Precursor Systems Analyses of Automated Highway Systems

RESOURCE MATERIALS

Contract Overview Report

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FOREWORD

This report was a product of the Federal Highway Administration's Automated Highway System (AHS) Precursor Systems Analyses (PSA) studies. The AHS Program is part of the larger Department of Transportation (DOT) Intelligent Transportation Systems (ITS) Program and is a multi-year, multi-phase effort to develop the next major upgrade of our nation's vehicle-highway system.

The PSA studies were part of an initial Analysis Phase of the AHS Program and were initiated to identify the high level issues and risks associated with automated highway systems. Fifteen interdisciplinary contractor teams were selected to conduct these studies. The studies were structured around the following 16 activity areas:

> (A) Urban and Rural AHS Comparison, (B) Automated Check-In, (C) Automated Check-Out, (D) Lateral and Longitudinal Control Analysis, (E) Malfunction Management and Analysis, (F) Commercial and Transit AHS Analysis, (G) Comparable Systems Analysis, (H) AHS Roadway Deployment Analysis, (I) Impact of AHS on Surrounding Non-AHS Roadways, (J) AHS Entry/Exit Implementation, (K) AHS Roadway Operational Analysis, (L) Vehicle Operational Analysis, (M) Alternative Propulsion Systems Impact, (N) AHS Safety Issues, (O) Institutional and Societal Aspects, and (P) Preliminary Cost/Benefit Factors Analysis.

To provide diverse perspectives, each of these 16 activity areas was studied by at least three of the contractor teams. Also, two of the contractor teams studied all 16 activity areas to provide a synergistic approach to their analyses. The combination of the individual activity studies and additional study topics resulted in a total of 69 studies. Individual reports, such as this one, have been prepared for each of these studies. In addition, each of the eight contractor teams that studied more than one activity area produced a report that summarized all their findings.

Lyle Saxton
Director, Office of Safety and Traffic Operations Research and Development

NOTICE

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16. Abstract
The Automated Highway System (AHS) program component of the Intelligent Transportation Systems (ITS) is a broad national effort to provide the basis for, and transition to, the next major performance upgrade of the U.S. vehicle/highway system, through the use of automated vehicle control technology. As part of the Analysis Phase, the Precursor System Analysis (PSA) was performed to identify issues and risks associated with AHS. This contract overview report addressed part of Activity “F” for Commercial and Transit Aspects and Activity Area “O”: for Institutional and Societal Issues.

In Activity Area “F”, many areas were researched including: European mechanical/electronic guided bus state of the art technology summarization, motor carrier market segmentation by specific AHS Cluster Map descriptions, Dual Mode Transit prototypical applications for AHS, and right of way needs for Motor Carrier/Transit vehicles at stations/mainline locations.

There is a correlation between the extent of standardization on the one hand and complexity of the ASH on the other. The more the characteristics of vehicles are subjected to rules and standardized, the less the expenditure for integrating an ASH into vehicles and guiding them automatically. The recommended concept is to allow ASH Transit to be developed on a parallel path, while at the same time, ensuring that its technology development program be subset of the larger ASH research effort.

In Activity Area “O”, Institutional and Societal Issues of ASH, many areas were researched including: previous research, focus group research/conduction/analysis , and institutional issues. The early tasks involved the review of literature and presentations on institutional concerns as they relate to ASH. Later tasks developed focus groups that raised concerns and allowed for “trial ballooning” of potential solutions of such concerns. ASH will have significant effects upon interstate commerce. Institutional issues relating to commercial operators and those that enforce safety and economic regulations on the operators will be chief among those with critical potential problems stemming from deployment of AHS. How those costs are allocated between industry and the different levels of government, and the effect of the costs on user fee and tax programs are key institutional issues

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CHAPTER 1: INTRODUCTION

The Automated Highway System (AHS) program component of the Intelligent Transportation Systems (ITS), formerly known as Intelligent Vehicle Highway Systems (IVHS), is a broad national effort to provide the basis for, and transition to, the next major performance upgrade of the U.S. vehicle/highway system, through the use of automated vehicle control technology. The long range goal is to significantly improve the safety and efficiency of the nation's surface transportation system through a national effort that best ensures the early, successful deployment of AHS. As part of the Analyses Phase, the Precursor Systems Analyses (PSA) are being performed to identify issues and risks associated with AHS.

1.1 ACTIVITY AREA SUMMARY DESCRIPTIONS

BDM Federal, Inc. was selected to investigate 2 of 16 major Activity Areas in the PSA of AHS Activity Area "F" in the AHS investigation research detailed the Commercial Motor Carrier and Transit Analysis of AHS. The second major area, Activity Area "0" draft with the Institutional and Societal Aspects of AHS. This contract overview report addresses the individual and cross-cutting conclusions identified from this PSA for the AHS.

1.1.1 Description of C&T Activity Area

In Activity Area “F”, Commercial and Transit AHS Analysis, a number of technical evaluations were studied, ranging from guideway right-of-way requirements, market needs determination, shared/separate guideway issue identification and comparisons of U.S. and European automated system technologies. Theoretical right-of-way design requirements based upon research into vehicles and guideways were provided. Using the geometric characteristics of the transit guideway, the option of totally separate rights-of-way and optional physical time shared management of common rights-of-way were evaluated. In this geometric and functional study, the concept of platooning was explored.

1.1.2 Description of I&S Activity Area

In Activity Area NON, Institutional and Societal Aspects of AHS, many areas were studied including previous research, focus groups, and institutional issues. The early tasks involved the review of literature and presentations on institutional concerns as they relate to AHS. Later tasks developed focus groups that raised concerns and allowed for "trial ballooning" of potential solutions of such concerns. A representative collection of the current research in the area of institutional issues facing AHS and ITS in general was compiled and reviewed. A primary focus of the research was to identify public reaction to AHS concepts wherever possible, and also refer to those studies and reports that addressed ITS issues as well as AHS. A finely tuned Focus Group Survey Instrument, used in focus group sessions representing a broad range of constituencies,~allowed the Federal Highway Administration (FHWA) to see firsthand how the institutions and people who have to make AHS a reality really think about the issues.

The institutional issues associated with AHS will pose significant difficulties for commercial vehicle operations (CVO) and the regulators who administer and enforce motor carrier safety and economic standards. The public and private sectors ultimately will share the total cost of an AHS system. How those costs are allocated between industry and the different levels of government, and the effect of the costs on user fee and tax programs are key institutional issues. As the intelligence and instrumentation of the system moves from mostly "in the roadway" to mostly "in the vehicle)" costs shift from the public sector (the usual financier of roadways) to the private sector (the usual financier of vehicle purchases).

1.2 CONTRACT FOCUS

The C&T report documents the findings of the analysis of AHS Commercial and Transit Aspects. This section identifies the purposes and objectives of the precursor level of analysis for commercial truck motor carriers and transit bus operators. Defining trucking industry regulator's constraints, documenting European automatic bus technology summarization and creating a prototypical AHS Dual Mode Bus concept are the primary objectives of this study.

The I&S report will discuss the purposes and objectives of the Institutional and Societal Issues Study of AHS at the precursor level. The societal areas of public acceptance impacts were investigated. Institutional issues as they relate to the public/private arena with a particular emphasis on issues affecting commercial motor carriers also were investigated.

1.2.1 C&T Purpose

The purpose of the motor carrier industry aspects portion of the study were as follows:

- Identify the needs of the industry, given its past experience with new technology, industry trends, and available AHS motor carrier market through topology/market segmentation.
- Develop a method of identifying the parts of AHS operations that uniquely defined motor carrier trends and relationships.
- Define the best approach, applicability, and benefits of AHS to motor carrier operations.

For the Transit industry, several aspects of research and prototype development were the defined purposes of this study:

- Research the existing and past technology for advanced bus concepts and define its applicability for AHS Transit.
- Develop a prototypical intermodal corridor using technologies like the Dual Mode Bus for a hypothetical AHS application.
- Prepare an exclusive research analysis on the state-of-the-art in advanced European bus technology looking at electronically and mechanically guided bus systems.

1.2.2 C&T objective

The report's objective is to present the key issues relating to the implementation of AHS in the commercial motor carrier and transit industries. Each industry has its unique set of needs, regulations, design restrictions, and funding sources. The relation between private, public, and joint public/private issues for these groups is a combined objective for the study.

The commercial motor carriers objectives relate to defining its industry's unique needs and redefining the standard AHS Representative System Configurations (RSCs) into a more correctly delineated AHS truck type cluster mapping. Then the definition of what portions of AHS could become applicable technological potentials for successful deployment can better be identified.

The transit objectives in this study focus on researching past advanced technologies and identifying "lessons learned." The European and Dual Mode Transit Bus experiences are used to help identify a potential successful U.S. implementation system for AHS deployment.

1.2.3 I&S Purpose

The purpose of the Public Acceptance portion of this study is threefold:

1. Summarize the available information regarding public acceptance of AHS.
2. Develop new information through the use of the focus group methodology applied to a selected set of target groups of relevant populations.
3. Suggest future directions in this process based on the analysis of this information.

The purpose of the second part of this report was to:

1. Develop an analytical framework for categorizing institutional issues.
2. Evaluate the criteria necessary to successfully deploy AHS in both the private and public sectors.

1.2.4 I&S Objectlves

This report, as it relates to the issue of Public Acceptance, focuses on the results of work aimed at addressing the following research questions:

- Based on a review of the open literature, what is known regarding the issue of public acceptance of an AHS as presently being developed in the United States?
- What attributes of AHS are likely to affect user acceptance, and how do perceptions vary across different segments of the public?
- What attributes of AHS are likely to affect community acceptance, and how do perceptions vary across different segments of the public?
- What research and policy actions could be taken to ameliorate public concerns and/or enhance acceptance of AHS?

From the institutional issues perspective, the objectives of this report are to identify several analytical frameworks of public, private and joint public(private sector impacts.

To ensure full coverage of the institutional issues three categories are considered:

- Mandate.
- Organization.
- Resources.

Mandates consist of vision, leadership, and authority. Most efforts that significantly affect the way that business operations are conducted require some kind of mandate from legislation, from executive orders, or from popular demand. With a mandate comes legitimacy and support for action. Impacts of the Clean Air Act Amendments (CAM) and the Intermodal Surface Transposition Efficiency Act (ISTEA) on the business sector will shape such mandates.

Issues associated with the "mandate" category reflect the lack of senior executive, political, or administrative support for the implementation of AHS. Mandate issues may arise when there is a strong public demand for a particular change but no executive-level response to implement the change, or when there is an administrative directive but no popular support for an action. They also may occur when there are conflicts among public sector entities on the implementation of a change.

The report objectives include the presentation of key issues relating to the need for defining the mandate for AHS affecting the public sector, the private sector or both jointly from many perspectives.

The key public sector issues include:

- Multi-jurisdictional regulation.
- Risk management.
- Resistance to change.
- Articulation of benefits.
- Commitment.

In the private sector institutional issues include:

- Market uncertainty.
- Privacy concerns.
- Legal concerns (particularly with respect to liability and insurance).

Joint public/private institutional issues include:

- Safety.
- Economic development.
- Environmental impact.

Another prime objective of this study is to discuss how issues relating to public/private collaborations, coordination, and communication can be achieved among multiple organizations, organizational roles and responsibilities, and administrative requirements.

Finally, an important objective is to identify a plan or approach focusing on the number and skill levels of human resources as well as the availability of financial resources.

1.3 ISSUES ADDRESSED IN EACH ACTIVITY AREA

Several major issues from both activity areas address many of the same regulatory constraints. They have different details, but contain common threads of coordination/cooperation mandated by legislative and regulatory statue. There are also many institutional issues that impact commercial motor carriers and transit operations. Much of the cross-outing observations have been the product of this combined research performed by a single prime contractor and several of the same subcontractors used on both activity areas.
The issue of public acceptance of AHS by the general and technical public has also began summarized in the I&S activity area of these PSA reports. Also identified were the mandate, organization, management, and resource issues in the public, private, and public/private areas.

1.3.1 Policy Developments In ISTEA

The AHS program is being developed as one aspect of the larger mandate of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, a landmark piece of legislation with far reaching policy implications. This section of the Commercial and Transit Report reviews certain key policies and mechanisms called for in that legislation which could have an impact on the development and deployment of a national AHS program, with particular reference to those policies issues relevant to the development of Commercial and Transit aspects of the program.

A major direction brought about by ISTEA is the mandate to incorporate freight planning into the established surface transportation planning process. At the metropolitan level, Section 1024 of ISTEA modifies the established transportation planning process in several ways, including the requirement that metropolitan planning incorporate 15 factors, which specifically include:

- Methods to enhance the efficiency of freight.
- International border crossings and access to ports, airports, intermodal transportation facilities, major freight distribution routes, national parks, recreation areas monuments historic sites and military installations.

At the statewide level, the law calls for a new requirement of a statewide planning process, which makes reference to 20 factors which include:

- International border crossings and access to ports, airports, intermodal transportation facilities, major distribution routes.
- Methods to enhance the efficiency of commercial motor vehicles.

Because the implementation of an AHS system could result in a major increase in the capacity of a roadway, it is important to review the general policy orientation of ISTEA towards the construction of general purpose roadways. Section 450.320 (b) of the State and Metropolitan planning regulations state:

"In TMA's designated as non-attainment for ozone or carbon dioxide, Federal funds may not be programmed for any project that will result in a significant increase in carrying capacity for single occupant vehicle (a new general purpose highway on a new location, or adding general purpose lanes, with the exception of safety improvements or the elimination of bottlenecks) unless the project results from congestion management system (CMS)…"[1]

New special purpose capacity, such as the creation of an High Occupancy Vehicle (HOV) lane, or a truck-only highway are specifically not included in this category. However, the creation of such a facility would most probably be integrally interrelated with the development of the Congestion Management System (CMS) and the Intermodal Management System (IMS). The following sections of this chapter review the role of these Management Systems in the ISTEA planning process.

1.3.1.1 The Congestion Management System

ISTEA calls for the preparation by the states of six "management systems" and a program of traffic monitoring. Those systems cover pavements, bridges, safety, public transportation facilities and equipment, traffic congestion and intermodal transportation facilities. The management systems are seen by US Department of Transportation (USDOT) as a strategic approach to meet the objective of operating the existing system better, and to plan for its future. In each of these systems the emphasis is on performance operations and maintenance. This chapter will briefly review the nature of these two management systems, and examine the implications of the Environmental Protection Agency's (EPA's) General Conformance rules on the implementation of major investment, such as a possible AHS system.

According to the regulations, the CMS is "a systematic process that provides information on transportation system performance and alternative strategies to alleviate congestion and enhance the mobility of people and goods'. Given that the CMS calls for the evaluation of projects and systems in terms of their ability to "enhance the mobility of people and goods," the mandate of the legislation is clear; the movement of goods is to receive attention similar to (or equal to) the movement of persons. Thus, the candidate AHS project - just like very other project in the system-will be examined for its contribution to the improvement of the flow of goods. Any early deployment of the concept which falls to incorporate freight elements would be at a significant disadvantage for processing through the CMS process.

The congestion management system is the mechanism for the analysis of the possible role of additional highway capacity in the region. It should be noted, however, that the legislative mandate is not against all capacity, but rather single auto occupant capacity. Thus, either an exclusive busway or an exclusive truck road could be built without such policy restriction. The clear policy thrust here cells for an incorporation of freight considerations into every project that is developed. From the beginning of the concept, incorporation of freight needs into the design of an AHS system would seem to be essential for the deployment of the technology within the context of the required CMS procedures.

ISTEA's policy limitation on the creation of new general purpose highway capacity outside of the context of a program to discourage SOV travel has major impacts on the development of the AHS program, and its need to incorporate both HOV and public transit elements from the outset of the program. Once the case for new lanes which would accommodate SOVs has been established, the CMS procedures call first for the incorporation of "all reasonable strategies to manage the SOV facility effectively (or to facilitate it's management in the future.") Thus, before the examination of off-facility strategies to discourage SOV travel (such as carpooling, variable work hours etc.) the facility itself is to incorporate elements which are consistent with the ISTEA policy towards SOV demand management. If, for some reason, early AHS deployment fails to include a vigorous program of higher-occupancy vehicle encouragement, the conflict with the legislative mandate revealed in the CMS could have highly negative consequences for the possibility of later deployment which did include such strategies.

1.3.1.2 The Intermodal Management System

When reviewing the concept of Intermodal transportation for its impact on the need to develop new transportation technology, it is worthwhile to go beyond the issue of the actual points of interconnection and their operation. Summarizing the results of TRB's first conference on ISTEA and Intermodalism, Prof. Michael Meyer wrote:

> "In intermodal planning, key interactions between modes, including not only transfers but also the policy and service interactions between alternative modes, are identified. An intermodal transportation system should be viewed from the perspective of the total trip. Therefore, not only are the points of interconnection between modes important but so too are the links that connect these points."[2]

The movement of goods in a state or metropolitan area is addressed both in the OMS and in the IMS. However, it can be argued that the CMS tends to examine the quality of this service largely as a subset of the larger issue of level of congestion, and the development of strategies to decrease that congestion. The IMS, on the other hand is tasked with the evaluation of the quality of the flow of goods, to be examined through the application of performance measurement which goes far beyond the question of roadway congestion. Professor Meyer writes that "IMS focuses on the intermodal movement of people and goods. However, transportation planning has not had a long record of successfully dealing with goods movement of either a technical or a process perspective. IMS now places greater emphasis on these issues. To many, this may seem like an understatement, as it can be argued that freight concerns have been functionally excluded from the planning process. For many states, it is the necessity of creating an IMS that is bringing representatives of the freight industry back to the table.

The Intermodal Management System calls for the monitoring and evaluation of the quality of non-SOV connections to major modal facilities, such as airports, seaports and intermodal passenger terminals. The argument can be made that these locations are good candidates for the kind of higher quality transit services that AHS Transit would be able to provide. The IMS should help to monitor the kinds of trends that are happening now, such the trend towards demand-activated services at airports. Section Five of this report will note that major components of a total IVHS strategy are now being implemented at major airports, including Automatic Vehicle Identifications systems and Advanced Passenger Information Systems.

1.3.2 The Clean Air Act's Conformity Regulations

In November of 1993, the EPA issued new Conformity Regulations which govern the manner in which a given transportation investrnent whether funded by traditional surface transportation sources such as FHWA and FTA (the Transportation Conformity Regulations), or by other sources, including FM$_1$ FRA and MARAD funds (the General

Conformity Regulations). These Regulations establish the process for determining if a given proposed investment can be found to be in conformity with the established State Implementation Plan, created under the terms of the Clean Air Act Amendments of 1990.

With the publication of the new regulations, EPA clarified that the owners of facilities covered under the "General" conformity regulations would indeed have to follow the procedures already established under the "Transportation" regulations, concerning the indirect emissions caused by a project outside of the boundaries of that project. As the final rulemaking notes, "the general conformity rule covers all other Federal actions, including those associated with railroads, airports, and ports." Importantly for the study of new transport technologies, EPA has made it clear that the general conformity rule will cover the indirect emissions caused by vehicles coming to and going from the new facility. In their preamble to the General Conformity Regulations, EPA noted:

> "Congress clearly intended the transportation conformity rule to cover the indirect emissions from vehicles that would travel *to and on* highways constructed with Federal support. Thus, the conformity review does not focus on emissions associated with only the construction of the highway project, but includes emissions from vehicles that later travel *to and on* that highway. The general conformity rule originates from the same statutory language and so must meet the same congressional intent... As described above the *transportation treatment provisions of the Act clearly require consideration of indirect emissions. Therefore, EPA conduces that the general conformity rule must also cover indirect emissions. 11(4)*

Thus, we have noted two areas of influence of the EPA conformity regulations on policies relevant to AHS deployment. First, and most positive, the regulations call for operators of airports, ports and freight facilities to come to the table to be responsible for the impacts of their facilities on off site situations. This, in itself widens the constituency of those concerned about the possible use of new technology for access to intermodal facilities. Secondly, the CAM-based process of SIP review changes the way in which an individual project is evaluated. By throwing the analysis into the larger arena, the project gets evaluated in a broader perspective of modal diversion, trip generation, trip distribution and land use change. The implications for the development of the AHS program seem to be clear: the given facility investment must be seen an a context beyond that of facilitating and encouraging the growth of SOV Travel.
In a way, the provider of an AHS facility is affected by the regulations in a manner similar to the provider of the airport services. In both cases it becomes imperative that the project be designed from the outset to deal with the totality of its impacts -- impacts which may occur on the facility and impacts which may occur off of the facility. For the AHS provider industry (whether that be an entity which is private, public, or a combination of both) the product of the investment should be planned from the beginning to have a proactive role within the context of the SIP. Early incorporation of both commercial and transit vehicles into the AHS candidate project will, in many cases, be an essential element of a strategy to bring about conformity with the SIP process.

1.3.3 The Needs of the Motor Carrier Industry

The application of AHS technologies to the motor carrier industry has not been well understood. The operating characteristics of the motor carrier industry are more complex operating characteristics than those of private automobiles. Moreover, the motor carrier industry is in rapid transition amidst a sea of technological, regulatory, and economic changes. A better understanding of the industry's characteristics is necessary to evaluate the application of AHS.

This chapter considers some of the more important trends shaping the motor carrier industry in the recent past and foreseeable future, and assesses the implications of these trends on the development and implementation of AHS programs. In addition, the chapter develops a methodology for segmenting and characterizing the motor carrier industry according to five principal dimensions --principal product carried, geographic range of operation, fleet size, routing variability, and time-sensitivity of deliveries. Three industry segments are characterized according to this taxonomy, providing a representative cross-section of trucking activities for use in evaluating specific AHS configurations.

1.3.3.1 Trends

In the past decade, an assortment of forces - from deregulation to the rise of intermodal freight movement to the application of new information technologies -- have dramatically reshaped the motor carrier industry. Additional changes are likely in the future. Many of these trends facing the industry have important implications --both positive and negative -- for the development and implementation of AHS in the motor carrier industry. These are listed in table 1.

Table 1. Motor Carrier Industry Trend implications for AHS

Industry Trend	Implication for AHS
Deregulation of intrastate trucking and subsequent restructuring and cost-containment pressures	AHS must offer motor carriers a competitive edge in their markets but carriers are not likely to support significant new costs
Evolution of trucking companies into full-scale, global providers of multimodal transportation and logistics services	AHS systems must be designed from regional national and multimodal perspectives
Rapid application of emerging information and communication technologies	Sophisticated trucks should easily adapt to new technologies, but motor carriers will be increasingly discerning consumers.
Rising labor costs due to changing demographics and increasing government regulation	Cost-effective AHS systems will offset higher labor costs, but AHS training will be an added expense

Many trends in the motor carrier industry were discussed in the C&T activity area such as:

- Modal share of freight movements.
- Customer service.
- Information technology.
- Labor pressures.
- Intermodal freight operations.
- Truck size/weight.
- Safety.

1.3.3.2 Motor Carrier Industry Typology

To evaluate the potential applicability of AHS to the motor carrier industry, it was necessary to understand the industry's characteristics. Traditional industry typologies based on regulatory status and revenues were not adequate because they overlooked key operational characteristics. In this section of the C&T report, an alternative typology of the trucking industry was developed, based on the following characteristics:

- Principal Product Carried, which differentiates among trucks carrying various types of products and accounts for the differing needs of the industries they serve.
- Geographic Range of Operation, which differentiates local, regional, and national operating scopes.

- Fleet Size, which differentiates motor carriers and their need and capacity for fleet management technology.

- Routing Variability, which differentiates motor carriers that operate repetitive, fixed routes, and therefore might make use of an AHS facility in their territory, from variable route carriers, who may change their destinations daily and therefore have less opportunity to use a specific AHS facility.

- Time-Sensitivity of Deliveries, which differentiates those segments of the industry that operate "just-in-time" delivery operations and may be particularly sensitive to travel time savings provided by an AHS.

The highly fragmented trucking industry reflects the complexity and diversity of the many businesses, industries, government agencies, and consumers it serves. The most common approach to industry segmentation has been to divide the industry by regulatory status and type of operation:

- For-Hire Truckload (TL) carriers.
- For-Hire Less-Than-Truckload (LTL) carriers.
- Private Truckload (TL) fleets.
- Private Distribution Less-Than-Truckload (LTL) fleets.
- Service fleets.

The new trucking industry taxonomy is based on the following operational characteristics, which are the most important for fleet management purposes:

- Principal product carried.
- Geographic range of operation.
- Fleet size.
- Routing variability.
- Time-Sensitivity of deliveries.

This segmentation of the motor carrier industry is essential to adequately identify the real needs and expected market benefit for AHS applications.

1.3.4 Transit utilization of AHS

Commercial and Transit Report presents a review of the possible role of Automated Highway Systems technology in the development of new systems of public transportation. In order the better understand the needs of the transit industry, a historical analysis was undertaken of major research efforts of the past three decades. These research efforts focused on the uses and limitations of bus technology in medium and high volume applications.

The development of AHS Systems offers the possibility of a revolutionary improvement in service improvement for the American transit industry. The prospect of free flowing guideway segments of the regional AHS network being available to transit vehicles offers many opportunities for high quality services to be routed over major routings in a high volume, high capacity format, with the cost of maintenance of these line segments largely (or entirely) borne by budgets other than the transit operator. (If, for example, it is assumed that on a given roadway link has a possible capacity of 4,000 vehicles per hour. Assuming that link had 60 buses on it which were providing 3,000 seats of capacity, the buses would represent about less than two percent of the vehicles on the system, and might equivalently bear only two percent of system investment costs.)

Buses, unlike trains, provide high levels of capacity by relying on a relatively high number of vehicles. There exist many design and operational issues associated with the operation of Systems which provide capacity by providing many smaller vehicles. The design of facilities, and routing/operational needs of these vehicles, must be thought through before the AHS system is defined.

1.3.4.1 Implied Needs of the Transit Industry

The transit industry wants to provide a higher quality of service, but cost is an overwhelming issue. In cities where the investment is made in rail the service is very popular. But even in these cities, expansion of the initial lines is a problem because of cost. Solutions are found for the downtown with careful planning in cities like Portland Oregon showing the way. But the extension of totally exclusive rights-of-way deep into the suburbs is very expensive. Because of the technology, the rights-of-ways cannot be shared with anyone, and the transit agency must bear the cost of construction and maintenance.

In a way cost becomes the Achilles heel. AS city after city seeks the kind of transportation worthy of a "world class city", the public is seeking something better than the bus service they presently know on the streets. In order to provide the citizens with something better, excessive operating/carrying costs are being experienced, which in the end, may be causing a fixed amount of subsidy to provide less service than would have been provided without the capital intensive projects.

Throughout the literature, it is common to reject bus systems in favor of rail because of the alleged inability of bus services to provide high levels of capacity. In order to understand what market niche seems to exist for AHS Transit services, it is worthwhile to review the direct data on the kinds of corridor public transportation volumes actually experienced in American cities outside of the unique example of New York City, New York. The data are relevant for two reasons. First, it is important to understand the range of volumes that presently available bus systems can handle, contrary to much popular belief Second, it is also relevant to the understanding of the upper range capacity levels that could be carried by buses along a given segment of an automated highway.

1.3.4.2 Explorations of Advanced Bus Concepts (1960's)

The rapid development of AHS requested by ISTEA suddenly throws the spotlight on the potential role of many buses (and quite possibly small buses) carrying major volumes of passengers. Fortunately, the existing literature of the past three decades has given extensive coverage of the special needs and potentials of buses carrying corridor volumes often associated with guided forms of urban transportation, such as light rail and automated guideway transit (AGT).

1.3.4.3 Development of the Dual-Mode Bus Concept

By the early 1970's, transportation researchers had begun to focus in on the concept of the Dual-Mode Bus, which operated in manual mode off of the guideway, then operated in guided mode along with other vehicles on the automated guideway. In a remarkable partnership both public and private researchers were pointing to a new direction for public transportation development. The results of those studies set an informative precedent on which to base the development of AHS Transit in the 1990's.

As research in advanced transportation nearly came to a halt in the early 1980s, interest in using buses in cost effective strategies remained strong. The Municipality of Seattle Washington undertook a series of studies of possible ways to develop a downtown bus tunnel; several of these studies reviewed recent advances in Europe towards the development of the dual mode bus. Although Seattle did not select the option of guided buses in the tunnel, the work that was undertaken provides a good model for the kind of research now needed in the development of AHS Transit.

The Seattle bus tunnel represents a major breakthrough in the development of high volume bus distribution facilities. With a present operations plan calling for more than 8,000 seats per hour, the Seattle work can be used to challenge earlier assumptions about the capacity limitations of bus facilities. Various new studies around the world are providing new data concerning the relative efficiency of advanced bus operations.

1.3.4.4 A Prototypical Intermodal Corridor Experience

The concept of a "prototypical corridor" has been used to test the applicability of various modes under a variety of hypothesized conditions. A prototypical corridor was created, for example, in both the Seattle research and the Copenhagen study. In order to test the concept of AHS Transit in a variety of service functions, we have created a "Prototypical Intermodal Corridor" which includes, a major airport (with an internal circulation system), a commenced (but not completed) HOV network, a downtown Intermodal Terminal, and a downtown needing improved distribution services. Realistically, we can imagine that the airport authority is looking at improved internal circulation within the airport, the state highway department is examining the possibility of more HOV lanes on the state highway, and the transit authority is looking at their options for improved downtown distribution. For the first time in Federal legislation, the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) now mandates:

1. That all of these separate components now be looked as a unified Intermodal System.

2. That $IVHS_1$ and other advanced technologies, be considered in that planning process.

The C&T report has reviewed the studies leading to the choice of technology in Seattle and Copenhagen focusing largely on the issue of capacity of advanced bus systems to handle the possible increases in demand. In each of those case studies, existing available bus technology was found to provide the most effective service for the demands forecast. However, in each case the issue is raised about the potential of AHS technologies to extend that capacity as they come into existence over time. Both of these examples consider a light-rail like formation of dispersed feeder lines assembling at a downtown gateway, with several miles of downtown distribution tunnel.

We examined a different kind of application, exploring the possible role of AHS Transit services between a major airport and major downtown activity centers. In this exercise, we will examine a context in which capacity is not the relevant issue. Indeed, it is shown that the actual number of air passengers needing transit service in a peak hour would not require any advanced technology. Rather than focusing on the issue of capacity, this exercise seeks to illuminate the role of AHS in providing highly specialized intermodal connections of the kind now being demanded by airline passengers for their ground access needs.

The prototypical AHS Transit was developed to be implemented in segments and over time, thus giving the maximum flexibility of AHS technology development, political realities, institutional constraints, and intermodal ownerships. The mid- and long-term decade development scenarios developed allow for the best flexible incremental use of these complex factors.

1.3.4.5 Summary of European Bus Technology

The development of guided buses in Europe goes back to the middle of the 1970's. The decisive aim of the development of this completely new bus system has been an increase in the attractiveness of the bus transport system as well as a reduction of costs in comparison to the construction of expensive rail transport systems. In order to achieve the system's readiness to go into production and collect proven operational experience, guided bus projects have been supported by government subsidies in several European countries (e.g. Germany and Sweden).

Within this development, two entirely different guided bus technologies have evolved: mechanical and electronic guidance. SNV has been substantially involved in the scientific research and evaluation of the respective projects for both lines of development Because electronic guidance offers the most advantages for the present AHS project, this technology is discussed in detail.

The C&T report described the most important electronic track guidance systems for buses which have evolved in Europe with regard to their technical characteristics and their current state of development. It also contains the findings and the experience which were gained from the various practical applications on test tracks as well as form regular public transport. Here it has to be taken into account that there are no active Systems currently operating in Europe. The track guidance system in the Channel tunnel will be the first purely commercial application.

One of the primary elements for an improved bus transport system is a right-of-way separated from individual traffic. The attractiveness of the transit system can be greatly improved with special lanes for buses: travel comfort can be increased and travel times can be shortened. Depending on local conditions, there are several possibilities for creating separate lanes for buses. On the surface, a bus lane or bus street can be provided for, or elevated or underground structures can be constructed. To what degree such right-of-ways improve the attractiveness of the transit system depends very much on the extent to which they are misused by individual traffic. The effectiveness of separate tracks can only be achieved with constructional separation, requiring additional space often not available in dense urban areas. The space required for separate tracks can be minimized with track-guided bus systems and this is often the only method available for creating separate bus lanes. Track guidance can assure effective, reliable, and punctual bus operation. It offers decisive advantages in those segments of the network where shortage of space does not permit a separate conventional bus lane such as at single narrow points, at intersections and at crossings with very heavy traffic. Bus stops and especially station platforms can be negotiated very precisely without damaging the tires.

Mainly two technologies have been developed: Mechanically guided buses that need fixed infrastructure such as guide-curbs alongside the track, and electronically guided buses that follow a cable embedded in the roadway.

On electronically guided buses, steering is effected by means of a hydraulic actuator linked to an electronic control system. The nominal course of the bus is normally marked by cables embedded in the surface of the bus lane. The antenna mounted beneath the bus measures the deviation of the vehicle from its true course, the electronic control system calculates the necessary correction and transmits the data to the actuator which operates the steering.

When planning guided bus routes, one has to consider that the routes must be very carefully integrated into the existing traffic infrastructure and that they have to be connected with the other modes of transportation. Keeping this in mind, one can distinguish between the integration of the guided bus route into the whole transportation system - paying particular attention to the interaction of guided bus and individual traffic -- and the connection of a guided bus system with other modes of public transport (i.e. underground, light rail transit, tram).

A large number of guidance systems were examined and evaluated in the initial stages of the development of this technological innovation in Germany. The following concepts of electronically controlled guidance systems appears to be the most realistic and worthy of further development:

- The M.A.N. System.
- The Breda System.

- The Mercedes-Benz System.
- The Channel Tunnel System of Mercedes-Benz.
- The Volvo low cost system for bus stops.

In Europe mechanical track guidance has market advantages in comparison with electronic track guidance. These advantages are due to lower system costs and to the possibility of supplementing available vehicles with mechanical track guidance equipment. On the other hand, with regard to new systems also electronic track guidance has chances of application, as the example of the Channel tunnel shows. Seen from the technological point-of-view mechanical track guidance has proved technically feasible and will more likely experience improvements in details in the short and medium term. In contrast to this, electronic track guidance still has a large potential for development. In order to be able to exploit this potential, a reference plant reliably working over a longer period of time would be required, as it is the case in the Essen application with mechanical track guidance.

The mechanical and electronic track-guidance systems developed in Europe have proved technically feasible and suitable for operational use. However, electric track-guidance systems are of the greater interest for an AHS. The mechanical Systems display features which make them less suitable for this purpose.

Leaving the track-guidance sections is only possible at special exit and entry points, which have to be driven through at low speed. This means that it is impossible either to overtake and or leave the track-guidance section in the event of a vehicle fault. If guide curbs are used (German system), all vehicles must have the same width in order to be able to run in the guideway trough. The AHS must be entered at certain specified entry points, which can only be driven through at moderate speed, thereby having a negative effect on the system as a whole.

European experience with electronic guideway systems can be summed up as follows with regard to their relevance to an AHS:

- The principle applied of guide cables with transmission facilities on the route and receivers in the vehicles means that the principal functions for fully automatic operation are available. For some functions (e.g. maintaining a fixed distance from the next vehicle ahead) an additional transmitter on board the vehicle is required.

- The safety philosophy selected of designing all the systems to be mutually redundant and allowing only one safe and stable system in the event of a system breakdown (as a rule a vehicle breakdown) has proven itself and should also be aimed at for an AHS. In the case of an AHS, however, in view on the larger dimensions involved - with regard to space requirements and the number of vehicles, a strategy will have to be developed for resuming service rapidly after a system breakdown.

In Europe, the optimal strategy for introducing a new type of system such as an AHS has proved to be introduction in phases: this procedure means that it is possible to remedy weak points in individual sub-systems before these are integrated into the overall system. The parallel development of individual sub-systems reduces the time required for development.

1.3.5 General I&S Methodology

To ensure coverage of the range of issues across all vehicle types, a combination of primary and secondary research was employed to identify and define the relevant issues. The scope of the literature review was narrowed to focus on the public acceptance of AHS as a means of making the searches manageable and within the time and cost constraints of the study. However, the issues that surface regarding public acceptance of AHS cover the range of the institutional and societal issues relating to the deployment of these technologies. As a result, the literature reviewed for this study does, in fact, represent a significant portion of the literature that looks at these more general issues.

The focus group methodology employed in the portion of the study dealing with the public acceptance of AHS was chosen because of the strengths this methodology has when used as an exploratory technique in the early stages of implementing new technologies such as those involved in AHS.

This report discusses the institutional and societal issues associated with the application of AHS to all vehicle types including private passenger cars, public transportation (including buses and mass transit vehicles), and commercial motor carriers. Although some issues will apply across all vehicle types, others will be unique to particular vehicle types such as commercial motor carriers.

Among the many institutional and societal issues surrounding the deployment of AHS, one that appears critical to the success of the program is that of public acceptance. Implementing new technologies, especially when the costs involved will likely be passed on to the users of the technologies as well as the communities affected, require that these users and communities perceive that the benefits outweigh these costs. Achieving the necessary level of public acceptance for the success of AHS will be a complex and challenging process and to determine the status of that process at the present time is one of the objectives of this study.

Commercial motor carriers are considered by some to be an ideal target market for early AHS applications, given their relatively small number (compared to private automobiles), their general for-profit orientation the negative public perception of trucks as contributors to highway problems, and the burdensome nature of motor carrier regulation. Nevertheless the extensive and unique set of institutional issues associated with the application of AHS to motor carriers severely diminishes the attractiveness of this market.

Recent clean-air and transportation legislation (e.g., CAM and ISTEA) have heightened the need for transportation programs to adhere to a variety of environmental and related community constraints. Demonstrating AHS's capacity to operate within these constraints thus represents a key challenge for the program.

1.3.6 Public Acceptance Literature Review

This review of the public acceptance literature has several important implications for the study of AHS public acceptance. The overriding finding is that there is very little empirical information on AHS public acceptance per se, but a range of information of related ITS and other technology acceptance. The implication of this finding is two-fold; first there is a need to initiate research activities to obtain empirical information on the AHS public acceptance (and the focus groups described in chapter 4 are an initial step in this direction). Second there is a need to develop a conceptual framework for understanding the dimensions of AHS public acceptance. and understanding how this may change over time.

This literature review provides guidelines for understanding possible dimensions for AHS public acceptance. Our review revealed two levels of acceptance as operative within the AHS context. The first level, "user acceptance" pertains to those potential users of the system. The literature we reviewed identified several issues as potentially affecting user acceptance; cost, safety, convenience were each noted several times as key factors in user acceptance. The second level, "community acceptance", pertains to the acceptance needed among a variety of institutional stakeholders. While some of the items (e.g. cost, safety) have application at this system level as well, the literature also revealed a host of other items that need to be considered: institutional capacity, public/private partnerships, and environmental impacts are all items that can affect community acceptance.

Based on these and related findings, the focus groups were devised to provide preliminary empirical information on acceptance as viewed from these two dimensions. The results, reported in the following chapter, should be viewed as an initial step toward developing a more robust empirical basis to guide the AHS program.

1.3.7 Focus Group Public Acceptance Issues

Participants for the first focus group were recruited from the list of planned attendees at an Institute of Transportation Engineers (ITE) conference held in I-a Jolla, California in March 1994 and the session took place on Sunday, March 20, 1994 at the site of the meeting. The composition of the group reflected the technical and transportation backgrounds of the members of the ITE community and had an environmental, focus. The second focus group was held on April 11, 1994 at George Mason University. Participants were graduate students recruited from the school's masters degree program in public administration, and were evenly divided as to gender and age. The participants were professionals with jobs in federal/local government, or with private sector firms.

The last two focus groups were recruited during August and September 1994 by Global

Exchange, Inc. a professional services firm specializing in conducting targeted focus groups and consumer research. The groups were held on September 28,1994 in Bethesda, Maryland.

1.3.8 Overview for Analytical Framework For Institutional issues

Institutional barriers are often narrowly defined as statutory or administrative constraints; for example, a statutory requirement (in some states) that vehicles be weighed on static scales (instead of using weigh-in-motion devices, which measure dynamic axle loads) for weight enforcements; or requirements that vehicles signal before making lane changes. Using this narrow definition makes it difficult to identify and understand the full range of non-technical barriers to implementing change, particularly change based on new technology. To ensure full coverage of the issues that might affect the implementation of AHS for commercial vehicles, three broad categories of institutional issues will be considered: mandate, organization, and resources. These were then observed from the public, private, and public/private perspectives.

1.3.8.1 Mandates

Mandates consist of vision, leadership, and authority. Most efforts that significantly affect the way that business operations are conducted require some kind of mandate -- from legislation, executive orders, or popular demand. with a mandate comes legitimacy and support for action.

Institutional barriers in the "mandate" category reflect the lack of senior executive, political, or administrative support for the implementation of AHS. Mandate difficulties may arise when there is a strong public demand for a particular change but no executive-level response to implement the change, or when there is an administrative directive but no popular support for an action. They also may occur when there are conflicts among public sector entities on the implementation of a change. Lack of a mandate may reflect not only opposition based on the full understanding of a particular change, but also a lack of education about the meaning of a change or lack of involvement in how the change will be implemented.

1.3.8.2 Organization

Without a mandate, there are no guidelines for the public or private sectors to organize efficiently to meet the goals and objectives that will fulfill that mandate. Even with a mandate, there may be challenges to ensuring that organizations are appropriately structured, organized, and administered so that the mandate is fulfilled. "Organization" issues reflect problems with how public and private sector organizations are structured to implement a particular change. These issues include problems associated with jurisdictional overlaps; unclear responsibilities; conflicting operating and administrative policies, as well as priorities; and cultural differences. These are critical issues for the implementation of AHS, which will require close cooperation and coordination between the public and private sectors.

1.3.8.3 Resources

If organizational priorities are confused or organizational structures are unclear, resources cannot be allocated efficiently in either the public or the private sectors. Sufficient resources (primarily money and people, although equipment and facilities may also be of concern) must be provided if technology-based change is to be successfully implemented. In the current environment, where the public sector appears to be chronically underfunded, agencies and programs must compete for scarce resources. This is particularly problematic when the benefits of proposed programs, such as AHS, are difficult to define and measure.

1.4 ITS AMERICA INVOLVEMENT

As part of the PSA effort in AHS the team members, particularly the Principal Investigator, was an active member of numerous ITS America specialty groups. Included were groups such as:

- Advanced Vehicle Control Systems Committee.
- Institutional Issues Committee.
- Commercial Vehicle Operations Committee.
- Societal Task Force.
- Intermodal Task Force.
- Public Exposure Task Force.

1.5 GENERAL REPORT FORMAT OF ACTIVITY AREA REPORTS

The general topic areas for the C&T report are summarized from the Table of Contents excerpts as follows:

Commercial and Transit Aspects Precursor Systems Analyses

The I&S report contains similar topical breakdowns taken partially from the report Table of Contents. These major topic areas are included here:

Institutional and Societal Issues Precursor Systems Analyses

CHAPTER 2: REPRESENTATIVE SYSTEM CONFIGURATIONS

Institutional and Societal issues were not reviewed excluding any particular of the original Calspan Representative System Configurations (RSCS). However, they were more accurately reviewed for commercial motor carriers and transit vehicles using the AHS Cluster Map presented in the C&T report. C&T uses are best described using this AHS Cluster Map methodology presented in detail in appendix A and chapter 4 in the C&T report.

The AHS technologies and services that might be available to the trucking industry need to be characterized for further analysis. Because the Representative System Configurations (RSC) developed by Calspan do not describe the world as seen by a motor carrier manager, an alternative set of "clusters" of AHS services and technologies is developed with respect to the characteristics of greatest interest to the motor carrier: how much control the driver has over the vehicle, and how much investment in technology will be required for each vehicle.

2.1 AHS CLUSTER MAP DESCRIPTIONS

Most AHS categorizations to date rely on the physical characteristics of roadway design and layout (e.g., segregated vs. non-segregated, barriers vs. without barriers, and guideways vs. special lanes) as their distinguishing characteristics, but these categorizations address only infrastructure differences. There are two major variables, independent of technology or configuration, that must be addressed in order to categorize AHS scenarios: the agent of vehicle control (driver vs. infrastructure) and the location of vehicle control (vehicle vs. guideway). For motor carriers, these are the critical variables.

2.2 RELATIONSHIP TO CALSPAN'S RSC'S

The Calspan Corporation developed the Representative System Configurations (RSCs) as a system for classifying variations of AHS. Under the RSC approach, each AHS is classified in relation to the following dimensions:

- The amount of dedicated roadway infrastructure required.
- The degree of command, control, and communications required.
- The types of vehicles (i.e., single vehicle equivalents, such as private automobiles, and/or multiple vehicle equivalents such as large trucks).

The Representative System Configurations (RSC) developed by Calspan do not describe the world as seen by a motor carrier manager. To address this deficiency, an alternative set of "clusters" of AHS services and technologies is developed from the motor carriers perspective. These clusters array various bundles of services and technologies according to the factors that are the most important to the motor carrier:

the options for control of the vehicle (i.e., from complete control by the driver to complete control by the infrastructure), and the location of control Systems (i.e., completely within the vehicle or completely within the guideway).

CHAPTER 3: HIGHLIGHTS OF TECHNICAL DISCUSSIONS

This chapter presents the highlights of both the C&T and I&S research areas, as well as their cross-cutting implications. This chapter also denotes a key activity area findings, observations, and recommended areas for further research investigation.

3.1 KEY ACTIVITY AREA FINDINGS

The key findings for both the C&T and I&S activity areas are summarized in this section.

3.1.1 C&T Findings

This concluding section of the report summarizes the findings involved in the identification of commercial motor vehicle issues as they relate to the constraints of institutions, market segments, fleet size/fleet ownership, and regulation constraints. The unique composition of the commercial motor vehicle market is best described by its own unique Representative System Configuration (RSC) equivalent groupings depicted as 19 distinct AHS Commercial Motor Vehicle Clusters shown in appendix A of this report. By using this more descriptive application to describe this unique transport segment, the best implementable deployment of AHS can more easily be identified.

The results of previous European advanced transit research/deployment/testing has produced many valuable "lessons learned" for the possible U.S. application of AHS. The results of the electronic/mechanical automated bus guidance technology advancements that took place in Sweden, Germany, Italy, Great Britain, and Belgium carried the state-of-the-art to an advanced technical level. This technology experience, coupled with the Dual Mode Transit applications of the United States in the 1970s, provided a unique confirmation for insertion into the concept of AHS Transit. The concept of this exclusive or shared guideway/right-of-way application may help to satisfy the passenger carrying capacity requirements needed at significantly lower infrastructure costs while adding greater route/service area flexibility to the transit operation. This new Dual Mode AHS Transit concept would extend the passenger capacity of transit bus based systems into and beyond the service capacity range of the more costly and location restrictive typical light/heavy rail service.

The flexibility of using fully automated line-haul transit buses on limited access right-of-way capacity facilities (i.e., tunnels, bridges, elevated tracks, or narrow available rights-of-way) and also having the full flexibility of local collector bus service at the terminus points is explored in the prototypical Dual Mode AHS Transit system between the hypothetical airport and urban centers described in the report.

The multimodal potential for such a facility could be realized by sharing commercial motor vehicle service in the system on a scheduled off-peak or contra-flow basis for automated trucks. Separate specialized truck-only off ramps and distribution clusters could be created to serve the urban/suburban goods movement market segment.

The use of "train-like" platooning of many vans and buses in the entering and exiting of transit stations at 40 kilometers per hour (25 mph) may pose significantly different technological challenges from the issues of vehicles entering and exiting from platoons at 97 kilometers per hour (60 mph). Similarly the challenge of increasing throughput capacity through the Express Bus Lane of the Lincoln tunnel may largely lie in the problem of reliably sending more buses through a complex multi-platform system within the bus terminal at the end of the lane.

These issues--the use of AHS technology in trip segments other than the automated highway segment -- may seem somewhat peripheral to the primary research effort of the AHS program. It is important that a research management structure be established that deals with those transit-oriented issues that need to be resolved in order for AHS Transit to gain full benefit of the automated highway systems being developed. At the same time, it is critical that the technological components designed to deal with these transit-oriented issues be developed to integrate back into the larger AHS system technology. Thus we are proposing a parallel development effort for AHS Transit, which remains a subset of the larger AHS research and development program.

Dual-Mode Transit may not be the best choice by itself but it can be an effective catalyst or component for an efficient multimodal transportation system. In the examination of a Prototypical Intermodal Corridor a staged process of implementing an ultimate system that could provide high quality, truly "seamless" transportation services under highly demanding conditions was explored. The long-term advantages of such a system were clear; what remains for further analysis is how much advantage is gained by AHS Transit over the interim phases of high investment in HOV/busway systems, which offer exceptional levels of benefit.

AHS Transit must be analyzed in terms of its role in a system where ultimately both benefits and costs are distributed over a wide cross-section of transportation users. A national research program must now be designed that at once acknowledges the uniqueness of the AHS Transit potential, while remaining true to the long term need to keep it a part of larger system.

The mechanical and electronic track-guidance systems developed in Europe have proved technically feasible and suitable for operational use. However, electronic track-guidance systems are of the greater interest for an AHS. The mechanical systems display features which make them less suitable for this purpose. Leaving the track-guidance sections is only possible at special exit and entry points, which have to be driven through at low speed. This means that it is impossible either to overtake and or leave the track-guidance section in the event of a vehicle fault. If guide curbs are used (German system), all vehicles must have the same width in order to be able to run in the guideway trough. The AHS must be entered at certain specified entry points which can only be driven through at moderate speed thereby having a negative effect on the system as a whole.

European experience with electronic guideway Systems can be summed up as follows with regard to their relevance to an AHS:

- The principle applied of guide cables with transmission facilities on the route and receivers in the vehicles means that the principal functions for fully automatic operation are available. For some functions (e.g. maintaining a fixed distance from the next vehicle ahead) an additional transmitter on board the vehicle is required.

- The safety philosophy selected of designing all the systems to be mutually redundant and allowing only one safe and stable system in the event of a system breakdown (as a rule a vehicle breakdown) has proven itself and should also be aimed at for an AHS. In the case of an AHS[1] however, in view of the larger dimensions involved with regard to space requirements and the number of vehicles, a strategy will have to be developed for resuming service rapidly after a system breakdown.

In Europe, the optimal strategy for introducing a new type of system such as an AHS has proved to be introduction in phases: this procedure means that it is possible to remedy weak points in individual sub-systems before these are integrated into the overall system. The parallel development of individual sub-systems reduces the time required for development.

3.1.2 I&S Findings

A variety of strategies are recommended for overcoming the non-technical barriers to the development and implementation of an AHS. These strategies are based largely on the experience with the planning, development, implementation, and evaluation of operational tests of ITS for commercial vehicles.

- Approach the development of AHS for commercial vehicles as a public/private partnership. A major "partnering program will be required to overcome the organizational and institutional problems among the public sector agencies as well as between the public agencies and the private sector motor carrier interests. All of the diverse elements of the industry, including labor should be involved in this effort from the outset. Delegating appropriate and clearly defined roles and responsibilities to the private sector stakeholders is essential.

- Select initial projects that have the most tangible, quantifiable, and demonstrable benefits to the commercial vehicle industry.
- Within the public sector partners, identify strong champions and advocates who can devote significant time to the endeavor and who have the clout to secure the necessary high-level commitments of resources.

- Demonstrate a strong commitment to improving the safety of commercial vehicle operations and protecting proprietary data.

- Minimize construction of new physical infrastructure without compromising both the provision of a high degree of actual and perceived safety of operation and the maintenance of historic service levels on pre-existing facilities.

- Ensure that the public sector (i.e., the state and Federal governments) commit to long-term predictable funding levels and realistic implementation plans and schedules. Wherever possible, implement programs in steps of phases, with established decision points at which to evaluate further activities.

- Establish appropriate goals for commercial vehicle AHS: is it to enhance operational safety, reduce congestion, reduce regulatory inefficiencies, raise revenues, enhance economic competitiveness, improve profitability, or some combination of these goals? To the extent that improving regulatory efficiency and revenue collections are goals, they could compromise the willingness of the industry to participate and reduce the chances of achieving safety and congestion goals. Make at least the early projects explicitly revenue-neutral in their impacts on the industry, to develop a reasonable level of trust and establish the credibility of the long-term benefits to the industry.

- Continue aggressive Federal efforts to enhance the technical reliability of travel demand and air quality modeling to improve the credibility of claims for environmental benefits that would accrue from an AHS for commercial vehicles.

- Emphasize early commercial vehicle AHS projects which have intermodal elements, particularly in enhancing the truck/rail interface, to help dispel the notion that AHS/CVO projects are an alternative rather than a complement to rail freight reinvestment.

- Install strong leadership and a dedicated full-time project manager for every AHS project for all project stages from planning and development through implementation. Designate a lead state and a lead agency for all operational tests. All parties must be committed to the project and assign representation to it with decision-making authority. Clearly define the project's agenda, priorities, and partnering responsibilities.
- Identify and accommodate cultural differences among the partners. Seek flexibility in approaching problem solving and be willing to change ways of doing business.

- Establish a clearly defined protocol for information flow among the partners. Maintain regular open communications. Ensure sufficient outreach also to parts of the community who may not be directly involved in program development

- Establish an effective partnership management structure, which is critical to bringing AHS development efforts to a successful conclusion. The need to give each stakeholder a voice and to coordinate the activities of multiple partners must be balanced by efforts to ensure effective decision-making protocols.

- Review the current procedures for the administration of projects involving Federal funds, as well as funds from other public and private sources. Determine whether the statutory accounting and administrative requirements can be accommodated through procedures that are less burdensome particularly for the private sector parties.

- Develop a privacy policy incorporating the Fair Information Principles developed during the 1970s: ensure that only relevant personal information is collected; inform individuals about what is being collected and how it will be used; make records available for inspection and review by the affected individuals; limit the availability of the information to those with a legitimate need to know; do not disclose information to a third party without due process; and establish appropriate security measures.[5]

- Prepare information packages to conduct educational briefings for interested public and private parties on the potential benefits of AHS. Use these briefings to build support and understanding among all affected constituents. Tailor materials to meet the needs of the various constituencies (e.g., commercial vehicle drivers).

- The Consortium should establish a research and development Program to address institutional and public acceptance issues related to AHS. While the technical aspects of AHS are daunting, acceptance of these technologies is vital if the program is to be successful. Therefore, the Consortium needs to initiate a series of research and outreach activities aimed at addressing key interests and concerns of various institutional and public stakeholder groups.

- As a part of this public acceptance program, the consortium should conduct a detailed assessment of the range and magnitude of interest and concerns across stakeholder groups. The findings reported in this study are exploratory; a more rigorous and exhaustive inventory of public
- acceptance issues is needed to firmly establish the baseline upon which AHS activities can build. This baseline should include an understanding of both the potential early users of AHS, as well as the concerns of key constituencies (e.g., environmental groups).

- As part of this public acceptance program the consortium should assess the influence of new information-and/or direct experience on institutional and public acceptance of AHS. The aforementioned baseline will provide an indication of the initial reactions of stakeholders to the prospects of AHS. It will, therefore be important to know how these opinions are affected by new information, such as will be developed by the Consortium. There are a variety of research and outreach methods that can be used to gain this understanding, including focus groups, simulation, and deliberative polling.

- The AHS Program should develop an outreach strategy that builds upon (the above) public acceptance findings, and in doing so, attends to the interests and concerns of a broad range of stakeholders, from AHS champions to AHS adversaries. However, one important impact of the research should be on the structure of the program itself; that is, key concerns should not just be dealt with via a public relations approach, but addressed in the technical program as well. For example, the concerns about costs and environmental quality that were raised in the course of this review, should be the subject of intensive analysis, so that information about these areas can be communicated in a credible manner.

In terms of a methodology, the focus groups demonstrated their value as a mechanism for soliciting public acceptance issues regarding AHS. They revealed a variety of issues that could form the basis for more sustained follow-up research, such as survey research. One disadvantage of the focus group methodology in this instance was the limitation for dealing with such an abstract concept like AHS. Perhaps the use of actual simulators in conjunction with the conduct of a focus group session would provide a useful mechanism for eliciting public reaction to more tangible aspects of AHS. Finally, there are program implications for how to best incorporate public opinion research within the context of a technology driven program.

Table 2 provides an overview of the various issues that were raised in the focus groups, along with whether the issue was viewed as a positive attribute (+) that would enhance acceptance of AHS, or whether the issue was viewed as a barrier (-) to such acceptance.

Table 2. Examples of Positive Attributes and Barriers to AHS From Focus Group Sessions

AHS FEATURE	USERS	COMMUNITY
Reduce Congestion	+	+
Safety	+ ,-	+ , -
Costs		
increase In vehicle Use	+	
Air quality	+,-	+ ,-
Convenience	+	
Equity		

LEGEND:
+(positive) - potential for enhancing public acceptance
- (barrier) - potential for constraining public acceptance

The table reveals several interesting and we feel important points. First, some of the features identified are viewed as both potential positive enhances and barriers to the deployment of AHS. And, this dual nature of the feature can surface both from the user and/or the community perspective. A good example of this phenomenon is the feature of safety. While both user and community perspectives saw increased safety as an important and in fact, likely crucial factor in promoting public acceptance of AHS, at the same time, the potential of what was perceived as a possible "catastrophic failure" of such a high-tech system was also identified as a major concern. A second finding is that some features emerge as being viewed as positive from one perspective and as a barrier from the other. The potential for an increase in the availability for vehicle use, for example was seen as a plus from the users perspective, while seen as a minus for many from the community perspective, leading as it might to a reemergence of congestion and environmental problems.

In some instances there is common agreement on the nature of the feature from both perspectives, and this can be in either category. For example, costs clearly surfaced as a potential barrier to public acceptance of AHS both from the users point of view as well as the community. This is not surprising since there are different costs involved. As a user, most participants felt that the in-car equipment costs would fall directly on them. However, from the community perspective, there were concerns for the added costs likely to accrue from the deployment of the system itself, things like infrastructure costs passed on to the taxpayers as a whole. What this does highlight, however, is the importance of the user/community distinction because it points that an AHS system "sold" to the community may very well "not" be deployed if it does not have sufficient tangible benefits for the users as well.

Some features were only raised form one or the other perspective. Convenience was seen as a potential plus from the users view, but did not surface when the discussions were from the community perspective. Likewise, Equity of an AHS system was raised when the community perspective was being focused on, not when the focus was on the users.

The issue of environmental quality was raised by all groups, though the importance given to it varied. In one focus group, which included several environmental professionals, the issue of environmental quality was the overriding concern. The opinions of this group were decidedly mixed. Some saw potential environmental gains through the appropriate application of AHS; others viewed AHS as a definite threat to environmental goals. In the other groups a more general concern was expressed about how any transportation improvements (such as AHS) would need to be consistent with environmental concerns.

3.2 KEY ACTIVITY AREA OBSERVATIONS

This section denotes the key observations of the C&T and I&S activity areas.

3.2.1 C&T Observations

Like the commercial motor carrier industry, the transit industry has many technical, institutional, and societal constraints. Most critical of these observations are noted here.

Observation # 1. The transit industry has been working for decades on the task of providing high quality service at reasonable cost. Innovative light-rail strategies have been developed to attain shared use of right-of-way on key segments where capital costs for total grade separation would have been excessive. Still, the cost of building and maintaining many miles of facilities has stifled the development of higher quality transit services across the country. If major high-speed segments of the AHS network that guarantee high performance operations could be provided and the cost of those segments borne by resources beyond the transit sector, significant cost savings could result compared with presently available technology.

Observation #2. The transit industry will not turn to the automated AHS for reasons of line capacity. The potential scale of capacity stemming from existing bus technology (as expressed both in the theoretical literature and in practice) far exceeds what most American cities will be able to utilize. The transit industry may, on the other hand, turn to AHS technology for a series of issues involving the management and control of large numbers of vehicles operating in extremely demanding conditions, such as the accessing of complex, multi-platform stations. AHS Transit should be seen as a family of key improvements that deal as much with reliability as with capacity; in turn, those reliability improvements may generate valuable dividends in terms of tighter, narrower geometric requirements.

Observation #3. Pathways to AHS: Our team has examined a variety of strategies for the development of AHS Transit ranging from ignoring it to redesigning the entire AHS work program to allow AHS Transit to be developed to the exclusion of private vehicles. Based on this policy review we are now focusing on the following concept for review by USDOT: allow AHS Transit to be developed on a parallel path, while at the same time, ensuring that its technology development program be a subset of the larger AHS research effort. Our examination of possible use of AHS Transit in our "Prototypical Intermodal Corridor" suggests that AHS Transit may play its most important role off the automated highway segment, and in such unique configurations as the on-line one-way loop, or in the automated dispatching through series of multi-slot off-line stations.

3.2.2 I&S observations

As pointed out earlier, the purpose for conducting these focus groups was to collect data that could provide insights into the answers to several of the research questions of the study. Specifically, the questions were:

- What attributes of AHS are likely to affect user acceptance, and how do perceptions vary across different segments of the public?
- What attributes of AHS are likely to affect community acceptance, and how do perceptions vary across different segments of the public?
- What research and policy actions could be taken to ameliorate public concerns and/or enhance public acceptance of AHS?

The focus group sessions were designed to lead the discussions through each of these questions. Based on the results, as described above, each of the individual sessions were successful in developing information relating to the questions. They each identified lists of features that they saw as likely to affect public acceptance of AHS and even suggest which ones were major. They were also able to surface these features from the different perspectives of the user and community, which confirmed our belief that this is an important distinction and one that should be given attention in future work. Finally, each group was able to identify both policy and research activities for consideration.

In each focus group, the full range of issues and concerns that have been raised in the literature and other sources were surfaced, although the emphases on specific issues varied considerably across the groups. Thus, while in one group the issues regarding potential environmental implications were discussed in great detail, other groups noted these issues, but devoted much less time to them. Issues raised did, as expected, differed when viewed from the user or community acceptance point of view. Regarding the former, for example, several possible advantages were raised such as safety and convenience, but so were corresponding concerns such as about catastrophic failure. Regarding the latter, while participants thought the system could be deployed in a way that would encourage multi-modal transportation use, there were concerns about possible effects on urban sprawl, etc. An overriding concern among all the groups was the cost of such a system as compared to the benefits it could provide to a user or a community.

3.3 RECOMMENDED FURTHER INVESTIGATIONS

As in C&T and I&S activities there were many areas that required further research or investigation before implementation of AHS can be realized. There are some areas that must be ongoing during all phases of the AHS evolutionary process.

3.3.1 C&T Further Research

The proper segmentation of the commercial motor vehicle industry into the AHS Commercial Motor Vehicle Cluster Map components offers a better definition of the best implementable deployment of AHS that can be more easily implemented. The C&T analysis also recommended that AHS Transit concepts should develop along parallel research modes to the main body of AHS. This will allow for a multimodal component with several possible funding sources identifying the needs of other companion Department of Transportation agencies such as Federal Aviation Administration and the Federal Transit Administration.

3.3.1.1 AHS Research For Transportation Policy Implications for Commercial Motor Carriers

The results of this initial analysis have a number of implications for future policy efforts intended to develop and promote AHS for the commercial trucking industry. A review of the potential matches between the operating characteristics of the representative motor carrier industry segments and the AHS technologies and services clearly suggests that the applicability of different AHS operations will vary with respect to different segments of the trucking industry. Policy makers must recognize that, with respect to AHS, trucking definitely is not a "one-size-fits-all" industry.

The most obvious ramification of this finding is that the benefits derived from public investment in any particular AHS will be unevenly distributed across the trucking industry. Certain industry segments may benefit greatly, while others obtain little or no advantages. Furthermore, implementation of a broad range of AHS may not necessarily yield benefits to a broad range of industry segments. Indeed, wholesale support of any and all AHS for the motor carrier industry would most likely be counterproductive, diffusing funding and resources rather than focusing them on the AHS that have the potential to benefit the largest segments of the trucking industry.

Consequently, policy makers must be highly selective in the AHS technologies and services they choose to develop. Moreover, those AHS that are developed must be implemented so as to make the costs and benefits equitable. The costs that any particular segment of the trucking industry bears should be proportionate to the benefits that segment will derive. This may mean depending heavily on user fees rather than industry-wide taxes to fund AHS projects. Alternatively, it may mean that the development of AHS for the commercial motor carrier industry is limited to those

Systems that require minimal infrastructure-based technologies and instead rely on in-vehicle devices. That way individual trucking firms could decide whether or not they wished to participate in a given AHS, and would bear the costs for only those technologies from which they would derive direct benefits.

3.3.1.2 Continuing Research Program For Commercial Motor Carriers

The results of this study suggest several areas in which additional research would be beneficial. First, the current "state-of-the-art" in AHS must be documented. Although the various AHS scenarios are based on current technologies (e.g., distance sensors, brake and throttle controls), significant challenges remain in terms of integrating these technologies to form systems that are user-friendly, reliable, and fall-safe. A study that evaluates the current level of development of each AHS cluster, as well as likely near-term advances, would help to determine how soon and at what scale each AHS variation could be implemented. This is particularly important with respect to the ability of each variation to accommodate commercial motor carrier traffic. Further efforts to refine the clusters themselves also are recommended.

Additional research would be useful in determining the actual costs to motor carriers of various AHS at different levels (e.g., geographic scope) of implementation. In particular, research is needed to determine how the various AHS compare in terms of both their infrastructure costs (which likely would be widely distributed) as well as their per vehicle costs (which individual trucking firms would bear). Not only would such research help to determine the acceptability of different systems to the trucking industry, it might also suggest ways of reconfiguring certain AHS to make their costs more equitable.

Research also is needed to investigate the specific technical and non-technical, or "institutional," obstacles to the widespread adoption of AHS by the commercial motor carrier industry. Specifically, there is a need to differentiate between AHS that are impractical for trucks because of physical constraints, which possibly could be overcome through technological advances; and AHS that are likely to be rejected because of concerns over driver complacency and incompatibility with the nature of commercial vehicle operations. The development of strategies to overcome obstacles to AHS implementation is possible only after the impediments are identified and analyzed.

Finally, more research is required to evaluate the operational characteristics of the motor carrier industry. This study has presented a methodology for studying trucking operations, and has analyzed some representative examples, but the trucking industry is large and complex; several dozen key market segments exist. All of these segments need to be understood in order to make a complete appraisal of the applicability of AHS to the industry.

3.3.1.3 AHS TRANSIT POTENTIAL

The use of "train-like" platooning of many vans and buses in the entering and exiting of transit stations at 40 kilometers per hour (25 mph) may pose significantly different technological challenges from the issues of vehicles entering and exiting from platoons at 97 kilometers per hour (60 mph). Similarly the challenge of increasing throughput capacity through the Express Bus Lane of the Lincoln tunnel may largely lie in the problem of reliably sending more buses through a complex multi-platform system within the bus terminal at the end of the lane.

These issues -- the use of AHS technology in trip segments other than the automated highway segment-- may seem somewhat peripheral to the primary research effort of the AHS program. it is important that a research management structure be established that deals with those transit-oriented issues that need to be resolved in order for AHS Transit to gain full benefit of the automated highway systems being developed. At the same time, it is critical that the technological components designed to deal with these transit-oriented issues be developed to integrate back into the larger AHS system technology. Thus, we are proposing a parallel development effort for AHS Transit, which remains a subset of the larger AHS research and development program.

Dual-Mode Transit may not be the best choice by itself, but it can be an effective catalyst or component for an efficient multimodal transportation system. In the examination of a Prototypical Intermodal Corridor, a staged process of implementing an ultimate system that could provide high quality, truly "seamless" transportation services under highly demanding conditions was explored. The long-term advantages of such a system were clear; what remains for further analysis is how much advantage is gained by AHS Transit over the interim phases of high investment in HOV/busway systems, which offer exceptional levels of benefit.

AHS Transit must be analyzed in terms of its role in a system where ultimately both benefits and costs are distributed over a wide cross-section of transportation users. A national research program must now be designed that at once acknowledges the uniqueness of the AHS Transit potential, while remaining true to the long term need to keep it a part of larger system.

3.3.2 I&S Further Research

The AHS public acceptance focus groups had little difficulty in identifying a wide range of potential actions that could be taken to enhance public acceptance of AHS or address some of the public concerns seen as barriers. A number of these policy actions surfaced in more than one of the group discussions. The groups were also able to articulate a number of areas and issues where further research appeared to be required before certain decisions should be made. Table 3 summarizes some of the areas cited by the different focus groups.

Table 3. Summary of Suggestions for Future Research and Policy Activities

• Demonstrations of system safety are very important to convincing potential users of its safety.
• Marketing studies should be undertaken to determine who needs/wants this system.
• Success will depend on the ability of the program to involve the private sector so as to ensure market/cost sensitivity.
• AHS should be structured taking more of a goals approach reflecting both user and community needs.
• AHS needs to be considered in light of other approaches (e.g., congestion pricing) for managing travel demand.
• Policy makers need to review all other alternatives and possibilities in reaching decisions.
• Planning and evaluation efforts should take into account all of the potential social and environmental impacts.
• Lessons learned from other technology push projects that went wrong should be identified and utilized.
• Policies must be implemented that will address the many privacy issues that the system is likely to generate.
• There may be a need to rethink the transportation system of the future rather than assume that it will be built on the present interstate system.
• Research and Evaluation studies should focus on a broad range of potential social and environmental impacts.
• Need to collect and analyze data on many of the key issues such as safety and congestion implications.
• Need to research in greater detail the potential economic implications of AHS as presently configured.

In summary, the focus groups we conducted were able to provide considerable input data for answering the research questions. While limited to only four groups for this study, it nonetheless appears to confirm that the focus group methodology is useful for generating important data relevant to the public acceptance issues surrounding the potential for successful deployment of AHS.

First , the focus groups demonstrated that public acceptance has both user and community elements that need to be considered in the design and deployment of AHS. User elements are key for any consumer element of acceptance. Community elements are important for general taxpayer acceptance as well as interest group acceptance. Second many issues surfaced and many suggestions were made for future policy and research activities and these need to be considered seriously. Third, the focus group methodology is an appropriate one to add to those methods already known for identifying important issues regarding public acceptance for developing technologies such as those in AHS. Also, the instrument developed for this study has proved useful in generating the information desired. These lead to the following recommendations:

- The Consortium should establish a research and development Program to address institutional and public acceptance issues related to AHS.

The overall recommendation of the study is to develop a multi-faceted research and development Program to deal with the variety of institutional and public acceptance issues that will affect the deployment of AHS. While the technical aspects of AHS are daunting, acceptance of these technologies is vital if the program is to be successful. Therefore, the Consortium needs to initiate a series of research and outreach activities aimed at addressing key interests and concerns of various institutional and public stakeholder groups. Based on the findings of the public/Institutional acceptance focus groups and the literature review, we recommend that this Program include - at a minimum --the following components:

- The Program should conduct a detailed assessment of the range and magnitude of interest and concerns across stakeholder groups.

The focus groups we conducted provide a preliminary assessment of the types of issues that are of major interest and concerns to some stakeholders. In particular, they demonstrated the benefits--such as safety and convenience--that potential early adopters may perceive as possible through AHS. They also demonstrated the pervasive cost and environmental concerns associated with the system. However, these findings are exploratory; a more rigorous and exhaustive inventory of public acceptance issues is needed to firmly establish the baseline upon which AHS activities can build. This baseline should include an understanding of both the potential early users of AHS, as well as the concerns of key constituencies (e.g., environmental groups).

- The Program should assess the influence of new information and/or direct experience on institutional and public acceptance of AHS.

Both the literature and focus groups revealed some low level of awareness of AHS. As such, the aforementioned baseline will provide an indication of the initial reactions of stakeholders to the prospects of AHS. It will, therefore, be important to know how these opinions are affected by new information, such as will be developed by the Consortium. There are a variety of research and outreach methods that can be used to gain this understanding. From the research perspective, in addition to further use of focus groups, there are at least two other techniques that should be useful to this end: deliberative polling and the use of simulators. Deliberative polling involves the sampling of citizen representatives and immersing them in a substantive area while polling their reactions. Use of simulators, a more common technique in transportation, involves simulating an AHS experience, and then querying participant reactions to this experience. These and related research methods could provided a more in depth understanding as to the extent to which initial reactions are confirmed or modified by subsequent experiences.

- The Program should develop an outreach strategy that builds upon (the above) public acceptance findings, and in doing so, attends to the interests and concerns of a broad range of stakeholders, from AHS champions to AHS adversaries.

The conduct of public and institutional assessment research should inform the design of an AHS outreach strategy. This strategy should be sensitive to the original concerns of stakeholders, while at the same time understanding the core concerns that may arise among informed stakeholders. Moreover, it should target strategies for both champions and adversaries alike. However, one important impact of the research should be on the structure of the program itself; that is, key concerns should not just be dealt with via a public relations approach, but addressed in the technical program as well. For example, the concerns about costs and environmental quality that were raised in the course of this review, should be the subject of intensive analysis, so that information about these areas can be communicated in a credible manner.

Incorporating public acceptance research will help ensure that AHS development will take into account the features considered important from a user and community perspective. Nonetheless, the challenge of doing this is considerable, given the strong technology-driven orientation of the AHS program. Special mechanisms will therefore be needed (through the AHS Consortium or U.S. DOT) to ensure that public opinion and related social science/institutional research is appropriately managed and interfaced with the technical development aspects of AHS.

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