of households for transportation (purchase, fuels, other vehicle costs, public transportation) constituted 17.1% of total household expenditures in 1992, second only to housing at 31.2% of expenditures.[(67)]

The social costs of congestion and highway accidents also are large in terms of wasted time and increased stress.

VMT and the number of vehicles on our highways has grown much faster over the past 30 years than the growth in population. Reductions in tail-pipe emissions and fuel consumption have been largely offset by these huge increases in vehicle use, raising serious questions about our ability to achieve sustainability in the transportation sector. Figure 12 showing how growth in VMT and number of vehicles has outstripped population growth clearly illustrates the problem.[68]

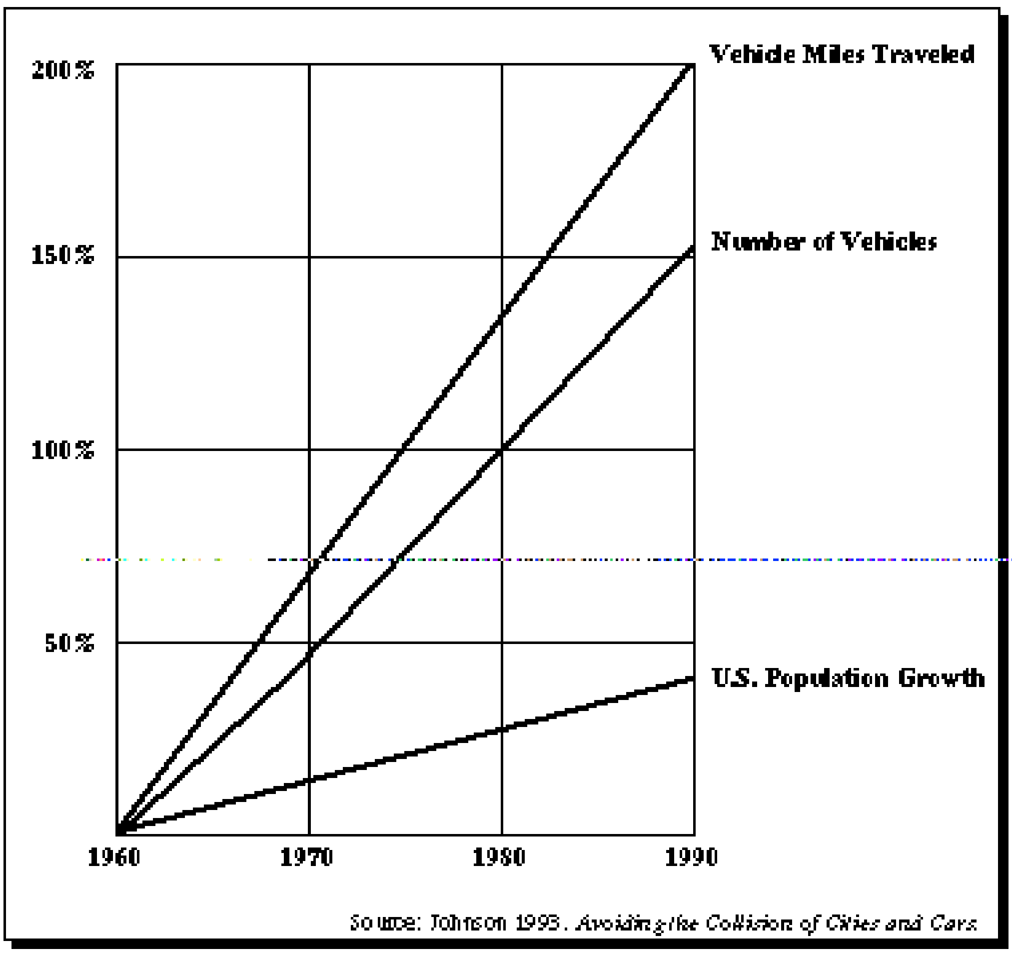

Figure 12. Percentage increase in travel, vehicles, and population since 1960 (U.S.)

Our national transportation and housing policies to date have encouraged automobile use through heavy subsidies for highways and roads, subsidized parking, and housing financing that encouraged suburban development, while very little support has been provided for mass transit (until quite recently), bicycle pathways, pedestrian access, and urban land use planning that reduces the need to use the automobile and encourages alternative modes of access. Urban planners believe that transportation policy must be better integrated with urban land use planning. Our wide-spread dependence on the automobile has tended to limit, rather than expand, access. Many western European countries have been more aggressive than the U.S. in pursuing policies that integrate land use and transportation, along with efforts to move to higher density urban settlement patterns that can support public transportation and provide increased multi-modal forms of access. Much higher percentages of people in Europe walk or bike to work, for example, than in the U.S. They have done this by providing bicycle and pedestrian infrastructure support, reducing or eliminating vehicular access to central cities, reducing or eliminating parking subsidies, and enforcing zoning regulations that encourage higher density settlement. Pursuit of greater access, rather than increased mobility, may be one way to approach sustainability in transportation.

Implications for AHS

Our point is that AHS will enjoy wider acceptance if it can be positioned in support of sustainability goals. Sustainability in any societal system, be it economic, energy, development, agriculture, or transportation, cannot and will not occur over night. It is appropriate, however, to consider how our society can start moving in the direction of sustainability, and progress toward the long-term goal of sustainability will likely enjoy a measure of public and political support. In transportation, we believe that sustainability will increasingly be used as a public measuring stick to make decisions about alternative approaches, expenditures, and technologies. This criterion will be applied to AHS technologies too. In order to gain the needed level of public acceptance to allow for the successful deployment of AHS, there are several important considerations, relative to the expressed goals of AHS technologies, that should be examined.

We need to present a clearer picture of what portion of the overall set of issues discussed above can be expected to be addressed directly by AHS. We can estimate, for example, the portion of accidents on rural and urban highways that might be amenable to reduction by AHS systems. But in terms of realistic deployment scenarios for any given state or metropolitan area, only some small fraction of the roadways are likely to be rendered accessible to AHS, given cost, logistical, jurisdictional, political, and other considerations. In addition, it is likely that a subset of the roadway lanes (perhaps only one lane each direction out of a six lane highway for example) might be converted to AHS, at least initially. It is not clear how that will change the overall accident experience of that

"In transportation, we believe that sustainability will increasingly be used as a public measuring stick to make decisions about alternative approaches, expenditures, and technologies."

roadway from what it would have been without AHS, though the presumption is that the AHS component will be much safer. We also don't know how much impact latent demand may have on further increasing the numbers of vehicles using that roadway system, which in turn will affect safety performance. Public interest groups and urban transportation planners are starting to raise questions about the potential secondary impacts on arterials that feed the entry and exit points on the AHS system, and what safety impacts may occur due to increased traffic, congestion, and speeds on these roadways. The complexity of this issue from an overall safety perspective is relevant to the public view of AHS as a sustainable system, in terms of overall traffic system safety (both AHS and non-AHS). Will AHS produce safety benefits in the aggregate that will be commensurate with the costs to obtain those benefits? Taking a least cost planning perspective on regional transportation planning, the question becomes one of how to evaluate whether AHS is the best alternative among many options to achieve the desired goals. And will it be feasible to sustain the benefits derived from the deployment of AHS into the future, or will persistent increase in numbers of vehicles and VMT that we now observe offset the benefits obtained? These questions suggest both a need for careful research and a need to position AHS carefully in the marketplace as a sensible option that is not significantly more costly than competing options and that supports a movement toward sustainable solutions to the complex set of underlying transportation problems.

In addition to safety benefits, AHS is positioning itself primarily as a technology to improve capacity and throughput on our existing highway systems. It is recognized that we are pretty much at the end of about a 40 year highway construction era, that current land use constraints make it increasingly more difficult to find and acquire the right of way needed for new highway or lane construction, and that the potential environmental consequences of new highway construction create significant public opposition to such proposals. Furthermore, the evidence suggests that new roadways, often created with the objective of relieving congestion, are filled to capacity and beyond almost as soon as they are created. This is not to suggest that no new roadways should be constructed. Rather, transportation planners generally are calling for a more balanced approach to the set of transportation problems discussed herein by considering a variety of capacity enhancement strategies coupled with demand-reduction strategies with the objective of moving toward a more sustainable transportation system.

Table 6 summarizes four policy categories that have been used to examine transportation systems from a sustainability perspective.[(69)] These include technology policies, demand-oriented policies, supply-oriented policies, and physical planning policies. Although AHS can be viewed as a technology option for addressing a number of transportation issues or problems, it has direct relevance for each of the other three policy categories. It would be advantageous from an institutional and public acceptance point of view

> "If it can be shown that an AHS helps conserve scarce resources, that it can pay its way on a continuing basis, that it does not contribute to increasing urban VMT, that it helps reduce (or does not increase) adverse environmental impacts, and that it contributes to the evolution of viable urban form, then that would be a tremendous plus for the program."

Table 6. Possible policy implications for AHS of sustainable transportation.

Sustainable Transportation Policy Strategies	Possible Policy Implications for Automated Highway Systems
<u>Technology Policies</u>: New technology developments in such areas as efficient vehicle and engine technology, more environmentally friendly fuels, alternative propulsion systems, ITS technologies, and infrastructure management systems have already had significant and beneficial effects on reducing adverse environmental impacts and increasing the safety of transportation systems. AHS falls directly in this category of policy alternatives.	• Couple AHS with programs that encourage fuel efficiency and renewable energy technology applications. • Implement AHS on advanced propulsion system vehicles first in order to emphasize AHS's support of sustainable technologies. • Consider restricting AHS applications to vehicles that meet higher than average fuel efficiency standards. Position AHS to provide an incentive to vehicle manufacturers to exceed current CAFE standards for AHS-equipped vehicles.
<u>Demand-Oriented Policies</u>: These policies are primarily directed toward changing transportation and mobility behavior. These include: pricing strategies to address peak traffic issues and deal with the substantial transportation cost subsidies built into our system; selective use of alternative transportation modes and the smoother interaction between modes; regulatory policy that impacts noise standards, vehicle inspections, speed limits, parking restrictions, and other traffic flow issues; and information programs. This category is relevant to AHS to the extent that AHS may influence latent vehicle demand.	• Encourage a least cost planning approach to deployment decisions for AHS. This means evaluating AHS as an option against alternative strategies. Therefore, it will be important to emphasize low cost implementation strategies. For example, vehicle-based AHS intelligence may be more acceptable and lower cost than an approach that requires high up-front infrastructure investments. • Focus on the potential for AHS to be a key player in an inter-modal system; that is, position AHS to link seamlessly with air, rail, public transportation, and non-vehicular modes. • Recognize the potential for AHS to induce additional traffic demand on non-AHS lanes and to create congestion on linked arterials, and couple AHS deployment with TDM strategies worked out with State and local agencies.
<u>Supply-Oriented Policies</u>: These policies are directed to the enhancement of transportation system capacity. These include: expansion of the physical infrastructure, such as adding lanes; improvement of public transportation systems; traffic calming measures; development of innovative infrastructure, such as light rail; and improved system management strategies. AHS may include the addition of new dedicated lanes or on/off ramps, and it may be applied to transit systems.	• Emphasize ways that AHS can support public transportation, either by direct application to buses, for example, or via intermodal links. Do not target SOVs. Consider AHS applications on existing HOV lanes in a mixed traffic mode. • AHS is likely to be viewed as competing with light rail proposals in many urban areas. AHS should have the advantage in terms of cost and convenience. • It will be essential to involve local jurisdictions in planning AHS deployment to avoid "network effects" and traffic management mismatches on side roads and at on/off ramps.
<u>Physical Planning Policies</u>: These policies address spatial location, land use patterns, zoning regulations, suburban sprawl, and the potential for the redistribution of human activities that have a structural impact on mobility patterns. AHS will impact these spatial patterns and therefore must be considered within a context of regional growth management planning.	• Integrate AHS into regional growth management planning. Position AHS as a strategy to minimize the negative effects of transportation infrastructure on mobility requirements. • Consider focusing AHS primarily on longer-distance corridor links, such as outlying airport to central city, or city to city, or connecting growth centers within urban areas. • Develop regional planning partnerships that encourage early stakeholder involvement in AHS decisions and imbeds AHS in a multi-agency systems planning perspective.

to be able to demonstrate that AHS can be used as a tool to help address issues that arise in each of the policy areas, and to make a positive contribution to sustainability through such mechanisms as reduced air emissions, reduced consumption of non-renewable energy resources (especially petroleum), reduction in the amount and length of trips, and a reconsideration of land use policies to approaches that are more conducive to sustainability in transportation. We agree with Nijkamp who suggests that "it seems plausible to assume that only a balanced package of the aforementioned four strategic options are able to pave the road toward environmentally sustainable transport."[(70)] If it can be shown that an AHS helps conserve scarce resources, that it can pay its way on a continuing basis, that it does not contribute to increasing urban VMT, that it helps reduce (or does not increase) adverse environmental impacts, and that it contributes to the evolution of viable urban form, then that would be a tremendous plus for the program.

At the federal, state, and local levels, transportation planning needs to be closely tied with growth management planning, environmental protection and restoration planning, and energy supply and demand planning. Historically, transportation managers have focused on road building and infrastructure creation as their main job; today, a broader perspective is needed that will be able to support the kinds of durable, sustainable, livable environments people desire. AHS has an opportunity to adopt the newer, more environmentally friendly perspective and position itself as a tool to help support a much broader policy mission than transportation planners and engineers have attended to until recently. We believe that this new orientation toward sustainability will significantly enhance the public acceptability of AHS.

"AHS has an opportunity to position itself as a tool to help support a much broader policy mission."

Issues Of Public Involvement And Equity In The AHS Decision Making Process

Introduction

Policymakers, program managers and technology developers are coming to realize that public input in public sector decision making is a given in the current social and political climate. Many decision makers are turning to public involvement as a way to manage public input so that it is beneficial to their decisions and projects. The public's demand for input comes from a realization that the way the decision making process is structured and managed plays a critical role in the way the project will be designed and implemented--and consequently, in both the nature and distribution of the impacts. The successful demand for public input into public sector decision making reflects and evokes a variety of issues about equity. Equity issues encompass not only those involving the distribution of costs, benefits, and hazards across populations, but also the distribution of access to and influence on the decision making process. A number of these issues have been raised about the ITS/AHS program--who will benefit from the program? Are they the same people who will be paying? How will disadvantaged groups be affected by the program? How have environmental considerations been taken into account? How will the environmental impacts be distributed geographically and socially? Other sections of this report have outlined the complex array of issues associated with the development and deployment of AHS and have identified some of the diverse players involved in the development and deployment of AHS at both the prototype and implementation stages. This chapter provides a brief overview of an approach to managing public input through the design and implementation of proactive public involvement efforts. It includes a discussion of the issue of equity in transportation program planning and its role in the need for and requirements of public involvement.

What Is Public Involvement and Why Do You Do It?

It is becoming increasingly clear that projects in the United States that affect the environment, public health and safety, the local economy, land use, social well-being, public expenditures--i.e., most large scale projects--will not be left to "the experts" to design and implement. Growing distrust of government and private decision makers alike, have reduced the public's willingness to delegate authority to agency and organizational representatives. Indeed the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), imposes a requirement for public involvement in the program's long-range transportation plans and inprovements.[71, 72]

James Creighton, one of the initial developers of public involvement planning, has concluded that the demand for public involvement represents a local adaptation to the highly indirect linkage between elected officials and public decisions manifest in the American system.[73] As shown in figure 13, the formal relationship between the citizens and either the program implementors or the regulators passes through a number of different branches of government, with the result that elected officials are only remotely linked to program implementors and regulators. Multiple formal and informal avenues exist for people and organizations outside the project team to provide input and exert influence on the decision making process. There is ample evidence that these avenues will be used, should the public not be able to work out an agreement with the program implementor. This has led to pressure for programs, particularly those utilizing public funds, to "open" their decision making process and has provided an incentive for program managers to be effective in developing an acceptable "adaptive response.

The purpose of public involvement is to provide a structure for this openness. Managers have a choice. They can provide a direct avenue of communication between the project team and those outside the team who have an interest in it in order to harness the interest of these "stakeholders" to improve the design, assessment, and implementation of the project. Alternatively, they can create barriers that force stakeholders to seek other, more indirect means of influence. Increasingly, managers and decision makers have found themselves in the position of

> "The purpose of public involvement is to provide a structure for open decision making."

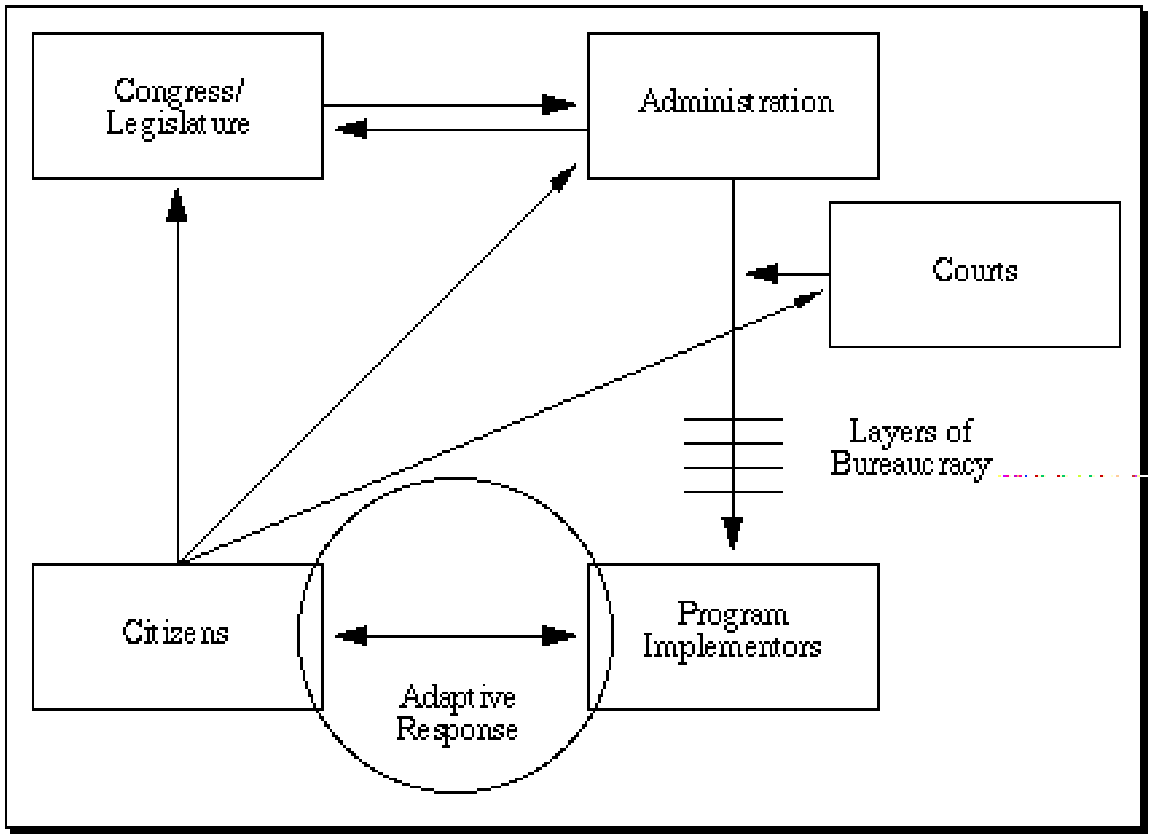

Figure 13. Alternative pathways for public involvement in decision making.

making a decision that did not count, and could not be implemented, because a sufficient number of people or organizations went around them, using other avenues for influence, and refused to recognize or accept the validity of the decision. Public involvement is a way for project teams to increase their influence over the public interaction process and to take an active role in identifying and addressing concerns and interests that could--and frequently should--affect the design and implementation of the program so that their decisions will count, and can be implemented.

Public involvement is fundamentally proactive. It involves managing the decision making process. It requires the project team to take the initiative to ensure that their decision making process is structured and paced in a way that allows effective utilization of input from the public and that their interactions with the public are structured in ways that elicit useful information, build respectful relationships, and enhance the ability of the participants to make informed decisions. It is becoming increasingly

> "Public involvement is a way for project teams to increase their influence over the public inter-action process."

clear that in managing complex programmatic decision making processes such as the AHS program, the key is to begin by identifying those who have knowledge about the institutional and social settings in which the project and technologies would be placed and who would be affected by changes in those systems. The next step is then to find out what they know and how they frame the problem, with a goal of negotiating rather than imposing agreement on the "facts" of the value of the system and the impacts and risks it might involve.

Key Concepts

Complexity: The AHS team will be made up of many different individuals making many different decisions dealing with different phases of the technology development-deployment continuum at many locations in the institutional system.(74) Many of these decisions will involve complex systems. The intrinsic complexity of many modern technological and resource management problems makes them differ in fundamental ways from non-complex problems. These differences significantly impact the need for public involvement and affect the nature of the issues managers are called upon to address, in part because they affect stakeholder's definitions of the problems and appropriate approaches and solutions. According to Waldrup,(75) complex systems, whether ecological, social, economic, or technological, share a number of features:

- They are dynamic and changing.
- Adaptive tactics evolve in relation to what others in the system are doing.
- They are sensitive to initial conditions--small differences in initial conditions can lead to large differences in subsequent events.
- Concepts are fuzzy, shifting, and recombining.
- Organisms in the system build models that allow them to *anticipate* the world, not predict it.
- Systems are self-organizing.
- Positive feedback provides the basis for growth.
- Adaptation builds upon learning and experience, taking advantage of what works and rejecting what doesn't work.

> "Growing system complexity has contributed to a lack of public trust in organizational management."

Growing recognition by the public that complex systems pose problems for prediction and control has contributed to the lack of trust and confidence in the organizations responsible for designing, operating, and overseeing such systems that has been building for several decades.[76]

The awareness and uneasiness about complexity and the demand for input has combined with the growing lack of public consensus on key societal goals and priorities that many feel reflects a fundamental transition in world-views or “paradigms” within the country, to place new demands on managers. Previously, problems typically came to “technical” managers after they had been reasonably clearly defined--either by consensus or the political process. The goals or desired outcomes were usually also reasonably well articulated and established. The challenge for the manager was to determine how to “solve” the problem to achieve the prescribed goal. Now, because this consensus has broken down and the political process has lost the will, ability, or authority to make decisions that can be implemented, managers frequently find themselves with problems that are ill-defined, and where there is strong disagreement about the nature of the desired outcome or solution.[77] Ravetz has developed a framework that illustrates the problem faced by many managers--situations where there are high systems uncertainties as well as high decision stakes.[78] In these situations, there is often a lack of consensus about methods and approaches, dispute about “facts” (which are often accused of being determined by or reflective of “values”), high polarization of interests, and a general confusion about what, exactly, is the decision to be made. And, with increasing frequency, no one but the manager is willing or able to take on resolution of the problem.

Stakeholders: One of the key issues in “open” decision making is determining who the decision making process should be open to. Who is the public? How do you know when you have made your process open to them? In a country as large and diverse as the United States, how do you go about attempting to open your process to “the public” in any effective way? Who are legitimate participants in the process? To address these issues, public involvement employs the concept of stakeholders and draws on the lessons of marketing and the concept of market segmentation. As the name implies, stakeholders are people who see themselves having an interest in or being affected by a decision or project. It is this interest or stake that provides the impetus for them to want to be informed about and have a say in the decision or project under consideration. People may see themselves interested in or affected by a decision for different reasons, including:

> “Stakeholders are people who see themselves having an interest in or being affected by a decision or project.”

- **Proximity** — People who live in an area affected by the project may see themselves affected by congestion, noise, influx of people, threat of dislocation, changes in aesthetics, etc.
- **Environmental Concerns** — In addition to the traditional issues of impacts on air and water quality, habitat, and so on, there is an increasing concern about the long-term, systemic consequences of projects and decisions and

implications for social and environmental sustainability.

- **Health and Safety** — There is increasing attention to the direct and indirect consequences of projects on public and worker health and safety as a result of project emissions, or the creation of additional hazards or potential for accidents.
- **Economics** — The characteristics of the project may create or eliminate jobs, enhance or threaten business opportunities, raise property values, increase taxes, or otherwise affect people's and organization's economic status. These affects are likely to be distributed unequally across the population, with some people benefiting and some people losing.
- **Use** — Some people are affected because they are users of a place, resource, or system that would be modified or eliminated by the proposed decision/action; others are affected because they are potential users of the new facility or system.
- **Mandate** — Some people see themselves affected by a decision making process because they or their organization has a legal or mandated responsibility for the resource or system that would be affected by the proposed action. State regulatory agencies frequently find themselves in this position, as do municipal governments who would be called upon to implement, manage, or permit a proposed facility or system.
- **Governance** — Some people have an interest in a decision making process because they see it as affecting how public agencies make decisions and fulfill their governance responsibilities. Those with an interest in governance frequently focus on the decision making process as much, if not more than, the substantive decision itself.

A corollary to the concept of stakeholding is the concept of "the silent majority." A fundamental premise of public involvement is that people differ in their stakes in a decision, and differ in the level of involvement they want to have in the decision making process. For most decisions, the majority of the population

> "People differ in their stakes in a decision, and differ in the level of involvement they want to have in the decision making process."

will not wish to be actively involved: they thus become the silent majority. They may chose not to be involved for a variety of reasons. They may not see that they have an interest or stake in the decision or the decision making process. They may feel that their interests are already being represented by someone they trust. They may have other demands on their time that take a higher priority. They may not realize that the decision is being made, or that they have a stake in the outcome. Or, they may not feel that they have the ability to influence the decision, and that there is no point in becoming involved. It is these latter three groups that are of concern to managers, because they represent people who are not involved now, but may want or need to become involved later.

Levels of involvement: Not all stakeholders want to be involved to the same degree in a decision making process. Greater involvement requires greater effort. It also results in greater impact. Lorenz Aggens and James Creighton,[79, 80] have identified six levels of involvement by stakeholders, which can be visualized as shown in figure 14. As indicated in the previous sections, there are numerous decisions associated with the AHS program, and a large number of different stakeholders. Because the AHS program involves a multi-stage development process, it is important to remember that different stakeholders will want to be involved in different ways at different points in the program. Any public involvement effort undertaken for the program will need to take this diversity and change into account.

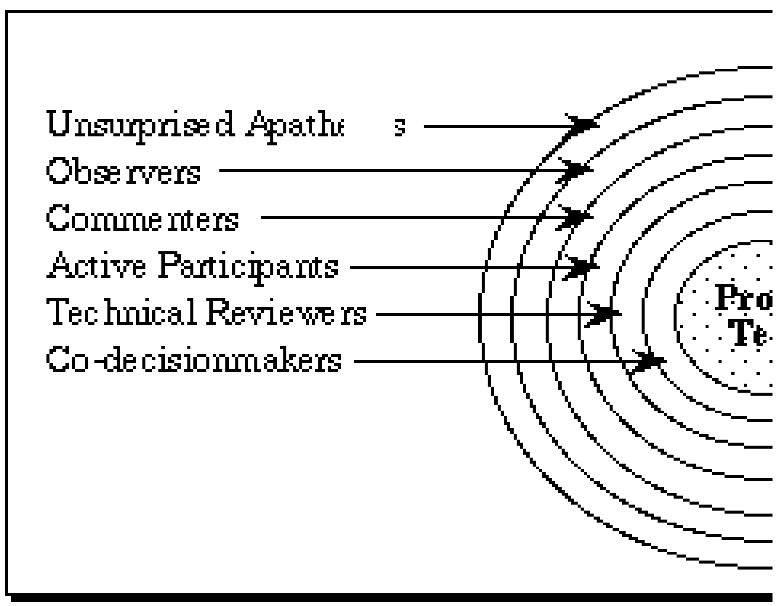

Figure 14. Levels of public involvement.

This diversity in level of involvement has led some managers to worry that public involvement programs provide too much influence to a relatively small, unrepresentative number of stakeholders and that the interests of the "general public" may not be adequately represented or protected. This is a particular concern in programs that are very controversial and in which the stakeholders have become significantly polarized. This can create a situation in which those without intense feelings or strong interests may decline to participate in order to avoid becoming enmeshed in community controversies and animosities. With programs like this, it is particularly important to supplement public meetings with informal get togethers and one-on-one informational data gathering efforts to make sure that the program maintains access to the views and perspectives of the less vocal, or potentially intimidated, members of the public. This is a special consideration when cultural or social differences may make it difficult or uncomfortable for potentially affected groups to participate. An important feature of effective public involvement is the development of a multiple channels for communication and relationship building. The objective is to be effective in providing useful information to the affected publics and effective in obtaining useful information back from them.

Decision making process: The public involvement being discussed in this section is focused on decisions, and the project responsibilities we are talking about involve management of the decision making process. One of the significant benefits managers have found from public involvement is the discipline that preparing to "go public" imposes on the team to lay out and clarify the decision making process. Thinking about how to involve stakeholders outside the project team in the decision making process makes managers realize that it is necessary to be clear about what decision they are trying to make, and how that decision will be made--on the basis of the manager's authority, by consensus, by vote--before they can determine how it might be effective to involve the public in the process. Thinking about having to answer questions in public from a potentially unsympathetic audience has been found to be a good way to identify previously unrecognized assumptions and gaps. In addition, considerable experience has shown that it is important to provide opportunities for public involvement early in the decision making process. This requires managers to lay out the decision making process for themselves and their team early in project development and to expose themselves to the diversity of viewpoints before they have consolidated their opinions about the conclusions that should be reached. In general, an analytic decision making process includes the following steps:

"Managers need to expose themselves to the diversity of viewpoints before they have consolidated their opinions."

- Define the problem
- Establish the objectives/determine the attributes of a solution
- Identify alternatives
- Establish evaluation criteria
- Evaluate the alternatives
- Refine the alternatives

- Select the preferred alternative.

The biggest problem many managers have in implementing an open decision making process is involving the public at the first step of the process–defining the problem–and disengaging the steps in the decision making process so that the public's input can be effectively incorporated and used. To address this problem, it can be valuable for project and program managers to conduct a "strategic analysis" of their program as they first start laying out the program activities. The contents of a strategic analysis are discussed below.

Equity: Another Challenge for Managers and Policy makers

In addition to the problems mentioned above, there is an increasing demand for managers and policy makers to explicitly address issues of equity and justice in their planning process. The Executive Order on Environmental Justice (12898), which was signed by President Clinton on February 11, 1994, gives federal agencies one year to develop a plan "that identifies and addresses disproportionately high and adverse human health or environmental effects of its programs, policies, and activities." It also requires agencies to:

- Ensure that minority and low income populations have access to public information related to human health and the environment.
- Conduct activities related to health and environment in a manner that does not discriminate against minority and low-income populations.
- Consider disproportionate health effects in conducting research and collecting data.

This is pertinent to the AHS program, given that key stakeholders have begun to raise questions about the environmental and safety consequences of AHS and about how ITS technologies may impact minority (race, age, physical handicap) and low-income populations differentially. For example, the program has been asked about how differences in the ability to afford cars or other AHS equipment or to exhibit the requisite operating skills would affect the distribution of users of the system. Additional questions have been raised about the fairness of dedicating existing lanes of the highways to AHS, thereby restricting those who choose not to acquire AHS capabilities and possibly increasing the tax burden for everyone when only some will benefit. These questions gain credence in light of a reexamination of the social impacts of urban transportation decisions conducted by Hodge that reveals significant inequalities in the distribution of both benefits, payments, and adverse environmental and community impacts of urban transportation development activities.[(81)] Significantly, these impacts were frequently not anticipated or specifically considered during the design and planning stages of the project. Furthermore, Hodge found evidence that historically, access to the decision making process was also inequitable, as a consequence of both intentional and unintentional decisions about the design and implementation of public involvement efforts.

> "The AHS program must attend to issues of equity in both the substance of the program as well as in the decision making process."

Another indication of the importance of planning to address issues of equity as a normal part of the decision making process is the emergence of a grassroots social movement, known as the environmental justice movement that unites environmentalism and social justice. By 1990, this movement had organized into an interlinked network of activists who are focusing on the environmental justice issue at three different levels--the community or grass-roots level, the state or regional level which provides training, lobbying, and pooling of resources for scientific and legal support, and the national level which provides scientific, legal, and political assistance on a national scope.[(82)] The existence of this movement, with a specific attention to issues of equality of access to the decision making process, is yet another indication that the demands for access to the decision making process are likely to be strong enough that they will succeed in being heard--one way or another. This means that the AHS program must attend to issues of equity in both the substance of the program as well as in the decision making process and is likely to be called upon to demonstrate how issues of equity are being considered and addressed.

Managing an Open Decision Making Process

There is growing evidence that the current circumstances require modification of the "standard" planning decision making approach for programs such as the AHS. Thompson and Trisoglio for example, suggest that under conditions of complexity and uncertainty, the linear approach that emphasizes prediction should be replaced with methods that emphasize scenario planning, and the development of new tools such as "decision-making under contradictory certitudes, ... clumsy institutions, and indicators of technological inflexibility."[(83)] In managing complex problems that involve risk, the key is to begin by identifying the risk bearers and the way in which they frame the risk problem, with a view to negotiating rather than imposing agreement on the "facts" of risk assessment. A systems perspective is needed that recognizes the critical importance of feedback, sensitivity to initial conditions, and interrelationships between systems parts. Such a perspective also points to the role of disequilibrium such as that generated by conflict, as part of the inevitable process by which change occurs. It emphasizes that seemingly small changes and events can have cascading effects due to feedback and amplification processes. Complexity theory suggests that events are highly unpredictable and that management strategies aimed at monitoring and adaptation may prove more effective than prediction and control. There is also assertion that these circumstances need public or stakeholder involvement, and that stakeholder involvement is an essential part of the decision process.

Given the difficulty of prediction in complex systems, the interrelationship of facts and values, heightened public expectations for involvement, and the need to be attentive to issues of equity, policies and management strategies that rely on prediction and control and unilateral implementation of management decisions are likely to fail. The notion of an elite decision maker balancing risks becomes very illusive; increasingly, the decision process is one of interaction and negotiation among stakeholders.

Involving stakeholders in a more collaborative decision process, however, expands the manager's traditional responsibilities and essentially requires a new management style. A fundamental change is required as management is viewed as a process of strategic planning about how problems should be addressed as opposed to implementing solutions that have already been identified. The recommended management approach envisages public involvement as the means of developing consensus on an acceptable course of action. The involvement process has cognitive, affective, and substantive goals:

- The cognitive goal is to develop a shared understanding of the nature of the problem among stakeholders and the project team. Meeting this goal entails adoption of a *convergence* rather than a linear approach to risk communication. Such an approach emphasizes the iterative and mutual nature of communication, which involves transaction of information among participants with differing frames of reference. Communication becomes a creative process of negotiating shared meanings over time.

- The affective goal is to develop a process that is viewed by stakeholders as equitable and rational, building a relationship among the stakeholders as the basis on which debate can proceed. Meeting this goal provides participants with the satisfaction of having been involved in the process of reaching a decision. It addresses psychological needs such as trust, equity, and feelings of self-worth.

- The substantive goal is to reach a decision that is acceptable and can be implemented. Meeting this goal involves a creative synthesis of viewpoints in developing an agreement that is broad-based and can better address the problem.

> "Strategies that rely on prediction and control and unilateral implementation of management decisions are likely to fail. The decision process is one of interaction and negotiation among stakeholders."

In order to design an effective public involvement approach, it is instructive to consider some of the key concerns expressed by stakeholders and managers/policymakers as well as to consider the implications of recent and on-going changes in their roles and responsibilities.

The types of concerns expressed by the non-team stakeholders about decisions being made that involve complex technological systems include:

- Increasing appreciation for the complexity of environmental and social systems.
- Greater concern for the environment.
- Consequent awareness and concern about not only primary impacts, but second and third order consequences (which are often labeled not “impacts” but “risks”--which makes them more difficult to detect and to attribute/assign responsibility/prove, and consequently more difficult to assess liability and to control), including environmental and health impacts.
- General lack of trust in the credibility, reliability, and ethical standards of organizations--which makes people more concerned about control.
- Anxiety that current science is not adequate for the complexity.
- Concern that current institutions are also not adequate for the complexity and long-term implications.
- Apprehension that scientists are spokespersons for policymakers and not the public.
- Recognition that the science conducted to support agency/policy decision making cannot be directly applied locally--it needs to be adapted to take into account local conditions; yet, scientists refuse to take local “experts” seriously or incorporate their information in their scientific/analytic models.

Interviews with managers and policymakers responsible for planning and implementing complex technological programs have found that they express concern about:

- Responsibility without authority.
- Personal liability issues.
- Being forced to sacrifice “technical soundness” for “political” acceptability.
- “Societal” issues being played out on their program.
- Conflict between short-term organizational goals and problem characteristics.
- Conflict between procedurally oriented compliance requirements and adaptive problem-solving requirements of the situation.
- Power of an [irresponsible] media to set agendas and influence public opinion.
- Being treated rudely or worse.

Further contributing to the difficulty are changing roles and responsibilities of the non-project stakeholders, the media, and the program managers and policy makers.

The non-project stakeholders tend to have:

- High expectations among at least some publics about their ability and right to influence decisions.
- Diffused/ambiguous responsibility for positions or decisions--unclear accountability.
- Frequently taken on the “watch-dog” role.
- Increasingly included or accessed highly specialized technical experts--which widens the range of “technical content” demanded, since some of the stakeholders continue to have relatively little familiarity or interest in the technical details.

The media has:

- New technologies that allow instantaneous, continual, and visual coverage of events.
- Tended to approach technological projects from an “investigatory” reporting--casting the media as watch-dog; whistleblower.
- An ambiguous degree of accountability for accuracy and fairness.
- Tended not to address technical aspects of the issue thoroughly, in detail, or in a balanced way.

Program Managers/Policy makers see themselves as:

- Accumulating increasingly broad responsibilities for defining the problem and acceptable solutions.
- Often operating in organizations that are experiencing instability--undergoing policy transitions and/or reorganizations.
- Frustrated in attempts to deal with the consequences of the decision making context that includes:
    - — Not being able to implement without “consent of the governed”.
    - — Having to deal with stakeholders who have little or no technical knowledge as well as those who are technical experts.
    - — Facing different world views/frameworks that make communication difficult.
    - — Dealing with stakeholders who have such different interests/values that communication and agreement are difficult.
    - — Lack of trust and respect that create unpleasant interactions until they have been overcome.

Implications for Management: How Do You Start?

Conducting an "open" decision making process requires planning, and it frequently requires adaptation of the way managers and their organizations have traditionally structured problems, set goals, collected information, made decisions, and interacted with "non-experts." An effective public involvement program helps managers through the decision making process by:

- Clarifying the decision making process.
- Providing an incentive to get the internal house in order in preparation for "going public".
- Information gathering.
- Identifying public concerns and values.
- Informing the public.
- Developing a consensus.
- Developing and maintaining credibility.

> "It cannot be emphasized strongly enough that it is important to begin public involvement early in the decision making process."

It cannot be emphasized strongly enough that it is important to begin public involvement early in the decision making process. Gaining agreement on the nature of the problem is essential for productive discussions about what should be done to solve the problem. Managers and policymakers frequently find that involving the public in defining the problem and delineating the nature of the solution is very difficult for them to do. They feel unprepared. They feel that they are going to lose control of the process. They feel they won't have all the answers. Nevertheless, the strongest finding of research on open decision making is that the openness needs to be started early. At the beginning of the decision making process.

Opening the decision making process is not an "add-on" activity. Like total quality management, it often requires managers and team members to re-examine their own personal style of decision making and management, modify their internal organizational structure and procedures, and undertake new and additional activities. These changes are frequently not easy to make. A number of managers responsible for complex programs have found that conducting a "strategic analysis" of the decision making process is a useful way for the project team to figure out what they are trying to do and to get their internal house in order. It also helps them open the process early.

A strategic analysis is essentially an opportunity for the project/program manager and project team to be sure they all understand what they are trying to do, sort out roles and responsibilities, build their team, assess the need for public involvement, and prepare themselves to involve the public in the decision making process. In conducting the strategic analysis, the team works through a series of questions:

- What is the decision?
- Why is this decision being made?
- What is the decision making structure--who is making the decision?
- What is the background of the decision?
- What previous decisions have already been made? Where are you in the decision making process?
- How does this decision fit with others that are being made?
- Who are the key stakeholders?
- What kind of public involvement effort is needed?
- Who needs to be involved in planning the public involvement effort?
- What is the schedule?
- Are roles and responsibilities within the team clear?

Special Public Involvement Needs of Technology Development Programs

Program managers using public funds to develop technologies face a number of challenges, some of which are common to all large-scale projects and some of which are unique because of the objective of gaining public acceptance of something new. Stakeholders are likely to call for the program to open the planning and technology development process, including the allocation of resources among technology choices, to public input on the grounds that the program is making important decisions with public funds. In addition, program managers have an incentive, as well as a responsibility, to maximize the likelihood that they are spending the public monies to develop technologies that will be acceptable to the public and that can be deployed effectively. For these types of programs, some project managers have found it beneficial to undertake two types of public involvement. The first is directed at the design and purpose of the program itself and is therefore similar to other programs; the second is directed at improving the program’s ability to select and fund promising and suitable technologies, and to increase the likelihood that those technologies are implementable from the perspective of the publics, including the regulators. Efforts to elicit public input on emerging technologies such as the AHS have run into a number of obstacles, perhaps the most serious being the difficulty of determining what type of input is appropriate at which stages of technology design--deployment process and understanding what type of information the publics will want to have in order to make judgments about the various technologies under consideration.

One recent effort to address this problem involved the Department of Energy's integrated demonstration program.[84] In this program, a significant effort was made to implement a public involvement process that elicited the views of the range of stakeholders about the information they would need about a technology in order to assess it's acceptability. By conducting a series of informal, face-to-face interviews with a variety of stakeholders, and then holding a series of workshops and focus groups that brought together the project managers, technology developers, and representatives of the public, this program developed a set of criteria that defined the information stakeholders expected they would use in judging the acceptability of the technologies under development. These criteria were then used to establish the information that the developers were required to generate for their proposed technologies in the test and evaluation process. Provision of this information was made a prerequisite for further funding. Although these technologies were not exactly comparable to those being developed for the AHS, the criteria that were identified through this process may nevertheless be useful for consideration in this program. They included:

- Performance of the technology
  --Functions as intended (i.e., it "works")
  --Practicality
  --Effectiveness in accomplishing task

- Cost
  --Start-up cost
  --Operations and maintenance cost
  --Life cycle cost

- Time and schedule
  --Years until available
  --Speed/rate
  --Years to finish

> "Stakeholders are likely to call for the program to open the planning and technology development process."

- Worker safety
  --Exposure to hazardous materials/hazards
  --Physical requirements
  --Number of people required

- Public health and safety
  --Accidents
  --Off-site releases
  --Transportation

- Environmental impacts
  --Ecological impacts
  --Aesthetics
  --Natural resources
  --Energy demands

- Public perception
  --Proponent reputation
  --Familiarity/understandability

- Tribal rights/future land uses
  --Capacity for unrestricted use

- Socioeconomic interests
  --Economic impacts
  --Labor force demands

- Compatability with existing interagency agreements

- Regulatory compliance

- System/infrastructure compatability

Another important aspect of this program's public involvement effort was to interview program managers and technology developers, as well as non-project stakeholders, about the decision making process as it pertained to their role in the program. This information was then used to identify when and what type of information from the public might be useful to the project team, and when and what type of information would be needed by the public in order to participate effectively.

A similar exercise would be useful for the AHS program, which, because of its complexity and duration, involves a number of imbedded decision making processes and multiple organizations. In order to conduct an effective public involvement effort to support this program, it will be important for managers to be sure they understand the decision making processes being utilized by the major program participants. Information gained from a public involvement program is only useful if it is available to the right people at the right time. The array of issues identified though even this preliminary analysis of the institutional and societal aspects of the AHS program indicate that a way of systematically addressing emerging issues, perspectives, and interests of the wide range of program stakeholders would be an investment likely to pay large dividends in the quality and acceptability of the program as it unfolds.

KEY RESULTS/CONCLUSIONS

Activity "O" has examined a range of institutional and societal aspects of the proposed Automated Highway Systems (AHS) program, and focused on the following particularly critical issue areas:

1. Perspective of environmental organizations.
2. State and local decision processes.
3. Role of the print media.
4. Legal liability risks.
5. Public perceptions of potential safety risks.
6. Sustainable transportation.
7. Public involvement process.
8. Equity.

To be successful in the long-run and to have an opportunity to initiate deployment of AHS in the short-run, the concept and its various systems configurations and operations must establish stakeholder acceptance. This analysis has examined the above significant institutional and societal component areas of the program with regard to their potential impact on public and stakeholder acceptance. Conclusions have been summarized under four topics or "success factors" that are considered pivotal from a public acceptance and system success standpoint: safety, costs, benefits, and public involvement. Key findings include the following:

Perspective of Environmental Organizations

Safety

Environmental groups are very concerned with the issue of safety. This concern is not focused not only on the safety of drivers participating directly in AHS, but also extends to the broader population that might indirectly be impacted from a safety standpoint by AHS. This would include neighborhoods through which traffic going to and from AHS entry/exit points might pass, and safety effects on other secondary arterials due to increased AHS-generated traffic. They lobby for "traffic calming" strategies to make neighborhoods safer and more livable for everyone. In addition, they express concern about the low probability, high consequence kind of systems accident that AHS might cause.

Costs

Environmental groups in general are sympathetic with a least cost planning kind of approach to addressing growth management, environmental impacts, and technology development kinds of issues. This calls for a comprehensive review of a full range of options for addressing particular issues that have environmental implications, and selecting those approaches or solution strategies that minimize costs. In the case of transportation congestion, or air emissions from vehicles, for example, they place a lot of emphasis on traffic demand management strategies as less costly approaches compared with many capacity enhancement strategies. The environmentalists are generally not, at this stage, well informed about AHS, but given what they understand about it, they tend to believe that AHS reflects a very costly, and from that standpoint inappropriate, strategy for addressing congestion, safety, and mobility problems. It will be important in the early going to work with the environmental groups to jointly explore least cost implementation options for AHS.

Benefits

Environmental groups are looking for transportation strategies that are primarily directed toward reducing air emissions, conserving non-renewable resources (particularly petroleum), and creating more livable human environments. Their focus is on achieving long-term management of the demand for vehicle travel, in recognition of the fact that past improvements in vehicle emissions and efficiency have been outstripped by growth in VMT and numbers of trips. With these stakeholders at least, FHWA will want to show that AHS emphasizes the movement of people more than vehicles, is coupled with strategies to prevent latent demand for travel from offsetting the efficiency benefits that AHS achieves, that emphasizes public transportation applications, and that provides equitable access to all components of the population. On this latter point, there is a big concern that a vehicle-based AHS will only benefit the well-to-do who can afford the service ("the BMW owners"). FHWA needs to work with environmentalists and others to assure the widest possible distribution of benefits from AHS.

Public Involvement

While only a minority of the public can be described as committed environmentalists, many more are sympathetic to the broad goals of the environmental movement. Therefore, environmental perspectives and arguments pro and con with respect to AHS will play a central role in any public discussions about AHS deployment plans and strategies. While many environmentalists are skeptical of AHS technology, their current perspective is based upon limited knowledge about AHS. Additional research that can demonstrate environmental benefits and allay fears about induced demand effects may change this basic point of view. Inclusion of AHS into growth planning models, and demonstration that AHS can support growth management objectives may persuade environmentalists to be more supportive. Demonstration of economic benefit accruing from environmentally sound AHS also may help to convince some environmentalists. FHWA should seek to present AHS as a tool that can effectively help achieve environmental goals, along with economic goals and better overall traffic management goals.

State and Local Decision Processes

Safety

Highway and driver safety are likely to be evaluated differently by individual drivers, by state and local transportation agencies and planners, by state legislatures, and by other transportation stakeholders. Individual drivers tend to rely on and trust their own driving skills more than unproved technology systems. Convenience, speed, and reliability are ranked higher by some than safety. Environmental groups tend to express concerns about low probability, high consequence safety failures, or to focus on the safety implications for secondary arterials that may experience traffic impacts from AHS. FHWA needs to understand how safety ranks among regional and local criteria, and tailor their deployment plans so that AHS addresses the priority concerns of different stakeholders in the different areas of the country.

Costs

State legislatures, state transportation planning agencies, and local transportation planners are very cost sensitive. They operate within tight budgets, and will look for proposals that either cost less than the alternatives and still meet their needs, or they will look for cost sharing support for those proposals. A typical first reaction to AHS is that it will be very costly. Evolutionary strategies that allow AHS technologies to be incrementally added to existing, accepted programs will likely fare better than complex, stand-alone, potentially costly proposals. Many states will face serious organizational constraints on their capacity to operate and maintain an AHS with regard to staffing, training, command and control capabilities, integrated facilities, and financial and manpower resources. The costs of various optional configurations of AHS must be carefully considered in discussions with recipient jurisdictions.

Benefits

State DOTs and MPOs must be convinced of the benefits of AHS *to them* before they will be willing to attempt to garner the public and political support that will be necessary to support decisions to deploy AHS. The benefits that different locations will likely focus upon will depend on their current experiences and problems with their transportation systems. Judgments are likely to be made in terms of the perceived equity of the distribution of AHS benefits--do stakeholders perceive the distribution to be fair? Is AHS easy and convenient to use? Is the system safe and reliable? Does AHS focus on moving people more than vehicles? Are the benefits sustainable over the long-term or is this a short-term fix? These are the kinds of benefit issues likely to be faced.

Public Involvement

There currently exists wide-spread ignorance about AHS, coupled with a dose of healthy skepticism. FHWA needs to work closely with state DOTs and encourage them to reach out to their constituencies to open a dialog about AHS. Planners need to understand AHS concepts and to think about how AHS fits into their current transportation planning activities. Early and substantial public/stakeholder involvement is crucial. Also, involvement of local jurisdictions is critical for AHS success. This is particularly necessary to address such network effects as arterial congestion, congestion at AHS entry/exit points, the integrated management of local traffic control systems with AHS systems, and other inter-jurisdictional issues.

The Role of the Print Media

Safety

AHS is currently most often represented in the print media as a far-in-the-future technology (at least 25-30 years away), the apparent end point of the long list of ITS technologies being applied to our transportation systems. While media treatment of AHS specifically has been limited, science fiction terminology like “Buck Rogers” and “The Jetsons” is not uncommon. The media often present an image of a platoon of vehicles traveling at very high speeds (80 to 100 mph) with very close gaps (“1 yard). The media present a typical picture of AHS as a hands-off/feet-off system, with further implications that the driver will not need to pay attention to the functioning of the vehicle (brain-off). While the media have not, up to this point in time, commented very extensively on the safety of AHS, the general imagery of AHS that they offer is not likely to conjure up images of very safe travel in the minds of the public. While the media are generally supportive of the AHS concept at this early period in the conceptualization of AHS, their representation of AHS is neither accurate nor complete. FHWA needs to establish a dialog with media journalists and communicate clear images of AHS that emphasize its safety aspects.

Costs

The presumed high costs of AHS are included in media discussions of potential disadvantages of AHS. The media generally have very little information or basis on which to speak accurately about the costs of AHS with any authority. They need to better understand the range of AHS optional deployment strategies and what kinds of costs are associated with those options, and how those costs are likely to distributed over the driver, the private developers, public agencies, or the taxpayer.

Benefits

Some of the benefits of AHS as represented by the media include: congestion relief; driver safety; reduced air pollution; economic stimulus; improved public transit; enforcement of traffic rules; and, aid to older drivers. The majority of media articles that have been published to date represent AHS in a positive light.

Public Involvement

The role of the media is one of interpreting AHS technology for a public readership, and the media can exert a significant impact on shaping public opinion and public acceptance. The media currently represents, and will continue to represent, the main source of information about AHS that is available to the driving public. National and regional transportation managers should establish early and close working relationships with the various journalists to assure that a balanced, accurate picture of AHS is presented to the public and that media errors or misinformation are corrected without delay. The media should be viewed as an ally and updated frequently as the program evolves.

Legal Liability Risks

Safety

In analyzing considerations of legal liability for vehicle accidents, we have assumed that AHS as demonstrated or deployed will improve vehicle safety overall: that is, accidents will be fewer and less severe and resulting personal injuries and property damage will decline.

Costs

To the extent AHS results in an overall improvement in vehicle safety, it should reduce the costs of motor vehicle accidents, and thus decrease liability risk in the aggregate. However, three aspects of this overall reduction in accident costs could create disincentives for vehicle manufacturers and roadway authorities to participate in AHS.

First, to the extent AHS transfers control from the driver to the vehicle, the roadway authority, or a combination, the liability for the fewer and/or less severe accidents that do occur may shift to these parties. From their standpoint, the increased proportionate share of liability may more than offset the reduction in total liability and thus increase their net liability risk.

Second, to the extent AHS increases uncertainty about the causes of accidents and who is responsible, it may increase the number, complexity, and parties to lawsuits, thereby raising transactions costs and the potential for reputational damage, and thus increase litigation risks. (System configurations that divide control among the driver, the vehicle, and the roadway could add complexity to determining responsibility for accidents and thus exacerbate this problem.)

Third, to the extent AHS creates the possibility of accidents involving large numbers of vehicles, it likewise creates the possibility for "catastrophic liability" that could severely damage or destroy individual participants, especially smaller private firms.

In principle, it should be possible to manage the legal risks of AHS accidents to overcome disincentives to participation. To the extent AHS increases highway safety and thus reduces liability for accidents in the aggregate, it creates a windfall for the liability "winners", which can be tapped if necessary to create institutional arrangements that compensate the liability "losers" so that all participants would be as well or better off as in the absence of AHS.

Benefits

Vehicle manufacturers and roadway authorities will weigh the legal liability risks (and any other risks) against the potential benefits of participating. This calculation will largely determine whether they require some form of compensation to manage their liability risks and, if so, what level and type of assistance.

Public Involvement

Vehicle manufacturers and roadway authorities need to be involved early in discussions with each other and other key stakeholders about the nature of liability risks, the impact of alternative system configurations, and alternative arrangements for managing the legal liability risks.

Public Perceptions of Potential Safety Risks

Safety

Descriptions of AHS deployment with "hands off, feet off" driving, especially when close gaps are involved, usually prompt expressions of concern about potentially catastrophic AHS system failures. Literature review shows that most people are positive about automatic controls as long as human control is possible as a back-up; automatic elevators and airport terminal trains are examples. Yet a frequent theme in science fiction horror stories is technology that runs out of control. Uncertainty about risk occurrence and consequences often causes people to make worst-case assumptions.

As with any technology that has some measure of inherent risk associated with the possibility of catastrophic failures, it is crucial to attend both to the engineered design aspects of the system that reduce that risk, and to address the ways in which the public perceives those risks. The way that the driving public is likely to view AHS safety is every bit as important and valid as the way that engineers interpret the safety of the technology systems behind AHS. In fact, the former perceptions of safety will be more central to the success of AHS than the safety “facts” derived from engineering assessments, because the former determine who people will behave.

Preliminary discussions with members of the public suggest that safety risks may be perceived to be a greater hazard than engineers believe are likely to occur. Also, to the extent that AHS can accurately be characterized as a tightly-coupled, complex technology system, the probability of occurrence of a catastrophic system failure that will be difficult to mitigate increases. FHWA needs to seek ways to open a dialog on AHS safety that addresses these issues. Systems designs that reduce the technological complexity and system couplings may also reduce risks and the perception of risk, such as through a greater emphasis on vehicle-based intelligence versus infrastructure-based intelligence.

Costs

The public is generally more concerned with safety than cost when considering exposure to technology risks. To the extent that additional costs can be shown to enhance system safety, the public can be expected to be supportive of those expenditures.

Benefits

Among the factors working in favor of public acceptance of AHS is a generally positive attitude toward advanced technology. The way in which computers have overcome their poor reputation of 30 years ago is instructive. Phased deployment that does not require the public to place blind faith in unproved technology will be essential. Technologists and developers must be careful not to oversell AHS, and they must be careful that they are not perceived as claiming that “nothing can go wrong”. Either error will provoke public distrust and lead to anger when problems do occur. One way to reduce the perceived riskiness of AHS would be to build in ways that the driver can exercise some control over the vehicle as a backup to a system failure. Another is to emphasize the safety benefits that are gained by AHS in exchange for some very small measure of risk.

Public Involvement

A central strategy for addressing perceived risk is public involvement and education. FHWA needs to seek to understand how different components of the public perceive AHS, particularly with regard to safety risks associated with the technology. Then information can be prepared that directly addresses their questions and concerns in this regard. In this way perceived safety risk can be successfully be addressed and public acceptance can be gained sufficiently to allow for AHS deployment.

Another key factor is to demonstrate early success with the technology. Early failures will be picked up by the media, likely blown out of proportion, and the risks as people come to understand them will be significantly amplified. Dealing with amplified risk perceptions later in the program will be much more difficult and costly than engaging in an open dialog about the risks at the outset, with an eye to designing a system that meets peoples' expressed needs and addresses their risk concerns. An important side benefit of this approach is that it increases trust in the management of the technology system, which serves to reduce people's concerns with the risks inherent in that technology.

Sustainable Transportation

Safety

Environmentalists and other stakeholders have expressed concern with the effect AHS may have on demand creation, and the impact latent demand may have on further increasing the numbers of vehicles using the roadway system, which in turn will affect safety performance. Public interest groups and urban transportation planners are raising questions about the potential secondary impacts on arterials that feed the entry and exit points on the AHS system, and what safety impacts may occur due to increased traffic, congestion, and speeds on these secondary roadways. The complexity of this issue from an overall safety perspective is relevant to the public view of AHS as a sustainable system, in terms of overall traffic system safety (both AHS and non-AHS). Will AHS produce safety benefits in the aggregate that will be commensurate with the costs to obtain those benefits? AHS proponents need to look beyond the primary safety benefits that AHS offers for dedicated rights-of-way, and they need to consider whether these safety benefits can be expected to persist into the future.

Costs

Systems that are not sustainable can be characterized as drawing down on a line of credit. Depletion of non-renewable resources (automotive fuels) and increasing contributions to urban air pollution cannot be sustained over the long term. The costs are measured not only in dollars, but in human terms (the costs of congestion, accidents, ill health, and stress). A sustainable approach to AHS would take account of strategies for reducing travel demand as a way of reducing some of these costs to society of transportation. Advocates of sustainable transportation support a least cost planning approach that would evaluate the costs and benefits of a broad range of transportation and non-vehicular modes of access (e.g. telecommuting), including AHS, to make better transportation planning decisions.

Benefits

AHS deployment strategies that focus on moving people more than vehicles will help put a lid on growing levels of VMT and lead to more sustainable solutions that benefit not only AHS users, but also society as a whole by making for more livable communities, reducing demands on costly fuel resources, and improving the quality of the environment.

Public Involvement

Environmentalists and other citizens concerned with how public policy can help shape the relationships between technology, the environment, energy use, development, and quality of life, are increasingly applying sustainability as a yard stick to measure success. The acceptability of AHS as a new transportation technology is likely to be increasingly judged in terms of its contribution to helping meet sustainability goals. Politically influential stakeholders, such as environmental organizations, along with selected federal and state agencies, are pressing for greater attention to sustainability, and transportation managers can expect to be held to similar performance standards.

Public Involvement

Because public involvement (PI) is covered in each of the seven other topic areas in this summary section, it is not discussed in each of the category areas here. The overall goal of public involvement can be framed in terms of improving the quality of decision making and the influence that members of the public can have on that process. Within this overall perspective are the supportive objectives of developing a shared understanding of the nature of the problem among stakeholders and the project proponents, developing a PI process that is viewed by stakeholders as equitable, and reaching a decision that is acceptable and implementable.

It seems clear that the AHS program must be able to work with a diverse collection of stakeholder groups and individuals, and that these stakeholders will actively press for an influential role in decision making on this program. AHS developers and managers should be prepared to work from the outset with stakeholders who best understand the institutional and societal context within which AHS will be sited, and be prepared to negotiate approaches and decisions about AHS conceptual development and deployment with them. AHS management must be prepared to alter decision making based in input from the PI process.

Equity Issues

Safety

The perceived equity of AHS will be a critical factor in its ultimate acceptability and implementability. Minority populations, who often are concentrated in urban cores, perceive themselves to disproportionately impacted by the adverse health and safety consequences of urban developments. Highway projects have disproportionately split their neighborhoods, marginalized businesses in their communities, and made access to the benefits of suburbanized job opportunities difficult to attain. AHS planners need to be attentive to avoid similar potential impacts from this new technology. Environmentalists have expressed concerns that entry/exit sites not unfairly burden minority neighborhoods, leading to more traffic and safety impacts. From a different perspective, concerns are being expressed that only the wealthy will have access to the important safety benefits that AHS will afford. These kinds of equity issues that have both direct and indirect implications for safety need to be addressed with sensitivity.

Costs

Questions have been raised about AHS in terms of the ability of various segments of the population to be able to afford AHS equipment (low income), to have adequate access to AHS (people without personal automobiles), or to have the requisite operating skills (elderly, disabled). Stakeholders perceive the costs of AHS to be very high, and they are concerned about who will pay. Questions have been raised about how differences in the ability to afford cars or other AHS equipment or to exhibit the requisite operating skills would affect access to the system. Additional questions have been raised about the fairness of dedicating existing lanes of the highways to AHS, thereby restricting those who choose not to acquire AHS capabilities and possibly increasing the tax burden for everyone when only some will benefit.

Benefits

AHS has the potential, depending on how it is configured and deployed, to make its benefits available to all of society. For example, if AHS is coupled with traffic demand management policies, then AHS drivers will benefit by using AHS configured lanes, and non-AHS drivers will benefit from reduced congestion in other lanes. Strategies that encourage AHS to use alternative fuel vehicles, or applications on multi-passenger vehicles, will provide direct benefits to the AHS participants and indirect benefits to society in terms of more equitable access to everyone, reduced congestion, and improved air quality, to mention only some of the more important benefits.

Public Involvement

Open and fair access to AHS decision making processes is a measure of program equity that ties in with the public involvement challenges discussed in this report. It is important to reach beyond those segments of the population who will be purchasers of AHS vehicles to those who are not likely to want or be able to afford AHS, but who stand to benefit from the broad societal advantages that AHS potentially offers. It is also important and strategic to include into a dialog about AHS those stakeholders who are skeptics or detractors. The objective is not to try to win everyone over to AHS, but rather to learn from a full range of perspectives on this technology how to enhance the benefits for as many people as possible and reduce the overall drawbacks of the technology as much as possible.

APPENDIX A

ELECTRONIC SEARCH SERVICES AND SEARCH STRINGS

Dialog Information Retrieval Service

See Folder for Appendix A -- xeroxed copies of DIALOG Files

Search Strings

The following are combinations of words and phrases that were used to locate articles containing mention of AHS:

smart or intelligent (w/ 2 words of) vehicle or cars or car or automobile or highway

avcs

advanced vehicle

advanced vehicle (w/) control

automated (w/) vehicle (w/) control

automated (w/) highway (w/) system

ivhs

intelligent (w/) cruise

automatic (w/) cruise

automatic chauffeur

intelligent chauffeur

Expanded Academic Index

The Expanded Academic Index provides indexing and abstracting for approximately 1,500 scholarly and general interest periodicals, covering all major fields of study in the humanities, social sciences, and science and technology. *Copyright (c) 1989 Information Access Company, division of Ziff Communications Company.

Search Strings

Search word combinations used in this database were:

smart (w/) car

automated (w/) highway (w/) system
smart (w/) highway

intelligent (w/) cruise

intelligent (w/) vehicle

automatic (w/) control (w/) system

automat* (w/) car

automat* (w/) vehicle

intelligent chauffeur

automat* chauffeur

avcs

ivhs

automat* (etc.) includes all words with the first seven letters = automat, such as automatic, automated, ...

APPENDIX B

DESCRIPTION OF METHODOLOGY AND CORROBORATIVE PROCEDURE

Issues that were considered either positive (possible benefits of AHS) or negative (possible negative consequences of AHS), descriptors that define what different journalists envision an AHS would be like, and evaluations of tone such as pro, con, or neutrality are mentioned as occuring in articles that also mentioned AHS. For example, 43 articles that mentioned AHS were concerned with congestion reduction. Twelve articles state that mass transit should be pursued primarily or instead of other transportation technologies. Thus, congestion relief has been more prevalent (appears 1/2 of the time) when the media has discussed AHS than preferences that favor mass transit (appeared 1/8 of the time).

It would be a mistake, however, to conclude that the media thinks that AHS is the best form of congestion relief, regardless of whether or not mass transit issues are addressed. The data do not support such a conclusion. Too few of the articles were predominantly concerned with AHS. Of the 87 distinct (non-reprint) articles, only 11 focused primarily on AHS. Of these only three were longer than one page in length.[1] Many articles mentioned AHS. For example, a series of guest editorials by Marcia Lowe were critical of AHS. Yet these were not considered as predominantly devoted to AHS; they focused primarily on ITS in general.

Another result of the corroboration process was the finding that the "descriptive issues" (those elements that describe the AHS in both "partial" and "primary" articles) did not vary significantly between evaluators. The physical descriptions: "hands off/feet off, high speed component, platooning, electrification, and sci fi references" were generally agreed upon by the reviewers of these articles. This enables the analysis not only to give information on those articles primarily devoted to AHS, but also to describe the context and physical characteristics of AHS as they appeared in all other print media references.

Systematic review of the articles also helped determine which aspects of the articles should be reported on. Some initial criteria, such as region of publication, yielded too little data to be of consequence. Other categories, such as most original articles printed by journalists, were added later in the process.

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[1] These three articles are: Goldman, Jay, "Automated Roads Called 'Inevitable' Cars May Drive Us to Work Someday", *San Jose Mercury News*, 1/7/86, p. 1C; Horine, Don, "Cars on Autopilot Likely by 2002", *Palm Beach Post*, 10/19/92, p. 1A; Zygmont, Jeffrey, "Automobility: Cars that Drive Themselves"*Omni*, April 1993, p. 38. These three discuss AHS in depth and are useful for seeing what the few most knowledgeable journalists think about AHS.

APPENDIX C

Environmental Interviews
Carey, Bill Urban Ecology, Seattle, WA
Devine, Paul Pacific Energy Institute, Seattle, WA
Fenne, Tracy Foundation for Research on Economics and the Environment, Seattle, WA
Ferrill, Mike Sierra Club, Seattle, WA
Gunby, Virginia 1000 Friends of Washington, Seattle, WA
Horn, Dianne Environmental Consulting Services Sustainable Seattle, Seattle, WA
Hurley, Peter Washington Environmental Council, Seattle, WA
Leed, Roger Environmental Attorney, Seattle, WA
Lehman, Chris Institute for Transportation and the Environment, Seattle, WA
Lippman, Roger National Center for Appropriate Technology, Seattle, WA
Ortman, David Friends of the Earth, Seattle, WA
Ostrum, Aaron Alt-Trans The Washington Coalition for Transportation Alternatives, Seattle, WA
Schullinger, Sallie Greenpeace, Seattle, WA

State and Local Interviews
Briglia, Peter ITS Program Manager WSDOT, Seattle, WA
Hallenbeck, Mark Ishimaru, John Washington State TRAC, Seattle, WA
Legg, Bill Traffic Division WSDOT, Seattle, WA
Pethick, Don Richter, Karen Cipriani, Ralph Puget Sound Regional Council, Seattle, WA
Rutherford, G. Scott Associate Prof. of Civil Engineering University of Washington, Seattle, WA
Smith, Mike Formerly Transportation Planner with PSCOG, Seattle, WA
Ulberg, Cy School of Public Affairs (also WA State TRAC) University of Washington, Seattle, WA

The following information was sent out to interviewees prior to the interview in order that they could better understand some general background information on AHS and could have some time to think about some of the issues that we wanted to discuss with them. The AHS background document was the then most current version of the description of AHS that has been undergoing continual development by Mitre and FHWA.

General Interview Protocol

We are conducting a series of interviews to discuss social and institutional issues surrounding transportation generally, and the proposed Automated Highway System specifically. Our objective is to inform our client, the Federal Highway Administration, of what issues should be considered in the pursuit of the Automated Highway Systems Project (described on the following pages).

Here are some topics we hope to explore during the interview:

Transportation Improvement

- What do you envision for the future of Seattle's transportation system?
- Do you think safety improvement and congestion relief deserve priority attention?
- If a new transportation project were to be launched in the Puget Sound area, what institutional players would have to be involved? What are their main concerns likely to be?

Environmental Issues

- What are some of the key issues of transportation policy in regards to the environment?
- What do you see as two or three of the most important transportation goals for improving the environment?
- How can transportation policy contribute to sustainable development?

The Automated Highway System

- What do you see as the major benefits of the AHS system?
- What are its major faults?
- Can you think of any ways that AHS should be structured to make it a better system? What are the most important issues that AHS should address?
- Can you fit an AHS into your vision of Seattle's transportation future?
- Would the proposed AHS have to be changed to be something that your organization could advocate? What changes would have to be made?

- Were you previously familiar with the Automated Highway Systems project and/or concepts? Do you think many other people are? Do you have a sense of their dispositions towards it?

The following pages describe the Automated Highway System (AHS) that the Federal Highway Administration is pursuing under ISTEA. We will be interested in your responses to the program.

Any recommendations of additional people or organizations would be most appreciated.

Thank you very much.

APPENDIX D

LIST OF PARTICIPANTS IN THE ADOT WORKSHOP
Phoenix, Arizona
April 15, 1994

NAME	ORGANIZATION
Agah, Manny M.	ADOT-SPMS (Special Projects Management Serivces)
Bruggeman, Dave	BRW-Phoenix
Jashua, Sarath	ADOT-ATRC (Arizona Transportation Research Center)
Jonas, Glenn	ADOT-FMS (Freeway Management System)
Macdonald, Dan	ADOT-Roadway Design Services
Lance, Dan	ADOT-Phoenix Construction (Head engineer for construction in the Phoenix District)
Manthey, Mike	ADOT-Traffic
Markovetz, Steve	BRW-Denver
Olivarez, David R.	ADOT-TOS (Traffic Operations System; Head of a freeway traffic operations center being constructed)
Parker, Dave	ADOT-Risk Management Division
Powell, Dan	ADOT-DM (District Manager; District-1 Engineer)

The following questions were developed for use in a workshop with ADOT in April 1994. The workshop discussion on institutional and societal issues was videotaped:

- How familiar is Arizona DOT with AHS? ITS?
- How would you describe Arizona DOT's current attitude toward AHS/ITS (e.g., pro, con, skeptical, agnostic)?
- How would you characterize Arizona DOT's likely interest in hosting an AHS demonstration project?
- What are the major environmental issues that are affecting transportation planning in Arizona?
- How are these issues affecting highway planning and management?
- What organizations (government agencies, interest groups, etc.) are involved in raising or responding to these issues?
- What are their respective positions on these issues?
- How have these issues been resolved?
- How would AHS "play" to the organizations with environmental interests (identified above)?
- What are the major considerations that would tend to encourage implementation of AHS in Arizona?
- What are the major considerations that would tend to impede implementation of AHS in Arizona?
- Relative to other states, is Arizona a good candidate or a poor candidate for AHS? Why?

APPENDIX E

LIST OF PARTICIPANTS IN THE WSDOT RESOURCE GROUP MEETING

NAME	ORGANIZATION
Ayres, Jerry	WSDOT, PT&RD
Baden, Brett	Battelle Seattle Research Centers
Becker, John	Battelle, Pacific Northwest Labs, Richland, WA
Brahaney, Michelle	MITRE Corporation, Washington, D.C.
Briglia, Peter	WSDOT, Seattle, WA
Burch, Skip	WSDOT, Asst. Secretary, Headquarters
Cluett, Chris	Battelle Seattle Research Centers
Earnest, Bob	WSDOT, Traffic Design/Operations, Eastern Region
Fischer, Ed	FHWA, Urban Systems Engineer, Portland, OR
Hall, Megan	FHWA, WA
Haro, Bill	Traffic Engineer, City of Bellevue, WA
Hilsinger, George	WSDOT, Traffic Operations Engineer, Yakima, WA
Hornbuckle, Chuck	WSDOT, Olympic Region
Jacobson, Les	WSDOT, NW Region, Seattle, WA
Lay, Rodney	MITRE Corporation, Washington, D.C.
Legg, Bill	WSDOT, Seattle, WA
Mitchell, Dirk	City of Bellevue, WA
Morris, Fred	Battelle Seattle Research Centers
Nelson, Howard	METRO Transit, Seattle, WA
Peach, David	WSDOT State Traffic Engineer
Swanson, Richard	WSDOT, Olympic Region
Wong, Mike	King County Public Works, Seattle, WA

Selected Discussion Questions. The participants in the WSDOT Resource Group meeting were encouraged to think about a number of questions as a way of initiating and focusing the discussions. These included:

- What are some of the potential benefits and costs of AHS, including non-monetary advantages and disadvantages?
- How might AHS be paid for? What fiscal strategy makes sense for this region?
- How can AHS be used as a "tool" that state DOTs and local MPOs can use to help address regional/local transportation problems?
- What is the likely process that might be followed in Washington State for considering AHS or other Intelligent Transportation Systems (ITS) technologies for further development and deployment?
- How would a deployment decision be made?
- Who are the key stakeholders in such a decision(s)?
- Will AHS be politically and publicly acceptable to people in this region?
- How can public acceptance for AHS be achieved?
- What are the key issues upon which public acceptance depends?
- Does AHS make sense for WA State?
- Could AHS help contribute to sustainability in our transportation system? If so, how?

A Brief Questionnaire
on
Automated Highway Systems

A meeting was held on August 30, 1994 in Seattle, WA with members of the WSDOT Resource Group to discuss the topic of Automated Highway Systems (AHS). We would like to ask members of the Resource Group a few brief questions so that we can gain a broader perspective from this group on the topic of AHS. Your responses will be helpful to us in considering how best to proceed with this very new technology in considering possible applications to Washington State. You may want to review the attached meeting report and accompanying descriptions of AHS before responding.

Note that your name will not be associated with your comments in the compiled results of this questionnaire. We are interested in the overall perspective of the Resource Group as a whole, so we ask that you be candid in your responses.

We would appreciate your completing this brief questionnaire and sending your responses by October 14, 1994 to **Peter Briglia** at MS: JD-10, or WSDOT, 1107 NE 45th St., Suite 535, Seattle, WA 98105-4631. Questionnaires also can be faxed to: (206) 685-0767. Contact Peter at (206) 543-3331 if you have any questions.

Use additional pages to respond if necessary.

1. What do you see as three (3) main benefits of AHS? Briefly explain.

2. What are three (3) main issues or concerns you have about AHS and its applicability to your organization/jurisdiction? Briefly explain.

3. Does AHS, as you currently understand it, have the potential to help you address transportation needs of your organization/jurisdiction? If so, please explain how. If not, please explain why.

4. Do you think that transportation planners and the driving public will find AHS acceptable?
   Why or why not?

5. What will it take to gain a sufficient level of public acceptance to make AHS feasible?

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[1] On the actual questionnaire that was mailed out, ample space was provided after each question for responses. It has been consolidated here to save space and to convey the intent and content of the questions.

6. All things considered, do you think AHS makes sense for Washington State? Please briefly explain.

Thank you very much for taking the time to respond. Your input will be very valuable in helping us gain a more complete perspective on Automated Highway Systems.

Your name: ______________________________

Title: ______________________________

Address: ______________________________

Phone: ______________________________

FAX: ______________________________

REPRESENTATIVE SYSTEM CONFIGURATIONS (RSC)

For the purpose of this document, the research team considered four primary representative system configurations (RSCs). Detailed descriptions of these RSCs can be found in the AHS Precursor Systems Analyses Overview Report. Only the characteristics of these RSCs relative to the research in this activity area are contained herein.

In general terms, the RSCs can be summarized as follows:

Representative system configurations.

RSC	Traveling Unit	Headway Policy	Vehicle Intelligence	Guideway Intelligence
1. Average Vehicle Smart Highway	Individual Vehicle	Uniform	Average	Active
2. Smart Vehicle Average Highway	Individual Vehicle	Platoon	Autonomous	Passive
3. Smart Pallet Average Highway	Pallet	Uniform	Autonomous	Passive
4. Smart Vehicle Passive Highway	Individual Vehicle	Independent	Autonomous	Passive

Note: [1]RSC 2 consists of three lane configuration variations, resulting in a total of six specific RSCs.

Each RSC used in this research requires a specific definition of the associated roadway configuration. Three of the four primary RSCs (i.e., 1, 3, 4) were assigned only one roadway configuration, and one of the RSCs (i.e., 2) was assigned three different roadway configurations. The result is a total of six variations of the four primary RSCs, described by their *mainline*, *AHS access*, and *separation characteristics*.

Mainline

None of the RSCs investigated in this research effort involved a roadway which is completely AHS for all lanes, with no provisions for non-AHS vehicles. However, three distinctly different mainline roadway configurations were associated with the target RSCs and considered:

1. Two lanes in each direction, with the left lane in each direction serving mixed AHS and non-AHS traffic.

2. Three lanes in each direction with the left lane in each direction serving only AHS traffic.

3. Two lanes in each direction serving non-AHS traffic and a reversible lane between the non-AHS lanes serving only AHS traffic.

AHS Access

Access to the lane in which AHS is provided can involve a variety of entry/exit designs, some of which require maneuvering through non-AHS traffic to get to the AHS lane. Others simply provide direct access to the AHS lane via an exclusive ramp system.

For the sake of this research, entry and exit facilities were addressed only at a high level to determine compatibility with roadway design strategies. The main interest in entry/exit for this effort is simply to acknowledge whether a ramp system is on the left or right side of a lane set, spacing between terminals, and whether the ramp is intended for mixed or exclusive AHS flows. Other research teams have conducted detailed studies of entry/exit facilities (Area J—Entry/Exit Analysis) and their deployment, and have documented those results in other reports.

The following AHS lane access components were considered germane to the RSCs in this research:

1. Mixed Ramps—AHS vehicle enters/exits the freeway facility by using the same ramp facilities as non-AHS vehicles. Special lanes may be provided for AHS vehicles on the ramps to facilitate check-in and check-out, but the AHS vehicle must maneuver through non-AHS lanes when traveling between the AHS lane and the ramp system.

2. Exclusive Ramps—All entry and exit points serving the AHS are provided by ramps intended exclusively for the use of AHS vehicles only and are physically located such that no maneuvers by AHS vehicles through non-AHS traffic are necessary to reach the AHS lane.

3. Transition Lane—Similar to the mixed ramp concept where AHS and non-AHS vehicles utilize the same ramps, but includes a transition lane located adjacent to the AHS lane. The transition lane is used for maneuvers into and out of the AHS lane. Traffic flow in the transition lane may be AHS only or mixed flow, and AHS vehicles must maneuver through non-AHS lanes and traffic to reach the AHS lane.

Lane Separation

The means by which separation of AHS and non-AHS traffic is accomplished is closely associated with how entry/exit may be accomplished. In terms of the RSCs considered for this research, the following two concepts were considered:

1. None—Separation of AHS and non-AHS traffic is accomplished by signing and striping only.

2. Barrier—Physical barrier used to separate AHS and non-AHS traffic streams along the length of the AHS lane.

Using these characteristics, the resulting six variations of the four primary RSCs are summarized as follows:

Global RSC characteristics.

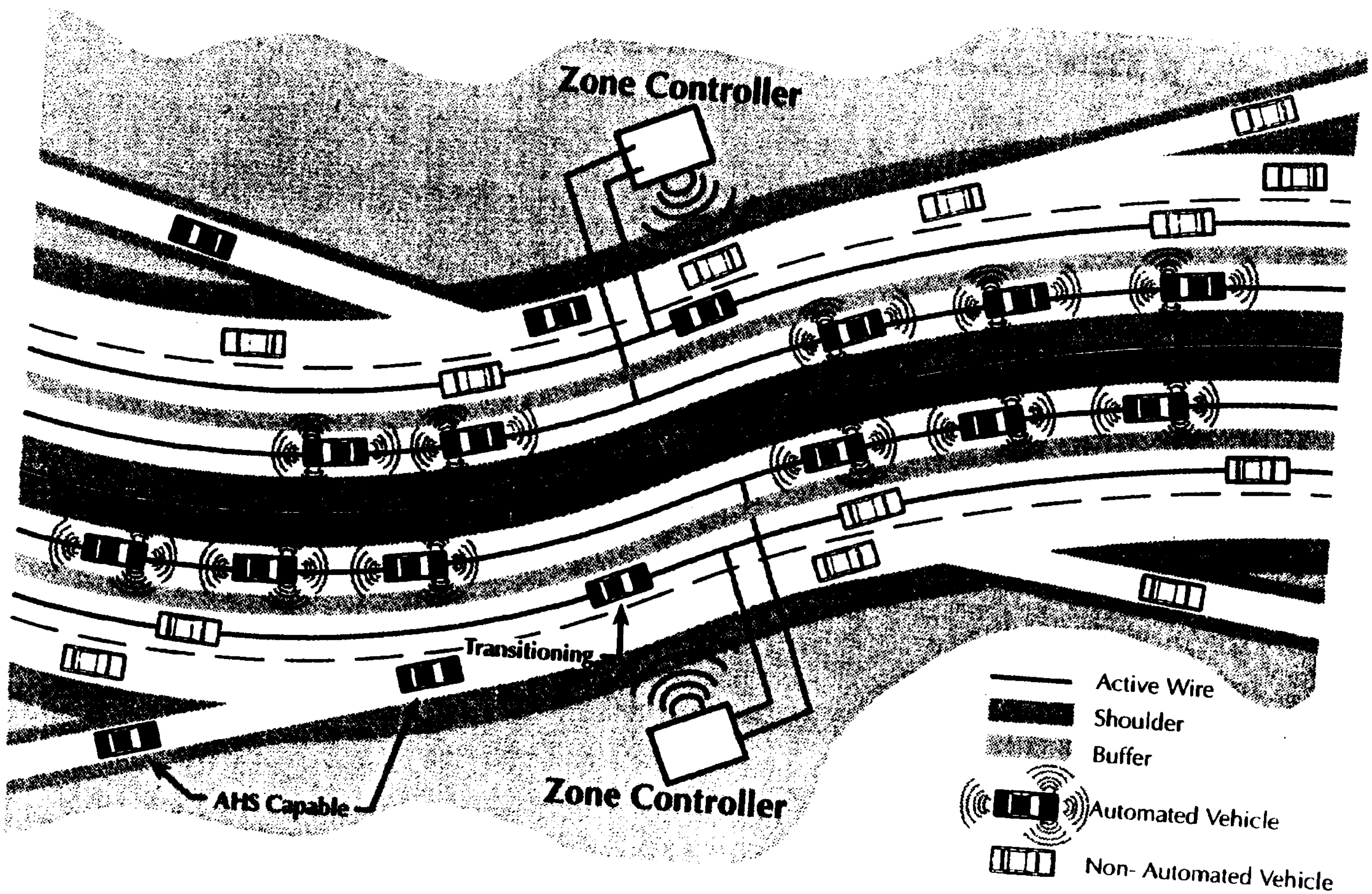
RSC	Mainline Roadway Configuration	AHS Lane Access			Lane Separation	
		Mixed	Exclusive Ramps	Transition Lanes	None	Barriers
1	3 Lanes each direction Exclusive AHS Lt. lane	X		X	X	
2A	3 Lanes each direction Exclusive AHS Lt. lane	X			X	
2B	3 Lanes each direction Exclusive AHS Lt. lane		X			X
2C	2 Non-AHS lanes each direction Reversible excl. AHS center lane		X			X
3	3 Lanes each direction Exclusive AHS Lt. lane		X			X
4	2 Lanes each direction Mixed traffic Lt. lane	X			X	

The graphics on the following sheets illustrate the general roadway configurations of the six variations of RSCs used in this research. The basic assumptions as to how each RSC would operate in summarized in Table 7. Detailed descriptions of characteristics beyond the roadway deployment characteristics may be found in the AHS precursor systems analyses overview report.

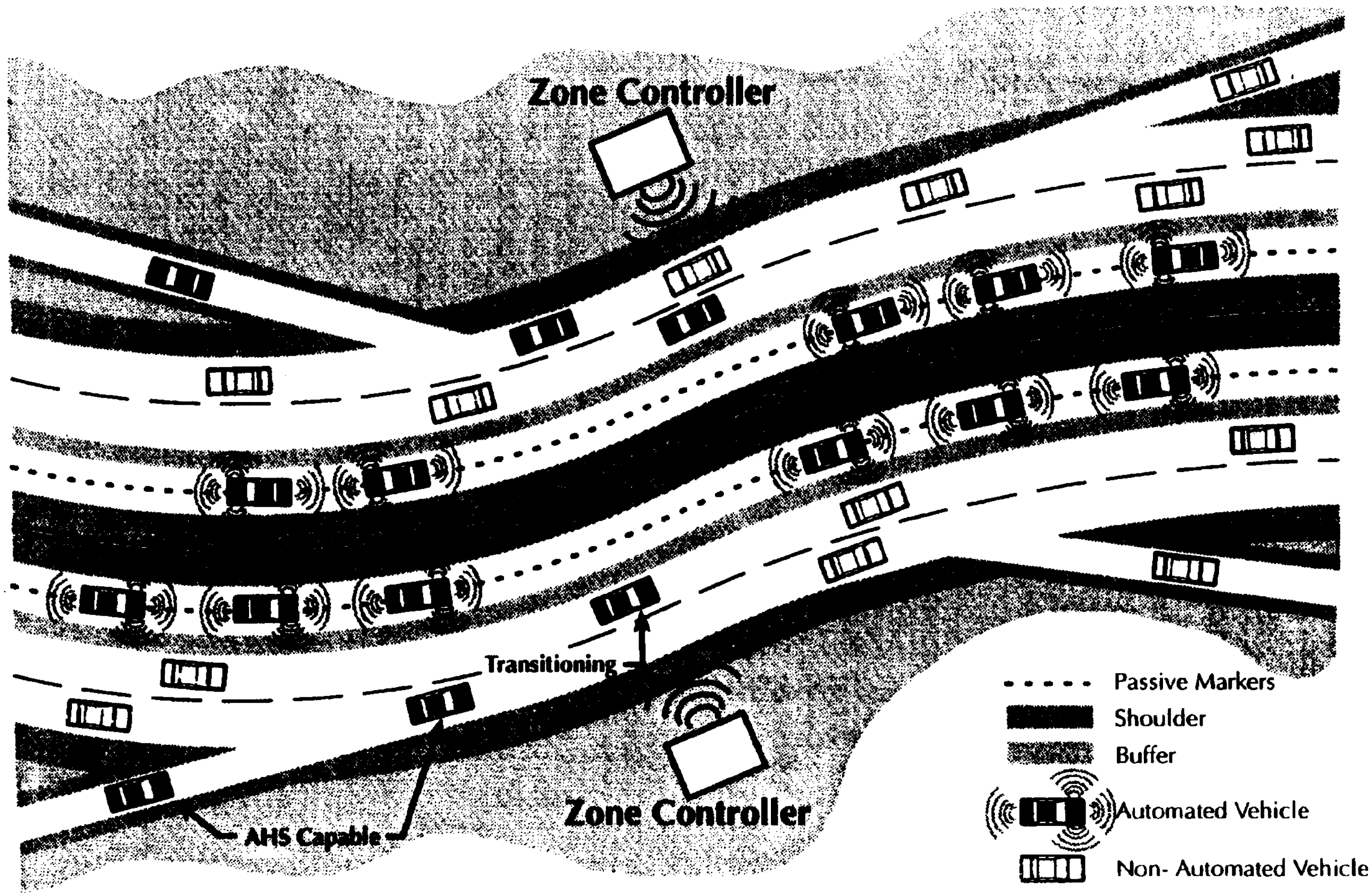
Table 7. RSC assumptions.

Parameter	RSC 1	RSC 2	RSC 3	RSC 4
Vehicle Type	Individual Passenger Car	Individual Passenger Car	Single Car Pallet, Automatic Control Only	Individual Passenger Car
Headway Policy	Uniform	Platoon	Uniform	Independent
Vehicle Intelligence	Good	Smart	Smart	Very Smart
Roadway Intelligence	Good	Average	Average	Dumb
Lane Configuration	Mixed traffic on inside AHS lane with manual traffic on outside lane	Dedicated AHS lane(s) with transition lane and manual lane(s)	Dedicated reversible AHS lane with pullover space adjacent to AHS lane	All lanes mixed traffic
Barriers	None	None	Between AHS and Non-AHS Lanes Only	None
Entry/Exit Ramps	Current Type	Current Type	Current Types for Non-AHS Dedicated for AHS	Current Type
Transition to AHS	Where: In AHS lane When: At driver command after sector control OK How: Manual switch	Where: In Transition Lane When: At driver command after sector control OK How: Manual switch	Where: In Pallet Attach & Detach Area When: Upon link to pallet How: Automatic with link	Where: In AHS lane When: At driver command after sector control OK How: Manual switch
Check-Out of AHS Vehicle Systems	Combination of periodic certification and polling of internal sensors	Combination of periodic certification and polling of internal sensors	Pallets under control of central authority—Inspected before allowing on AHS	Combination of periodic certification and polling of internal sensors
Failure to Transition Results In:	Driver must continue under manual control	Driver must continue under manual control in transition lane or re-enter manual lane	Essentially cannot fail to transition unless driver refuses to enter destination	Driver must continue under manual control

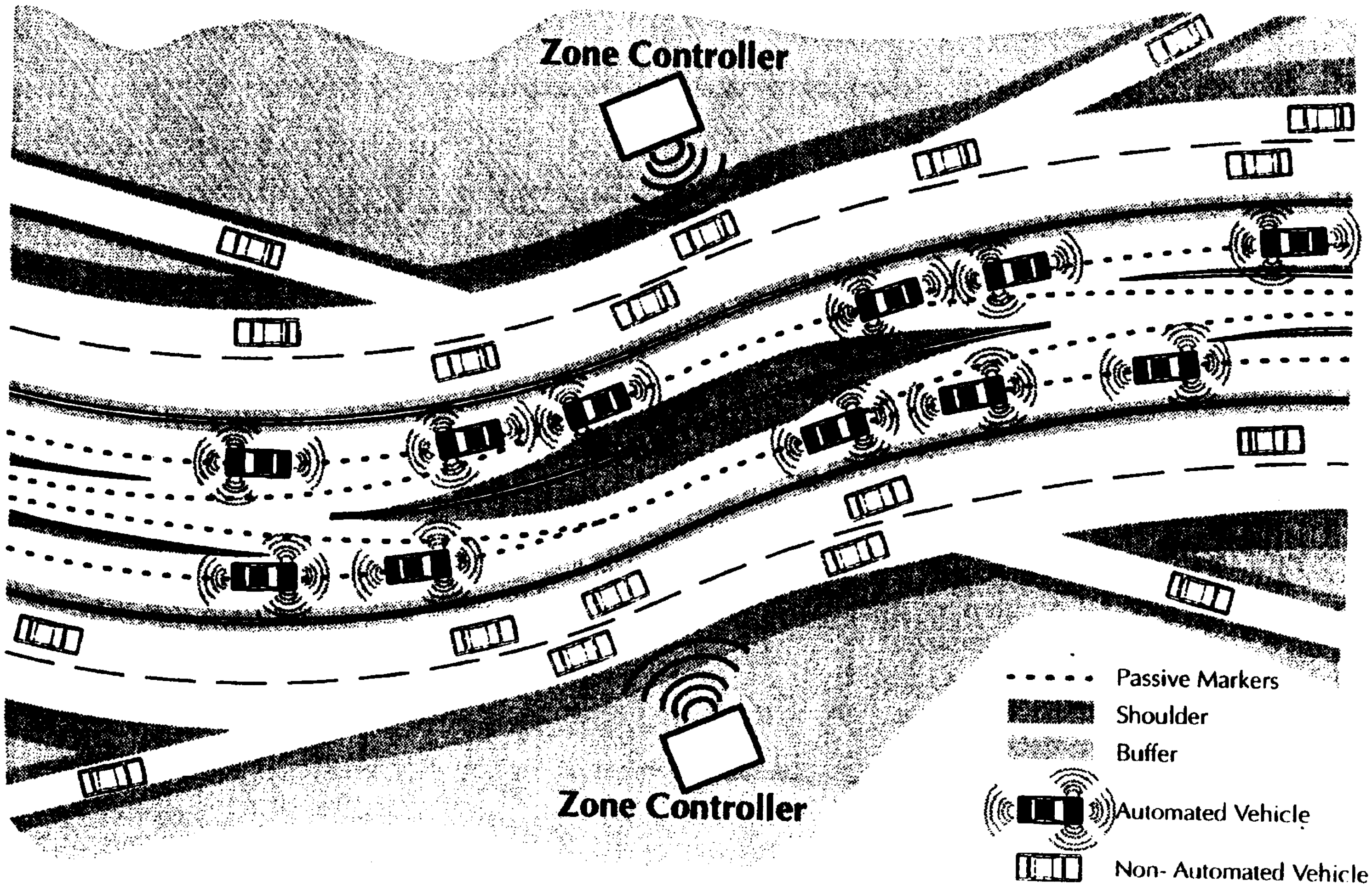
Average Vehicle/Smart Highway/Dedicated Lane/Transitions



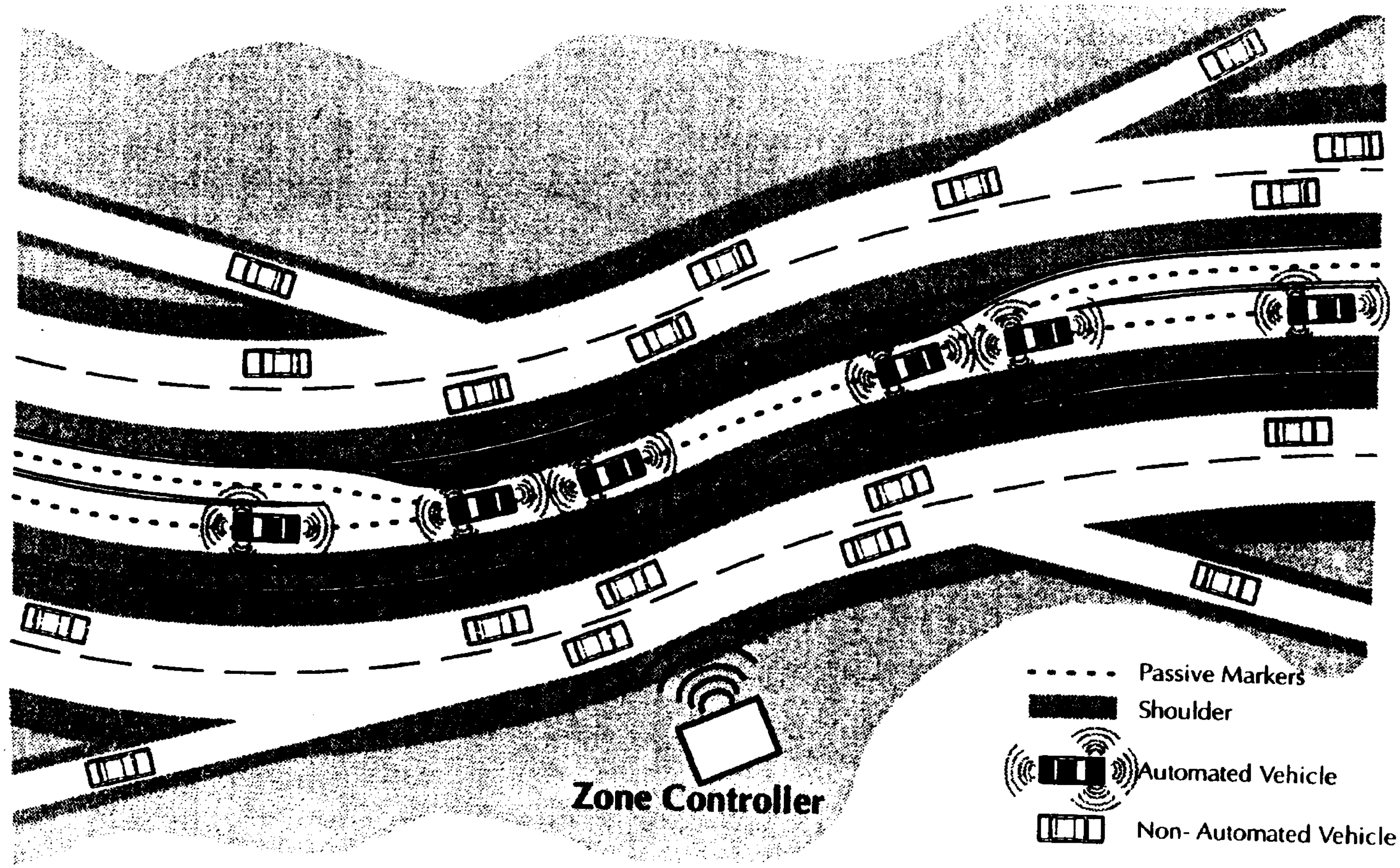
Smart Vehicle/Average Highway/Dedicated Lane/Transition



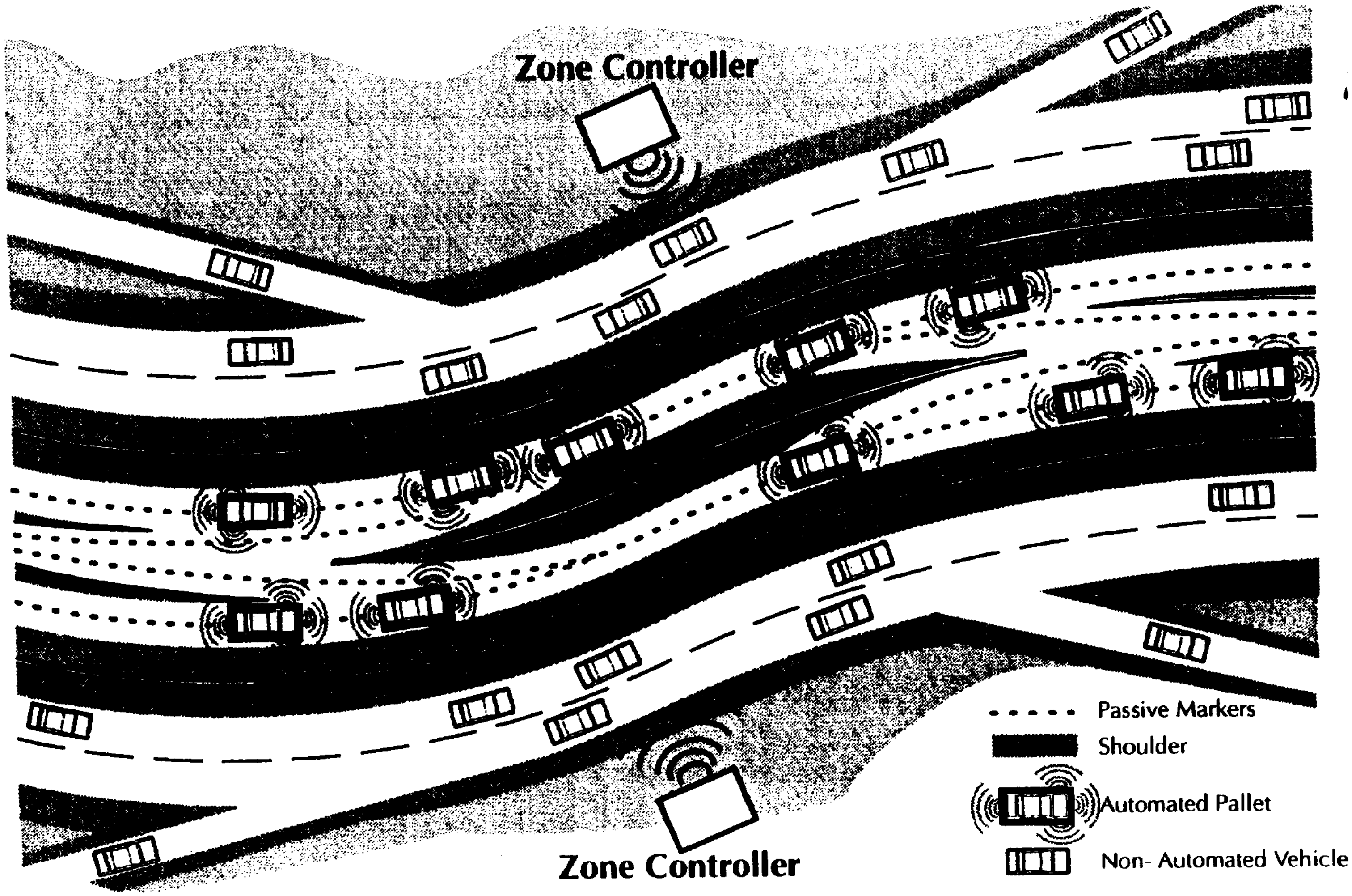
Smart Vehicle/Average Highway/Exclusive Lane/Ramps



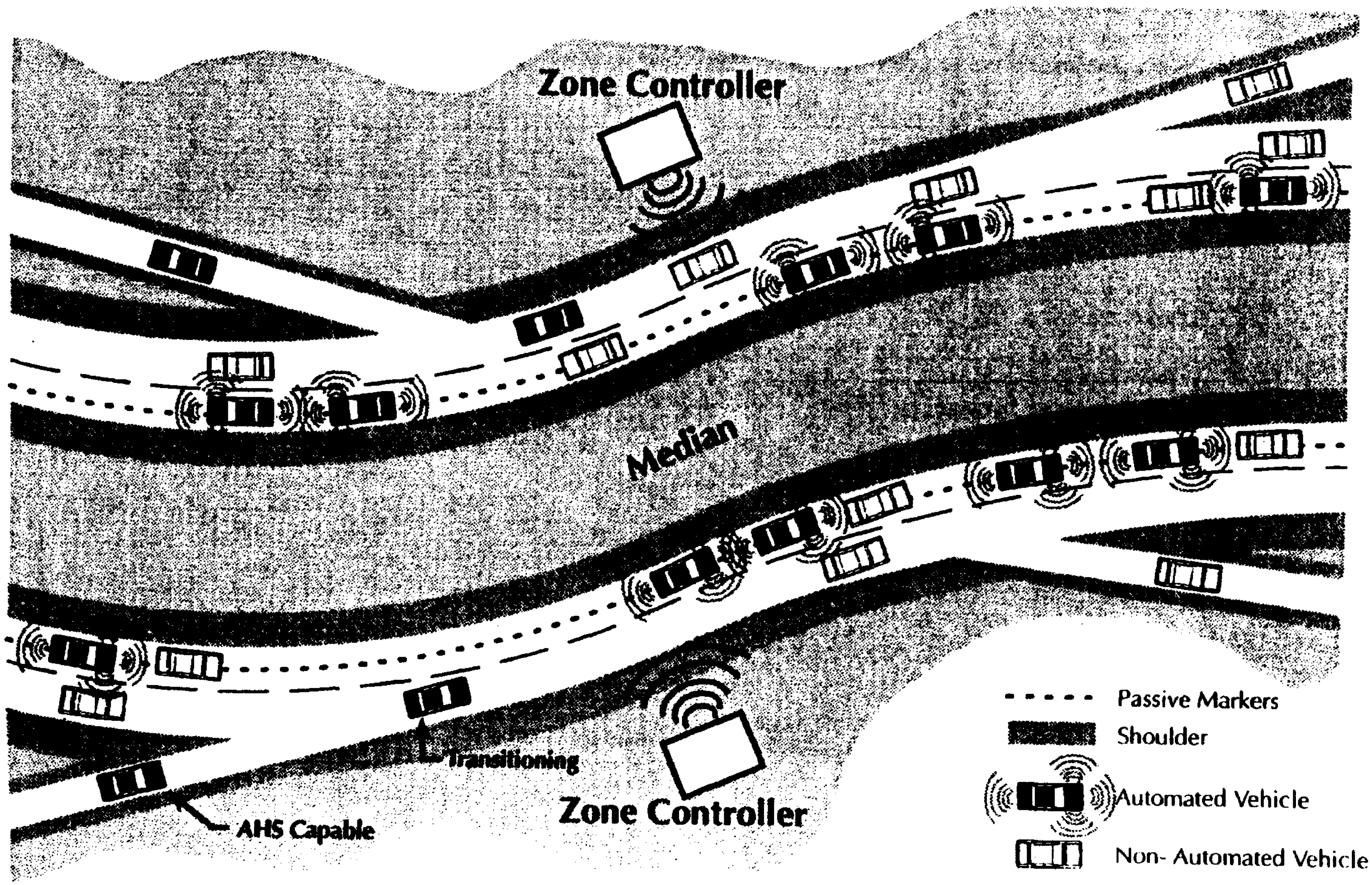
Smart Vehicle/Average Highway/Reversible Median



Smart Pallet/Average Highway/Exclusive Lane/Ramps



Smart Vehicle/Dumb Highway/Two Lane Mixed



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