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Economic Development Division

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June 9, 1997

The Honorable Constance Morella
Chairwoman, Subcommittee
on Technology
Committee on Science
House of Representatives

Subject: Surface Transportation: The Department of Transportation Proposes Significant Changes to Its Automated Highway System Program

Dear Madam Chairwoman:

This report responds to your request for information on the current goals and future direction of the Department of Transportation's (DOT) Automated Highway System program. This program seeks to increase the capacity of the nation's highways and to improve safety by automating many driving tasks and enhancing drivers' ability to avoid accidents. An automated highway system includes a spectrum of technologies, ranging from intelligent vehicles that can notify drivers of unsafe situations to technologies that assume full control of driving tasks. This report provides information on (1) the potential benefits and drawbacks of implementing a fully automated highway system and (2) DOT's proposed changes to the Automated Highway System program and the implications of these changes.

In summary, we found the following:

- According to DOT and the National Automated Highway System Consortium, a fully automated highway system could significantly enhance the safety of highway travel by reducing or eliminating accidents caused by "human factors"–that is, by fatigue, inattentiveness, or poor decisions on the part of drivers. In addition, a fully automated system could increase highway capacity and reduce travel times because automatically driven vehicles could travel on an intelligent roadway within a few meters of one another at normal highway speeds or faster. However, automated highway system analysts have noted that before these benefits can be realized, significant operational issues will have to

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be resolved. For example, the greater numbers of vehicles on an automated highway could create bottlenecks at exit points as more traffic reenters nonautomated streets. In addition, a fully automated highway system raises important questions about the technology's impact on air quality and land use, about liability, and about the program's costs and benefits. These issues have been studied but not yet resolved under the Automated Highway System program's initial research efforts.

- According to DOT officials, in January 1997 DOT began to consider refocusing the direction of the program from long-term efforts to deploy a fully automated system to shorter-term research designed primarily to develop and test near-term technologies. As a result, the program will no longer focus on developing "revolutionary" technologies intended to produce a fully automated highway in the next 20 or 30 years. Instead, the program will be "evolutionary," testing and deploying increasingly advanced technologies over the next 6 to 8 years to enhance drivers' ability to avoid accidents and improve safety on the nation's highways. For example, the program will focus on collision avoidance warning systems that notify drivers when they are too close to other vehicles. DOT is proposing these changes because the administration and the system's potential users did not widely support the long-term fully automated vision and DOT believed that the program needed to produce short-term benefits to remain viable. The program's shift from a long- to a short-term focus creates uncertainties, including (1) whether the public/private consortium leading the Automated Highway System program will restructure its membership or dissolve, (2) how the refocused program will coordinate its research with comparable research conducted by the National Highway Traffic Safety Administration, and (3) how the Department will sustain investments in important long-term, high-risk research. DOT officials expect to resolve many of these issues by the end of the summer.

BACKGROUND

Established by the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991, DOT's Intelligent Transportation Systems (ITS) program has received $1.3 billion in federal funds to advance the use of computer and telecommunications technology to enhance the safety and efficiency of surface transportation. The principal long-term research component of the ITS program is the Automated Highway System program, which involves research and development on a number of advanced technologies designed to automate many driving tasks. The automated highway system concept includes several levels of automation.

These range from an intelligent vehicle that can notify the driver of imminent unsafe situations and assume temporary control of the vehicle to avoid collisions, to an advanced autonomous vehicle that controls driving functions such as steering and braking on normal roads, to an advanced system in which the infrastructure and the vehicle interact and assume full control of the driving tasks as long as the vehicle operates on an intelligent roadway. ISTEA directed the Secretary of Transportation to develop an automated highway and vehicle prototype with the goal of having the first fully automated roadway or automated test track in operation by 1997.

In the first years of the program, DOT contracted with various organizations, such as Raytheon and the University of California, to study the technical feasibility and benefits of implementing a fully automated highway system, as well as the barriers to doing so. Since fiscal year 1995, the National Automated Highway System Consortium[1] (Consortium) has led the program under a 7-year cooperative agreement with DOT. The Consortium–a public-private partnership including representatives of government, industry, and academia–is responsible, under the direction of DOT's Federal Highway Administration (FHWA), for defining the long-term vision for a fully automated system. The cooperative agreement calls for DOT to provide up to 80 percent of the $202 million originally budgeted for the 7-year effort.

From fiscal year 1993 through fiscal year 1997, DOT committed about $72 million to the program–$14 million to the pre-Consortium studies and $58 million to the Consortium (see enc. I for more information on the program's funding). With its funding, the Consortium has assessed a number of safety system technologies; examined numerous automated highway system prototype concepts; and led a broad outreach effort consisting of workshops and forums for more than 100 associate Consortium partners. In addition, the Consortium planned and developed an automated highway system test-of-feasibility demonstration, scheduled for August 1997 in San Diego. As part of the ITS program, DOT's National Highway Traffic Safety Administration (NHTSA) also is researching vehicle-based crash avoidance technologies to help improve safety on the nation's highways. These technologies are the building blocks of a fully automated highway system. Both FHWA's automated highway system research

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[1]The Consortium is a group of governmental, industrial, and academic organizations that includes the Federal Highway Administration and the California Department of Transportation; Bechtel, Delco Electronics, General Motors, Hughes, Lockheed Martin, and Parsons Brinckerhoff; and Carnegie Mellon University and the University of California.

and NHTSA's crash avoidance research are managed and coordinated by the Joint Program Office, which is responsible for managing all ITS research.

A FULLY AUTOMATED HIGHWAY SYSTEM OFFERS POTENTIAL BENEFITS BUT HAS POTENTIAL DRAWBACKS

According to DOT and Consortium documents, a fully automated highway system would enhance safety and expand capacity on the nation's highways. Before a fully automated highway system could be deployed, however, a number of technical and operational questions would have to be addressed. In addition, analysts have noted that a deployed automated highway system could have significant environmental, legal, social equity, and budgetary implications.

Literature that we reviewed from DOT and other sources maintains that a fully automated highway system could make the nation's highways safer. As envisioned, all components controlling a vehicle–the steering, braking, and acceleration–would be fully automated, preventing the driver from making errors as long as the vehicle remained on the automated road. Such a system could thus reduce or eliminate accidents attributable to human error, which account for the large majority of highway fatalities and injuries.

According to DOT's analyses and the literature we reviewed, a fully automated system could also significantly reduce congestion and increase capacity without requiring the construction of additional roads or lanes. On a fully automated highway system, vehicles could be grouped together in platoons. Separated by a few meters from one another, they could travel at speeds ranging from normal highway speeds up to 125 miles per hour. Upon entering a fully automated highway, a driver would indicate the desired destination and the system would assume the tasks of driving. A central computer would manage traffic and determine which vehicles to platoon, when to change speeds, and when to separate individual vehicles from their platoons. Because of the reduced distance between vehicles and the higher speeds, highway capacities would be significantly increased. Also, automated control could allow for narrower lanes, enabling jurisdictions to add new lanes on existing highway rights-of-way. Finally, a fully automated roadway could improve the flow of traffic by eliminating the irregular speeding and braking that occur because of differences in drivers' abilities and driving habits. According to a DOT estimate, highway capacities could be doubled or tripled under full automation.

However, according to DOT-funded studies[2] and other technical papers, the Automated Highway System program must overcome a number of operational issues before it can fully realize these improvements in safety and efficiency. First, a fully automated highway system could require additional rights-of-way near entrance and exit ramps to form platoons and conduct safety checks on vehicles. This additional area might not be available in densely developed urban and suburban locations. Second, the additional traffic generated by the automated highway might produce congestion on the exit ramps and connecting nonautomated roads. This effect might negate some of the benefits of improved traffic flow and create opposition to the automated system in residential and commercial areas affected by the increase in traffic. Third, the failure of a vehicle's braking or steering system on a fully automated highway could interrupt the flow of traffic and possibly cause a chain reaction accident. Some analysts have noted that vehicles would have to be more reliable than current cars and that the maintenance requirements for such vehicles could be very expensive. Requiring backup systems on vehicles or a lane dedicated to disabled vehicles could add significantly to the cost of vehicles or infrastructure.

Finally, even if all operational issues were resolved, a number of other issues would remain. First, the additional capacity that a fully automated system would allow might produce more air pollution and promote urban sprawl. If more vehicles were accommodated at faster speeds on a fully automated highway, vehicle emissions might increase and degrade air quality. In the long run, commuters might live farther from the workplace, encouraging urban sprawl and greater dependence on the automobile. Second, in the event of an accident on a fully automated highway, liability issues might arise. Since the automated system is intended to eliminate accidents attributable to human factors, the victims of an accident might blame either the vehicle manufacturer or the state highway department. Both automakers and state highway departments might be reluctant to embark on full automation unless their liability were limited. Third, equity issues would have to be addressed. Vehicles equipped to travel on a fully automated highway might cost more and be affordable only to affluent travelers. Since the costs of construction and maintenance might be higher for a fully automated highway than for a conventional highway, critics contend that the Automated Highway System program would use public funds to support affluent drivers who could afford to buy automated vehicles. Finally, according to Consortium, Joint Program Office

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[2]Summary and Assessment of Funding from the Precursor Analyses of Automated Highway Systems, DOT (Oct. 1995).

and American Association of State Highway and Transportation Association (AASHTO) officials, the states are concerned about the costs of constructing and maintaining fully automated highways. Dollars for maintaining even today's conventional highways are scarce, and some have noted that the investment required to implement a fully automated system would not be feasible for the foreseeable future.

DOT IS REFOCUSING THE AUTOMATED HIGHWAY SYSTEM PROGRAM TO EMPHASIZE NEAR-TERM TECHNOLOGIES

DOT is currently changing the Automated Highway System program's focus from long- to short-term–or from a revolutionary to an evolutionary approach. Instead of attempting to develop a system that would significantly increase the capacity of the nation's highways, DOT is proposing to emphasize technologies designed to help drivers avoid accidents. According to DOT officials, this change does not mean that DOT is abandoning the long-term goal of deploying a fully automated highway system. However, this change, which resulted from limited support for the program's original objectives, creates uncertainties about the future of the program and DOT's long-term research agenda.

The New Program Is to Focus on Developing and Testing In-Vehicle Crash Avoidance Technologies

Under the program's new focus, DOT would develop and test three levels of increasingly advanced crash avoidance technologies, including several vehicle-based technologies currently under study by NHTSA. Level 1 technologies would include collision avoidance warning systems to notify drivers when they come too close to other vehicles or begin to steer off the roadway. Level 2 technologies would include advanced collision avoidance warning systems to alert drivers to potential crashes in more complex driving situations, such as at intersections. It would also include other advanced technologies to monitor drivers for signs of drowsiness, analyzing their head movements and blinking patterns; enhance drivers' vision at night and in fog; and temporarily take control of vehicles when drivers fail to respond to in-vehicle warnings. Finally, level 3 technologies would include further advances in collision avoidance, including technologies to control steering, acceleration, and braking.

According to a senior NHTSA official, NHTSA has completed substantial research on level 1 and level 2 technologies. The official said that one important unanswered question about these technologies is whether drivers can process the information the technologies provide without impairing safety. The official stated that the new program would conduct simulated driving tests and

develop vehicles equipped with one or more new technologies to learn more about drivers' reactions to the new technologies.

Consistent with the near-term emphasis of the refocused program, DOT anticipates that when level 1 is completed and level 2 is under development in 6 to 8 years, it will have developed prototype vehicles that include several crash avoidance technologies. In addition, DOT expects to have completed field tests of the vehicles by the end of the level 1 and 2 periods. According to a NHTSA official, if these technologies can be made cost-effective, they should be marketable at that time. With the implementation of these technologies for assisting drivers, NHTSA estimates that it can eliminate around 1 million of the 6.4 million crashes that occur on the nation's highways each year. The schedule for implementing the more advanced level 3 technologies is longer, extending well into the next century.

According to officials from ITS' Joint Program Office, two main factors prompted the change in the Automated Highway System program's focus. First, there was virtually no support within the administration, particularly within the Office of Management and Budget, for research that was not expected to produce benefits for 20 to 30 years. Second, feedback that the Consortium received during its outreach sessions with stakeholders–such as state highway agencies, local transportation planners, and environmental groups–revealed limited support for the fully automated system. This view was shared by an AASHTO official, who said that most state highway agencies are interested in short-term infrastructure, maintenance, and safety issues and do not posses the long-term planning horizon to support a fully automated highway system. As a result, the Joint Program officials said, they had to refocus the program to make it viable.

The Program's New Focus Leaves Many Issues Unresolved

Although the program's new focus may yield near-term benefits, the change raises important questions for the program's future. While these issues have not been resolved to date and the final outcomes may not be known for a number of months, DOT officials said they expect to resolve many of these issues by the end of the summer.

According to DOT and Consortium officials, the change in the direction of the Automated Highway System program may affect the Consortium's membership–some partners may drop out or the Consortium may dissolve altogether. Although DOT and the Consortium operate through a cooperative agreement, DOT decided to shift the program's emphasis to vehicle-based research. This

type of research–which may be relevant for some Consortium participants, such as General Motors and Delco–may not be of interest to more infrastructure-based members, such as Bechtel, Parsons Brinckerhoff, and California's Department of Transportation. In addition, the administration's proposal for reauthorizing ISTEA includes a provision limiting the federal cost share to 50 percent for long-range research undertaken in partnership with private entities. This provision could reduce the federal share for the Automated Highway System program from 80 to 50 percent. Consortium officials stated that after polling their members, they concluded that the Consortium would likely fold should this provision remain in the final bill and apply to the refocused program. However, according to these officials, the Consortium intends to refrain from taking any action until DOT completes the design of the new program and legislation reauthorizing ISTEA is enacted.

The program's new focus requires the Joint Program Office to make decisions about how to coordinate research for the Automated Highway System program and for NHTSA's research program. DOT officials said they need to develop a new program structure and identify the relative roles of various organizations. The officials envisioned that the refocused research would combine the work of NHTSA, FHWA, and the Consortium's remaining members. In addition, in April 1997, FHWA requested the Transportation Research Board (TRB) to assess the appropriateness of the Automated Highway System program's goals, identify ways to reorient and combine FHWA's and NHTSA's vehicle-highway research and development, and review the role of the Consortium. However, TRB will not complete its final report until several months after the Joint Program Office expects to complete its plans for restructuring the new program. Nevertheless, Joint Program Office officials stated that TRB's report will provide additional information to help them refine the structure and guide the future direction of the program.

Finally, the change in focus raises questions about how DOT will sustain its long-term, high-risk research efforts. The Automated Highway System program was the principal long-term research element in the ITS program. Under its new focus, the Automated Highway System program may retain its original goal for the distant future, but actual research and testing will focus on the near-term deployment of collision avoidance and warning systems. In September 1996, we reported that transportation experts believe that DOT's surface research portfolio lacks a sufficient focus on long-term, basic research.[3]

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[3]Surface Transportation: Research Funding, Federal Role, and Emerging Issues (GAO/RCED-96-233, Sept. 6, 1996).

However, as DOT and administration officials noted, a long-term research effort is difficult to defend and sustain because tangible results often lie beyond a near-term horizon.

AGENCY COMMENTS

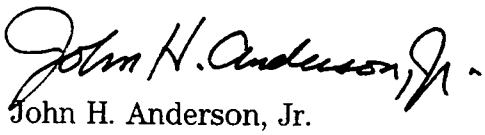
We provided a draft of this report to DOT for review and comment and met with the Director of ITS' Joint Program Office and FHWA and NHTSA officials to obtain the Department's comments. The Director had two overall concerns with the information provided in the report. First, she said that, in her opinion, the report implied that DOT had abandoned the vision of a fully automated highway system. She stated that although the program's new focus will emphasize near-term technologies and concentrate on in-vehicle technologies, DOT views these technologies as "stepping stones" to full automation. As a result, she emphasized, DOT is not abandoning the concept of full automation. We agreed to include this point in the report. Second, she said that although the program faces the current uncertainties cited in our report, she believes the Department has made progress in developing a new program and will resolve most of these uncertainties by the end of the summer. We also agreed to include this point in the report. In addition to these comments, the Director and other DOT officials provided several technical and editorial comments, which we have incorporated where appropriate.

SCOPE AND METHODOLOGY

We conducted our review from April 1997 through May 1997 in accordance with generally accepted government auditing standards. To prepare this report, we reviewed key FHWA, NHTSA, and Consortium documents. In addition, we reviewed numerous research articles and technical papers and interviewed key individuals from AASHTO, the Surface Transportation Policy Project, and the Environmental Defense Fund to understand the automated highway system concept, as well as its benefits and drawbacks. We discussed the Automated Highway System program and its new focus with officials from ITS' Joint Program Office, NHTSA, FHWA, and the President's Office of Science and Technology Policy, as well as with knowledgeable individuals from the Consortium and the Institute for Transportation Engineers.

Major contributors to this report were Joseph Christoff, Michael Hartnett, David Lichtenfeld, and Gail Marnik. Please call me at (202) 512-2834 if you or your staff have any questions.

Sincerely yours,



John H. Anderson, Jr.
Director, Transportation
Issues

PUBLIC AND PRIVATE FUNDING FOR THE AUTOMATED HIGHWAY SYSTEM PROGRAM, FISCAL YEARS 1993-97

Dollars in millions

	1993-94	1995	1996	1997 (planned)	Total
Commitments					
Federal share[a]	$ 14.1	$ 19.2	$ 16.5	$ 22.0	$ 71.8
Consortium's share	0	2.5	8.2	8.5	19.2
Total commitments	**$ 14.1**	**$ 21.7**	**$ 24.7**	**$ 30.5**	**$ 91.0**
Expenditures					
Federal	$ 14.1	$ 8.8	$ 19.4	[c]	$ 42.3
Consortium	[b]	2.5	8.2	[c]	10.7
Total expenditures, fiscal years 1993-96	**$ 14.1**	**$ 11.3**	**$ 27.6**	[c]	**$ 53.0**

[a]Total federal commitment includes both contract authority granted under ISTEA and funds provided through the appropriations process.

[b]Not applicable.

[c]Not available.

Source: DOT.

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