Evolution of New Generation Automated Highway System (AHS): A Review

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Abstract: *Research in automated highways has clearly indicated that automated vehicle control technology offers major improvements in the safety and efficiency of existing highways. With this in mind, Congress directed the Secretary of Transportation to enhance and focus the nation's research into fully automated intelligent vehicle highway systems. The Automated Highway System (AHS) program is a government industry academia collaboration to apply automated control technology to the vehicle highway system to greatly improve the safety, mobility, and quality of highway travel. The efficiency of the automated vehicle highway system is expected to help conserve energy resources to make more efficient use of existing transportation facilities and to contribute to a sustainable future transportation system. The deployment of AHS is intended to support community economic development and land use planning goals and to be compatible with urban air quality goals. Wherever possible, these improvements will be made using the existing highway infrastructure.*

Keywords: Intelligent Transportation System, MPO, HOV, Navigation.

Introduction:

The AHS program has been established to be the stepping stone to automated vehicle highway transportation in the 21st century. The program focuses on a planned evolution 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 during the next decade. Drivers will be offered Intelligent Transportation System (ITS) services such as adaptive cruise control, which is a cruise control system that maintains 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 automated 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 Program. With nationwide planning and infrastructure integration, AHS will become both a logical and major evolutionary step in our highway transportation system. 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 improved information flow among vehicles, travelers, and the infrastructure, the enhancement of safety and security, and the dismantling of institutional barriers. During 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. Therefore, the promise of AHS is an expansion of the collision avoidance safety benefits and a major performance gain in flow capacity for a given land area 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 security 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.

Objective of the Study:

The National Automated Highway System Consortium has prepared this document to introduce the current objectives and characteristics expected of a fully automated highway system, with the goal of balancing the needs of users and other stakeholders. These objectives and characteristics are goals and measurable targets used to guide requirements, system specifications, constraints, and criteria for AHS design concepts, prototype testing and deployment of the system. This document is useful as a point of departure to stimulate discussions with stakeholders and interested parties.

Review of Literature:

Today's vehicle highway system functions surprisingly well with its more than 6 million kilometers of streets, roads, and highways and its 190 million vehicles. However, it cannot keep pace with society's increasing transportation needs. Driven by population growth, the demand for mobility as a fundamental economic need is in direct conflict with our ability to fund new conventional highways and maintain a clean environment. The total vehicle kilometers traveled in the nation is predicted to nearly double by the year 2020, and our population will grow 50 percent by the middle of the twenty first century. We will need to make more efficient use of existing transportation facilities. Although traffic fatalities have decreased significantly in recent

Years, there are still more than 40,000 lives lost annually on the nation's highways, and there are more than 1,700,000 serious disabling injuries. The annual cost to the nation in dollars is estimated at more than $156 billion. Traffic volume has increased anywhere from 38 and 54 percent for each of the last three decades. Because system capacity has not kept pace with peak demand, 70 percent of all urban interstate peak hour traffic is congested, and this figure is predicted to grow to 80 percent by the year 2000. A large portion of this congestion is caused by incidents on our highways (e.g., crashes, breakdowns, obstacles in the lane). Congestion is projected to worsen by 300 to 400 percent over the next 15 years unless significant changes are made in the surface transportation system. In many areas, the traditional solution of building more lanes is becoming less viable because of limited rights of way, cost, citizens' concerns about the impact on the quality of life in their communities, and environmental requirements. Today, congestion alone costs the nation an estimated $100 billion in lost productivity annually. It also increases driver frustration and discomfort as congestion becomes worse and travel times become less predictable. Also, some drivers, including the elderly, are intimidated or frightened by highway travel. Moreover, fuel consumption will rise as trip time’s increase due to either length of the trip or time delays. In addition, predictability of delivery times will become less reliable, thereby increasing the frustration of customers of the shipping industry. As traffic volume and congestion continue to increase, methods to reduce exhaust emissions will be necessary to maintain air quality. The key emissions produced by individual vehicles have decreased between 70 percent (oxides of nitrogen) and 100 percent (lead) since 1970. Nevertheless, the vehicle-highway system is still one of the largest contributors to air pollution in urban areas as a result of increases in the vehicle kilometers traveled, vehicles idling in congestion, and the driving habits of the vehicle operators. The nation's concern is reflected in the Clean Air Act, which has established emission guidelines that must be accommodated in transportation planning. Therefore, the vehicle highway system must continuously strive to meet this demand. In particular, the system must improve in the areas of safety, congestion, air quality, and trip quality. The AHS program addresses fundamental human limitations to improving the vehicle-highway system, such as driver reaction times and fatigue. These factors are major contributors to accidents and congestion on our nation's highways. "Automated vehicle control" directly addresses these issues. It is because of human limitations that automation is essential for improving our vehicle highway system. To illustrate, the most common form of crash is the rear end collision. Ten percent of all cars and 25% of all trucks experience a crash of this type during the vehicle's lifetime.8 Single vehicle roadway departure and lane change/merge crashes represent about 32% of all accidents. Often times secondary accidents occur with each primary accident as a result of gawking, intrusion, and obstacles associated with the primary incident. The fatality rate is sharply higher at night: the night fatality rate is twice as high in urban and three times as high in rural areas compared with the day rate. More than 40% of the fatal crashes involve impaired drivers (drivers under the influence of alcohol, or experiencing drowsiness and fatigue). In addition, about 25% of crashes that result in fatalities occur on wet or icy roads. Finally, a lane volume of 2,200 vehicles per hour may be close to what humans can safely manage, and in many cases this rate is not achieved because of weaving or distractions such as stalls, collisions, or incidents in other lanes. Improvements in highway design, traffic management, vehicle safety design, and improvements in driving under the influence, safety, and speed enforcement programs have allowed modern highways to sustain passenger vehicle flow rates of up to 2,200 vehicles per lane per hour, while decreasing the number of fatalities per 100 million kilometers traveled by 30 percent. These benefits should be delivered with due care for natural resources and the environment. The results of a significant body of research suggest that a fully operational AHS can dramatically affect our nation's vehicle highway transportation system by improving the safety and efficiency of highway travel for a broad spectrum of vehicle types, including passenger, commercial, and transit vehicles. These improvements may also reduce vehicle emissions through reductions in stop and start traffic. Projections indicate that AHS lanes will double or triple the safety and efficiency of existing highway lanes. In sheer economic terms, if the AHS even approaches these kinds of benefits, this program will represent one of the most productive transportation investments ever made. The NAHSC has established the fundamental guidelines and capabilities for the AHS concept. An AHS will safely operate properly equipped vehicles under automated control on properly equipped lanes. Human errors and inefficiencies will be virtually eliminated when all vehicles in lane are fully automated. It is currently assumed that AHS lanes will be adjacent to, and similar in structure to, the other highway lanes. Entry to the AHS may be similar to entry to some of today's high occupancy vehicle (HOV) lanes or through dedicated entry stations. The fully automated AHS will be developed through a planned progression from today's vehicle highway system. This transition will be simplified because some of the basic services needed for an AHS are starting to appear in today's vehicles and highway systems. Use of these services is expected to increase during the next decade. Metropolitan areas are already upgrading their highway infrastructure with such services as electronic toll systems for nonstop toll collection, and automated incident detection for faster responses to crashes and other incidents. All have the potential to improve the efficiency of highway systems. The AHS will build on and guide this progression to ensure vehicle and infrastructure compatibility. With nationwide planning and vehicle and infrastructure integration, AHS will result from logical progressive steps over time. An AHS will use modem electronics to safely and efficiently move AHS equipped vehicles along instrumented, dedicated highway lanes under fully automated vehicle control with no driver involvement required. Manually driven vehicles will be denied access to the AHS lanes. AHS equipped vehicles will be able to operate under manual control on conventional lanes. On conventional lanes, the driver may choose to use partial automated vehicle control capabilities. This mode of operation known as "partial AHS" will offer some increase in safety and reduced driving strain compared to completely manual operation while on highway lanes used by all vehicles. AHS will be able to accommodate private, commercial, and transit vehicles. The extent of support for each type of vehicle is likely to be a local implementation decision. The AHS primary system control may require interaction between the vehicle and the roadway. This interaction will be non contact electronics based design as opposed to a mechanical, physical contact design. The AHS will consist of at least two major subsystems: the vehicles and an infrastructure. The vehicle subsystem will contain the portion of the system that actually moves along an AHS. The vehicle subsystem includes sensors, data processing, actuator, linkage, and communications equipment. The AHS will automate the following driver functions to control vehicle movement.

AHS Entry: The system will enter vehicles onto the automated highway with simultaneous speed adjustment between several vehicles to successfully merge vehicles.

AHS Exit: The system will move vehicles from the AHS lane and will return control of the vehicle to the driver after ensuring that the driver is prepared to safely operate the vehicle.

Object Detection and Collision Warning! Avoidance: The system will detect moving and stationary objects on the automated lanes and will avoid collisions with these objects.

Longitudinal Vehicle Control: The system will adjust the vehicle speed, both to maintain a safe overall speed (as influenced by environmental conditions), and the appropriate longitudinal distance between vehicles.

Lateral Vehicle Control: The system will steer the vehicle by sensing the lane boundaries or lane centers of the automated lane and control vehicle steering to keep the vehicle in the lane, coordinating lane changes and entry/exit maneuvers.

Navigation: The system will track the vehicle's position on the highway network to ensure that the vehicle leaves the system at the driver's desired exit or guide the vehicle to another exit of the desired exit becomes unavailable.

Maneuver Coordination: Using the vehicle's absolute or relative position on the highway with communication between vehicles, the system will coordinate vehicle maneuvers.

The infrastructure subsystem will contain all other aspects of the AHS not found in the vehicle. This includes, but is not limited to, communications equipment, roadways, control centers, sensors, and operations and maintenance facilities. The AHS will not be a standalone system. It will be developed and integrated with other transportation systems. It will supplement existing vehicle highway systems for state and Metropolitan Planning Organization (MPO) transportation planners and other policy makers. It will allow safer, more efficient, and cost effective highways to be designed while still meeting a region's environmental guidelines and societal goals. An AHS will support varying modes of transportation, but not limited to, local and trunk. Line transit services, commercial truck and taxi services, and shuttle services to major trip generators such as airports and commercial centers. All of the improved conveniences in the flow of information as a result of ITS technologies will be incorporated. In addition, AHS will provide faster transit and more reliable guide ways on which to operate. Users will not only be better informed of available service, but more attracted to faster, more reliable, and more direct service. Travelers as well as commercial users will find many new important ways to facilitate their activities. Typical of the early stages of any important innovation, it is impossible to anticipate all the entrepreneurial responses that will serve the user needs. There will be common standards so that an AHS equipped vehicle from one region of the country will be able to travel on an AHS in any other part of the country. Local vehicle size and performance restrictions may be different not to allow, for example, AHS equipped heavy trucks to operate in high congestion central business districts at certain times of the day.

Conclusion:

The AHS will be collision-free in the absence of AHS malfunctions and will include malfunction and incident management capabilities that minimize the number and severity of collisions that occur, as well as reducing the amount of time needed to respond to incidents that do occur. The AHS will provide substantially increased safety to vehicle highway users. Automated control will greatly eliminate driver generated errors attributable to poor judgment, fatigue, unpredictable behavior, and personal impairments. Up to 93% of highway crashes are attributed to driver error. IS By transferring driver control to the AHS vehicles while on AHS highways, the automated system will reduce vehicle mishaps per highway kilometer by as much as 50 to 80 percent. The AHS will interact positively with on board vehicle monitoring systems so that defective and manually controlled vehicles are excluded from automated control lanes. The AHS will show a reduction in the occurrence rate per highway kilometer of fatalities, severe injuries, and property damage for AHS vehicles under automated control of at least one half the current rates for highway traffic. This reduction will be accompanied by an ability to decrease the rate of mishaps resulting in minor injury or property damage on similar types of highways. The AHS will be designed to ensure that the safety of manually operated vehicles will not be degraded by AHS. In normal operating conditions, the driver will transfer vehicle control to the automated system as a condition of entry into the automated lanes. The AHS will control the vehicle while it is in the system. Control will be returned to the driver upon exiting the automated system. This will help ensure that driver errors, both personal and those by drivers in nearby vehicles, will not result in a mishap. The automated system will take appropriate measures to ensure that the driver is ready to take control from the automated system before control transfer. To help increase safety in case of unexpected events, the system will enable the driver to signal an emergency and bring the system to a halted condition or other fail safe state of operation. This is similar to the emergency signaling provided on public buses and trains.

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