AN OVERVIEW OF AUTOMATED HIGHWAY SYSTEMS (AHS) AND THE SOCIAL AND INSTITUTIONAL CHALLENGES THEY FACE

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BACKGROUND AND INTRODUCTION

The idea of automated driving dates back more than 50 years, when General Motors (GM) presented a vision of “driverless” vehicles moved under automated control at the 1939 World’s Fairs in New York.[1] In the late 1950s, research by industrial organizations conceptualized automated vehicles controlled by mechanical systems and radio controls. After the first appearance of computers in the 1960s, researchers began to consider potential uses of computers to provide lateral and longitudinal control and traffic management. The fully automated highway concept was initially examined by GM with sponsorship from U.S. Department of Transportation (DOT) during the late 1970s. In this period, the focus was placed on automated vehicles operating on a highway, because the computers were not powerful enough to consider a fully automated highway.[2]

Advances in computing technologies, microelectronics, and sensors in the 1980s provoked commercial interest in technologies that might enhance driver capability and perception, and both public and private sector researchers examined partially automated products and services.[3] Among others, the University of California Partners for Advanced Transit and Highways (PATH) program has carried out significant research and development efforts in highway automation since the 1980s. As various advanced transportation technologies emerged that could assist driving, on one hand, and enhance traffic efficiency, on the other, interest in fully automated driving – or integrated auto-highway technologies – grew once again.

With the passage of the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA), efforts were focused on early prototype development and testing of fully automated vehicles and highways. The Act prompted the U.S. DOT to establish the National Automated Highway System Research Program (NAHSRP), whose goal was to develop specifications for a fully automated highway system concept that would support and stimulate the improvement of vehicle and highway technologies.[4]

In late 1994 the U.S. Department of Transportation launched the National Automated Highway System Consortium (NAHSC). This consortium was comprised of nine major categories of organizations, including academia, federal, state, regional, and local government, and representatives from the vehicle, highway, electronics, and communications industries. The consortium attempted to expand the program’s expertise and resources, and believed that the collaborative approach among stakeholders would be

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[1] Lay, Rodney K., Gene M. McHale, and William B. Stevens. *The U.S. DOT Status Report on the Automated Highway Systems Program*. Working Note 95W0000093. Mtretek Systems, Center for Telecommunications and Advanced Technology. McLean, Virginia. July 1996. pg. 2-10.
[2] ibid.
[3] *National Automated Highway System Research Program: A Review*. TRB Special Report 253. Transportation Research Board, National Research Council. National Academy Press. Washington, D.C. 1998. pg.15.
[4] ibid. pg.63.

critical in building the common interest that would be required for the early development and deployment of fully automated highway systems.[5]

However, following the passage of TEA-21 in 1997, U.S. Department of Transportation withdrew financial support from the National Automated Highway System Research Program (NAHSRP), the systematic, long-term research on Automated Highway System (AHS).[6] This decision was the result of both a shortfall in research funds and the shift of U.S. DOT's priorities to promoting adoption of near-term, safety-oriented technologies. In spite of the decision that the NAHSRP could not be continued, a review[7] conducted by the Transportation Research Board (TRB) concluded that the creation of the consortium was an innovative approach to meet the nation's long-term highway capacity and safety needs, and that highway technology would be crucial to meeting these needs.

Many studies on the technologies performed by National Automated Highway System Consortium (NAHSC) are now partially continued in a couple of federal programs such as the Intelligent Vehicle Initiative (IVI) with more focus on a nearer-term horizon. The Intelligent Vehicle Initiative emphasizes in-vehicle technologies that could be a potential means for increasing safety and reducing urban congestion over time, with the goal of achieving more sustainable transportation. In addition, these vehicle control and safety technologies are regarded as potential steps to deploy and implement a fully automated highway system in the future.

However, significant barriers to the introduction and commercialization of these innovative technologies remain. The loss of federal funding for systematic long-term research on automated highway systems is a problem, since significant investment in research is needed to overcome technical challenges and design implementation strategies.. Although the current short-term research is making great advances in vehicle control system technologies, comparatively little attention is being given to the larger systems issues such as implementation pathways, public acceptance, financing, and so on.

The National Automated Highway System Research Program (NAHSRP) had attempted to overcome barriers in introducing automated highway system and technologies. However, the program was not successful in reaching a meaningful consensus among stakeholders on what future highway technology will be or how new technologies should be introduced. With no clear picture of the future technologies, the social and economic consequences of highway automation remained murky, and made it even more difficult to reach agreement on what to do next. This lack of consensus on the key issues eroded support for the full implementation of an AHS in the near term

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[5] ibid. pg.64.

[6] *Surface transportation: the Department of Transportation Proposes significant changes to its Automated Highway System program*. GAO/RCED-97-177R. U.S. General Accounting Office. Washington, D.C. 1997.

[7] *National Automated Highway System Research Program: A Review*. TRB Special Report 253. Transportation Research Board, National Research Council. National Academy Press. Washington, D.C. 1998.

With this history as background, in this paper I review past and current efforts toward developing automated driving technologies. I examine in particular the imlementation issues and the problems that National Automated Highway System Research Program (NAHSRP) has experienced.

In the following section, I will describe the characteristics of AHS and the AHS-related federal vehicle and highway technology programs. I will then discuss about the problems of National Automated Highway System Research Program (NAHSRP) with the aim of pointing out non-technical barriers to deploy the system and implementation dilemma facing this technological innovation oriented program. The last part of the paper will address specific non-technical barriers with an emphasis on liability issues raised by automated highway proposals and constituent technologies.

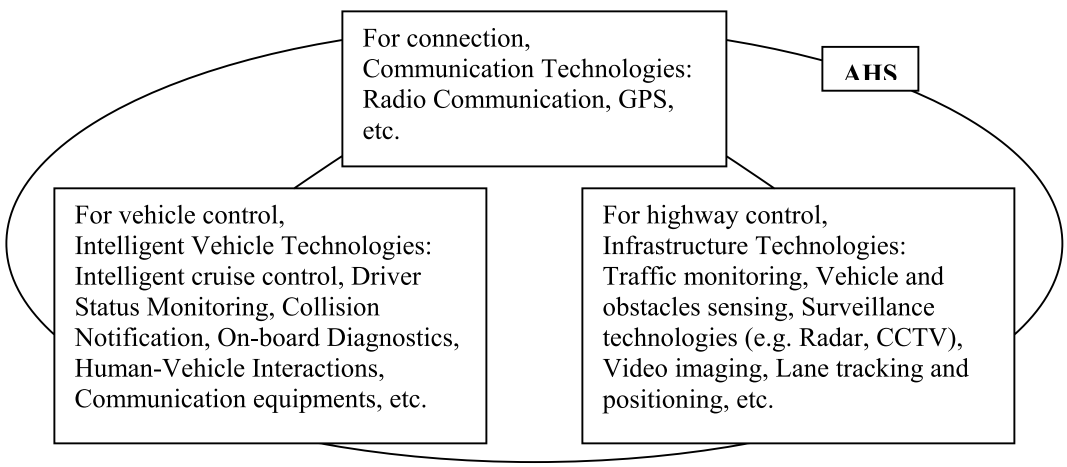
OVERVIEW

What is an Automated Highway System?

The Automated Highway System (AHS) concept defines a new relationship between vehicles and the highway infrastructure. AHS refers to a set of designated lanes on a limited access roadway where specially equipped vehicles are operated under completely automatic control.[8] AHS uses vehicle and highway control technologies that shift driving functions from the driver/operator to the vehicle (Figure 1). Throttle, steering, and braking are automatically controlled to provide safer and more convenient travel. AHS also uses communication, sensor and obstacle-detection technologies to recognize and react to external infrastructure conditions. The vehicles and highway cooperate to coordinate vehicle movement, avoid obstacles and improve traffic flow, improving safety and reducing congestion. In sum, the AHS concept combines on-board vehicle intelligence with a range of intelligent technologies installed onto existing highway infrastructure and communication technologies that connect vehicles to highway infrastructure.

[8] Rillings, Jim. The National Automated Highway System: Cooperative Program. National Automated Highway System Consortium. February 1997. pg.4.

(Figure 1) Diagram: The concept of AHS technologies



The System Concept and Technologies

Concepts of Automated Highway System (AHS) can be classified into two groups, partially automated systems and fully automated systems, depending on the extent of the automation. Partially automated systems include notification and warning systems, temporary emergency controls and continuous partial controls, which take limited control of the vehicle in emergency situations. They automate certain routine parts of driving but rely on manual control for most driving functions.[9] Fully automated driving would let drivers be totally disengaged from all driving tasks.

The National Automated Highway System Consortium (NAHSC) defined several alternative AHS concepts, from cooperative to fully automated, depending on the degree to which vehicles and infrastructure work together. Table 1 shows these alternative concepts and four functions that they can address – vehicle positioning, lane changing, dealing with obstructions in the road, and managing congestion.

While current vehicles use new technologies mostly for safety or driver convenience, e.g., air bags, antilock brakes, adaptive cruise control, power steering, the vehicles on an AHS system would require much more new technology that communicates with the roadway. As Table 1 suggests, in the simplest forms of AHS these would focus on the detection of other vehicles and obstacles. Technologies that already do this to some extent are beginning to be added to luxury vehicles or are sometimes an option that can be selected by the consumer; e.g., collision warning systems. Other technologies that would be precursors to the communications technologies in an AHS system are also being introduced; these include navigation assistance systems, traveler information systems, and vehicle locator systems. Their acceptance in the market is taken as an indicator of eventual consumer acceptance of the broader AHS concept.

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[9] *National Automated Highway System Research Program: A Review*. TRB Special Report 253. Transportation Research Board, National Research Council. National Academy Press. Washington, D.C. 1998. pg.32.

Table1) Alternatve Concepts for Automated Highway Systems[10]

System Concept	Local Position Keeping	Lane Changing	Obstruction on Roadway	Flow Control
Autonomous: Fully automated vehicles employing sensors and computers operate along with manually driven vehicles without requiring infrastructure assistance and communication.	Vehicle automatically senses vehicle ahead and roadway problems	Looks for and moves into an opening	Vehicle brakes for detected obstacles, changes lanes if possible	
Cooperative: Vehicles equipped with onboard sensors and computers would share information with other vehicles to coordinate maneuvers and enable fully automated travel.	Vehicle Sensors, communications from other vehicle for land changes or platoons	Cooperative negotiation among vehicles	Vehicle senses, communicates warning and coordinates maneuvers	
Infrastructure supported: Fully automated vehicles operate on dedicated lanes, using global information and two-way communication with smart infrastructure to support vehicle decision-making.[11]	Same as cooperative, but within guidelines from the infrastructure	Same as cooperative	Infrastructure or vehicle senses, communicates to vehicles; vehicles coordinate	Infrastructure monitors traffic, formulates responses, send parameters to local groups of vehicles
Infrastructure managed: The automated roadside system provides inter-vehicle coordination during entry, exit, merging, and emergencies.[12]	Vehicles sensors, communications from other vehicles and infrastructure as needed	Vehicle requests lane change; infrastructure responds with commands for surrounding vehicles	Infrastructure senses sends commands to vehicles based on infrastructure or vehicle detection, or vehicle actions	Infrastructure monitors individual vehicles, commands vehicles as needed, including entry and exit
Infrastructure controlled: Same as above, but infrastructure takes the entire control in all driving situations.	Infrastructure sense vehicle positions and sends commands to control throttle, braking and steering	Infrastructure determines need for lane change from origin-destination data, controls all necessary vehicles	Infrastructure senses, sends commands to vehicles based on infrastructure or vehicle detection, or vehicle actions	Infrastructure monitors individual vehicles, performs optimizing strategy through control of individual vehicles

[10] Table 1 is reorganized and enhanced mainly from *Automated Highway System (AHS).* Attachment A: AHS Technologies. U.S. DOT/FHWA. 1997.
[11] Congress, Nita. "Smart Road, Smart Car: The Automated Highway System". *Public Roads Online*. Autumn 1996. *http://www.tfhrc.gov/pubrds/fall96/p96au46.htm*
[12] ibid.

Potential Benefits

Researchers have attempted to estimate benefits that might accrue from the implementation of automated highway systems. Table 2 summarizes potential benefits. Many of the benefits shown in the table are fairly speculative; the systems they would depend upon are not yet in existence and there is no clear evidence that the system can produce the following benefits in reality.

Table2) The Potential Benefits of AHS[13]

Element	Benefits
Roadway capacity	More vehicles can be accommodated on the highway. The number of vehicles per hour per lane can be significantly increased as traffic speeds are standardized and increased and headway distances are decreased. It is expected that two to three times more vehicles could be accommodated through elimination of inefficiencies caused by inattentiveness, merging, weaving, and lane changing.
Safety	Driving safety will be significantly greater than at present. The human error factor will be removed. Some estimates state that overall 50 percent improvement can be realized with AHS application.
Weather	Weather and environmental conditions will impact little on high performance driving. Fog, haze, blowing dirt, low sun angle, rain, snow, darkness, and other conditions affecting driver visibility and thus, safety and traffic flow will no longer impede progress.
Mobility	All drivers using AHS can be safe, efficient drivers. AHS offers enhanced mobility for people with disabilities, the elderly, and less experienced drivers.
Energy consumption and air quality	Fuel consumption and emissions can be reduced. In the short term, these reductions will be accomplished because started-and-stop driving will be minimized and because on-board sensors will be monitored to ensure that the vehicle is operating at top performance. In the long term, the AHS can support future vehicle propulsion/fuel designs.
Land use	Land can be used more efficiently. Roads will not need to take up as much room, since AHS facilities should allow for more effective use of the right of way.
Commercial and transit efficiency and economic gains	More efficient commercial operations and transit operations. Commercial trucking can realize better trip reliability to support "just-in-time" delivery. And, transit operations can be automated, extending the flexibility and convenience of the transit option to increase ridership and service.
Travel time savings and economic gains	Travel time savings: AHS can restore free-flow travel conditions from congested speeds in urban highway travel, thereby reducing the travel times. In addition, for long-distance intercity travel, it permitted higher cruising speed than today's driving. Therefore, time that AHS frees up could be used for other purposes.[14]

[13] Table 2 is reorganized and enhanced mainly from *Automated Highway System (AHS).* Attachment B: AHS Benefits. U.S. DOT/FHWA. 1997.
[14] Shladover, Steven E. "Why We Should Develop a Truly Automated Highway System". *Transportation Research Record 1651*. Paper No. 98-0641. pg.66~73. pg.66.

As the table indicates, it is anticipated that automated highway and related advanced vehicle control and safety technologies would significantly reduce traffic congestion and enhance safety in highway driving. This in turn would potentially cut travel time, and therefore, driving would be more predictable and reliable. The Mobility 2000 report, sponsored by the Texas Transportation Institute, projected that collision prevention systems could reduce accidents by 70 percent, or 90 percent on fully automated highways.

Research focused on collision prevention systems has estimated possible savings in a relatively short period of time. For example, collision avoidance systems have been estimated to have the potential to reduce annual loss of life on U.S. roads by 50 percent by 2020.[15] In addition, preliminary National Highway Traffic Safety Administration estimates show that rear-end, lane-change, and roadway-departure crash-avoidance systems have the potential to reduce crashes by one-sixth, or about 1.2 million crashes a year.[16]

The Federal Programs Associated With Automated Highway System

National Automated Highway System Research Program (1994~1997)

In October 1994, U.S. Department of Transportation (DOT) entered an agreement with industry to develop the AHS concept and inaugurated the National Automated Highway System Consortium (NAHSC). With a broad range of views on AHS, the consortium consisted of public and private stakeholders including General Motors, Bechtel, Caltrans, the Carnegie Mellon University Robotic Institute, Delco Electronics, Hughes Aircraft, Lockheed Martin, Parsons Brinkerhoff, and University of California Partners for Advanced Transit and Highway (PATH) program. The consortium carried out the ational Automated Highway System Research Program (NAHSRP) from 1994 to 1997. Through a consensus process, the program tried to specify, develop, and demonstrate a prototype AHS and provide for evolutionary deployment that can support regional and local transportation needs. The program sought opportunities for early introduction of vehicles and highway automation technologies to achieve initial benefits for all surface transportation users.

The first demonstration of AHS was held in 1997 , using the I-15 Express Lane in San Diego County, CA. The roadway was a 7.6-mile section of High Occupancy Vehicle (HOV) lanes, separated from the main north- and southbound lanes of I-15 by concrete barriers with the addition of communication equipments. Although what was shown was not necessarily the specific features of the future automated highway system, the demonstration showed practical applications of the latest technologies to the driving task and give people its first glimpse of Automated Highway System (AHS).[17]

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[15] Web site for *Intelligent Vehicle Initiative, Transportation Science and Technology*, U.S. Department of Transportation. *http://scitech.dot.gov/partech/intelveh/intelveh.html*

[16] ibid.

[17] *National Automated Highway System Research Program: A Review*. TRB Special Report 253. Transportation Research Board, National Research Council. National Academy Press. Washington, D.C. 1998. pg.51.

Although the demonstration showed that progress had been made, the U.S. DOT withdrew financial support from National Automated Highway System Consortium and shifted its priorities to short-term, safety oriented technology development. Federal support for AHS-related research moved to the federal Intelligent Vehicle Initiative (IVI) program (discussed below.). DOT concluded that the long-term vision of AHS could not be given priority due to the deficit in federal research funds; DOT also judged that a full-scale AHS application was not yet realistic due to a variety of non-technical and operational problems. In short, these institutional and operational problems were the barrier to further support for the consortium.[18]

Intelligent Vehicle Initiative (IVI) Program

The Intelligent Vehicle Initiative (IVI) is a government-industry partnership to accelerate the development and commercialization of safety- and mobility-enhancing driver assistance systems. The program merges all vehicle-focused ITS activities, with two major goals: 1) to reduce the number of highway crashes and pedestrian casualties and the resulting injuries and fatalities; and 2) to improve the effectiveness of intelligent systems to assure safe vehicle operation in residential and pedestrian activity centers. In particular, the program aims to develop and deploy intelligent vehicle systems that completely consider the driver's capabilities and limitations, rather than focusing on developing highway infrastructure technology.[19]

Ongoing work on crash avoidance, obstacle sensing, intelligent speed control, in-vehicle information systems, automated highway systems, and motor carrier safety provides a strong foundation for conducting intelligent vehicle research. Such systems are designed to warn drivers, recommend control actions, or introduce temporary or partial automated control of the vehicle in dangerous situations.[20] Preliminary National Highway Traffic Safety Administration (NHTSA) estimates show that rear-end, lane-change, and roadway-departure crash-avoidance systems have the anticipated benefits, collectively, to reduce crashes by one-sixth, or about 1.2 million crashes a year.[21]

However, U.S. DOT acknowledges that the development of a safe and affordable intelligent vehicle will be a long and difficult task in which IVI must triumph over numerous technical hurdles and non-technical barriers. A primary technical hurdle is to develop technologies that complement and accomplish the human visual and higher cognitive abilities by which collision avoidance occurs. One of the critical non-technical issues is the need for the ongoing support of the automotive industry. The active role of

[18] ibid. chapter 3, 4.
[19] *Intelligent Vehicle Initiative Business Plan*, U.S. DOT, Intelligent Transportation Systems Joint Program Office. July 2000.
[20] Web site for *Intelligent Vehicle Initiative, Transportation Science and Technology*, U.S. Department of Transportation. *http://scitech.dot.gov/partech/intelveh/intelveh.html*
[21] ibid.

automakers and their suppliers is needed for achieving the program's strategic goal and outcomes in the future.[22]

The Intelligent Vehicle Initiative's work is closely associated with the National Intelligent Transportation Infrastructure and Enhanced Transportation Weather Services Initiatives, and it will provide a further application for the technical foundation to implement Automated Highway System in the long run.

NATIONAL AUTOMATED HIGHWAY SYSTEM RESEARCH PROGRAM: LIMITATIONS OF PUBLIC-PRIVATE PARTNERSHIP[23]

The National Automated Highway System Research Program (NAHSRP) enhanced the transportation community's understanding and recognition of the numerous technical and practical issues associated with fully automated vehicles and highways.[24] The 1997 San Diego demonstration was an opportunity to test the capabilities of different automation technologies in a controlled yet complex setting of vehicle and roadways. In addition, the consortium examined several automated highway system concepts, and its system assessments flagged important issues that will warrant early consideration as automation capabilities are developed.[25]

Despite these achievements, the Transportation Research Board committee evaluating the program in 1998 argued that the National Automated Highway System Consortium was not effective in achieving its goals. The TRB committee pointed out several major problems of the program. They can be summarized as the lack of consensus in public-private partnership and the consortium's conflicting dual responsibilities as both an evaluator and as a promoter of AHS. The following sections discuss these issues.

The Difficulty of Consensus Building

The consortium included nearly 100 associate members who represented nine categories of stakeholders: the vehicle industry, government agencies, the highway design industry, vehicle electronics, environmental interests, trucking operators, transit operators, transportation users and the insurance industry. This group had widely varying perspectives. The consortium generally sought a fully automated highway concept, but there were conflicting views as to the steps and strategy of deployment.[26] The consortium in general suggested the importance of operating full automation on dedicated lanes to maximize its benefits. However, among the associate members, many state and local

[22] *Intelligent Vehicle Initiative Business Plan*, U.S. DOT, Intelligent Transportation Systems Joint Program Office. July 2000.
[23] Discussion of this chapter is mainly from *National Automated Highway System Research Program: A Review*. TRB Special Report 253. Transportation Research Board, National Research Council. National Academy Press. Washington, D.C. 1998. chapter 4.
[24] ibid. pg.9.
[25] ibid.
[26] ibid. pg.7.

officials were skeptical and concerned about the political difficulties of investing in dedicated lanes devoted to fully automated vehicles. Environmentalists and planners were further concerned about overall effects on vehicle emissions, land use, and increase of traffic volumes. Moreover, vehicle manufacturers and insurers were mainly interested in how liability issues could be resolved.

Research focused on demonstrating the automated technology, with less attention given to the diverse political and institutional issues raised by stakeholders. Consequently, the consortium did not make much progress on finding ways to resolve these latter issues and reach an agreement. The focus on technical development and deployment largely resulted from the consortium's dual, yet conflicting responsibilities, discussed in the following section.

The Consortium's Conflicting Dual Role

The National Automated Highway System Consortium has dual responsibilities, both to evaluate and to promote fully automated highway systems. U.S. DOT was to be a member of the consortium as well as oversee it and fund it. The Transportation Research Board committee pointed out that *NAHSC's ability to fully and critically evaluate automated systems was susceptible to criticism in light of its promotional role.*[27] DOT's dual roles as research funder and concept promoter also created conflicts.

For example, the DOT- funded studies' conclusion[28] on *liability, environmental impact, and transportation infrastructure issues associated with AHS seems especially too optimistic and highly conjectural, based on workshop discussions without serious review. Close examination of the workshops sponsored by the consortium fails to reveal how such conclusions were reached.*[29] In general, the consortium lacked the objectivity that is essential to sound research and evaluations, and reflecting its promotional role, tended to produce reports favorable to the consortium's goals.

The Consortium's Structural and Operational Limitations

The inflexibility of the partnership

Given the consortium's role as a promoter, its inclusive, consensus building structure limited program flexibility and complicated management. The fixed membership, pre-allocated budgets, and consensus decision-making process slowed its responsiveness, and it made it difficult for the partnership to respond to changing government funding levels and priorities. By the same token, given the consortium's responsibility for evaluation,

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[27] ibid. pg.10.
[28] *Workshop Report: Joint Workshop on Liability Issues in Advanced Vehicle Control and Automated Highway Systems*. NAHSC/AASHTO/ITS America. Washington, D.C. February 1997.
[29] *National Automated Highway System Research Program: A Review*. TRB Special Report 253. Transportation Research Board, National Research Council. National Academy Press. Washington, D.C. 1998. pg.57.

having members with an interest in favorable outcomes supporting deployment of new technologies and concepts affected the objectivity of the work, and hindered the effectiveness of open discussion on many issues during the collaborative process.[30]

The overly optimistic mission

The consortium initially envisioned that it could demonstrate fully-automated highway technologies and scenarios in three years and to select a preferred system within seven years. However, selection of the system is closely related to active outreach to transportation users and providers to reach a meaningful agreement. Given that the consortium failed to resolve the social and institutional issues entangled with automated highway system, and that its dual, yet conflicting role undermined the effectiveness of the partnership, this mission was excessively optimistic and difficult to achieve.[31]

Failure to address the non-technological issues

The consortium focused on the technical aspects of automated driving (e.g. obstacle detection, platooning, and lane-keeping). Given the overly optimisitic mission, this focus was perhaps unavoidable. While some stakeholders emphasized the need to address the many non-technical concerns (e.g. liability, socioeconomic impacts), [32] these concerns were not given enough attention, leaving them as major barriers to further action.

Comments

The review of experience with the National Automated Highway System Research Program illustrates how programs can fail if they do not pay attention to the full range of issues and if they mix promotion with evaluation. In the case of the automated highway program, promoters focused on developing the technologies and disregarded or downplayed issues that would later become the stumbling blocks for the whole program.

The partnership formed for the NAHSRP did not work well because it mixed promotion and evaluation. A separation of these two objectives would certainly be in order in any future program.

However, collaborative arrangements integrating the interests and resources of the public and private sectors should continue. This collaborative approach will be essential to the long-term AHS research and development, as it facilitates shared commitment and risk. It also provides stakeholders with access to understanding technologies and ideas as well as financial resources, and therefore, it can create links between organizations and industries that can have a long-lasting impact on newly developed transportation technologies.

[30] ibid.
[31] ibid. pg.6.
[32] *Boston Stakeholders Forum Summary Report*. National Automated Highway System Consortium. May. 1996.

More flexible partnerships and cooperative arrangements should be designed for evaluation, development, and promotional functions. Comparing to the National Automated Highway System Consortium, the Partnership for New Generation Vehicles (PNGV) can give us the meaningful lesson with regard to the structure and the operation of a partnership. Although the structure of PNGV is also very inclusive, the membership is not really fixed, and rather flexible and stakeholders are free to enter and exit the partnership program depending on their interests and the topics discussed in the program.

On top of this, external reviews and evaluation of research efforts are essential for future partnership programs, because they can guarantee more objective evaluation on the effectiveness of programs. Objective evaluations are critical in assuring that proposals will be successful and not just based on wishful thinking.

While short-term payoffs are important and improvements in highway capacity, safety, and efficiency are key objectives, research also needs to institutional issues and human behavior issues so that these can be integrated into technology design and development. It is difficult to achieve transportation improvement by only focusing on technology without considering social and human behavioral issues.

SOCIAL AND INSTITUTIONAL CHALLENGES FOR AUTOMATED HIGHWAY SYSTEMS

The introduction of new technologies often creates social tensions. For instance, although talking on the phone while walking. or driving is commonplace nowadays, there are concerns about its safety, and debates continue over whether it is rude to use a cell phone in public places such as restaurants or on a bus. Similarly, mature technologies experienced social challenges when they were introduced. The first automobiles were seen as rich people’s toys, and former President Woodrow Wilson, then head of Princeton College, warned students about showing off their vehicles before the townsfolk, who he presumed would never have cars.

The programs to achieve the transportation improvement through new technologies likewise face social and institutional challenges. For automated highway systems the challenges include concerns about land use and environmental impacts, effects on people’s mobility if they are unable to afford or use the new technologies, effects on local government-owned transportation systems, and impacts on financing systems. These impacts will be discussed here.

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Unclear Social and Environmental Impacts

One of the critical problems for the automated highway system development is that the impact of AHS on society and environment is unclear yet.[33] Studies necessarily must be speculative since the system has not yet been implemented apart from the San Diego demonstration project. The following topics are ones that have generated considerable disagreement.

Congestion at Entry and Exit

There is concern that if AHS are implemented the greater numbers of vehicles on an automated highway could create bottlenecks at its entry and exit points as more traffic reenters non-automated streets. This might offset most of the benefits of the traffic flow improvement on the automated highways. The U.S. DOT acknowledged that it was a serious concern to design an interchange that can integrate with surrounding non-AHS roads to ease the problem.[34]

Unclear Impact on Land Use and Environment

Tthere are concerns that commuters might live farther from the work place, because an automated highway system promises to increase the accessibility of more distant locations through higher freeway speeds.[35] Therefore, it possibly encourages urban sprawl and greater dependence on the automobile. The concern about land use pattern and urban development raises also the serious question on the AHS's positive role regarding air quality, noise, etc. If more vehicles were accommodated at faster speeds on a fully automated highway, vehicle emissions might increase and degrade air quality, as AHS might encourage more Vehicle Mile Traveled (VMT). This conflicting result may provoke the fundamental question of whether or not automated highway system is much more efficient, comparing to traditional highway or other transportation modes such as light rail and high-speed rail.

Safety

Some argue that it is uncertain how Automated Highway Systems impact on overall highway safety, because the failure of a vehicle's braking or steering system could severely disrupt the highway traffic flow and cause a chain reaction accident.[36] In addition, there are remaining questions: What level of safety is attainable and sustainable

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[33] *Surface transportation: the Department of Transportation Proposes significant changes to its Automated Highway System program*. GAO/RCED-97-177R. U.S. General Accounting Office. Washington, D.C. 1997.

[34] Lay, Rodney K., Gene M. McHale, and William B. Stevens. *The U.S. DOT Status Report on the Automated Highway Systems Program*. Working Note 95W0000093. Mtretek Systems, Center for Telecommunications and Advanced Technology. McLean, Virginia. July 1996. pg.8-2.

[35] *Surface transportation: the Department of Transportation Proposes significant changes to its Automated Highway System program*. GAO/RCED-97-177R. U.S. General Accounting Office. Washington, D.C. 1997. pg.5.

[36] ibid.

within a realistic cost? How much safety equipment can be required and still achieve public acceptance?[37] How efficient can the system be if safety requirements are set at extremely high levels?.[38] The trade-offs between the technology level, cost, and the safety level have not been addressed yet.

Equity

Since tremendous amounts of public funds could be spent to deploy an automated highway system, social equity issues must be addressed. A key question is whether it would be fair and politically feasible to dedicate travel lanes to automated vehicles, and spend public funds, if many low-income motorists cannot afford automated vehicles. Studies have not addressed specific issues of whether and how state and federal government might provide incentives to commercialize automated vehicles, how the system should be financed (e.g. toll system/ other sources), and how equity concerns could be reduced. There also may be different equity issues involved with different vehicle users (e.g. private, commercial, transit vehicles).

The Dilemma of Transition From Conventional Highway to Automated Highway

There has been a debate between those who favor an evolutionary deployment of automated high systems and those who promote full-scale conversion of regional highways to the system.

Some researchers involved in the National Automated Highway System Research Program believed that a regional conversion strategy would be a more effective way to implement a fully automated system.[39] They argued that the evolutionary approach would be neither easy nor efficient since many drivers will not invest in such basic technologies as adaptive cruise control and lane-keeping technologies. They recommended that at least one lane of a regional highway should be converted to an AHS-equipped corridor so that initial users can fully benefit from the system. In addition, to demonstrate the benefits, government vehicles and transit vehicles would be converted first to automated vehicles.[40]

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[37] *National Automated Highway System Research Program: A Review*. TRB Special Report 253. Transportation Research Board, National Research Council. National Academy Press. Washington, D.C. 1998. pg.37.

[38] Lay, Rodney K., Gene M. McHale, and William B. Stevens. *The U.S. DOT Status Report on the Automated Highway Systems Program*. Working Note 95W0000093. Mtretek Systems, Center for Telecommunications and Advanced Technology. McLean, Virginia. July 1996. pg.8-3.

[39] National Automated Highway System Consortium. April 1997., National Highway Traffic Safety Administration, US DOT. January 1997., Lay, Rodney K., Gene M. McHale, and William B. Stevens. July 1996.

[40] Shladover, Steven E. “Progressive Deployment Steps Leading Toward an Automated Highway System”. *Transportation Research Record*. No. 1727. pg154~161. 2000., Shladover, Steven E. “Why We Should Develop a Truly Automated Highway System”. *Transportation Research Record* No. 1651. pg. 66~73. 1998.

Others argued for gradual implementation, believing that there would be inadequate justification to convert or build highway lanes with full automation with public funds if only a few vehicles, mostly owned by the affluent, would be able to use the system in its initial years. This side also argued that even the vehicle owners who can pay for automation technologies may not be willing to equip their cars with this technology, if only one or a few corridors have highway lanes equipped for AHS use. Thus, they suggest that, as an evolutionary approach, focus should be placed on market penetration of near-term advanced vehicle control and safety technologies.

After the U.S. DOT's decision[41] was made to withdraw from the National Automated Highway System Research Program, AHS research has mostly followed the evolutionary model. Today, many efforts are being made to develop and commercialize the basic AHS-related technologies such as adaptive cruise control and collision-warning features. The technologies are expected to measure and predict the technical feasibility and the commercial attractiveness of the future automated highway system and finally to use those technologies as a foundation for the transition toward the fully automated vehicle/infrastructure control system.

However, this approach does not really address institutional and social problems that still require resolution. These problems may in fact interfere with wide adoption of particular technologies as well as systems. Furthermore, there has been little effort to evaluate the eventual desirability of full-scale automation, and views on the issue have remained extremely divided.

Recently, there has been some discussion of the need for a more systematic approach. The U.S. General Accounting Office's report[42] concluded that DOT's surface research lacks a sufficient focus on long-term concerns. A recent article[43] by Steven Shladover points out that AHS could be implemented before some of the more advanced individual technologies are available, and suggests proceeding with substantial effort in developing the system design and integrating the technologies. Another recent article[44] suggests a progressive deployment strategy integrated with research and development. These articles may rekindle the discussion on detail strategies of full-scale deployment of the AHS system.

Even so, since technology implementation is related not only to technical feasibility but also to the marketing and implementation strategy for public acceptance, the current discussion in the field lacks attention to these issues.

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[41] *Surface transportation: the Department of Transportation Proposes significant changes to its Automated Highway System program*. GAO/RCED-97-177R. U.S. General Accounting Office. Washington, D.C. 1997.

[42] *Surface Transportation: Research Funding, Federal Role, and Emerging Issues*. U.S. GAO Report No. GAO/RCED-96-223. September 1996.

[43]Shladover, Steven E. "Why We Should Develop a Truly Automated Highway System". *Transportation Research Record* No. 1651. pg. 66~73. 1998.

[44] Shladover, Steven E. "Progressive Deployment Steps Leading Toward an Automated Highway System". *Transportatio-n Research Record*. No. 1727. pg154~161. 2000.

Public Acceptance

For AHS to obtain public acceptance, it must be designed and implemented with many complex human factors[45] and operational reliability considerations. The decision on which vehicle controls are automated and how these systems interface with the driver will affect seriously system safety and the level of public acceptance. In addition, the extent to which motorists would accept reduced manual control of their vehicles of be willing to travel in automated vehicles at close following distances, on narrower lanes, and at higher speeds is not clear yet.[46] Full automation of the nation's road cannot be attained in a day, until a careful review as to human response and system safety, and market analysis on potential users can be successfully addressed. User fears, inertia, and distrust on new technology are typically too strong to be eliminated without gradual and systematic implementation strategies.

Institutional Issues

The vision of deployment of local and regional automated highways requires the public sector to consider the issue of institutionalization of automated highway systems. Successful institutionalization would reduce potential political and economic conflicts and would specify the roles and responsibilities of each public and private actor. Key institutional issues include finance, regulation, and organization.

Finance: Who Will Pay for AHS?

U.S. DOT's 1996 report[47] identified several issues concerning the finance of automated highways, but these issues have not been discussed actively since the U.S. DOT withdrew its financial support for the long-term research on AHS. Yet, it is worth summarizing the significant issues in the following[48]:

- The main ways to cover automated highway system costs and the structuring of the costs
- How much should the federal government provide support to states and locales for operation and maintenance?
- The entity to finance and build the AHS infrastructure (public, private)
- The way of pricing the system
- How to induce sufficient private investment

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[45] Congress, Nita. "The Automated Highway System: An Idea Whose Time Has Come". *Public Roads On-Line*. Summer 1994. *www.tfhrc.gov/pubrds/summer94/p94su1.htm*

[46] *National Automated Highway System Research Program: A Review*. TRB Special Report 253. Transportation Research Board, National Research Council. National Academy Press. Washington, D.C. 1998. pg.37.

[47] Lay, Rodney K., Gene M. McHale, and William B. Stevens. *The U.S. DOT Status Report on the Automated Highway Systems Program*. Working Note 95W0000093. Mtretek Systems, Center for Telecommunications and Advanced Technology. McLean, Virginia. July 1996.

[48] These issues are refined from Lay, Rodney K et al. July 1996. pg. 8-7.

- The priority to be given to investment in conventional highways vs. automated highways
- The rights and privileges that the operating entity can have.

A principal dilemma is that, given limited financial resources and a backlog of needed investments in conventional traditional transportation projects, AHS deployment is likely to be limited for the next decade or more, [49] unless alternative funding sources are found. In many urban areas, maintenance alone absorbs the majority of available funds, and transportation agencies are left with little funding to use on new projects of any sort. This suggests that either new funding sources would need to be found or else the benefits of AHS would have to be so convincing that transportation officials would put AHS projects ahead of other desired transportation investments.

Organizational Issues

Many operational issues can arise in considering the role of state and local government in building and operating highways. The AHS will include technically complex components such as advanced electronic sensors, on-line computers and software, and communication systems. Installation and maintenance of these systems may present a significant challenge to the operators. Since AHS will introduce an increased level of complexity for highway operations, the following issues[50] should be addressed:

- The ability of state and local transportation agencies to build, operate and maintain the sophisticated networks of automated highway; changes that might be needed in personnel hiring practices, pay scales, etc.
- The capability of state and local jurisdictions to work together effectively in planning and operating AHS
- The regional institutional integration to support the efficient operation of AHS
- The training of technical staff to deal with the system
- The structure of ownership of facility (public or private)
- Responsibility for standard-setting for new equipment and operations.

Privacy

Privacy is a sensitive issue for the public. A study[51] by U.S. DOT sees the issue optimistically, arguing that privacy is not a serious barrier to the implementation of automated highway systems. Yet the study still notes the continuing debates about privacy standards, and also recognizes public sensitivity to the use of personal information, and concerns about proper handling of personal information. For example, because AHS employ automated surveillance technologies to communicate with other

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[49] *A Report to Congressional Committees: Challenges to Widespread Deployment of Intelligent Transportation Systems*. U.S. General Accounting Office. Report No. GAO/RCED-97-74. February 1997. pg.9.
[50] These issues are refined from Lay, Rodney K et al. July 1996. pg. 8-8.
[51] *A Report to Congress: Nontechnical Constraints and Barriers to the Implementation of Intelligent Transportation Systems*. U.S. DOT, Joint Program Office for ITS. January 1997. pg.E-33.

vehicles and the highway infrastructure, as other intelligent transportation system technologies do, it raises a concern over privacy.

Despite the optimism of DOT, the issue is not easy to deal with and there are no distinct criteria for designing a privacy standard. DOT's study suggests that most people have ambivalent attitudes on the issue.[52] They want their privacy protected on the one hand, but they might also be interested in the benefits produced by an automated highway system's use of private information. This is similar to the situation with credit cards, where many people worry about privacy of information, but nevertheless obtain and use credit cards. Researchers also have suggested that privacy means a variety of different things, including solitude, autonomy, anonymity, and individuality; [53] it is thus hardly surprising that people can't achieve a clear consensus on the solution as well as the severity of the problem.

Currently, few studies are being carried out to address the issue. A recent survey[54] on CCTV reveals that *public agencies have not implemented any structured or formal programs to explain the safeguards against privacy violations* and they do not have any procedures to evaluate whether their informal public outreach has been effective. U.S. DOT argues that *when benefits of AHS are clearly perceived as outweighing any adverse on privacy, the technology is less likely to be constrained*.[55] Nevertheless not much effort has been made to "showcase" the merit of technology vis-à-vis the invasion of personal privacy.

Intellectual Property Issues

Most research efforts to develop technology applied for AHS are being conducted through partnerships between public and private sector organizations. The private sector worries that because the retention of intellectual property rights by U.S. DOT or state agency may be too broad, it is not easy for it to recoup costs used at the predevelopment stage.[56] On the other hand, the public sector attempts to give the public the full access of technology by acquiring the right to use such intellectual property for public purposes.[57] They also are concerned about creating a monopoly for certain technologies. The differing concerns of the partners not only causes problems in the field of intellectual

[52] *A Report to Congress: Nontechnical Constraints and Barriers to the Implementation of Intelligent Vehicle-Highway Systems.* U.S. DOT. June 1994. pg.8-3.
[53] Albert, Sheri and Kingsley E. Haynes. *Privacy and the Intersection of Geographical Information and Intelligent Transportation Systems*. The Institute of Public Policy. George Mason University. Fairfax, VA. *http://www.spatial.maine.edu/tempe/alpert.html*
[54] Clinger, Stephen and Daniel R. Abedon. *Summary of Findings for CCTV Privacy Policy Survey and Examples of Existing Privacy.* Eastern Resource Center, Baltimore, MD. April. 2001. pg.4.
[55] Lay, Rodney K., Gene M. McHale, and William B. Stevens. *The U.S. DOT Status Report on the Automated Highway Systems Program*. Working Note 95W0000093. Mtretek Systems, Center for Telecommunications and Advanced Technology. McLean, Virginia. July 1996. pg.8-7.
[56] ibid.pg.8-7.
[57] *A Report to Congress: Nontechnical Constraints and Barriers to the Implementation of Intelligent Transportation Systems*. U.S. DOT, Joint Program Office for ITS. January 1997. pg.E-27.

property rights but also inhibits the collaborative approach in their research and development effort.

Often, reaching agreement on proprietary rights is difficult and time-consuming. A firm does not usually want to reveal and jeopardize its original hardware or software products in order to develop other AHS-related technologies such as in-vehicle navigation and route guidance systems with public support. In addition, many inclusive partnerships embrace market competitors, so a firm does not want to give a direct competitor access to proprietary information. Consequently, the allocation of rights in intellectual property has been a significant hurdle in developing public-private partnerships. If the right is commercially exploitable and developed with government funds, it is much more difficult to reach a meaningful consensus.

LIABILITY ISSUES

Presently, the primary burden of the cost of vehicle accidents rests with the drivers and the owners of the vehicles, because most of highway collisions are due to driver error.[58] However, the increased automation resulting from the adoption of certain automated highway technologies could shift liability to the developers and operators of automated systems. Thus a major issue concerns the resolution of who is to be responsible for accidents on automated highway systems: the non-driving driver, the auto-highway authority, or the auto manufacturer.

U.S. DOT concluded optimistically, based on the NAHSC's review[59] in 1996, that liability issues would not present any barriers to the development and implementation of AHS and it would not impact negatively on entry of private sector firms into the development of technology. Transportation Research Board report[60] in 1997, however, pointed out that the evaluation of NAHSC could be distorted because of its conflicting role as an evaluator of the program as well as a promoter. Concerns still, therefore, remain with regard to level of driver control of the vehicle, and the transfer of control between the driver and the system. Furthermore, prospective manufacturers and operators of AHS initially expressed concern that deployment of AHS would result in increased exposure to tort law claims. The following examines general issues that should be addressed to overcome liability concerns related to Automated Highway System.

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[58] ibid.

[59] *Workshop Report: Joint Workshop on Liability Issues in Advanced Vehicle Control and Automated Highway Systems*. National Automated Highway System Consortium. Washington, DC. February 1997.

[60] *National Automated Highway System Research Program: A Review*. TRB Special Report 253. Transportation Research Board, National Research Council. National Academy Press. Washington, DC. 1998.

General Concerns on Liability

Uncertainty of New technologies and "Chilling-effects"

Stakeholders are sometimes unwilling to bear the legal liability associated with adopting new and unproven technologies, unless the returns are extremely high. In developing new highway infrastructure technology, many companies in construction and auto industry are concerned about health, safety, or environmental hazards issues; in some cases the concerns may be great enough to deter them from adopting new materials and technologies.

In the case of new AHS technologies, some have speculated that this issue would produce a "chilling-effect" on the entry of the private sector into the development of technology.[61] Although the 1997 U.S. DOT report[62] argues that there is no evidence that fear of liability has deterred industry involvement, concerns still exist that even if research and development proceeds, the issue may arise again when deployment is under consideration.

The history of air bag deployments may be instructive. Advertisements have depicted air bag deployment as a soft cushion experience, while in reality it is a very violent event. Rental car companies have been sued for malfunction of equipment because of injuries due to air bag deployment, even when the air bags functioned as designed. One problem is that the airbags does not meet the expectations set up by advertising, and most drivers do not have any more specific knowledge.[63]

Concerns about liability also may lead to highly conservative regulation and practice. For example, concerns about liability have led many transportation departments and traffic engineers to reject traffic calming devices such as speed humps and roadway narrowing. If a state highway department were to operate an AHS in such a way as to minimize its liability risks, what would the effects be? Conservative operating rules might result in lowered roadway capacity , higher costs, and less congestion relief.

Concerns about liability blocking the development of a new industry led to Congressional limitations on liability for nuclear power and air transportation. Limits on liability provide protection for the industry and may offer a degree of reassurance to potential participants, but also limit consumer recovery in case of actual harm. Whether such liability protections are justified is a question worthy of consideration, should this topic come up for AHS.

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[61] *A Report to Congress: Nontechnical Constraints and Barriers to the Implementation of Intelligent Transportation Systems*. U.S. DOT, Joint Program Office for ITS. January 1997. pg.E-2.

[62] ibid. pg.E-23.

[63] This case is quoted from *Workshop Report: Joint Workshop on Liability Issues in Advanced Vehicle Control and Automated Highway Systems*. National Automated Highway System Consortium. Washington, DC. February 1997. pg.24.

Standards Development

Standards are essentially a statement of accepted practice and as such, can offer some protection to those who follow them. That is, compliance with standards is evidence of reasonable behavior. Thus development of standards could offer a manufacturer or operator some degree of protection from liability.

Well-drafted standards thus can help support implementation of AHS by reducing risk. It On the other hand, detailed standards or too early set up of standards can block technology innovation. Thus standards development could be a double-edged sword.

Even with standards, the degree of protection they offer the manufacturer or operator from liability is not necessarily total. In determining liability, some states consider whether following the standards was reasonable under the particular circumstances. Another question is what legal protection compliance offers if someone uses the product in a manner that is foreseeable but is not according to the designer's intent.

Tort Reform

Liability law is a branch of tort law, and in the US, most tort law is formed and enforced at the state, not federal, level, with each state having a different set of laws and traditions. Much tort law is also common law, that is, judge-made law that has evolved over the years, although legislation also shapes tort law.[64]

Tort law thus impacts the development and application of technologies for automated highways both by establishing the contours of liability and by establishing damages that are allowed. Tort reform might reduce the risks for AHS by changing liability rules, limiting the recovery of damages, and/or reducing the costliness of the claims processes.

However, a huge sector of the economy has vested interests in the existing system of compensating people for injuries on the highway system, as it has evolved over many years. Hence tort reform is a big issue that will not necessarily be easily resolved for AHS.

Public education on AHS

Liability can be reduced when customer expectations are consistent with what a particular product can actually do. Education on AHS will be a crucial issue so that the public has realistic expectations. Customer expectations for AHS can also develop as the customers gain experience with various technologies. As shown in the case of air bags,misinformation about how technologies will work can create liability problems.

[64] ibid. pg.17.

'Pros and Cons' on Liability Issues by Stakeholders

A primary cause of liability problems is that all players in the AHS field want benefits of using of the system but want others to take the risk and provide the necessary protection. The following will review concerns on liability issues raised by each stakeholder in order to understand specific points of liability and the position of each stakeholder on Automated Highway System.

NAHSC (The National Automated Highway System Consortium) and ITS America[65]

The different interest groups within NAHSC had not reached a consensus about what the liability issues are, until 1997 in its dismissal. However, they and ITS America identified the general boundaries of liability concerns like the following[66]:

- Who is responsible for accidents in general, if the drivers' role in AHS is significantly less than in conventional highway? (Drivers, System managers, manufacturers)
- How to proportion liability among the various participants in an automated system
- How to transition from personal liability to systemic liability
- Greater liability issue would be incurred with mixed-flow rather than dedicated lanes, but it is easier to deploy mixed flow first and then dedicated lanes later. How to solve conflicting issues between deployment sequence and liability sequence
- How to get the driver to use the system the way he is envisioned to use it. There is an issue of training the driver how to comprehend and use the system, and prevent misuse of the system.
- Building the safety and security into the system costs money. How to make systems attractive to the market both in features and in cost.

Technology Manufacturers

Manufactures regard potential liability costs as a serious bar to entering markets, and hence they worry that liability issues could hinder the development of AHS. They are interested in having federal standards established to alleviate their liability if possible, whether by regulation or legislation. They argue that in designing AHS system, it is critical to predict the amount of exposure to liability. However, as mentioned before, standards cannot offer complete protection and they may have detrimental effects as well as positive ones.

Technology manufacturers also raised the issue of liability for vehicle maintenance. Soecific questions posed include the following[67]:

[65] ITS America consists of about 50% private sector companies and 50% academia, government, and associations. Its mission is to foster public-private partnerships to increase the safety and efficiency of surface transportation through the application of advanced technologies.
[66] ibid. pg.32.
[67] ibid. pg.33.

- Whose responsibility is it to maintain the vehicle?
- What responsibility do manufacturers have to maintain these automated vehicles?
- Will the car manufacturers be ultimately liable for the product if there is a malfunction in the vehicle?

They want some protection in general, if they comply with standards and concern about user understanding and appropriate use of technology.

Insurers & Attorneys

Insurers and attorneys mainly raise the issue of risk allocation.[68] They are interested in developing risk management and financing techniques and are concerned about how uninsurable risk could be treated, what coverage needs to be procured, and how broad that coverage should be. They in general worry about uncertainty of the related technologies.

U.S. Department of Transportation and State governments

U.S. DOT and state governments raised the following issues[69] in the 1997 Joint Workshop on liability in AHS, regarding the ownership, deployment and maintenance of AHS.

- Who is going to be the owner of AHS?
- What is the responsibility and limitation of liability of the owner?
- Who should develop and promulgate standards? (States recognize that it may be appropriate for the federal government to be promulgating standards for the states to live under but states try to promulgate their own standards.)
- Who is going to have the control and authority over the systems?
- How will the integration of traffic control devices with new AHS technologies take place?
- How to train transportation officials and vehicle drivers for the effective operation of AHS
- How the standards in a state can harmonize with the one in other states?
- How can the responsible organizations effectively deal with hardware, software, and users?
- How can the responsible organizations protect confidential information and what range of information should be confidential?

Comments

Multi-party relationships are often adversarial rather than collaborative. Every stakeholder group needs and wants to minimize its exposure to liability. Automated highways cannot be implemented without one or more groups assuming much of this

[68] ibid.
[69] ibid. pg.34

burden. Nonetheless the issue here is how much and who is going to take more responsibility than others. How to resolve this problem is crucial to attract more investment in technology innovation.

ITS America, having an optimistic view on liability issues, thinks the greater problem is fear of liability rather than liability itself.[70] The way they approach the issue is to design the system to yield major safety benefits so that public can accept it more easily.

Technology manufacturers have worried about liability issues much more than the public sector or ITS America. They urge that liability issues be identified and resolved.

CONCLUSION

One of the main reasons why the National Automated Highway System Research Program (NAHSRP) failed was that the program was trapped in technology-optimism. Several U.S. DOT reports on AHS show that there are no technical and non-technical showstoppers. However, legal, institutional, and societal challenges just as critical as technical issues. Moreover, these institutional and societal issues cannot be settled in one day, because they are much to do with people's perception, behavior, consensus and social changes based on those.

It is important to demonstrate that AHS brings major transportation benefits in terms of safety, efficiency, affordability and usability, and environment in order to achieve its development goals. Yet, as we can see in the case of NAHSRP, program acceptance is not just based solely on technological capabilities but also on people's social,economic, and environmental concerns.

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[70] ibid. pg.41.

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