A STRATEGY FOR THE IMPLEMENTATION OF THE AUTOMATED HIGHWAY SYSTEMS (AHS) FROM A PUBLIC INSTITUTIONAL AND SOCIETAL PERSPECTIVE

by

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SUMMARY

The United States has one of the best transportation systems in the world. The system is heavily dependent on the automobile. In advancing the transportation system, the automobile will stay a major part of the system. Automated Highway Systems (AHS) are the next step up for the automobile. In introducing the new system, the National AHS Consortium should sell AHS to the public. If the public does not have a good perception of AHS, the system will not be successfully implemented.

The report is divided into three sections. The first section consists of explaining the public institutional and societal issues where impediments and possible solutions to impediments will be discussed. Section two rates the issues on degree of difficulty in implementation and section three gives a recommendation for a strategy for implementation.

In recommending a strategy, all issues must be addressed to ensure implementation. The privacy of an AHS traveler has to be ensured. The driver has to be comfortable in the driving task and functioning of the car. AHS has to be designed in an open management system where public groups can input on the design. Marketing of AHS has to be well planned to ensure the public perceptions are not detrimental to the implementation of AHS.

AHS should first be implemented in a very controlled environment. An exclusive bus lane for transit purposes is the most ideal situation for this. The bus lane will allow the agencies to monitor the system very closely. At the same time, AHS should adopt an autonomous strategy, a smart car/dumb highway configuration. This configuration will allow the auto industry to gradually introduce automated vehicles. When automated vehicles become affordable for the general public, an AHS system can be built combining smart car and smart highway strategies.
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INTRODUCTION

Automated Highway Systems (AHS) through the use of automated vehicle control technology is seen as the next major performance upgrade of the United States vehicle-highway system. The AHS program component of the Intelligent Transportation Systems (ITS) is a broad national effort to provide the basis for, and transition to, this major upgrade. The long range goal of AHS is to significantly improve the safety and efficiency of the nation’s surface transportation system in a national effort that best ensures the early, successful deployment of AHS (1).

Background of AHS program

AHS is seen as the next evolutionary step of the automotive transportation system. The development of AHS in the 21st century can be compared to the interstate system of the 20th century. The interstate system today gives the United States economy an extreme advantage over other countries. With AHS deployment nationally, the United States will stay a step ahead of the world.

The evolution of the highway system to automated control may be a transition through stages of control assistance, partial control, and eventual full control. The potential performance gains for AHS are the primary reasons for AHS deployment. Performance gains include smaller vehicle headways, increased speeds, higher merging precision, and higher capacity.

Future Vision of AHS

When people envision the future, automated vehicles are in the picture. Many futuristic movies have slick rounded aerodynamic vehicles. The vehicles seem to have every comfortable convenience possible. The driver enters the car through an automatic door. He/she sits down, punches a few buttons, verbally gives a direction to the computer, and then leans back and relaxes, as his automated car travels free of human control along the streets of some futuristic city. The driver or passenger then prompts a display on a video screen to watch TV, make a video phone call, or play some video game.

The future vision of AHS is not that automated. With a prototype due out in 2001 the automated car will look much like current models. The difference between current and automated models of cars will be a few outside sensors on the car and twice the amount of on-board computers. The new automated car will be capable of interacting with the driver and respond to driver instructions.

The future roadway will differ little from today's roads. The difference will be more audio video cameras on top of signs and buildings, and tiny sensors in the road. The sensors in the road and in the cars will exchange information and direct the car along the correct path. The car and roadway will exchange information constantly while completing the driving task.
Institutional/Societal Issues

Transportation is an integral part of society in the United States. Transportation is the means by which people gain access to activities that enable them to be functioning members of society. Activities include employment, education, recreation, health care, and shopping. However, some people are restricted to certain roles or functions within a society, because of the lack of access. Figure 1 shows the interaction of transportation with the social/political/economic system. The important thing to note about the figure is the feedback arrows. Each major system has a feedback arrow back to itself, and both systems are connected by feedback arrows. This displays how the transportation system and the social/political/economic system depend on each other (2). A change in the transportation system changes the other parts of the transportation system and the social/political/economic system. Transportation is a major part of the public's lifestyle.

Figure 1. Interactions of the transportation system with the social/political/economic system (2).
Table 1. Societal factors attendant to transportation systems (2).

<table>
<thead>
<tr>
<th><strong>Access</strong></th>
<th><strong>Distribution Effects</strong></th>
<th><strong>Economic Factors</strong></th>
<th><strong>Traffic Effects</strong></th>
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<tbody>
<tr>
<td>Access of poor, young, aged, and physically disadvantaged</td>
<td>Availability of food and energy</td>
<td>Affordability</td>
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<td>Access to employment</td>
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<td>Isolation of population</td>
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<td>Non-users of system</td>
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<td>Transit Users</td>
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The implementation of AHS will have an impact on the public's social lifestyle. Any change in the public's way of functioning from the implementation of AHS needs to be studied. There are many societal factors attendant to transportation systems. Table 1 list 61 societal factors (2). In the deployment of AHS many of these societal factors will need to be addressed. The AHS Precursor Systems Analysis (PSA) Program has identified the following 16 activity areas to be studied before the implementation of AHS (one of these areas is Institutional and Societal Aspects):

- Urban and Rural AHS Comparisons
- Automated Check-In
- Automated Check-out
- Lateral and Longitudinal Control Analysis
- Malfunction Management and Analysis
- Commercial and Transit AHS Analysis
- Comparable Systems Analysis
- AHS Roadway Deployment
- Impact of AHS on Surrounding Non-AHS Roadways
- AHS Entry/Exit Implementation
- AHS Roadway Operational Analysis
- Vehicle Operational Analysis
- Alternative Propulsion Systems Impact
- AHS Safety Issues
- Institutional and Societal Aspects
- Preliminary Cost/Benefit Factors
The Institutional and Societal Aspects Area consist of the following eight sections.

- Regulatory - dealing with insurance, vehicle manufacturing, and roadway construction
- Legal Aspects of A H S - tort liability, legislative requirements and zoning
- Licensing of Operators and Vehicles - the pre-operational and real-time check-in requirements during operation
- Funding Alternatives - Federal and state deployment and operations cost, licensing fees, user fees, vehicle purchase costs, taxation, penalties for non-A H S vehicles
- Zoning and Environmental Impacts - air and noise pollution and sustainable development
- Access and Priority for Local Fire, Ambulance and Police
- Impact on Interstate Commerce
- Social Acceptance - public perception, quality of life, and market incentives

Each section looks at different aspects of A H S. Many of the sections have overlapping boundaries and are interrelated. This report concentrates on any issue affecting the public institutional and societal concerns.

Objectives

This study was to present recommendations for the deployment of A H S from the public's point of view. To ensure the success of A H S, the customers and the automotive traveling public have to be satisfied with the product. This report's objectives were the following.

1. Identify the institutional and societal issues dealing with the public about A H S. Explain why this is of importance to the public and how, possibly, the public can be comforted about their concerns.

2. Examine the public's institutional and societal issues of A H S and find the impediments to implementation and possible solutions to the problem.

3. Compare the public institutional and societal issues in the difficulty in overcoming the impediments to implementation. The public issues will be rated in a comparison of urban and rural/suburban locations, autonomous and subordinated vehicles, automobile and transit modes, and restricted and unrestricted facilities.

4. Develop a strategy to implement A H S based on location, vehicle type, mode, and facility.
Study Focus

The focus of this study was the public perceptions of AHS and the possible configurations of the automated highway system. Through a comparison of the configurations and public concerns, a recommendation of implementation is proposed. The study was designed to give some insight into how the public should be considered to ensure a successful implementation. It also explained the different possibilities in how AHS will be configured. The report was focused in this way because the public is the customer of the transportation system and the customer always comes first.

Report Study

The study produced five tables comparing how public institutional and societal issues affect the different system components. The first table contains a rating system of 1 to 5.

1. very easy
2. easy
3. difficult
4. very difficult
5. extremely difficult

The ratings are a measure of the difficulty in solving the impediments to implementation. The four other tables list positive and negative aspects of different system components as they are related to public issues. Different system components include location, mode, transit, and vehicle type.

The strategy for implementation was based on the five tables. Through an analysis of the five tables, the configuration of components found easiest to implement is recommended.

The two different vehicle types are an autonomous vehicle and a subordinate vehicle. The autonomous vehicle or smart car is empowered to direct all car motions. The vehicle will have inboard sensors to determine lane position and to detect the positions of other vehicles and obstructions. The vehicle will also contain an inboard information processing computer to receive and transmit information and respond properly to information from sensors. The subordinate vehicle or average vehicle will be dependent on the roadway for control and command functions. The subordinate vehicles would have actuators to control vehicle operations (steering, accelerating, braking, etc.) and computers to interface with the roadway control system (3).

Location is divided into rural/suburban or urban areas. This is important in the study of deployment because of the traffic in rural/suburban areas between major urban centers. The reduction of travel times between cities shows great benefits, especially for commercial trucking uses. Of course, in urban areas there is a greater need to solve traffic problems.
AHS can be deployed in two modes, the automobile and transit. The automobile is the primary mode of transport for most people. However, if AHS can be deployed in a manner that makes transit more appealing to the public, it may be more beneficial for a transit deployment.

There are two facilities, restricted and unrestricted. The restricted facility would be very similar to HOV lanes, except instead of minimum passenger requirements, the lane would be restricted to automated vehicles. The unrestricted facility would be a roadway where automated vehicles and non-automated vehicles function together.
PUBLIC INSTITUTIONAL AND SOCIETAL ISSUES

The public's view on AHS is one of the most important factors in the deployment of AHS. If AHS is going to be successfully implemented, the general public must believe that the benefits will greatly outweigh the costs of AHS. Some of the most crucial issues affecting public opinion on the deployment of AHS were divulged in some public focus groups by BDM Federal, Inc (4).

There were four focus groups. The first group consisted of attendants at an Institute of Transportation Engineers (ITE) conference. The second group were graduate students at George Mason University and the last two groups were people recruited by Global Exchange, Inc., a professional services firm specializing in conducting targeted focus groups and consumer research.

Each group had similar comments about AHS. Table 2 gives a summary on what each group considered positive and adverse features of AHS. All groups seemed to have overlapping comments on the deployment of AHS. Of course, the ITE conference group had more technical concerns than other groups. This difference is important in understanding how AHS managers address the public's concerns. The public is not going to care about the efficiency of AHS vehicles, average trip length, or any technical transportation term. They are going to be concerned about their safety, privacy, costs, and lifestyle. AHS managers should concentrate on the public's concerns when addressing the public on AHS.

Another important aspect of this study was to realize the effect AHS will have on the public. AHS will change the way people drive, people perceive, and people use the automobile. The way in which people will react now and in the future to the automated automobile is important. Hence, the reason studying public concerns about AHS was so important. Some of the most critical public and social issues are discussed in the report. The issues include privacy, driver comfort, equity, and risk perception.
### Table 2. Public Focus Groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Positive</th>
<th>Negative</th>
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<tbody>
<tr>
<td></td>
<td>User</td>
<td>Community</td>
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<tr>
<td>ITE conference attendants</td>
<td>Convenience</td>
<td>Reduce congestion</td>
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<td></td>
<td>Travel time</td>
<td>Safety</td>
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<td>Travel time savings</td>
<td>Vehicle throughput</td>
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<td></td>
<td>Access to services</td>
<td>Speed control</td>
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<td>George Mason University graduate students</td>
<td>Convenience</td>
<td>Reduced Congestion</td>
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<td></td>
<td>Time Savings</td>
<td>Lower Costs</td>
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<td></td>
<td>Fuel Savings</td>
<td>Lower Insurance</td>
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<td></td>
<td>Acess for Rural Drivers</td>
<td>Economic Development</td>
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<tr>
<td>Recruited people</td>
<td>User Friendly</td>
<td>Decrease congestion</td>
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<td></td>
<td>Safety</td>
<td>Increase safety</td>
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<td></td>
<td>Reliability</td>
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<td>Cost/effective</td>
<td>Broad based</td>
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<td></td>
<td>Convenience</td>
<td>Elderly</td>
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<td></td>
<td>Decrease insurance</td>
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<td>Recruited People</td>
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<td>Reasonable costs</td>
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<td>User-friendly</td>
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<td>Decrease congestion</td>
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The main impediment concerning privacy is the possibility of travel time and destination information leaking out into the wrong hands. The public may not want to relinquish its privacy in locations of travel to the transportation agencies. The question is will the benefits of AHS outweigh the cost of privacy. For instance, if AHS cuts travel time to work in half will this benefit outweigh the individual's concern of the transportation center knowing where a driver works.

Privacy is not just an AHS issue. The issue of privacy reaches throughout the new information society. In the Information Super Highway Age, the privacy of people may never be completely secure. Computer hackers will always be around trying to gather or steal information. AHS has to secure the support of the public by showing personal travel information is safe in the transportation operations center computer bases.

The Constitution of the United States of America protects public privacy only from the federal government, not from local and state governments. Therefore, information about persons considered as a matter of public record is provided by states and local governments. These include civil filings, court records, traffic tickets, divorce records, tax rolls, property rolls, and voter registration information. However, congress is currently under pressure to pass a "Privacy Bill of Rights" where the individual would be notified when electronic information gathering takes place. Persons would be required to give authorization that their personal information could be released. Some form of legislation concerning privacy may lighten the negative effect this issue has on implementing AHS.

Solutions

The impediment of privacy of travel trip information may be solved outside of AHS by another section of government. The ITS community believes that drivers will relinquish some privacy for improved delivery of transportation services. However, there are a few methods that can lessen the degree in which a person's privacy is invaded. One method is encryption of computer information. Through the use of code names and encoded languages, a person's travel records could be hidden from information seekers. Another method is identification on a zone basis rather than a regional operations network where information cannot travel across zones. In this scenario, vehicle trips would terminate and begin at zone boundaries. Recorded trips would be limited to individual zones where recorded trips in different zones could not be linked together. Equipping AHS authorized vehicles with electronic identification tags could be one way to minimize the risk of privacy invasions. Travel records would be kept in a computer chip on the vehicle and information concerning a prepaid debit account could be stored to allow toll charges, if used, to be deducted as the vehicle enters or exits AHS without transferring data between vehicles and a central TOC. A further method is deleting or removing vehicle location records quickly to prevent the copying of information which would reduce privacy concerns. The computer systems would simply trash or delete a travel trip as soon as a trip was completed. Public assurance, through a broad educational effort aimed at potential AHS users will be required to develop a trusted transportation information system. If the public feels less threatened as new AHS technology is introduced, the greater the possibility AHS will succeed.
Equity

A major issue in any federally funded program today is equity. When the government funds a transportation project, the project is expected to provide an equal service that all can access. Transportation is more than the moving of goods. It is how people function in society (2). Three issues of equity covered in this report are cost, use, and decision making input.

Cost

Cost is a public issue for two reasons.

1. The AHS system is going to be very expensive.
2. The government can not spend massive amounts of money if the benefits do not outweigh the cost.

Because AHS will be very expensive, the majority of the cost will pass to the consumer. Criticism will arise if AHS is only for the privileged few who can afford high tolls and expensive automobiles. If the majority of the public cannot use the system, support for AHS will dwindle. The government is under tight budgetary restraints and the front-end cost of AHS will increase government spending long before AHS is operational (6). The system has to show great benefits to justify the total cost. Now let us think about it. If a new transportation roadway is built for AHS and the public does not see great or good benefits in time of travel or safety, the public will think AHS is a big farce, a waste of taxpayer's money, and a transportation engineer's dream.

Use

Equity is an issue when it comes to the deployment of AHS in a region. When a new transportation innovation is introduced and improves the transportation service in an area of a region, the public in other areas will want the same innovation in their area of town. Therefore to please the public, AHS should not be deployed in only one area of an urban, suburban, or rural region. AHS in some form or fashion should be deployed throughout an entire region.

Another issue concerning use is the diverse groups that will be using the automated transportation systems. AHS shows promise in benefiting the elderly, the handicapped, the blind, the deaf, and other disadvantaged groups of the travelling public. The deployment of AHS has to facilitate the needs of different sections of society in some fashion.

Decision Making Input

The deployment of AHS will affect the lives of many people. Because AHS will alter the way people function in society, many stakeholders will want input in the deployment of AHS. The issue of equity is not just concerned with the distribution of costs, benefits, and hazards across a population, but is also concerned with the distribution of access to and influence on the decision making process.
Equity is the treating of all stakeholders in a project at the level which represents their stake in the project. Stakeholders are people who see themselves as having an interest in or being affected by a decision. Federally funded projects are required to listen and satisfy each stakeholder to some degree. If a certain stakeholder is not satisfied with their level of input or the results of the project, they often sue the government. To prevent lawsuits and to satisfy all stakeholders, project managers, today, are looking into a more open style of management. In an open style management, AHS managers should ask:

- Who are the stakeholders;
- How do you reach the stakeholders in an effective way; and
- Who are legitimate participants in the process of creating, designing, and building AHS?

There are numerous reasons why people have an interest in the decision making process of AHS. Stakeholders in AHS include environmentalists, safety and health experts, minority groups, income groups, future users of AHS, responsible organizations, governments, and the "silent majority (7)."

Past transportation decisions have brought great benefits to the country. However, those same decisions in later years were frowned upon because of air and noise pollution, and the segregation of communities. In the decision making process of designing the AHS system different questions need to be addressed.

- Who will benefit from the system?
- Are they the same people who will pay for the system?
- How will disadvantaged groups be affected by the system?
- How have environmental considerations been taken into account?
- How will the environmental impacts be distributed geographically and socially (7)?

Solutions

Deployment of AHS is dependent on many impediments being solved. Equality of cost, use, and stakeholder input must be displayed by AHS managers. For AHS to receive financial support from the government, the benefits clearly have to outweigh the cost of AHS. To minimize cost, the private sector should bear the brunt of AHS cost by buying automated automobiles. The different levels of government, however, will bear the cost of automated transit systems and roadway infrastructure.

Even if AHS managers minimize the cost of AHS, they still must demonstrate that the benefits of AHS out weigh the cost. An automated system should provide enough of the following benefits where AHS supporters can demonstrate that benefits really do out weigh the cost.

1. Crashes due to human error are eliminated.

AHS should have no crashes occur because of driver error or computer malfunction. The increased safety of AHS should reduce or eliminate the need for driver's insurance.
2. Increased efficiency of highway operation reduces congestion.

A H S electronic vehicle control should improve the capacity of highways by managing traffic flow efficiently. The highways should have a higher density of vehicles traveling at higher speeds decreasing travel times. Economic development will then grow because of the increased performance of the transportation system.

3. Transportation system is accessible by all.

The system should be accessible to all travelers (young, mature, elderly, handicapped and etc.). This would achieve an equality in A H S use.

Equality of use can be achieved through good regional planning and vehicle design. By planning to implement an A H S facility throughout a region and designing vehicles for any driver deficiency, all persons will have access to A H S technology. Regional planning could include A H S bus lanes, A H S H O V lanes, and A H S roadways. Deployment on a regional basis would serve the entire public of that region. However, regional deployment may not be a necessity. If the stakeholders on a certain uncongested corridor do not feel the need for an automated system, a corridor may be avoided initially. Regional deployment can be done in an urban area by deploying in all freeway corridors. Regional deployment in suburban/rural areas can be done by connecting most major cities. Access throughout a region is important, but equality of access should also be ensured to handicapped individuals through technology such as voice input for blind drivers (if a vehicle does not need a driver to steer).

Equality in decision making input is achieved through an open management style. In an open management style, managers make an attempt to satisfy all stakeholders. The manager initiates contact with all stakeholders. This creates an avenue for communication and a good working environment between stakeholders and transportation planners. Avenues may include public meetings or personal interviews. A manager will try to negotiate with stakeholders instead of imposing decisions on them. The key in this management style is the manager's effectiveness in communicating to stakeholders of how a project benefits them.

**Driver Acceptance**

The evolution of the current automobile into the automated automobile needs to occur in a way which people will accept. Full A H S deployment is many years away, and automobiles will be improved with tremendous technological advances in on-board systems. The system will be designed to improve occupant comfort, increase general safety, and reduce fuel consumption.

Future models will include improved entertainment centers, voice input/recognition devices, adaptive cruise controls, near obstacle detection systems, and smart card setups. Early emphasis must be placed on educating the driving public as to what advantages the Automated Highway Systems will provide. The advantages include increased vehicle and occupant safety, reduced travel time, environmental benefits, driver convenience, and reduced driver stress.
User Interface

The public acceptance of a new vehicle will depend on its ease in driving. If the vehicle is difficult to drive then people will shy away from using it. The automated vehicle is like any computerized interactive system. It needs to be driver/computer friendly. The driver must have easy access to all AHS communicative equipment. AHS equipment on vehicles will provide preliminary and current trip planning information. Any classification of driver whether old, young, fast, slow, experienced, or inexperienced should be able to drive the car. The driver must be able to do all functions of driving and communicating in a manner that does not increase the risk for an accident (5).

Driver Responsibility

The driver's interface with the car brings up another small issue concerning responsibility. How much will the driver be expected to do while performing the driving task? To what extent will additional skills be required to use AHS (6)? Will drivers need to be trained to react with voice commands instead of physically driving the car out of unwarranted situations? Is the driver liable in cases of accidents? If AHS happens to bring on more responsibilities, how much AHS training will a driver need (6)? How much additional driver training will be needed? Will drivers want more or less responsibility in controlling a car?

Driver Control

Driver acceptance of an AHS vehicle also depends on the amount of control a driver will relinquish. A primary reason for the fear some people have concerning air travel is that they are not in control. When AHS vehicles start traveling at higher speeds and in platoon configurations, how will drivers feel? Many people think the ideal of automated driving sounds great, but people do not know how they will act when their automated car is travelling at high speeds and in platoons with small headways. Regardless of the AHS safety record, drivers and passengers will continually have these fears of not being in control and will be reluctant to give up control of their car, a prized possession.

Minimizing driver psychological discomfort is important. People, today, give up control of their cars to other drivers. Will people tomorrow, give up their cars to computers? Do people trust their personal computer to the extent where their lives depend on the computer? Automated vehicles will require drivers to trust computers with their lives.

Solutions

The issues of driving an automated vehicle will be solved by many trials and tests. Some AHS researchers are addressing the psychological concerns of AHS driving by diversionary techniques. These tactics consist of video and audio information. Televisions, radios, compact computers and other entertainment components may be used to distract drivers away from vehicle motion. Other techniques include darkening windows where passengers of cars can not see out of the car. These techniques may work. However, techniques to get the driver up to date on where he will be taking over control of the car must also be devised.
The issue of liability is not seen as a show stopper. The overall safety of AHS is predicted to be much greater than the current transportation system. However, accidents will occur. Tort liability can be solved through tort reform. By placing caps on damage awards and limiting the terms under which punitive damages may be sought, drivers, companies, and governments will be less liable (3). From another perspective, AHS will increase highway safety and thus reduce liability for accidents in the aggregate. Many will benefit and few will lose. Institutional arrangements can be formed so that the “winners” can compensate the “losers”. Thus all participants would be better off than before (7).

Time is the answer for driver control. The older generation does not trust computers because they did not grow up with computers. As Peter Harris writes concerning ITS, “Interest in the use of ITS features involving the use of computers or computerized maps at home, work or in cars is significantly greater among younger people, reflecting their greater computer literacy.” As the younger computer generations grow older support for computer controlled automated vehicles will grow, because people will be more willing to relinquish control of their car to a computer. The most effective way, however, is to convince people of an automated cars safety through demonstrations. The AHS prototype to be completed in 2001 is a great opportunity to market the performances of AHS.

Risk Perception

People are very prone to fear. Fear is usually associated with not completely understanding or controlling a situation. Fears or perceived risks could be the most troublesome impediment AHS has to overcome. If the people fear AHS to the extent that the benefits can not overcome the fear, AHS will fail.

To determine what the public is perceiving as risks in the automated system, focus groups were held by BDM Federal, Inc. From the public groups, perceived risks included costs, equity, environmental concerns, privacy, human failure, and catastrophic occurrences. There are also future risks, risks that will develop as AHS progresses forward. When accidents or breakdowns occur on the AHS system, the media will be quick to report it, especially if it is catastrophic. The challenge to AHS’s implementing agencies will be providing constant positive reinforcement to the general public on AHS.

People react largely on their perceptions regardless of the "real" merits of a situation. If AHS is perceived to pose unacceptable safety risks, the deployment of AHS may not succeed. However, if public perceptions are factored into the design of AHS, successful deployment is much more likely. Public perceptions will determine the fate of AHS in America.

Safety Risks

The major concern of the public is who is in control of their safety. As children are greatly dependent on their parents for safety, AHS travelers will depend on the automated computer systems for safety. AHS has to overcome the travelers perceived safety risk to successfully deploy AHS.
When catastrophic accidents occur, many times it is because of human error. Errors by airplane pilots and air traffic controllers are highly publicized when airplane crashes occur. Also errors at nuclear plants by humans are publicized. The possibility of AHS having catastrophic crashes needs to be addressed. The public is aware of the many dangers new technologies face when first implemented. Mitigating the chance of catastrophic accidents occurring is a must for AHS. The safety of AHS will be under the public’s microscope for a long time (7).

Marketing

There has been little information on AHS distributed to the general public. For most people, the only way they learn of new technologies is from newspapers and magazines. Therefore, most people’s impression and opinions of AHS have significantly been influenced by the print media.

The reason the media is so important to the success of AHS deployment is the potential for sensationalism (7). If a catastrophic or fatal accident occurs on an automated vehicle system, the media has the potential to magnify the public’s risk perception of AHS through its coverage. The media is always searching for newsworthy topics that will attract a public response. When AHS is deployed the media will follow it closely. Anything remotely close to a sensational news story will be reported.

Initial articles by newspapers and magazines have described AHS in different ways. The most common description is 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. Articles also associated the electrification of cars and platooning with AHS. Some articles use the description of “trains of cars shooting down highways at 100 mph.” Benefits expressed by articles included increased safety, congestion relief, increased capacity, national competitiveness, environmental improvement, and time savings. Disadvantages included environmental degradation, increased complexity, catastrophic accidents, loss of privacy, increased sprawl, and side road impacts (7).

Demonstrable Benefits

The public has to understand the safety benefits of AHS. A successful deployment of AHS depends on the ability to demonstrate its benefits effectively. AHS must appear desirable to a full range of stakeholders. If AHS cannot display substantial performance and safety benefits, the public may not support the expense of the system. The public’s acceptance of AHS will be greatly dependent on their perception of benefits.

Solutions

The solution to the driver’s perception of safety risks is simple. AHS must perform to its expectations. With automation, crashes should be minimal and catastrophic crashes almost zero. AHS needs to have a record where persons traveling in cars are less likely to die than people traveling in airplanes. Today, it is safer to fly in airplanes than drive in cars, however people do not always perceive flying as being safer than driving. Because of catastrophic airplane crashes and the related media attention, people think of plane traveling as being risky. AHS needs more than good performance records to minimize safety risks. AHS’s positive performance records need to be heavily marketed to the public.
The media has a large influence on the general public. For this reason, transportation officials need to aggressively work with the media and constantly provide the media with consistent, comprehensive information that reflects AHS’s current plans and thinking about. Officials cannot allow the media to make their own conclusions from misinformation about AHS. AHS managers must clear up any misinterpretations and successfully articulate the truth about AHS. The media will be a huge asset if AHS managers can forge a successful relationship.

Jeanne Janes writes, “Citizens need to be sold on the idea of spending millions of dollars to manage the traffic in their respective communities. They need to understand the benefits of traffic management.” This selling approach was used in San Antonio for TransGuide and can be applied to AHS. There are four lessons to be learned from TransGuide which can be applied to AHS. The first lesson is to be proactive. Those who know about AHS should tell the good news and the bad news for that matter) before the media gets its own story. Second, proponents of AHS should remember to influence the influentials. They should make sure government and transportation leaders in states, cities, counties, and towns are informed and updated. Third, simplify the concept and orchestrate messages so as to speak with one clear voice. The stakeholders do not need to know how to build a system; they simply need to know how AHS will affect them. Fourth, advocates need to remain flexible to take advantage of opportunities no one could foresee at the start of the project.

In proposing the deployment of automated roadways, AHS proponents must demonstrate the benefits of an automated system. A well developed prototype is the one answer. A prototype will be a visual aide in showing the public how safety will be improved. By demonstrating the benefits of AHS in the event of crashes, the prototype will be very helpful in minimizing the public’s fear of computer controlled cars. The greater the safety benefits of AHS, the greater support it will receive.

The best solution is time. Time will allow the majority of the public to trust computers. The public’s attitudes toward computers will change when computers become a staple in life. Automated cars have to coincide with automated appliances. When people get used to smart machines in their house they will be have an easier time trusting computer driven cars.
FINDINGS/RESULTS

Public institutional and societal issues will be a major impediment in the deployment of AHS. In the deployment of AHS certain issues will be harder to overcome than others. Table 3 gives a measure of comparison between different public issues and system components. The ratings in Table 3 are a subjective judgment based on the public issues and system components addressed in the report. The ratings are not based on any empirical data. Table 3 contains a rating system of 1 to 5, as mentioned before in the report.

1. very easy
2. easy
3. difficult
4. very difficult
5. extremely difficult

Table 3. Comparison of Public Issues to System Components.

<table>
<thead>
<tr>
<th>Issues</th>
<th>Impediments</th>
<th>Vehicle Type</th>
<th>Location</th>
<th>Mode</th>
<th>Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Autonomous</td>
<td>Subordinate</td>
<td>Urban</td>
<td>Rural/sub-urban</td>
</tr>
<tr>
<td>Privacy</td>
<td>Protection of Personal Travel Data</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Equity</td>
<td>Cost</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Use</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Decision Making</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Driver Acceptance</td>
<td>User Interface</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Driver Responsibility</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Driver Control</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Risk Perception</td>
<td>Safety</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Marketing</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Demonstrable Benefits</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

In recommending a strategy for the implementation of Automated Highway Systems (AHS), Table 3 is used as a reference in determining where to initiate deployment. Through the examination of Table 3, the public issues from the most difficult to the easiest are found to be risk perception, equity, privacy, and driver acceptance. In comparing the public issues to the different alternative system components, the implementation process will be determined.
**Vehicle Type**

There are two vehicle types in this study, autonomous and subordinate (Table 4). The autonomous or smart car is going to have more automated equipment on-board. The subordinate car or average car will be dependent on the roadway system for control and command functions.

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Autonomous</th>
<th>Subordinate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automation in Car</td>
<td>Higher Cost</td>
<td>Dependence on Roadway System</td>
</tr>
</tbody>
</table>

A successful implementation of AHS is not going to hinge on whether the vehicle is an autonomous or a subordinate vehicle. The type of automated vehicle selected for implementation will not significantly matter in the public acceptance of AHS. The public is going to be very interested in the new technology of automated cars regardless of the vehicle type. The one difference between smart and average cars is the location of control. An autonomous car will keep driving control inside the car. This may feel more natural or familiar to drivers when driving. People may feel they have more control because the majority of automated equipment will be in their automobile. They will feel more comfortable because they are in fact more responsible for their safety. Drivers would have to maintain the automated equipment in their cars. With a subordinate car, the drivers would have to rely on the people who maintain the roadway system.

**Location**

Urban and suburban/rural locations are considered in this study (Table 5). The obvious difference between the two locations is the difference in populations. An urban area is going to have more stakeholders to appease in the design of an AHS facility. An urban area also has more transportation problems such as congestion, air pollution, and urban sprawl. Therefore, citizens of urban areas would be more likely to support proposed improvements to the transportation system of their city.

Rural/suburban locations along the existing route of freeways between major cities have a few advantages over the urban areas in the implementation of AHS. One advantage of rural/suburban locations is less daily traffic. The less traffic a roadway has the less an AHS vehicle will have to maneuver. In addition, rural/suburban locations usually have longer trip lengths which support less driving maneuvers. The design of an AHS facility will be less complex because rural/suburban areas do not have complex interchange designs as would urban centers.
Table 5. Comparison of Locations.

<table>
<thead>
<tr>
<th>Location</th>
<th>Urban</th>
<th>Rural/suburban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater Population</td>
<td></td>
<td>Less Traffic</td>
</tr>
<tr>
<td>More Stakeholders</td>
<td></td>
<td>Longer Length Trips</td>
</tr>
<tr>
<td>Bigger Demand for Improved Transportation</td>
<td></td>
<td>Less Complicated Design</td>
</tr>
</tbody>
</table>

Mode

Mode is a big issue when thinking of implementation. The big difference between transit and the automobile is the affordability of the automated system to low income groups. Transit is seen as the option which allows any income level traveler to use the automated highway system. If a lane of a freeway was dedicated to strictly automated vehicles, only the wealthy could afford cars necessary to travel on the road. This would only be acceptable if the benefits, such as reduced congestion, to those still in the conventional freeway are sufficient and appreciated. As Joseph Elias writes, "It would be hard to conceive of a politically acceptable way to dedicate an existing lane for the faster movement of privileged private vehicle operators." Less conflict would probably be generated in the creation of a bus lane where all income levels could afford the system.

Table 6. Comparison of Mode.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Transit</th>
<th>Automobile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affordable to Low Income groups</td>
<td></td>
<td>Consumer Pays for Automation</td>
</tr>
<tr>
<td>Privacy is protected</td>
<td></td>
<td>Greater Traveler Comfort</td>
</tr>
<tr>
<td>Give control to Bus Driver</td>
<td></td>
<td>Love of A utomobile</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Entertainment Equipment</td>
</tr>
</tbody>
</table>

Another concern where transit is more beneficial than the automobile deals with privacy. A person's privacy is protected when riding transit because he or she does not have to be identified to ride a bus. He or she merely needs to pay for the transit service. In an automobile, a person may be required to divulge information on the recent inspection of AHS equipment, the pre-planned trip route, and their driver license information.

People naturally give control of driving to the operator of a transit vehicle. The difference in an automated system is the driver of the transit vehicle will give their control over to an automated control system. The public will feel uncomfortable in giving the control of driving their own vehicle over to a computer. The driver when not driving will still feel he is responsible for the driving task.
The advantages of the automobile have to with driver comfort. The automobile will probably provide a more comfortable ride with better seats, plus the automobile will have better entertainment equipment in radios, computers, and televisions. People love their automobiles and will want automation in automobiles.

Facility

The big difference between a restricted and an unrestricted facility is demonstrable benefits (Table 7). A restricted facility will allow automated cars to travel in platoon formations which would increase the capacity of lanes. Higher speeds would also occur in a restricted facility because there would not be any nonautomated cars traveling at slower speeds.

<table>
<thead>
<tr>
<th>Facility</th>
<th>Restricted</th>
<th>Unrestricted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher Speeds</td>
<td>Mixed Traffic</td>
<td></td>
</tr>
<tr>
<td>Platooning</td>
<td>More Maneuvers</td>
<td></td>
</tr>
<tr>
<td>More controlled system</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In a restricted facility the driver will feel more secure because of the automated environment. The automated car will be in a restricted facility with other homogeneous automated cars executing the same driving task. In an unrestricted facility, the driver will feel uncertain about their safety and the car's capability to perform the driving task. Because of the uncertainty of computer driving decisions, the passenger of the automated car may feel apprehension in the car's capability of detecting unusual and unsafe maneuvers.
APPLICATION OF RESULTS

The initial stages of AHS deployment should occur in the following way.

1. Automobiles, trucks, and buses are gradually upgraded to the state of automated control.

   The current automobile will gradually turn into the automated automobile. Over a period of 20 to 50 years, the current vehicle should be upgraded. Some of the features proposed to be introduced in the Buick XP2000 (a vision of a car in the 21st century) include eight air bags, a remote entry system, "Heads Up" display on windshield, voice input/recognition devices, adaptive cruise controls, near obstacle detection systems, and smart card setups.

   Through a gradual upgrading of vehicles, the public or customer will be introduced to computer interaction equipment over a period of years. The public must first get accustomed to traffic management information devices in the car, adaptive cruise controls, and obstacle detection systems. When the automated vehicle is introduced to the market, the public will be ready to accept and trust the computer automated controlled vehicle.

2. AHS bus lanes should be deployed in selected congested corridors of urban areas. This is before the car becomes the automated car.

   In a congested corridor of an urban area, where there is limited room for the addition of new freeway lanes, an automated bus lane is appropriate. The main reason AHS should first be deployed as a bus lane is because of equity. If an AHS lane was deployed first just for the privileged few who could afford new automated vehicles, major public opposition from low income groups may surface.

   A transit system's service would improve from the benefits of AHS. Because of an increase in traveling speeds, the traveling times on buses would decrease. This would give the commuters more reason to ride transit. If a substantial number of riders switch to transit, congestion on the main lanes of the freeway would decrease.

   The automated bus system would also provide an avenue for AHS proponents to show how an automated system would operate. A bus lane would give AHS proponents a visual aide to show the public that an automated system is indeed very safe. If the automated bus lane operated over a period of time without any automated breakdowns or any catastrophic accidents, the proponents could boast that an automated highway system could function better than the current system in areas of traveling speeds and traveler safety.

3. Construction of automated facilities begins.

   The construction of automated facilities should be a natural process. Freeways should naturally be changed into automated roadways as routine reconstruction takes place. The ideal is to build automated lanes in a way where they can be switched from general use lanes to automated use lanes very easily.
An automated lane should not cost much more than a regular lane. Building automated roadways will be paid for by the government through federal, state, or local transportation agencies. Automated roadways would require putting in some type of lane sensor in the current roadways if automated cars can not travel simply off of lane markers.

4. Autonomous automated cars start to be sold as construction of a substantial automated roadway network nears completion.

The automated cars should be smart cars. The cars should have the majority of the automated equipment on board. In this deployment the cost of the automated system would be paid for by the buyers of automated cars. The cars will be expensive at first. In addition to automated features cars will be equipped with ITS information devices for traffic management. The ideal is for the automated equipment to be on-board the car where it can travel simply by sensing lane markers in the roadway and sensing locations of adjacent cars.

Automated cars should start to be sold several years before the opening of an automated roadway system. It is important to have a substantial automated car base before the opening of automated roadways. When the automated roadways are opened, the roadways need to be used. Motorist need to be ready to use automated roadway before the opening. If the roadway is not used from day one complaints from non-users may occur.

5. Automated roadways for automobiles should be introduced in rural/suburban freeway locations between two major urban centers.

The location of the first automated roadways should be in long stretches of roadway where trips are of substantial length. The new automated roadway could be a restricted lane or an unrestricted lane. Preferably, the roadway would contain a restricted automated lane. A restricted lane would be more beneficial for its users. The unrestricted lane roadway would be used in locations where an additional lane could not be added or where a lane could not be dedicated for automated use. These automated roads would also be available for commercial truck uses.

The reason for deploying an automated system in a rural/suburban area first over an urban area is simple. One, a rural road network would be easier to construct. There would not the complicated interchange designs and opposition would be minimal. Two, the initiation of the driver into automation will be easier on long stretches of roadway where the vehicle simply follows the lane. The driver would feel more comfortable because of the elimination of lane changes on a restricted facility and minimal lane changes on an unrestricted facility. The driver's perceived risk would be less on a rural/suburban facility.

6. The opening of automated roadways in urban freeway corridors occurs as a substantial part of urban automated roadway system is complete.

The opening of urban freeway facilities should occur when a driver does not have to shift out of automated control each time he changes freeways. In an urban area once a motorist enters automation on a freeway, he or she should not have to leave automation until exiting the freeway system. One reason is to ensure regional deployment. Another reason is automation is supposed to simplify the driving task. Switching between automation and non-automation may complicate the driving task or people may not like switching between automation and non-automation frequently.
7. As demand increases on system, automated lanes are added to existing automated roadways. When automated lanes reach their capacity, additional lanes will be needed. Automated roadways need to be metered to eliminate congestion. Automated vehicles on an automated roadway system should always be traveling at high speeds to ensure benefits like shorter trip times.

8. Automated roadways are deployed in urban and rural arterials, collectors, and locals due to the natural growth of system. This stage of deployment will occur in the far, far future.
RECOMMENDATIONS

The main impediment in AHS deployment will be public perception. Public perception of AHS's vision will be important in the planning of automated roadways. The vision of what AHS will be in 100 years needs to be addressed. There needs to be a futuristic vision of major urban population centers and rural/suburban areas. This question raises the issue of how AHS is going to affect the development of cities. What do the federal, state, and local governments want cities to look like in 100 years?

The problem extends from the current system. When the freeways were started to be built no one knew the consequences this would lead to. Suburban sprawl was not foreseen as a problem. The concern of the public is what will AHS produce? Will AHS add or solve the current problem, and what problem will AHS bring in the future? AHS may not be a solution to the problem of today, but can be part of a new future transportation plan for the 21st and 22nd centuries.

The current automobile transportation system is like a company looking into the future and understanding changes have to be made. Changes that will help it adapt to a new and changing world. The main problem is seeing the changes through and not letting roadblocks get in the way. Convincing the transportation field that AHS is the wave of the future will be a great task. For the transportation agencies are the ones who will be selling AHS to the public. There are going to be many transportation engineers who will question changes need to be made. The answer is the United States has to stay ahead of or equal to the rest of the world in transportation. A good transportation system gives the economy a good functional working environment.

The first key in changing a company is creating a new vision and a new goal. The goal of the AHS program is to provide the basis for, and transition to, the next major performance upgrade of the U.S. vehicle-highway system through the use of automated vehicle control technology. The final goal for the distant future is to completely restructure the automobile system into an automated automobile system.

The vision is what AHS has to be sold on. Solving individual issues is nice, but a final vision of a complete automated system showing great benefits is the key selling point. A vision will give the public a perception that the AHS program is planning ahead for the 21st and 22nd century. A vision will also give a more realistic vision of AHS to public instead of letting the media make up stories.

The vision of AHS should answer the questions. How big will cities grow? Do cities need to plan for more than just an AHS system? Do cities need to change transportation planning to deal with problems, such as urban sprawl? Do we need to reduce the current use of the automobile? Does the introduction of ITS and especially AHS need to coincide with a huge movement to change the perception of transportation? Do we need to convince people to live closer to work? These and many other questions need to be addressed.

Marketing of AHS needs to be occurring. No matter how much the public knows, they will question the benefits of the system. Marketing through education, the media, and AHS proponents is important in answering the public's questions.
A prototype should be built as a complete roadway system to be used in the marketing of AHS. The prototype cannot be a small one road system. To examine the effects of automated vehicle control in detail, the prototype must be a complicated system. The prototype must examine freeway travel, arterial travel, and local travel for the automated vehicle. The prototype should be used as the initial centerpiece in marketing AHS. If the public is impressed with the prototype, their perceptions will be positive on what AHS can provide them in the future.

Much research is needed in human recognition of giving control of the car and their lives to computers. Research that deals with how the automated car will react with the driver.

A study needs to be performed on how to positively teach people to use AHS equipment and how to drive an automated car. People like things that are easy to use. If learning how to drive an AHS car is easy, the drivers are more inclined to like the system.
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