EXECUTIVE SUMMARY
THE UNITED STATES DEPARTMENT OF TRANSPORTATION
AUTOMATED HIGHWAY SYSTEM PROGRAM
REPORT TO CONGRESS

The Automated Highway System (AHS) Program will provide the stepping stone into automated vehicle-highway transportation in the 21st century.

This executive summary synopsizes the status report on the U.S. Department of Transportation's (U.S. DOT) Automated Highway System (AHS) program in response to Congress' request for the same by April 1, 1995.

Recent research on automated highways has clearly indicated that automated vehicle control technology significantly improves the safety and efficiency of *existing* highways. With this in mind, Congress included Section 6054(b) in the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 to enhance and focus the Nation's research into automated highways:

The Secretary [of Transportation] shall develop an automated highway and vehicle prototype from which future fully automated intelligent vehicle-highway systems can be developed. Such development shall include research in human factors to ensure the success of the man-machine relationship. The goal of this program is to have the first fully automated roadway or an automated test track in operation by 1997. This system shall accommodate installation of equipment in new and existing motor vehicles.

The AHS program responds to that Congressional guidance. The program involves a government/industry/academia collaboration that explores all areas associated with bringing automated vehicle control technology to the U.S. highway system. Its mission is to greatly improve the mobility, safety, and quality of highway travel. Increased efficiency should also help to conserve energy resources and to be compatible with urban air quality goals. In many cases, these improvements will be made using existing highway infrastructure.

The program focuses on a planned evolution to AHS from today's vehicle-highway system. This transition will be simplified because some of the basic automated vehicle controls needed for an AHS are starting to appear in today's vehicles; use of this technology is expected to increase over the next decade. Drivers will be offered Intelligent Transportation System (ITS) services such as *adaptive cruise control*, a cruise control system that helps a vehicle maintain a safe following distance from the vehicle in front of it; *collision warning and avoidance* to help prevent both rear-end and side-swipe crashes; and, *lane keeping*, which will hold a vehicle safely in its lane. Similarly, ITS technologies such as infrastructure-to-vehicle communications for Traveler Information Services and Advanced Traffic Management Systems will be deployed in the coming years. The AHS program will build upon and integrate with the evolution of these ITS services to ensure overall compatibility. To this end, current AHS activities are fully

coordinated with the ongoing development of a National ITS Architecture. With nationwide planning and infrastructure integration, AHS will become the next logical major evolutionary step in our highway transportation system.

Substantial issues are associated with the role of vehicle-highway automation on sustainable transportation and society in general. These issues must be addressed along with the technology issues of performance, reliability, and affordability. Research focused in these areas is a key part of the AHS program, combined with extensive stakeholder involvement. The program seeks a national consensus of the AHS stakeholders on both the system approach and deployment strategy based on results of this research.

The envisioned AHS would operate properly equipped vehicles under full automated control on dedicated lanes. All vehicles in the AHS lane would maintain a safe operating distance from the vehicle in front and stay in their lane of travel. With all vehicles in the lane automated, the opportunity for human mistakes and inefficiencies would be significantly reduced. It is currently assumed that many AHS lanes will be adjacent to, and similar to, the other freeway lanes, and entering AHS lanes may be similar to entering some of today's High Occupancy Vehicle (HOV) lanes or toll facilities.

Automation is essential for our Nation's surface transportation system in the 21st century.

Our vehicle-highway system is expected to continue as our Nation's primary mode of transportation for the foreseeable future. Americans also desire "green mobility," that is, more efficient transportation with proper care for the environment and land use.

Our Nation's vehicle-highway system presently carries 89 percent of all passenger miles of travel and 32 percent of the Nation's ton-miles of freight revenue [National Transportation Statistics, 1992]. It is a primary and essential link in our Nation's economy with an in-place infrastructure and societal role that is expected to continue.

It is increasingly difficult for our vehicle-highway system to meet the growing travel demands.

The reality is that the Nation's highway transportation system is rapidly reaching the limit of its ability to handle additional demand and serve the increasing transportation needs of the public and commerce. The increasing daily congestion of our Nation's highways reflects this. This travel demand on our highways is projected to continue increasing into the future.

Automation is one of the most promising approaches for improving vehicle-highway system performance.

The ITS program is investing substantial resources to improve the performance of our current transport systems. ITS is focused on such areas as improving information flow among vehicles, travelers, and the infrastructure; enhancing safety and security; and dismantling institutional barriers. Over the next decade or so, deployment of the ITS services within a coherent national architecture will result in gains in safety and transportation efficiency. Vehicle-highway automation is the natural evolution of these technology investments, integrating crash avoidance enhancements on vehicles and communication capabilities in our highway systems. AHS holds the promise of expanding collision avoidance safety benefits *and* providing a major performance gain in flow capacity for a given right-of-way compared to today's systems based on manually driven vehicles.

In fact, AHS is capable of providing a level of performance and service that is a generation beyond other ITS services. An AHS can double or triple the efficiency of today's most congested highway lanes while significantly increasing safety and trip quality. An AHS would serve all highway users, opening up new opportunities for transit bus operation, enhancing the safety and productivity of heavy trucks, and offering improved convenience and dependability to the traveling public. Its efficiency can help reduce both fuel consumption and individual vehicle emissions and will ensure maximum use of our existing highway infrastructure investment.

The AHS also provides near-term spin-off safety and efficiency improvements.

The AHS program is addressing automated vehicle control technology. This technology is increasingly being used in other ITS services to help save lives, reduce crashes, and enhance trip quality. The AHS program research and development is enabling the earlier introduction of these near-term crash avoidance safety products. Further, the AHS program is providing a framework so that near-term use of automated vehicle control technology in ITS services will be consistent with their potential transition to AHS.

A long-term strategic program and partnership is necessary to accomplish highway automation.

The U.S. DOT role is essential to exploring highway automation and in supporting long-term, high-risk R&D that industry and the States cannot undertake alone. The AHS program is the most comprehensive long-range R&D effort within the U.S. DOT focused upon an efficient and safe highway system to carry us through the 21st century. A strategic program for automated vehicle control R&D has been defined and U.S. DOT has formed a public/private partnership to research and define the AHS approach.

The U.S. DOT partnership is with the National AHS Consortium (NAHSC), a team of the Nation's major vehicle/highway system stakeholders_industry, State and local governments, user representatives_who will eventually build, own, operate, and use AHS. If AHS, as a large-scale effort, is to be successfully developed and implemented, this partnership must continue. Neither the public nor the private sector alone can implement AHS alone or provide all the needed

expertise. The vehicle manufacturers must cooperate with the highway builders and operators to develop vehicle and highway instrumentation and equipment that complement each other and gain the full benefits of automation.

The U.S. DOT will continue to facilitate the partnership on a cost share basis with non-Federal partners and represent the Nation's transportation and societal needs in the NAHSC.

Automated highways enhance our Nation's international competitiveness in the next century.

The U.S. program in highway automation is by far the most focused and comprehensive internationally. This program puts our industry and Nation in a global leadership position. Deploying AHS as part of a robust surface transportation system should increase transportation productivity and strengthen our Nation's ability to effectively compete in a global economy. It will provide rapidly expanding new markets for the U.S. automobile, vehicle electronics, and highway construction industries. The markets will grow first with the introduction of more near-term ITS products and services and then continue to increase with full highway automation. The 20 percent cost sharing commitment by non-Federal consortium partners shows the promise of these new markets.

Results have already shown that AHS holds great promise for addressing most of our Nation's highway transportation needs early in the next centuryboth the opportunities and the challenges.

The Analysis Phase of this Program has been underway for more than two years. Part of this Phase included "Precursor Systems Analyses" (PSAs) that involved in-depth research by 15 industry teams during 1993-1994. The findings show that the promise of AHS is real, although clearly many substantive issues and challenges lie ahead. However, the unanimous opinion of this research community is that no "show stoppers" were found. Many challenges were addressed, particularly in societal and institutional areas, which are now receiving further attention by the NAHSC, and will be key to national consensus discussions.

Some of the key findings of these analyses are:

- **Travel safety** - Should increase significantly; some estimates up to 80 percent improvement. This is based on analysis of causal factors in crashes, and of automated reactions that would help avoid inadequate and inconsistent human responses that often result in crashes. However, more investigation is needed to determine how the human driver will interact with the automated system. Human factors studies of the human-automation interface are ongoing, and will be specifically targeted to understanding how to integrate the human role into an AHS.

- **Efficiency** - AHS can double or triple the number of vehicles traveling on a highway lane and also eliminate driver merging, weaving, unsafe car following and lane changing. By tailoring the AHS for transit vehicle, commercial trucks, and High Occupancy Vehicle (HOV) operation, AHS can have a dramatic impact on movement of people and goods. AHS supports transit vehicle operations. The best means of integrating the volume of vehicles carried by AHS into a regional traffic network to increase transport efficiency is a challenge that was addressed

extensively in the PSA work, and it will be a challenge to and will be the focus of continued NAHSC investigations. For AHS to decrease overall congestion, it must be part of a region's integrated transportation plan that includes demand management in those urban areas where it may be needed.

- **User comfort and access** - Focus group participants anticipated that highway travel on AHS would be far less stressful in an AHS environment than on current (non-AHS) highways. Some participants expressed concern that AHS may not be accessible to everyone.

- **Trip time reliability** - Travel times on AHS should be more dependable because of the consistent AHS traffic flow. Traffic volumes at AHS entry and exit points must be carefully addressed to avoid congestion. The researchers concluded that an AHS deployment must be integrated with a region's other transportation resources.

- **Air quality** - AHS could reduce tailpipe emissions of individual vehicles during travel due to fewer rapid accelerations and reduced congestion, and can fully support alternate fueled vehicles. However, the capacity and attractiveness of an AHS may attract additional vehicular traffic and encourage single occupancy vehicle (SOV) travel. Researchers recommend making AHS deployment responsive to comprehensive land use planning. In dense urban areas, they recommend employing demand management policies to ensure reduced congestion, and to discourage increased SOV traffic. They also recommend considering environmental impact when larger volumes of vehicles travel in a concentrated corridor.

- **Mobility** - The AHS may attract drivers who avoid today's freeways (e.g., senior citizens and persons with disabilities). A national AHS network would enhance the Nation's mobility for all users, including truckers. Smooth transition to full vehicle control, defining a highly reliable and safe system which is also affordable and accommodating nationwide compatibility and local/regional tailoring are examples of system aspects that must be resolved.

- **Acceptance** - Introducing new approaches and technologies often creates tensions. AHS deployment will face the same challenges that other transportation improvement programs encounter in the planning and approval process. In addition, an AHS deployment will need to face the challenges that are unique to the integration of this new technology into the community.

The National AHS Consortium, a public/private partnership, will objectively choose the approach to highway automation that best meets the Nation's needs.

AHS PROGRAM STRUCTURE

The AHS program is planned around three broad phases as shown in the Figure 1. The National AHS Consortium is responsible for conducting the second phase, Systems Definition. This phase has been underway since late 1994. The talent and perspective of the many stakeholders are fundamental to the program approach in all phases.

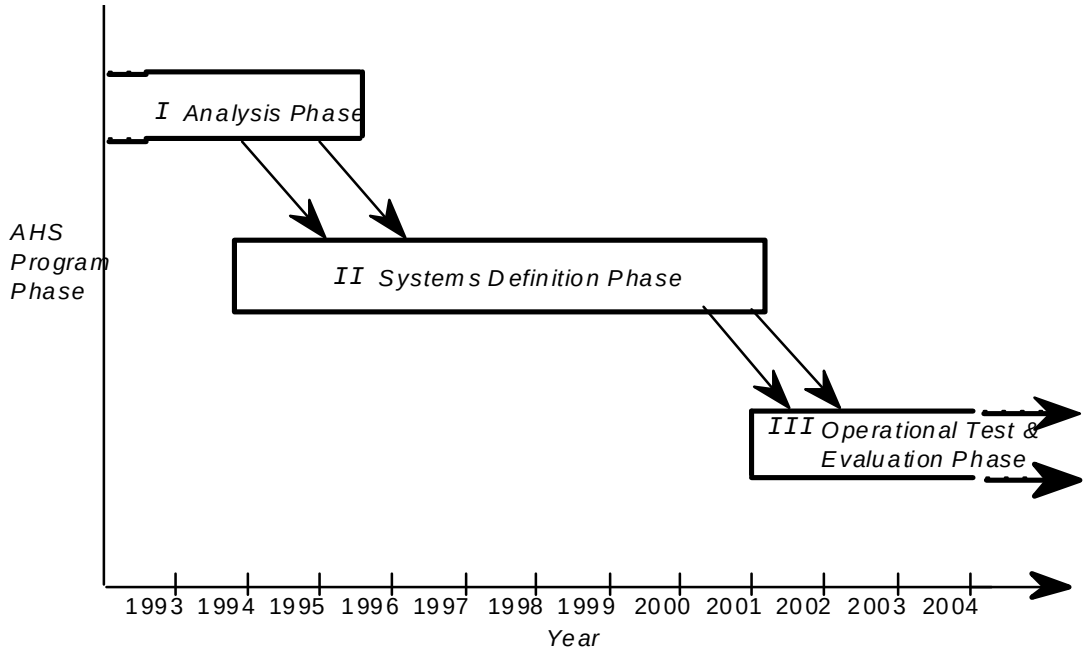

Figure 1
Phases of the AHS Program

• The **Analysis Phase** establishes an analytic program foundation. It consists of: (1) Precursor Systems Analyses (PSA) by 15 contractor teams that addressed automated vehicle control requirements and issues in 16 topic areas; (2) a human factors study effort to develop AHS human factors design handbook; and (3) National Highway Traffic Safety Administration (NHTSA) analyses to investigate other ITS automated vehicle control-based services that avoid collisions through warning and control; these services may be part of the planned evolution into the AHS.

• The PSAs identified issues and risks associated with various AHS concepts and design areas. A final conference of the PSA researchers was held in November 1994, and all contract teams have submitted final reports. The National AHS Consortium (NAHSC) is actively using these findings in their research.

In addition to being publicly available through the National Technical Information Service (NTIS), all PSA research reports will soon be available on CD-ROM and can also be accessed through a World Wide Web page (http://www.volpe.dot.gov/ahs/).

• The **Systems Definition Phase** is being conducted by the NAHSC working in partnership with the Federal Government. The consortium includes representatives from the vehicle industry, highway industry, State and local governments, regional and metropolitan transportation agencies, and electronics/communications industries associated with the vehicle and communications market.

The milestones of the consortium program are as follows: (1) establishment of performance and design objectives, (2) a 1997 proof-of-technical-feasibility demonstration, (3) identification and description of multiple feasible AHS system concepts, (4) selection of the preferred AHS system configuration, (5) completion of prototype testing, and (6) completion of system and supporting documentation including a planned evolution from other ITS services.

The AHS prototype will demonstrate the potential of automation applied to vehicles and highways *as a system*, as well as the potential benefits of a deployed system. The NAHSC is focused on the joint goals of sustainable transportation and improved mobility through prudent and innovative use of technology.

NAHSC activities are in full swing. A Stakeholder Participation program, as part of the broader Outreach effort, has resulted in the acceptance of over 60 organizations as Associate Participants to date, with many more expected to join as the program progresses. Systems requirements development, concept definition and evaluation, planning for the 1997 demonstration, societal and institutional analyses, and exploration of the potential of automation for commercial freight movement and bus transit, are examples of the many areas of intense activity.

• The **Operational Test and Evaluation Phase** is currently not funded. It would logically follow a successful completion of the Systems Definition Phase and include (1) integrating the preferred AHS system configuration into the existing institutional, technological, regulatory, and highway environment; (2) evaluating this configuration in a number of operational settings; and (3) establishing guidelines by which the U.S. DOT will support AHS deployment.

RECOMMENDATIONS

Continue Congressional support for the AHS Program through Phase II until AHS feasibility is determined and the system for the Nation has been chosen.

Since the passage of ISTEA established the program, a national consortium of state/regional transportation agencies, vehicle manufacturers, and highway industry representatives has been formed and is conducting the AHS program in cooperation with the U.S. DOT. These stakeholders are committing their skilled resources and management energies. This momentum must be maintained to realize the promise of the automated highway in operation.

The ISTEA legislation emphasized the 1997 Demonstration as an important milestone; it has been framed in a full program of six major milestones over the next 7 years. For this reason, it is imperative that the support for the program go beyond the demonstration milestone.

Therefore, continued Congressional support for AHS in subsequent authorizing legislation is necessary to maintain consistent investment by the non-Federal partners, and to determine the preferred feasible configuration for the Nation.

Establish Congressional support for AHS Operational Test and Evaluation (Phase III)

Beyond the 1997 demonstration is the selection and prototype testing of the preferred AHS configuration. Upon completion of the systems definition phase, the preferred configuration will next undergo operational test and evaluation. The support for this phase of the program is crucial to the successful deployment of AHS. Only through operational testing can the public understand, experience, and appreciate the promise of AHS. Much of the cost associated with the operational test and evaluation phase will be shared by private sources through public/private partnerships.