SECTION 8

BENEFITS AND COSTS

The goal of the PSA research in this area was to identify the major benefits and costs of an AHS, and to attempt to define metrics for some of the elements. This section describes the results of these PSA research efforts...a high-level attempt to: (1) define a model for structuring AHS costs and benefits; (2) quantify the potential impacts of a conceptual automated highway system; and (3) define how an AHS might be financed.

The research was conducted by three teams using very different strategies and assumptions; the results provide a good sense for the problems that face those who would answer the questions: "How much will AHS cost, and, How should we represent the benefits?" Table 8.1 compares the three approaches. The combined output provides the following:

- A national perspective from a survey of AHS project initiatives (PATH)
- A generic Cost/Benefit Analysis (CBA) based on an existing urban freeway (PATH)
- A review of the uncertainties in applying a CBA to AHS (PATH)
- A traditional transportation project parametric CBA model (Delco)
- A CBA reflecting the introduction of AHS as a **new product**, designed for extrapolation to the national level (Delco)
- A traditional US DOT-type MOE analysis treating four highways (Calspan)
- A framework for organizing AHS CBA efforts (Calspan)

8.1 BENEFITS

The AHS should provide benefits in all of the stakeholder categories; that is, those who will design, build, deploy, operate, and use the AHS. Benefits should accrue to users, communities, State and regional transportation agencies, US. industry, and society as a whole. The following is a qualitative description of the types of benefits that have been identified to date. As with any new capability which offers a step-change in system performance, efficiency, and accessibility, we can expect as yet undefined applications with benefits to stakeholders not yet imagined. It is critical that efforts to identify, measure, and evaluate all these benefits continue, building on the PSA findings. The PSA evaluations

Table 8-1. Comparison of the Characteristics of the Three Cost/Benefit Analyses

	PATH Team	Delco Team	Calspan Team
Approach	Life-cycle CBA of three evolutionary stages of AHS to be introduced into a defined existing urban corridor; assumptions guided by intent to develop "representative " results leading to a range of generic insights.	Traditional highway construction project CBA for development in an existing corridor. Baseline plus two options plus AHS highway (four scenarios) for typical MPO comparative decision support. Demand data and assumptions guided by recent studies (DMJM for infrastructure, Hughes Electronics for vehicle equipment), and intent to develop ROI type answers for federal executive/legislative decision makers.	A framework for identifying and accumulating AHS system element costs (vehicle and infrastructure) that is inclusive/comprehensive, and reflects the costs and benefits for an incremental/evolutionary approach to AHS implementation. Assumptions are guided by an operations perspective and the intent to develop a tool for exploring C/B threshholds, for addressing a comprehensive list of costs and benefits, for evaluating these lists, and for ranking them.
Vehicles	Mixed with defined equipment.	Mixed with defined equipment	Mixed
Infrastructure	California Route 101 (Hollywood Freeway) from Hollywood to central Los Angeles.	Route I17 in the Phoenix non-attainment region	Long Island Expressway, Boston Artery project, the National Beltway (I495), NY State thruway sections.
Scenarios	1. AHS Ready (e.g., ICC +automated steering) 2. No lane chg, 3500-4000 vplph 3. Full AHS: 7000 v/hr/lane	1. Base case 2. Converted HOV lane 3. Additional general purpose lane 4. Converted AHS lane	The framework will be populated with detailed infrastructure cost data and parametric vehicle cost data.
Product:	Illustrative benefits (qualitative) and associated costs ($) for a range of site difficulties (e.g., lane additions, elevated sections present in an existing corridor) presented in the context of a survey of AHS-like project study findings, and an assessment of the uncertainties in developing CBAs for AHS.	Parametric model suitable for continued research (into alternate scenarios), with particular sensitivity to the distribution of stakeholders' benefits and the relationship between AHS vehicle costs and AHS market penetration & demand. Costs and benefits rolled up into relative dollar measures for 2010 and 2017.	A tool for organizing/developing CBA inputs and studies. A basis on which to assemble subsystem costs (for elements and increments); a catalyst for common data dictionary; and, using the available practical cost data, a basis for exploring the relative outcomes (e.g., benefits and costs against service levels) of high level AHS program initiatives.

relied on traditional measures such as trip time and accident rates; what follows is, therefore, an agenda for the areas needing expansion and improvement.

8.1.1 User Benefits

The AHS will provide travel services to a full range of today's highway users. The prime urban market for AHS is made up of commuters, HOV lane users, transit operators, and truckers. All will benefit from reduced congestion and reliable travel times (Calspan). Rural users will benefit from faster trip times (from higher speeds) and greater safety as run-off-the-road crashes are virtually eliminated. Benefits will accrue to all users; however, the relative level of the benefit may vary. For example, trucking operations may benefit more from the dependable travel times and greater safety than from user comfort.

- **Reduced congestion** - Addition of an AHS lane to a freeway increases the capacity of the freeway; if the addition is coupled with demand management policies, such as HOV and transit lanes and/or parking management, then congestion will be relieved. This will reduced travel times for both those traveling on the AHS as well as those that continue to travel on the manual freeway lanes (Calspan, Delco). Calspan suggested that a target trip time savings of one minute per travel mile on the AHS is probably achievable with a dedicated AHS lane and proper entry and exit provisions. Their modeling of the LIE projected travel time reductions of 38 percent; reductions of 48 percent were projected for the Washington Capital Beltway (I-495). In Calspan's study, all traffic in the corridor experienced reduced travel times. Measures for congestion mitigation must be developed.

- **Trip time reliability** - Travel times should be much more dependable because of the consistent AHS traffic flow due to automated traffic management. However, congestion at AHS entry and exit points could off-set this advantage. The AHS, as a supplement to the existing roadways, must be integrated with the existing highway system. Measures for the interaction of the AHS flow and the existing road system must be developed.

- **Greater travel safety** - Estimated improvements ranged from a minimal 30 percent better assuming automated traffic mixed with manual traffic (Calspan and Battelle) to 80 percent better (Calspan). This is based on analysis of causal factors in crashes, and of automated reactions that would help avoid inadequate and inconsistent human responses that often result in crashes. However, the reliability of the automated response and the human reaction to this assistance requires further research. In general, it would appear that fewer crashes should translate into reduced insurance rates. However introducing dual airbags can be correlated with different driving habits and changed accident patterns. The specific impact on system safety from deploying an AHS must be explored.

- **User comfort and access** - Focus groups anticipate far less stress and worry in highway travel for those using AHS. For many travelers (commuters) the AHS may translate into increased work time (the office in the car); on long trips under AHS control, this may mean increased leisure time (e.g., read a book). These benefits will be real, but translating them into a dollar value will be difficult. Even though all travelers enjoy the benefits of reduced congestion, only those on the AHS will enjoy the increased safety and comfort. This raises concerns about equity and accessibility across society. Comfort and convenience are marketing realities for many commodities; they are examples of new measures of benefit in transportation services that require study and quantification.

- **Mobility** - A national AHS network will enhance the Nation's mobility for all users including shippers, transit companies, senior citizens and the handicapped. Smooth transition through several stages of driver assist systems on the way to fully automated vehicle control must accommodate all categories of users. Defining a highly reliable and safe system which is also affordable and provides nationwide compatibility with local/regional tailoring will be a major challenge. To help with the decisions along the way, we need an expanded understanding of, and measures for, these system mobility aspects.

8.1.2 Community Benefits

The AHS will represent a powerful supplement to a community's transportation system as it is augmented to meet growing needs and/or problems. It will provide communities with several specific benefits:

- **Air quality** - There are indications that per-mile tailpipe emissions of individual vehicles will be reduced on AHS due to smoother travel and less congestion. However, the increased capacity from AHS may attract additional vehicular traffic. Approaches and policies for ensuring that this added capacity results in reduced congestion and increased passengers-per-vehicle--such as car pooling, demand pricing and transit-only lanes--must be defined and correlated to AHS.

- **Need for right-of-way** - Relative to construction of new highway lanes to add capacity, there will be less land needed for highway rights-of-way by allowing increases in traffic flow to be handled on existing rights-of-way. In many cases this will mean that the costs (both direct and indirect) of building a new highway can be avoided

- **Transit support** - Bus transit systems will benefit from AHS services through faster, more reliable service. In addition, bus-only lanes and integration with local transit operations can extend this benefit; for example, transit terminals that connect to local routes and/or rail services could be provided.

- **Integration with ITS services** - In many ways, the AHS is a logical extension of other ITS services and integrates nicely with them. As discussed above, the AHS is the next logical step for the partial vehicle control services such as ACC and collision avoidance. AHS also will integrate into an existing traffic information service where it will be viewed as yet another transportation asset upon which travel planning and information can be provided. AHS will also integrate nicely with existing traffic management centers; again, it will be another highway resource to be monitored and to be integrated into the other community roadways. The level of weather and congestion monitoring required for AHS is greater than for other ITS services, so AHS can enhance travel management for the entire region by feeding these enhanced monitoring results to the regional transportation management center. Finally, AHS could integrate nicely with commercial vehicle operations improvements such as automated vehicle identification, electronic permits and registration and weigh-in-motion.

- **Less demand for emergency services** - Because of the reduced crash rate on the AHS, demand on a community's support services--such as fire, rescue and emergency room--should be less. AHS should allow better response times from these services when they are needed in the community.

8.1.3 State and Regional Transportation Agency Benefits

The State and regional transportation planning agencies are key stakeholders in the AHS. They will need to integrate AHS into their planning activities, including statewide State Implementation Plans (SIP) and regional or local Transportation Implementation Plans (TIP). They must view the AHS as a desirable, cost-effective investment alternative that can be tailored to meet their community's transportation needs. As a platform for local transportation policy initiatives, the AHS will provide the following benefits:

- **Peak efficiency** - Estimates are that an AHS will allow two to three times as many vehicles per peak-hour of travel compared to today's manual highways, often using existing highway right-of-ways. This will come from increased traffic density and speed per lane because of the tighter operating tolerances possible with full automated control. It also comes from providing a more uniform driving performance by eliminating variances caused by human distractions and by reducing acceleration, deceleration, and unnecessary lane changing. And it also comes from the possibility of narrower lanes allowed because of the more accurate AHS steering accuracy. However, this increased capacity must be integrated with the local roadways to obtain an overall increase in transport efficiency.

- **Gradual transition** - The AHS can be built one segment at a time. This will allow a long-term upgrade for major highways and a smoother transition from today's vehicles, highways, and drivers. A smooth installation and practical operation for AHS are also achievable using automated design, deployment and maintenance approaches (UC Davis).

- **Investment return** - Early cost/benefit analyses indicate that an AHS may be able to provide a favorable return on investment when compared with other transportation options in many potential deployment environments.

- **Emissions conformance** - Because of its increased efficiency, AHS offers state and MPO-planners a tool for both increasing capacity and meeting the Clean Air Act (Amended) requirements in non-attainment areas. AHS will also increase the efficiency of other programs aimed at reducing total VMT through transit, HOV lanes, and demand pricing

8.1.4 United States Industry Benefits

The AHS will also offer major benefits to industry:

- **AHS Market** - Vehicle manufacturers, highway construction firms, and vehicle electronics companies will enjoy substantial, long-range market opportunities as AHS is deployed nationally. These opportunities will be available to all because of interoperability standards and regulations. International market opportunities should also be available since the US. AHS effort is at the forefront of AHS development worldwide. For vehicle manufacturers, near term automated vehicle control products (e.g., ACC, collision avoidance) will benefit from the technology research efforts of the AHS program.

- **Trucking** - Trucking firms will benefit from safer highways and more efficient roadway operations, particularly more reliable point-to-point travel times which will translate into lower operating costs and support for realistic just-in-time inventory control for its customers. A more advanced AHS may offer potentially substantial labor savings because a single driver may be able to operate a vehicle longer, or because the requirement for operators of some vehicles on special systems may be reduced or eliminated.

- **Market access** - Industry in general will benefit from increased transportation reliability, mobility, and flexibility.

8.1.5 Societal Interests

Some of the Nation's broader societal needs will be addressed by the AHS. These include:

- **National Highway System supplement** - As a supplement to the National Highway System, the AHS will help meet the goal for an inexpensive, reliable national network of highways that will increase our Nation's mobility. This will increase the Nation's robustness and vitality.

- **Increased mobility for disabled and disadvantaged** - People who are disadvantaged in some way tend to be cautious in planning travel because of accessibility and the ordeals of highway travel. The AHS may offer increased mobility for these people by assuming many of the more arduous driving tasks.

- **Reduced fossil fuel consumption and emissions** - The AHS can reduce both fossil fuel consumption and emissions per vehicle mile traveled. And when coupled with other programs and policies aimed at demand management, this should have a national impact as AHS implementation increases.

- **Defense conversion** - During AHS development, defense and aerospace firms can employ their expertise in this "civilian" application. In the long run, these firms will have opportunities to compete as the AHS implementation results in the creation of opportunities nationwide.

- **Tort liability** - Fewer crashes should result in substantially fewer tort liability cases. However, in those cases where there are crashes on the AHS, it is not clear at this point who would be responsible. A definitive set of rules and/or legislation that clearly pre-defines this area would be helpful; they might help reduce the painfulness of initial tort liability claims in a new AHS.

- **Emergency response** - An AHS, with its system-wide management, should be highly responsive to local and regional emergencies and evacuations.

8.2 COSTS

It is difficult to recognize and quantify the costs of a system that is still in the conceptual stages and where many unknowns concerning design performance and operational concepts (such as the distribution of liability) still exist. Nevertheless, the PSA studies were able to use available cost information, coupled with engineering judgments on the unknown elements, to develop scenarios that were quantified. The PSA research used traditional methodologies to develop the profiles of various AHS configurations as well as to define baseline cases (otherwise called the 'do nothing' approach) on which they performed the reported cost analyses. Although the specific approach each team took is different, the results--taken as a whole--provide preliminary evidence for the economic feasibility of AHS; and under favorable assumptions, several approaches anticipated a strong economic rate of return.

The PATH research team studied an evolutionary approach using the catalyst of AHS Ready Vehicles, and installation of low-cost infrastructure to support automatic steering on inter-city highways. Elemental roadway costs were based on a specific implementation along the US 101 freeway in Los Angeles. For the year 2020, high capacity AHS appears to be most viable in a select group of cities, reasonably amounting to 7,500 lane-kilometers, supported by 25 to 40 million vehicles. Associated annual cost savings would amount to $2.3 billion per year. This represents a five percent annual return on a $11 billion investment, deferred twenty-five years.

From a cost based perspective, PSA researchers determined the minimum viable peak hour AHS market penetration of vehicles to be nine percent. Below this level, AHS operations actually reduced the overall highway capacity. The penetration needed for viable operation of a single AHS lane in a corridor was judged as 5 to 15 percent (Delco, Battelle, Calspan); at this level, the number of vehicles that should be attracted to an AHS lane were sufficient to justify its operation as a dedicated facility. However, one cost analysis (Delco) estimated the peak-hour threshold at 33 percent; this serves to show the uncertainty at the present state of the AHS costing art.

For example, there are uncertainties associated with the vehicle costs for AHS. Much of the equipment needed for an AHS may well be part of the standard vehicle by the early part of the 21st century. Electronic actuators, communications antennae for roadside communications, and on-board health-monitoring systems may be common by then. If a vehicle is designed with a potential AHS-upgrade in mind, then much of the increment needed for an AHS capability in a vehicle may be electronics and software (Delco). "Software costs on a per-vehicle basis will be modest due to the large number of vehicles. At a 70 percent market penetration (70 million vehicles), a cost of $5 per vehicle would amount to $350 million dollars of software development." (Calspan).

Another viewpoint is: What will the consumer be willing to pay? One conservative estimate puts the owner tolerance for increased vehicle cost at $500 per year. A second comparison was with the typical price curves for introduction of new options to vehicle owners. As an example, initial units may cost over $2,500, and market penetration will be very low--only among those with higher disposable income. As prices drop to $1,500, the number of units sold may increase ten-fold. Then as the price drops to under $1,000, the option becomes more-or-less a standard offering. The price of in-vehicle navigation units in Japan is following a similar price/penetration curve. (Hashimoto, 1994)

Many of the conventional cost categories that are associated with traditional roadway projects are also applicable to an AHS. How these may change is significant in absolute terms, and, as it may impact the AHS specific elements of an integrated regional system. It is possible that the magnitude of the cost may be greatly reduced due to the configuration of an AHS. For instance, the AHS could use existing right-of-way alleviating the high costs associated with obtaining previously undedicated right-of-way or require less than adding conventional lanes or transit. Furthermore, with increased capacity of these lanes, the demand for additional lanes could turn out to be low, possibly allowing for conversion of under utilized lanes to other uses such as bicycle right-of-way. These are just a couple of infrastructure related aspects that would have significant cost impacts.

Working with the three PSA reports would lead to many other differentiators (between AHS and conventional highway projects). There will also be "Added Costs." Currently, the interstate infrastructure does not rely heavily on electronic equipment for normal operations. Preliminary designs of an AHS all have strong emphasis on electronic infrastructure necessary to operate the system. These types of costs for highway projects are not traditionally built into conventional cost equations in this environment. Therefore it will be necessary to incorporate this into future planning and costing models. Also, the upgrade of a region's traffic management center and/or its traveler information services to accommodate AHS will also need to be considered.

How future AHS concepts evolve with regard to the balance of development between the vehicles and the infrastructure, and the scope of system wide (regional) traffic management plans, will all play into the actual deployment costs. Practical projections of the value of benefits and the system costs must be made as the program continues.

8.3 FINANCING

The PSA researchers explored financing alternatives in a general way to see whether they would impact the benefit/cost analysis work. The results were inconclusive as a function of the lack of definition—the business of "what and where" needs to be decided before funding strategies can be selected.

The general findings were that potential revenue sources include: public tax, individual subsidies, tolls, fee for use (including priority), special tax districts including those structured similar to public utilities, private development, governmental funding, and public/private partnerships. These correlate in many ways with funding approaches identified for other ITS services.

Since the private sector could potentially build an AHS facility faster and more cost-effectively than the government, rates of return defined by contracts between state and developer could be used and once the investment is recovered and the agreed profit is realized, the road could be turned back to the State.

Some likely methods to obtain revenue for system deployment and operation include user fees, private investments, equipment fees, and involvement of the insurance industry. The question arises concerning which part of an AHS should come first—the roadway infrastructure or the intelligent AHS-equipped vehicle? This clearly has great impact on the funding strategy. The more vehicle-based the system is, the greater the cost is to the individual owner and the less operating costs for the infrastructure. A test track will not be satisfactory to demonstrate the financial success of an AHS. Real-world deployment(s) will be necessary before major financing decisions can be made.

Market research is needed to help understand the public's willingness to accept various financing approaches such as congestion pricing over other alternatives. A complicated taxing system could be detrimental to the success of an AHS system. On the other hand, a totally toll-financed system could reduce equity concerns (no tax subsidies); however, not everyone could afford access. This brings up concerns of discrimination for people with lower incomes. In the final analysis, the potential user must perceive enough benefit to be willing to accept the costs.

And, after the system is built, the (perhaps more challenging) concern will be for funding the system's operation and maintenance. The issues associated with a fee-for-use or congestion pricing with an AHS system focus on whether vehicle cost is a bigger concern than fee for use of infrastructure. Clearly, financing is an AHS cost, and, the method of financing will influence the AHS benefits.

LIST OF REFERENCES

References in this report refer to the Precursor Systems Analysis teams selected to study the sixteen activity areas. Below, the manager of each team is given, the members of the teams are listed, and the Final Reports that were produced are given.

BATTELLE

Team Manager: Jerry Pittenger, Battelle Institute, Columbus, Ohio

The Battelle team consisted of the following entities:

Battelle Institute
BRW
Mass. Institute of Technology
Ohio State University
Transportation Research Center
University of Minnesota

Nine Final Reports were delivered in December, 1994:

Contract Overview
Task A *Urban and Rural AHS Analysis*
Task E *Malfunction Management and Analysis*
Task H *AHS Roadway Deployment*
Task I *Impact of AHS on Surrounding Non AHS Roadways*
Task J *AHS Entry/Exit Implementation*
Task K *AHS Roadway Operational Analysis*
Task N *AHS Safety Issues*
Task O *Institutional and Societal Aspects*

BDM

Team Manager: Mike Martin, BDM, McLean, Virginia

The BDM team consisted of the following entities:

BDM
Cambridge Systematics, Inc.
George Mason University
SNV
Sverdrup Civil, Inc.

Three Final Reports were delivered in December, 1994:

Contract Overview	
Task F	*Commercial and Transit Aspects*
Task O	*Institutional and Societal Issues*

CALSPAN

Team Manager: Joe Elias, Calspan Corp., Buffalo, New York

The Calspan team consisted of the following entities:

Calspan
BMW
Dunn Engineering
Farradyne Systems, Inc.
Parsons Brinckerhoff
Princeton University
TRANSCOM
Connecticut Department of Transportation
Massachusetts Department of Transportation
New Jersey Department of Transportation
New York State Department of Transportation
NY State Thruway Authority

Calspan addressed all of the activity areas; their findings were produced as eight Final Reports delivered in December, 1994:

Volume I	*Overview Report*
Volume II	*AHS Comparable Systems Analyses*
Volume III	*AHS Roadway Analysis*
Volume IV	*AHS Systems Analysis*
Volume V	*AHS Malfunction Management and Safety Analyses*
Volume VI	*AHS Alternative Propulsion System Impact*
Volume VII	*Commercial and Transit AHS Analysis*
Volume VIII	*AHS Institutional, Societal and Cost Benefit Analysis*

DELCO

Team Manager: Herb Hall, Delco Systems Operations, Goleta, California

The Battelle team consisted of the following entities:

Delco Systems Operations
DMJM
Hughes Aircraft Company
University of California (PATH)
General Motors Corporation

Delco addressed all of the activity areas; their findings were produced as seventeen Final Reports delivered in December, 1994:

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

HONEYWELL

Team Manager: Mahesh Jearage, Honeywell Navigation and Systems Architecture, Minneapolis, Minnesota

The Honeywell team consisted of the following entities:

Honeywell Technology Center
Purdue University

University of California (PATH)
University of Minnesota

Two Final Reports were delivered in December, 1994:

Malfunction Management Activity Area Report for AHS Health Management
Comparable Systems Analysis

MARTIN MARIETTA

Manager: Rich Luhrs, Martin Marietta Corp., Littleton, Colorado

One Final Report was delivered in December, 1994; it contained:

Volume I	*Executive Summary*
Volume II	*Maneuver Definition and Functional Requirements*
Volume III	*AHS System Concept Definition*
Volume IV	*AHS System Concept Evaluation*

NORTHROP-GRUMMAN

Team Manager: David Blancett, Northrop Corp., Pico Ravera, California

The Northrop team consisted of the following entities:

Northrop
PATH

One Final Report was delivered in December, 1994:

AHS Check-In Activity

PATH

Team Manager: Steve Shladover, University of California, Richmond Field Station, Richmond, California

The PATH team consisted of the following entities:

PATH
Bechtel
California Department of Transportation

California Polytechnic State University
Lawrence Livermore National Laboratory
Rockwell International
University of Southern California

Five Final Reports were delivered in December, 1994:

Overview		
Task A	*Urban and Rural AHS Comparisons*	
Task H	*Roadway Deployment Analysis*	
Task J	*Entry/Exit Implementation*	
Task P	*Preliminary Cost/Benefit Factors Analyses:*	
	– Vol. I	*Cost/Benefit Analysis of Automated Highway Systems*
	– Vol. II	*System Configurations: Evolutionary Deployment Considerations*
	– Vol. III	*Electronics Cost Analysis*
	– Vol. IV	*Roadway Costs*
	– Vol. V	*Analysis of Automated Highway System Risks and Uncertainties*
	– Vol. VI	*Review of Studies on AHS Benefits and Impacts*

RAYTHEON

Team Manager: Mike Shannon, Raytheon Corp., Tewksbury, Massachusetts

The Raytheon team consisted of the following entities:

Raytheon Company
Daimler Benz
Ford Motor Company
Georgia Institute of Technology
Tufts University
University of Southern California
VHB

Ten Final Reports were delivered in December, 1994:

Volume I	*Executive Summary*
Volume II	*Automated Check-In*
Volume III	*Automated Check-Out*
Volume IV	*Lateral and Longitudinal Control*
Volume V	*Malfunction Management and Analysis*
Volume VI	*Commercial Vehicle and Transit AHS Analyses*

Volume VII	*Entry/Exit Implementation*
Volume VIII	*Vehicle Operational Analysis*
Volume IX	*AHS Safety Issues*
Volume X	*Knowledge Based Systems and Learning Methods for AHS*

ROCKWELL

Team Manager: Richard Barber, Rockwell AESD, Anaheim, California

The Rockwell team consisted of the following entities:

Rockwell International Corp.
University of California (PATH)
Systems Technology, Inc.

Five Final Reports were delivered in December, 1994:

Overview
Vehicle Operations Analysis
Malfunction Management and Analysis
Lateral and Longitudinal Control Analysis
Vehicle Evolution Analysis

SAIC

Manager: Cary Vick, SAIC, McLean, Virginia

One Final Report was delivered in December, 1994:

Legal, Institutional and Societal Issues Related to the Deployment and Operation of an Automated Highway System

SRI

Manager: Randal Galijan, SRI International, Menlo Park, California

One Final Report was delivered in July, 1995:

Use of Global Positioning Satellite (GPS) Carrier-Phase Integration for AHS Vehicle Control

TASC

Manager: David Whitney, TASC, Reading, Massachusetts

One Final Report was delivered in December, 1994:

HiVal: A Simulation and Decision Support System for AHS Concepts Analysis

TRW

Team Manager: R.L. Pickel, TRW LBC-1, Redondo Beach, California

The TRW team consisted of the following entities:

TRW
California Polytechnic State University

One Final Report was delivered in December, 1994:

Alternative Propulsion Systems Impact

UC-DAVIS

Team Manager: Bahram Ravani, University of California, Davis, California

The UC-Davis team consisted of the following entities:

University of California, Davis
California Department of Transportation

One Final Report was delivered in December, 1994:

Automated Construction, Maintenance and Operational Requirements for AHS