National Automated Highway System Consortium Technical Feasibility Demonstration Summary Report

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National Automated Highway System Consortium

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NAHSC

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Celeste Speier		Appendix G Demo Days Surveys
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Celeste Speier		Appendix I Media Event Attendees

Acronyms and Abbreviations

AAA	American Automobile Association
ACC	adaptive cruise control
AHS	automated highway system
ALTS	automatic location and tracking system
AP	Associated Press
AVCS	automated vehicle control system
CAATS	California Alliance for Advanced Transportation Systems
Caltrans	California Department of Transportation
CCTV	closed circuit television
CHP	California Highway Patrol
CMU	Carnegie Mellon University
DPC	Demonstration Presentation Center
ORV	Obstacle Removal Vehicle
FA	Free Agent
FCWS	forward collision warning system
FTT	Future Transportation Technologies
GIS	geographical information system
GM	General Motors
GPS	global positioning system
HOV	high occupancy vehicle
HUD	head up display
Houston Metro	Houston Metropolitan Transit Authority of Harris County
ICC	intelligent cruise control
IDV	Infrastructure Diagnostic Vehicle
ISTEA	Intermodal Surface Transportation Efficiency Act
ITP	Integrated Test Plan
ITS	intelligent transportation systems
MC	Miramar College
MOA	Memorandum of Agreement
NAHSC	National Automated Highway System Consortium
NHTSA	National Highway Traffic Safety Administration
NSA	North Staging Area
NTP	National Trade Productions, Incorporated
ORV	Obstacle Removal Vehicle
OSU	Ohio State University
PATH	Partners for Advanced Transportation and Highways
PR	public relations
PSA	passenger staging area
PVC	polyvinyl chloride
SAE	Society of Automotive Engineers
SCY	South Control Yard
TBD	To Be Determined
TBR	To Be Reviewed
TMC	Transportation Management Center
TMS	Transportation Management System
TSB	Temporary Service Building
VIP	Very Important Person
VVIP	Very, Very Important Person (Distinguished Guest)

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EXECUTIVE SUMMARY

This report describes the planning, development, execution and results of the National Automated Highway System Consortium (NAHSC) Proof-of-Technical-Feasibility Demonstration - Demo '97. Demo '97, held August 7- 10, 1997, was mandated by the Intermodal Surface Transportation Efficiency Act of 1991. This demonstration met that historic milestone.

Purpose

The purpose of the demonstration was to show the technical feasibility of a fully automated vehicle-highway transportation system. Fully automated operation is where the vehicles' throttle and brakes are controlled automatically to keep the vehicles moving without collision, and the vehicles' steering is controlled so that the vehicles follow their desired path. Several alternative technologies capable of providing automatic braking, steering, and throttle control were showcased. The demonstration also showed that near-term "partially automated" services such as adaptive cruise control, collision warning and lane keeping could assist drivers when the vehicle control is not fully automated.

Background

Research has shown that an automated highway system (AHS) may be able to help transportation agencies solve some of their problems by (1) substantially increasing the safety of the vehicles traveling under automated control; and (2) increasing the efficiency of existing highways and, thus, help reduce traffic congestion and vehicle emissions.

- Increased Safety - Studies have shown that automating vehicle control could result in dramatic increases in safety. There are over forty thousand fatalities and more than five million disabling injuries on our nation's highways each year (NHTSA). It is estimated that 90 percent of all crashes are either caused by or contributed to by driver error (NHTSA). Automated control can eliminate driver error.

- Increased Efficiency - Preliminary analysis of AHS predicts that lane capacity can be increased by two to three times the capacity of today's highways. An AHS can increase highway capacity without building new highways. This should help reduce congestion; traffic congestion costs the nation over $50 billion annually in lost productivity (IVHS Strategic Plan Report to Congress) and a single mile of new highway can cost $5 to $50 million (Caltrans), whereas equipping a single mile of an existing four lane highway for AHS operation can cost $40 to $50 thousand (NAHSC). Significant decreases in emissions should also result from smoother vehicle operation and reduced congestion.

For these reasons, the US Department of Transportation, following congressional guidance, formed a program to research the feasibility of AHS.

The NAHSC was competitively selected by the U. S. Department of Transportation to conduct systems feasibility, definition and prototyping of a safe, reliable, cost-effective automated highway system (AHS). One of six milestones for the Consortium was the conduct of a technical feasibility demonstration. The NAHSC is a collaboration of nine major Core Participants: Bechtel, California Department of Transportation (Caltrans), Carnegie Mellon University, Delco, Hughes (now Raytheon), General Motors, Lockheed Martin, Parsons Brinckerhoff, University of California PATH (Partners for Advanced Transit and Highway), and U.S. Department of Transportation.

The Consortium also includes over 120 Associate Participants who are automated highway stakeholders; that is, the entities that will design, develop, deploy, operate, use and/or maintain automated highway systems. These Associates help ensure the development of a national consensus.

The 1997 Demonstration of Technical Feasibility, or "Demo '97" involved each of the nine Core Participants and several of the Associate Participants.

Demonstration Scenarios and Technologies

Seven different approaches to AHS, or "AHS scenarios", were demonstrated on a 7.6 mile segment of High Occupancy Vehicle (HOV) lanes on Interstate-15 just north of San Diego California. These demonstrations integrated the latest technological achievements in vehicle-highway automation. In conjunction with the Interstate-15 demonstrations, the Consortium conducted a large exposition at a near-by community college. Additional vehicle demonstrations, static equipment displays, simulations, and product information booths were also provided at the exposition. In addition to being the third major milestone in the NAHSC program, the event played a key role in advancing public awareness of smart car/smart highway benefits.

The range of technical approaches demonstrated in the seven operational scenarios was broad. Three of the scenarios were developed by the nine Consortium Core Participants; one of these involved an Associate Participant, Metropolitan Transit Authority of Harris County. The balance of the scenarios were developed by four Associate Participants: American Honda Motor Company, Eaton Vorad, The Ohio State University and Toyota Motor Corporation. The demonstration scenarios included:

- An automated maintenance vehicle which demonstrated AHS maintenance and operations.
- An evolutionary scenario which demonstrated vehicle developments transitioning from today's manually controlled vehicles to fully automated vehicles.
- A multi-platform free agent scenario which demonstrated automated transit buses and passenger vehicles operating side-by-side in a mixed platform (bus/car) mixed traffic (automated/manual) highway environment.
- A platoon scenario which demonstrated the benefits of operating automated vehicles in closely spaced formation.

- A trucking scenario which demonstrated adaptive cruise control and collision warning safety features on a full size tractor-trailer rig.

- Two additional scenarios which demonstrated transparent transition from one control technology to another.

Demo '97 Team Organization

The Demo '97 team was made up of employees and volunteers from more than 20 different organizations in the U.S. and Japan. The NAHSC coordinated the activities of the participating organizations to successfully (and safely) make this unique, multi-faceted event possible. All nine Core Participants and five Associate Participants were responsible for demonstration development. In addition, several additional Associate Participants supported other demonstration activities. They included Miramar College, San Diego Regional Transportation and Technology Alliance, San Diego Transportation Leadership Council, San Diego Association of Governments, Caltrans San Diego District Office, Society of Automotive Engineers, Southern California Automobile Association, Southern California Priority Corridor Project, California Highway Patrol, California Alliance for Advanced Transportation and many others. Contractors also played a key role in the planning and execution of the demonstration. National Trade Productions and Aurora Exhibits provided exposition event planning and Strat@com provided public education support.

The Demo Team was organized into seven functional areas as shown in Figure 1. Each activity area utilized representatives from many of the organizations listed above.

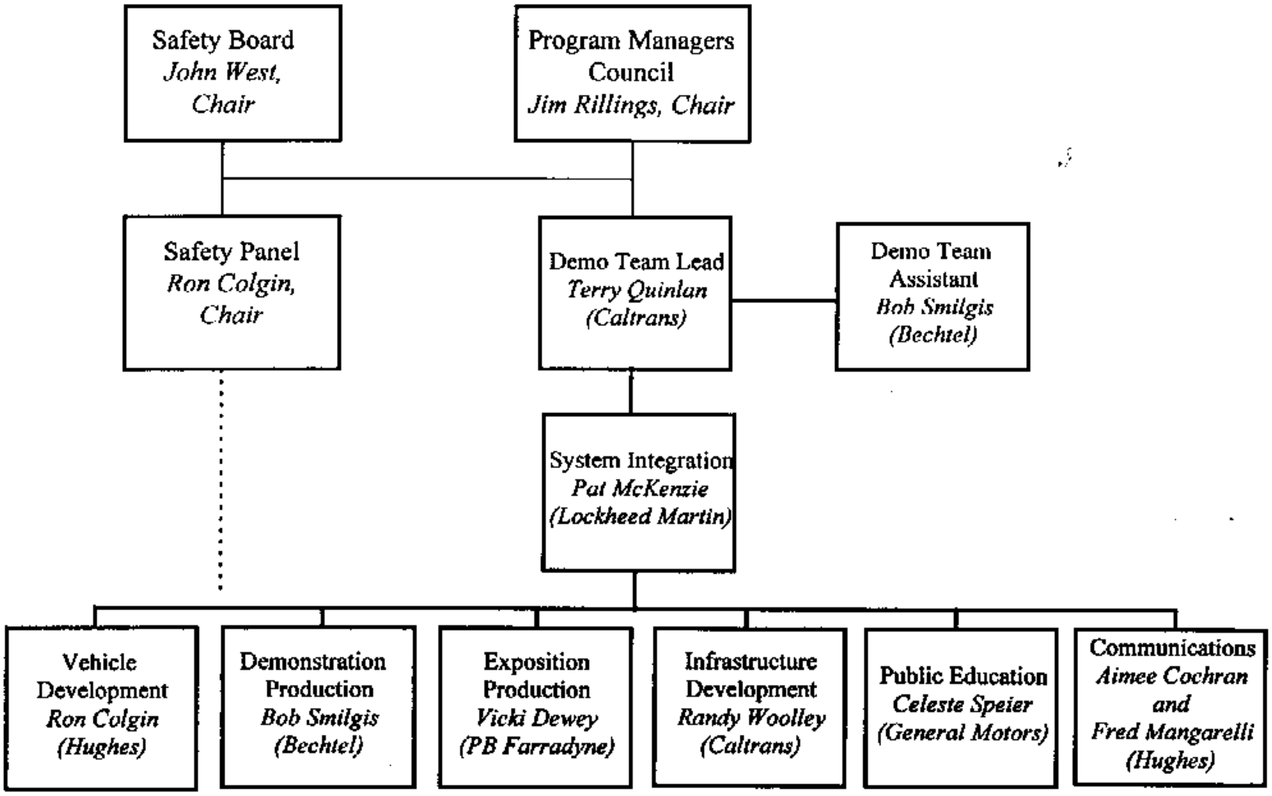

Figure 1 Demo Team Organization Chart

Each area of responsibility relied on staff from a variety of organizations to support subtask activity. In general, the Demo Team was a large multi-discipline/multi-organization team working toward a common goal. By the time the demonstration was executed, the Demo Team was performing as an effective unified organization.

Planning and Development

The demonstration was held 32 months after cooperative agreements were signed with USDOT. Planning began immediately after the agreements were finalized. In order to maintain the demonstration schedule, several key dates were established in the planning and development activities. The scope of all infrastructure modifications to the demonstration site and test facilities necessary to conduct the demonstration were defined by October 1995. By June 1996, all live vehicle demonstration systems were identified for integration into the demonstration plan. By January 1997 most of the infrastructure modifications were complete allowing testing and dry runs of the scenarios. By June 1997, all exhibits were identified and exhibitors were registered.

The planning and development activities were divided into the following areas: operations, site preparation, site logistics, vehicle production, and passenger management.

Operations

An organization consisting of the Caltrans site safety officer, Caltrans site manager, vehicle manager and passenger manager were the key elements for Demo '97 operations. The Caltrans site safety officer approved the lanes and staging areas for operation at the beginning of the day and turned the facilities over to the Control Center. Unless there was a problem, the Control Center had no further contact with the Caltrans site safety officer until the end of the day. The Caltrans site manager, vehicle manager and passenger manager then executed their respective procedures to prepare the vehicles, facilities, and passengers. Once all procedures were completed and the Caltrans site manager and site vehicle manager gave their approval, the operations manager gave the go-ahead to begin the sequence. The vehicle manager directly notified the appropriate dispatcher to release the scenario. The dispatcher then released all vehicles in the scenario as needed. As the procedures were completed, the operations manager updated a hard copy of the procedures. The scheduler updated an electronic copy of the procedure and relayed shuttle bus information to the operations manager. The vehicle manager tracked the progress of each scenario and obstacle vehicle on a white board.

Site Preparation

Site preparation for Demo '97 involved several key locations including the South Control Yard (SCY), North Staging Area (NSA), HOV lanes, and communications. The South Control Yard was located on a parcel of land adjacent to the entrance ramp to Route 163 from Kearny Villa Road. The SCY had entrances at the south end, and the north end providing bi-directional, barrier-protected access to the HOV lanes. This was the primary location where vehicle servicing took place. The SCY was comprised of a temporary service building, where offices, workshops, and garage facilities were located, and a temporary storage structure, which was used for overnight storage of the vehicles, as well as the loading area for passengers. Associate Participants had space available to them to set up temporary vehicle servicing and storage facilities.

At the north end of the lanes was the North Staging Area (NSA). A parcel of land adjacent to the Interstate-15 exit ramp to Ted Williams Parkway was leased as a staging area at the north end of the HOV lanes. This area was the focal point for exposure of the demonstration vehicles to the media during the demonstration days. This was also the principal hospitality area (on the lanes) for the Very Important Persons (VIPs). The area contained a hospitality tent, a media tent, and a driver break area.

Infrastructure modifications to the HOV lanes consisted of the following:

- Magnetic markers were installed into the concrete pavement in both I-15 HOV lanes for the PATH and Honda lateral guidance; the magnets will remain in place for future testing and development.

- The radar-reflective traffic striping tape was installed - two miles in each lane, with one mile of overlapping (installed in both lanes at the same location). The radar-reflective tape was in support of the Ohio State University scenario. The tape was removed after the Demo was completed.

- Nine Closed Circuit Television (CCTV) cameras were installed to facilitate live monitoring of the Demo by the Command and Control Center at the SCY and by the Demonstration Presentation Center at the Exposition site. The cameras remained in place for use by Caltrans Traffic Operations in the Transportation Management Center.

- Other changes were made to enhance the safety and aesthetics, and to improve communications of the demonstration teams.

Although Demo '97 proved to be a success, the planning and development process was not without challenges. Because the agreements between the Core Participants and USDOT were not formalized until November 1994, demonstration development activities were limited to just over thirty months. This time constraint restricted activities in all functional areas - vehicle development, infrastructure modification, and public education. Only existing vehicle technologies could be used in the demonstration, as other Consortium developments were not yet complete. Site selection and roadway modifications were necessarily placed on unprecedented fast-track.

Safety Board / Safety Panel

An independent Safety Board was convened to ensure the safety of the live vehicle demonstration. The Board was chaired by John West, Chair of the Program Management Oversight Committee. Board members included the Program Manager, Technical Director, safety experts from NHTSA, GM Proving Ground and Lockheed Martin.

The Board formed a Safety and Certification Panel; the chair of that panel was also on the Board. The Panel conducted safety reviews of each scenario demonstration. A pre-certification review, which included software safety, was held in the March - April 1997 time frame. A final review was held a few weeks before rehearsals began. For a team to be a part of Demo '97, it had to pass the rigorous one day certification test.

Findings of this independent Panel were given to the vehicle teams and the demonstration team for action, and to the Safety Board for decision-making.

Demonstration Production

Each of the seven live vehicle demonstration teams originated a scenario to showcase their automated techniques of highway operation. Each scenario was presented to the Demonstration Team which approved it or ask for some modifications. The Demonstration Production team planned, supported, coordinated and executed the live vehicle portion of Demo '97. See section 2.1 *Demonstration Scenarios* for a detailed description of each of the seven scenarios.

Vehicle Development

Each live vehicle demonstration team was responsible for its own design and development. This included vehicle modifications, communications, coolant sensors controls, processors and algorithms. Each team, however, was expected to meet critical overall deadlines, including certification. The Demo Team was responsible for ensuring coordination of infrastructure and communications needs. Within each scenario several vehicle development milestones were established for each vehicle development team.

The Associate Participant vehicle developers also established their own vehicle designs within general guidelines provided by the Demo Team. Vehicle development milestones were coordinated with the Demo Team periodically.

Passenger Management

A process was established for assigning and tracking Interstate-15 vehicle demonstration rides, and accommodating ride preferences. The primary goal of this process was to ensure that all invited guests were given a chance to ride in at least one live vehicle demonstration.

Invitations to ride were sent out to the entire invited guest list – about 2000 people. These invitations included a reply card to indicate day/time of ride preference. Due to the limited number of rides, rides were not guaranteed - the reply card ensured "best opportunity for a ride". As the replies were received, pre-assigned ride times were established based on the information received. This information regarding rides was tracked in a database developed to compile ride preferences and assignments.

Distinguished guests were given priority. Since many of the distinguished guests operate on very tight schedules, they were contacted by phone to encourage participation and obtain additional information on ride preferences.

Exposition Center

The Exposition Center was located at Miramar College, adjacent to the Interstate-15 on-lane demonstrations. The Exposition Center offered an in-depth look at innovative technologies and products. In addition to the on-lane demonstrations, the Exposition Center provided visitors with an opportunity to learn how an automated highway system could significantly improve highway travel. The Exposition Center included an Exposition Hall, outdoor displays and a complex of closed road courses for mini-demonstrations of automated vehicle technologies.

Public Education

The public education focus of Demo '97 was to ensure that the substance of the event was explained accurately and completely to all interested parties. The objectives of the public education effort were to:

- Communicate that Demo '97 met the Congressional mandate to demonstrate the technical feasibility of vehicle-highway automation, and emphasize the event's history-making aspects
- Increase the awareness of automated highway system technologies and the projected benefits to the stakeholders
- Explain the need for continuing NAHSC research

Results

Nearly three years of planning and development resulted in a very successful event. There were many ways in which attendees were able to actively participate in, and experience, Demo '97:

- The entry gallery through which all visitors passed that contained booths explaining what AHS is, its history, what its benefits are and how we will get there.
- A 33,000-square-foot Exposition Center with 37 AHS-relevant booths and displays; this included a theater where attendees could watch a live-video feed from the highway lanes.
- Four mini-demo test tracks--two of them gave attendees the opportunity to ride in an AHS vehicle, one demonstrated remotely-controlled construction equipment, and one was for a student unmanned vehicle contest.
- AHS vehicles operating on an eight mile segment of Interstate-15 HOV lanes in which designated attendees could ride.
- A public day (Sunday) in which the general public was welcome to attend--the first three days were by invitation only.
- The annual Future Transportation Technology conference co-sponsored by the NAHSC and the Society of Automotive Engineers (SAE).
- A USDOT by-invitation-only international AHS workshop.

Demo '97 proved to be the biggest automated highway system event in history. More than 3,500 people attended Demo '97 and nearly 9,000 automated miles were driven on the Interstate-15 lanes and on the mini-demo track.

The number of attendees at Demo '97 were within the range of what had been planned when the invitation list was compiled. Media attendance exceeded expectations, especially the media day just before the start of the Demo.

Hundreds of industry leaders, government officials, and the general public attended the demonstration to experience automated travel first hand. US Secretary of Transportation, Rodney Slater, visited the demonstration site prior to the opening ceremony and was impressed with his ride on an automated bus. Following the demonstration ride the Secretary stated that the Consortium had successfully met the challenge Congress had mandated in the 1991 ISTEA legislation.

Senator John Chaffee (prior to the Demo), Senator Barbara Boxer (mini-demo) and Congressman Duke Cunningham (I-15) were also able to take rides as were Mort Downey, Deputy Secretary of Transportation, and Christine Johnson, Director of the ITS Joint Program Office. The leadership unit of the Federal Highway Administration, including acting Administrator Gloria Jeff, and the Regional Administrators spent a day visiting the Exposition Center and riding automated vehicles on Interstate I-15.

Participation in the Demo Team itself was greater than expected. The NAHSC Demo Team was made up of employees and volunteers from more than 20 different organizations. Altogether, the seven operational scenarios demonstrated twenty-one automated vehicles running on seven different automaker platforms.

Even though the live vehicle demonstrations were staged demonstrations of technology and not prototype designs, this gave the engineers the opportunity (in some cases the first opportunity) to apply these technologies to vehicle-highway automation with hands-on engineering. Consequently, some significant engineering lessons were learned.

During the demonstration, some of the technologies seemed to perform better than others. Some of the variations were due to problems in the specific design used for the demonstration. One problem was due to the basic physics of the technology. For example, vision systems can be blinded by the sun, and tend to lose tracking when passing beneath overpasses where the shadow was in great contrast to the sun on the road surface. In these cases, engineering design may solve the problem, so meaningful comparisons cannot be drawn. Many other technical lessons were learned that will contribute to the more successful and robust design of automated vehicle and driver assist services in the future.

Riders were asked to respond to a number of pre and post demonstration questions to aid the Consortium and policy makers in future planning. Responses were very positive. Ninety-five percent believed AHS technologies would increase safety and ninety percent felt AHS technologies would reduce congestion. Cost was seen as the most significant barrier to implementation, with public acceptance and liability falling close behind. Although some riders said they would not purchase AHS technologies for their vehicle, nearly half of all respondents indicated that they would be willing to pay an additional $1000 for an AHS equipped car. Although these surveys are not conclusive, they show support of automated vehicle technology.

Demo '97 also generated tremendous media interest. "Never had so many reporters wanted to learn so much about ITS in such a short time" noted *Inside ITS*. Broadcast coverage included ABC, CBS, NBC, FOX, PBS, CNN, and NPR. AHS stories appeared in opinion-leader newspapers including the *Wall Street Journal, Washington Post, USA Today, New York Times,* and *Newsweek*. Stories featuring the "smart highway" ran in thirteen countries across five continents. All 50 states and the District of Columbia covered the event. The total estimated circulation to date, in the U.S. alone, exceeds 75 million.

1.0 INTRODUCTION

1.1 Background

The Automated Highway System program is a broad National effort to provide for, and transition to, the next major performance upgrade of the U.S. vehicle/highway system, through the use of advanced infrastructure systems integrated with automated vehicle control technology. These highway system upgrades focus on improvements in safety, efficiency, and environmental quality. The AHS program consists of three phases: the Analysis Phase, Systems Definition Phase, and Operational Evaluation Phase. The program is currently in the Systems Definition Phase having completed the Analysis Phase consisting of Precursor Systems Analysis, Human Factors Analysis, and Collision Avoidance Studies.

The Systems Definition Phase is being executed by the NAHSC, led by nine core participants in partnership with the US Department of Transportation (USDOT). Throughout the System Definition Phase, as part of the Test and Demonstration Work Breakdown Structure (WBS), demonstrations and operational tests were conducted to safely showcase progress and satisfy milestones. The 1997 Proof of Technical Feasibility Demonstration was the third milestone in the NAHSC program plan and was congressionally mandated.

Demo '97 satisfies a mandate in the AHS provision of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. The Act states that "The Secretary (of Transportation) shall develop an automated highway and vehicle prototype from which future fully automated intelligent vehicle-highway systems can be developed. Such development shall include research in human factors to ensure the success of the man-machine relationship. The goal of this program is to have the first fully automated highway or an automated test track in operation by 1997. This system shall accommodate installation of equipment in new and existing motor vehicles." The United States Department of Transportation Automated Highway System Program Draft Report to Congress, 1 April 1995 states "The Congressional mandated demonstration is designed to demonstrate the basic technical feasibility of fully automated AHS designs, and key technologies and functions." The 1997 Proof-of-Technical Feasibility Demonstration conducted by the National Automated Highway System Consortium responded to the congressional mandate and direction as described in ISTEA and the Report to Congress.

The Consortium's goals are reflected in the NAHSC mission statement:

"The National Automated Highway System Consortium (NAHSC) will specify, develop, and demonstrate automated highway system technologies. The specifications will provide for an evolutionary deployment that can be tailored to meet regional and local transportation needs. The Consortium will seek opportunities for early introduction of vehicle and highway automation technologies to achieve benefits for all surface transportation users. The NAHSC will incorporate public and private stakeholder views to ensure that an AHS is economically, technically, and socially viable."

The demonstration was designed to aid in this mission. The Consortium participants worked together to show the world what the future of automated travel might be. Demo '97 was a multiple day event spanning the period of August 7 - 10, 1997. Repeated demonstrations, target audience activities, and major media events were conducted throughout the four days. Live vehicle demonstrations on I-15 provided in-vehicle rides. An exposition located at near-by Miramar College provided smaller vehicle demonstrations, static equipment displays, computer simulations, and poster and literature displays. Complete video coverage of the live vehicle demonstrations was transmitted from the I-15 lanes to the exposition site.

The demonstration was not intended to represent a final system, rather a look at the capabilities and potential benefits of automated technologies in solving mounting transportation problems such as decreased safety and increased congestion.

1.2 Demonstration Objectives

The primary objective of Demo '97 was to satisfy the 1991 ISTEA congressional mandate that the Secretary of Transportation demonstrate a fully automated vehicle highway system on a roadway or test track by 1997. The NAHSC established these additional broad objectives for the demonstration:

- The demonstration would show a variety of technologies that provide a foundation for implementing a fully automated highway system.
- The demonstration would demonstrate partial automation services that are more near term and that may provide stepping stones to a fully automated highway system.
- The demonstration would show stakeholders and the public that AHS is both credible and achievable, and has application toward relieving the major highway transportation problems of safety and efficiency.

Several specific objectives of Demo '97 and the Exposition Center were also established by the NAHSC; they were to demonstrate:

- Key AHS elements and features adapted from existing technologies.
- Safe operations for the operators, visitors, observers.
- Longitudinal vehicle control by controlling vehicle braking and acceleration to maintain spacing between vehicles. ("feet free")
- Lateral vehicle control by controlling the vehicle steering to keep the vehicle in the lane. ("hands free")
- Lane changing.
- Coordinated lane changes between vehicles.
- Entry and exit maneuvers.
- Transition between manual and automated control.
- Maintenance of vehicle position in the traffic flow.
- Malfunction management capabilities.
- Collision warning.
- Collision avoidance control.
- Collision-free automated driving environment.

- Lane departure warning.
- Lane departure correction.
- Detection of moving and stationary objects on the automated lanes and avoid collisions with these objects.
- Entry onto the automated highway with simultaneous speed adjustment between several vehicles to successfully merge vehicles.
- Highway system's ability to track the position of the vehicles in real-time.
- Vehicle-to-vehicle communications.
- Roadway-to-vehicle communications (tag beacon).
- Ride comfort that is as smooth as good manual driving, with no sudden changes in speed or direction under normal circumstances.
- Multiple vehicle operations.
- Ease of maintenance and construction.

Table 1.2-1 summarizes the objectives that were met by each scenario and segment of Demo '97.

TABLE 1.2-1 Objectives Met by Each Live Vehicle Demonstration

	Scenario **							
Objective	PT	FA	MV	CT	AT	EV	MD	TRK
Adaptability from existing technologies	●	●	●	●	●	●	●	●
Safe operations for the operators, visitors, observers.	●	●	●	●	●	●	●	●
Automated Longitudinal (acceleration and braking) control.	●	●	✓ ◐	●	●	●	O	●
Lateral vehicle control (steering)	●	●	● ◐	●	●	●	O	
Automated Lane changing.	●	●	O	●	●	●		
Coordinated lane changes between vehicles.	●	●		●		●		
Lateral vehicle control during entry and exit maneuvers.			✓					
Transition between manual and automated control.	●	●	● ◐	●	✓	●		●
Maintenance of position in the roadway traffic flow.	●	●	● ◐	●	●	●	●	●
Demonstrate various malfunction management capabilities.	●		O			✓		
Collision warning.		O				O	O	●
Collision avoidance control.		O						
Demonstrate a collision-free automated driving environment.	●	●	● ◐	●	●	●		O
Lane departure warning.		●	O			●	●	
Lane departure correction.						●	●	
Merge vehicles.	O	●				●		●
Track the position of the vehicles in real-time.	✓		●			✓	✓	
Detect obstacles		●		●		●	✓	
Vehicle-to-vehicle communications.	●	●		●		●		
DPC to vehicle communications	✓	✓	●					
Roadway-to-vehicle communications.	✓		●	✓		✓		
Demonstrate ride comfort.	●	●	●	●	●	●		●
Multiple vehicle operations.	●	●	✓	●	●	●		●
Maintenance			●				O	

** PT = Platoon, FA = Free Agent, MV = Maintenance Vehicle, CT = Control Transition (Honda), AT =Alternative Technology (Ohio State University), EV = Evolutionary (Toyota), DPC = Demonstration Presentation Center, MD = Mini Demos, PS = Presentations, TRK = Truck (Eaton Vorad)

● =Strong Relationship O =Moderate Relationship ✓ =Weak Relationship ◐ =May be different for IDV and ORV

1.3 Demo '97 Scope

This event was a demonstration of technologies with possible applicability for a fully automated vehicle control system, or AHS. Since the preferred AHS system concept for the U.S. in the twenty first century has not as yet been selected, none of the concepts demonstrated are necessarily the preferred concept. The demonstration gave viewers a sense of what automated vehicle operation might be; however, the vehicles in the demonstration did not have the full functionality of either a prototype system for testing, or an operational system for public use.

The demonstration event included live vehicle demonstrations as well as an Exposition Center and the Society of Automotive Engineers (SAE) Future Transportation Technology (FTT) conference. The Exposition Center was the main hub of activity for Demo '97. It was located at Miramar College (MC) adjacent to I-15. All activities started and ended at this facility. Adjacent to the Exposition Center were four small demonstration tracks where a series of small demonstrations, or "mini-demos", were held.

The Interstate 15 reversible high occupancy vehicle express lanes served as the primary live-vehicle demonstration site. This is a 7.6 mile segment north of San Diego, California, as shown in Figure 1.3-1. The segment consisted of two twelve-foot-wide concrete paved lanes with two ten-foot-wide asphalt paved shoulders. Because of the number of test vehicles, only selected passengers were given the opportunity to ride. In addition, there was very limited space at the I-15 site to accommodate viewers. Consequently, large screen monitors, kiosks, and other communication devices were located throughout the Exposition Center to provide real-time and pre-recorded video of all I-15 vehicle demonstrations. Shuttle buses to and from the I-15 vehicle demonstration site originated at the passenger staging area at the Exposition Center.

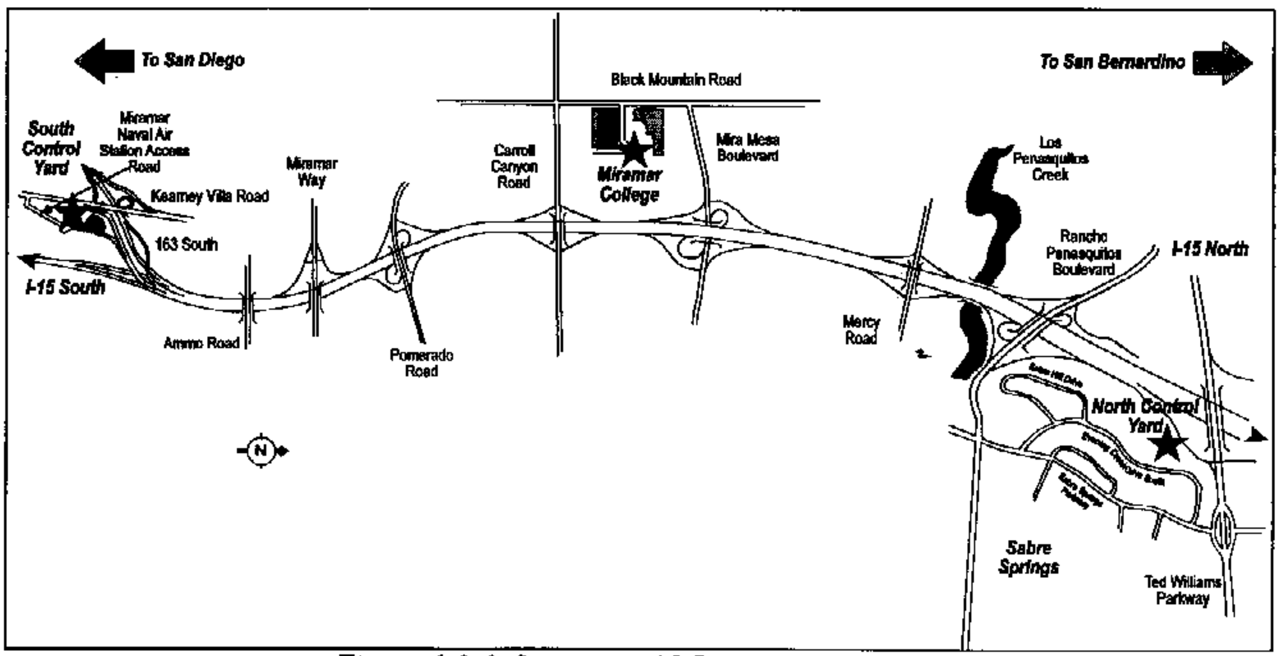

Figure 1.3-1 Interstate-15 Demonstration Site

1.4 Demonstration Overview

The live vehicle demonstration was conducted on a 7.6 mile segment of Interstate 15 north of San Diego, California, under the jurisdiction of Caltrans. This segment consists of two twelve foot wide concrete paved lanes with two ten foot wide asphalt paved shoulders. The segment is comprised of reversible High Occupancy Vehicle (HOV) lanes constructed in the median of I-15 which are open for inbound traffic during the morning commuting hours and outbound traffic during the afternoon commuting hours. Jersey barriers were installed on both sides of the lanes, providing isolation and protection from vehicles traveling in the normal traffic lanes. Two control yards were located at either end of the facility to provide for storing and securing of the demonstration vehicles. Public access was also restricted to the lanes through radio communications, video surveillance, and remote gate control by the local Caltrans Transportation Management Center (TMC). To ensure maximum safety, access was limited at all times to those individuals invited by the Consortium and approved by the Caltrans regional Traffic Management Center.

At no time was the public HOV facility adversely affected by demonstration activities. The TMC coordinated traffic management to ensure that the demonstration did not interfere or impinge on nominal traffic operations. Conversely, the TMC, with assistance from the California Highway Patrol, ensured that nominal traffic operations did not interfere or impinge on the demonstration.

Based on the demonstration location and date, the event demonstrated automated driving in fair weather conditions, with the exception of a record breaking rain shower on the morning of August 7, 1997.

1.4.1 Safety

Safety of all passengers, participants, and the general public was a top priority. An independent Safety Board and Safety Certification Panel were established by the PMC to oversee and ensure safety. As part of the Panel's procedures, rigorous pre-certification and certification tests were scheduled for all demonstration scenarios. In addition, extensive demonstration dress rehearsals were conducted three weeks prior to the demonstration. In addition, trial runs were conducted prior to each scheduled demonstration to ensure the readiness and safety of all systems, operators, and support services. Emergency support services were closely coordinated with local agencies and provided throughout the demonstration including ambulance, fire, police, towing, and all other appropriate services. In accordance with Federal and Consortium safety guidelines, a comprehensive Safety Plan was developed and strictly enforced throughout the demonstration planning, development, and execution process. The plan provided safety related requirements, guidance, and direction in the planning and execution of all test and demonstration sessions. All drivers were certified through this safety certification process and all vehicles were certified for both safety and ride comfort.

1.4.2 Public Education

A demonstration Public Education Plan was developed to address public relations and the handling of press prior to and during the demonstration. The plan served several functions. First and foremost, it set forth the vision, mission, and goals of the Consortium, and highlighted issues that were a key to the success of the demonstration. It also provide a basis for a contract workplan for a professional public relations firm (Strat@com). The plan provided a framework of required marketing and production activities in which Strat@com built upon to create and carry out a master plan. The Public Education activity was broken down into national and regional activities to suit the needs of both communities.

1.4.3 Participation

A Demonstration Participant Memorandum of Agreement was developed to ensure that all vehicle developers clearly understood all requirements and procedures applicable to participants of the Demonstration. The document, developed by the System Integration Team, required extensive review and revision by the Demonstration Team, program managers, and Consortium legal staff. The document was ultimately split into two parts, one containing legal and binding language related to liability and insurance and the other outlining basic expectations to be used as guidelines by all demonstration participants.

1.4.4 Vehicles

A number of different vehicle makes, models, and platforms were used to demonstrate the versatility of AHS technology. The scenarios included the following vehicle types: New Flyer Bus, Freightliner tractor/trailer truck, Volvo cab-over truck, Buick Le Sabre, Chevrolet Lumina van, Chevrolet Corvette, Honda Accord, Oldsmobile Silhouette, Oldsmobile Delta 88, Pontiac Bonneville, Toyota Avalon, Toyota Camry. All of these vehicles were used to demonstrate maneuvers on the High Occupancy Vehicle (HOV) facility. Although passengers were carried in all the demonstration vehicles, rides were limited due to time constraints. However, live video was provided on large screen monitors from I-15 to the exhibit hall.

1.4.5 Technologies

A number of promising technologies were demonstrated in San Diego during the demonstration. An AHS builds on a number of near-term advanced vehicle control and information systems like adaptive cruise control, obstacle detection, lane departure warning, in-vehicle navigation and roadside-to-vehicle and vehicle-to-vehicle communication. AHS takes advantage of these systems by combining them to provide lane-keeping (automated steering or "lateral" control), and vehicle-to-vehicle spacing (automated throttle and braking or "longitudinal" control). Most of the demonstration vehicles used radar technology for longitudinal control. However, lateral control was demonstrated using a variety of technologies. Some vehicles used vision based systems that actually "looked" at the road to determine lane boundaries. Other vehicles relied on radar signals reflected off special paint stripes on the roadway. And still others followed magnets embedded in the roadway. Two of the vehicle developers, American Honda Motor Company and The Ohio State University, demonstrated vehicles that switched from one control technology to another while traveling down the highway.

Essentially, four new systems were added to the vehicles to perform automated maneuvers. These included sensing systems such as a camera to track the roadway and radar to detect other vehicles and objects. A control computer processed the information received from the sensors and issued commands such as position, velocity, and acceleration signals. The command signals were processed by the control computer controlling the steering, braking, and throttle actuators which in-turn changed the steering angle and applied the brake or throttle as necessary. Additional human machine interface equipment was provided to aid the driver during control transition and to indicate exit locations and other pertinent information.

1.4.6 Scenarios

Seven different operational scenarios highlighted the benefits of automated highway technology during the demonstration. Four of the scenarios were developed by the nine core participants of the Consortium with the balance contributed by five remarkable associate participants. The scenarios are described in detail later in the report.

1.5 Demonstration Audience

The targeted audience of the demonstration included industry leaders and government officials with a particular focus on members of The United States Congress, The Executive Office of the President and Cabinet, state government officials, state transportation department officials, regional/metropolitan planning officials, general and trade media, special interest groups, representatives of applicable industries, and stakeholders. The Exposition Center was opened to the general public on Sunday including rides in the smaller vehicle demonstrations (mini-demos).

The vehicle demonstrations and exposition required elaborate passenger and audience support facilities, procedures, and media relations to ensure a safe, efficient, and favorable experience for the visitors. Passengers registered at the Exposition site and were shuttled to and from the I-15 lanes according to previously established ride appointments. Mentors were assigned to all VIPs and special media days were created to attend to the specific needs of press.

Statistics on Demo '97 audience (attendees) is provided in section 6 of this report.

2.0 DEMONSTRATION SCENARIOS AND TECHNOLOGIES

This section describes the live vehicle demonstration held on Interstate-15, the mini-demos held on the demonstration tracks adjacent to the Exposition Center and the technologies demonstrated at those events.

2.1 Demonstration Scenarios

There were three Core Participant scenarios and four Associate Participant scenarios. The seven scenarios are described in this section.

The Core Participant demonstration scenarios were organized in three categories:
1) Multi-Platform Free-Agent Scenario - Carnegie Mellon University, GM, Hughes and Delco with participation from an Associate, Houston Metro - Todd Jochem, Chris Barnes
2) Platoon Scenario - University of California - Berkeley PATH Program, GM, Hughes and Delco - Wei-Bin Zhang
3) Maintenance Scenario - Lockheed Martin and California Department of Transportation (Caltrans) - Tom West

Associate Participant demonstration scenarios consisted of:
1) Evolutionary Deployment Scenario - Toyota Motor Corporation Japan - Mike Wolterman
2) Control Transition Scenario - Honda R&D North America - Damon Delorenzis
3) Alternative Technology Scenario - The Ohio State University - Umit Ozguner
4) Commercial Vehicle (Truck) Scenario - Eaton VORAD Technologies - Bob Neff

2.1.1 Multi-Platform Free Agent Scenario - (Carnegie Mellon University / Houston Metro)

The Multi-Platform Free Agent Scenario was a combination and enhancement of the Carnegie Mellon University Free Agent and Houston Metro transit demonstration. Two 1996 Pontiac Bonneville sedans (P1 and P2), and a 1996 Oldsmobile Silhouette (P3), were integrated with two 1996 Low Flyer Low Floor buses (B1 and B2) to demonstrate a Multi-Platform Free Agent Scenario. The Multi-Platform designation of this demonstration indicates the same systems were integrated on various platforms—passenger vehicles, mini-vans, and buses—and those platforms interacted in the execution of the scenario. This scenario demonstrated a number of capabilities, including lane departure warning, lane keeping, headway keeping, obstacle detection and avoidance, and automated lane changing.

Segment 1: Entry and Mixed Platform Lane Departure Warning
The scenario began with B1, then P1, followed by B2 entering the right lane and accelerating to 45 mph. (Call this vehicle group G1.) Initially, each vehicle in G1 were operating manually. After G1 entered the right lane, P2 entered the highway in the left lane about 150 meters behind G1. P3 followed in the left lane about 75 meters behind P2 . Both vehicles accelerated to 45 mph. P2 was operating autonomously while P3 was under manual control. B1, B2 and P3 were being

driven manually toward the lane boundaries to demonstrate the lane departure warning function of those vehicles.

Direction of Travel

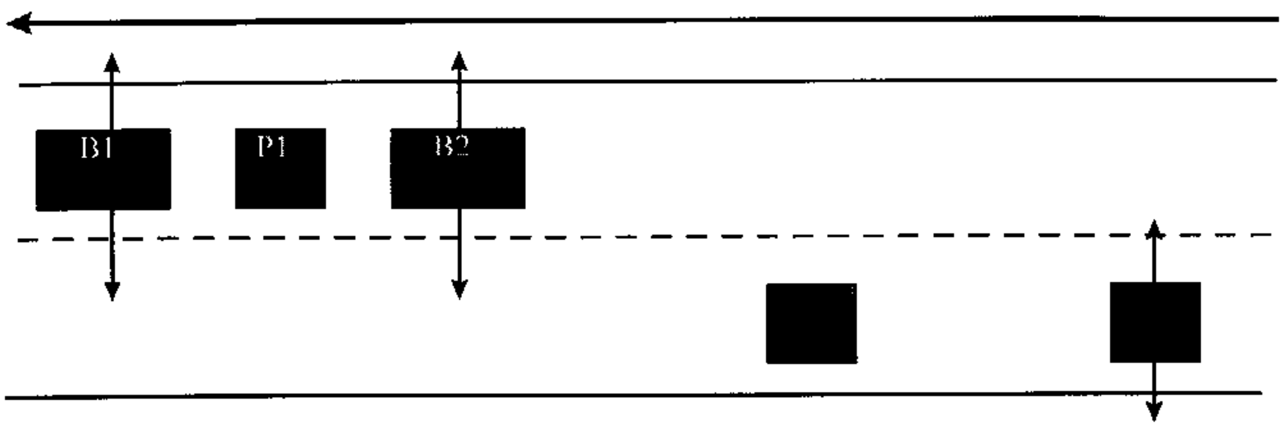

Figure 2.1.1-1 Entry and Mixed Platform Lane Departure Warning-Segment 1

Operation of all vehicles continued as described for 1 mile.

Segment 2: Headway Warning and Tailgater Lane Change
Autonomous operation was initiated in all vehicles in the scenario except P3. P2 and P3 accelerated to 60 mph and 65 mph, respectively. While passing B2, P1, and B1, P2 checked its side/rear looking sensors, waiting to see when it had passed all three vehicles and could safely move to the right lane. P3 closed the gap to P2 as they were passing G1. P2 warned of a fast approaching rearward vehicle and changed lanes when clear to do so. P3 detected that it was closing very quickly on P2 and alerted the driver. Once P2 passed B1, P2 initiated a lane change maneuver to the right lane in front of B1.

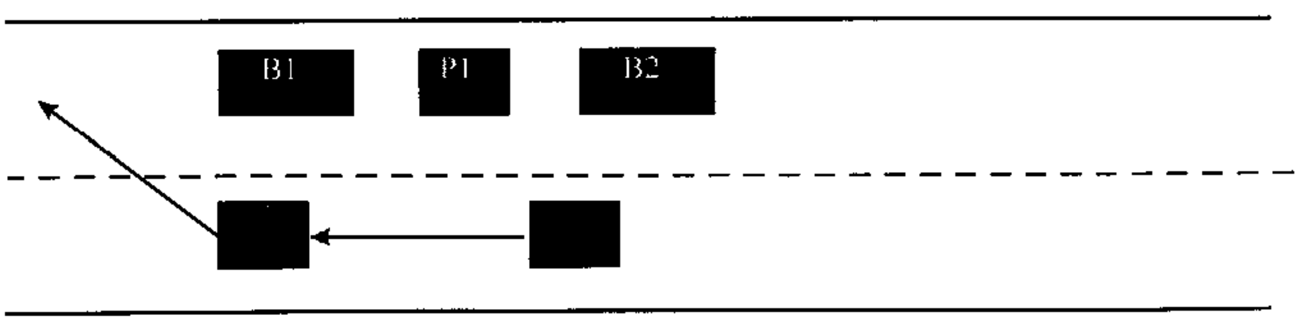

Figure 2.1.1-2 Headway Warning and Tailgater Lane Change - Segment 2

The maneuvers for Segment 2 took 1.5 miles to complete.

Segment 3: Lane Change and Passing
After P2 had safely passed G1, P2 changed into the right lane, and slowed to 55 mph. P3 changed into auto mode and continued past in the left lane. As P2 changed into the right lane, P3 continued past P2 and then executed a lane change maneuver to the right lane in front of P2. Simultaneously, P1 and B2 executed a lane change maneuver to the left lane and accelerated to 60 mph.

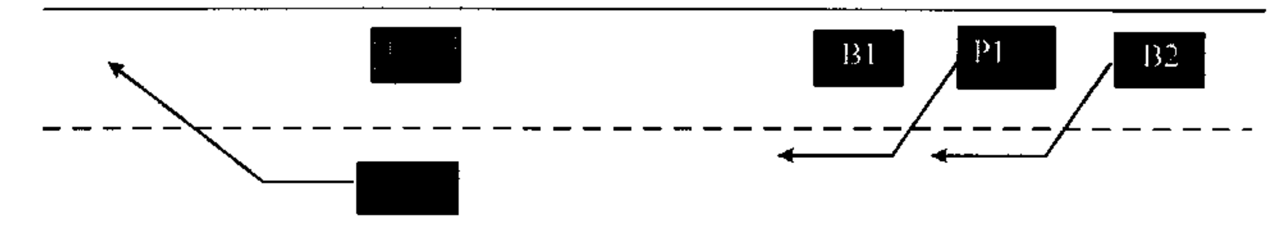

Figure 2.1.1-3 Lane Change and Passing-Segment 3

Segment 4: Advanced Cruise Control
While P1 and B2 were passing B1, P1 and B2 checked their side/rear looking sensors, waiting to see when they had passed B1 and could safely return to the right lane. After P1 and B2 had safely passed B1, P1 and B2 changed into the right lane, and slowed to 55 mph. These lane changes were not simultaneous, but occurred once the vehicle was clear.

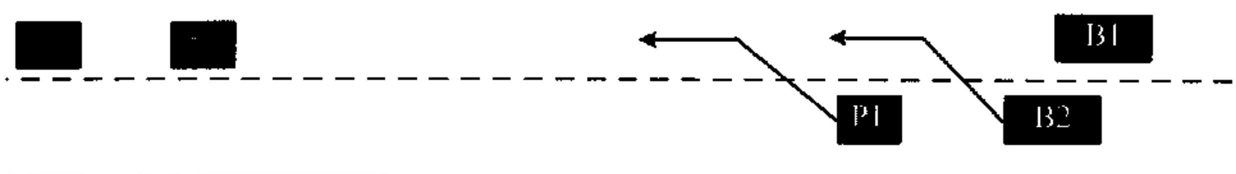

Figure 2.1.1-4 Advanced Cruise Control-Segment 4

Segment 5: Obstacle Detection and Avoidance
While traveling at 55 miles per hour in the right lane, P1, B2 and B1 initiated a lane change maneuver to the left lane. P3 detected an obstacle in the right lane and communicated the detection to P2. P2 communicated the detection of the obstacle to P1. P3 and P2 swerved around the obstacle in a tandum, coordinated maneuver and returned to their original lane. This demonstrated the usefulness of vehicle - vehicle communication. P1 may not have otherwise had adequate time to detect the obstacle, as P3 was in the line of site.

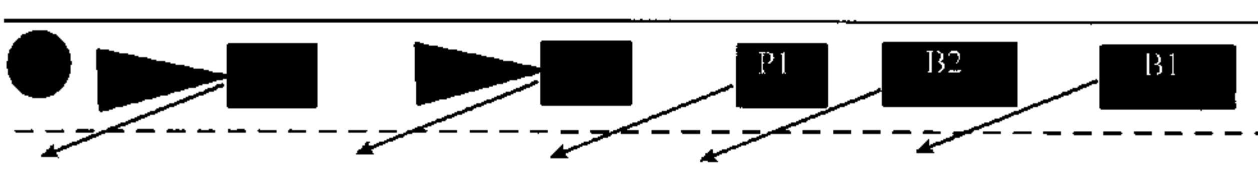

Figure 2.1.1-5a Obstacle Detection and Avoidance-Segment 5

Once B2 passed the obstacle, B2 changed to the right lane. B1 continued in the left lane past B2 and initiated a lane change maneuver to the right lane just to the front of B2. P1 continued in the left lane past P2 and initiated a lane change maneuver to the right lane just to the front of P2.

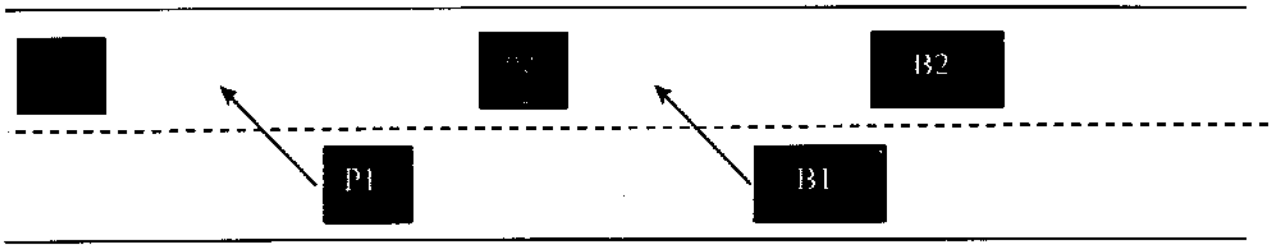

Figure 2.1.1-5b Obstacle Detection and Avoidance-Segment 5

Segment 6: Driver Interaction
As P1 was passing P2, the driver of P2 interacted with the car using the driver interface buttons on the steering wheel to initiate a lane change/passing maneuver to pass P1. The vehicle would not execute the unmanned lane change until P1 was clear, demonstrating how in vehicle systems can augment safely.

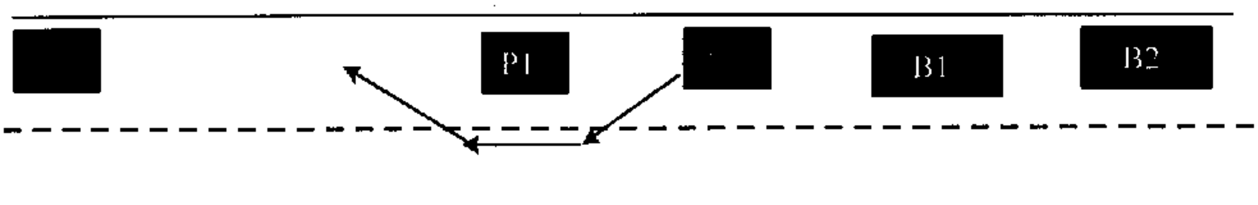

Figure 2.1.1-6 Driver Interaction - Segment 6

Segment 7: Obstacle Detection and Avoidance
While traveling at 55 miles per hour in the right lane, P1, B1 and B2 initiated a lanc change maneuver to the left lane. P2 detected an obstacle in the right lane and communicated the detection to P1.

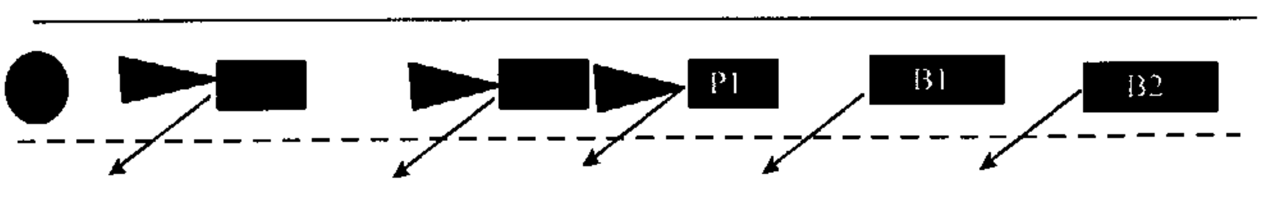

Figure 2.1.1-7a Obstacle Detection and Avoidance-Segment 7

P3 and P2 swerved around the obstacle. P3 continued in the left lane. P2 returned to the right lane. Once P1 passed the obstacle and P2 and showed driver interface. B1 and B2 continued in the left lane.

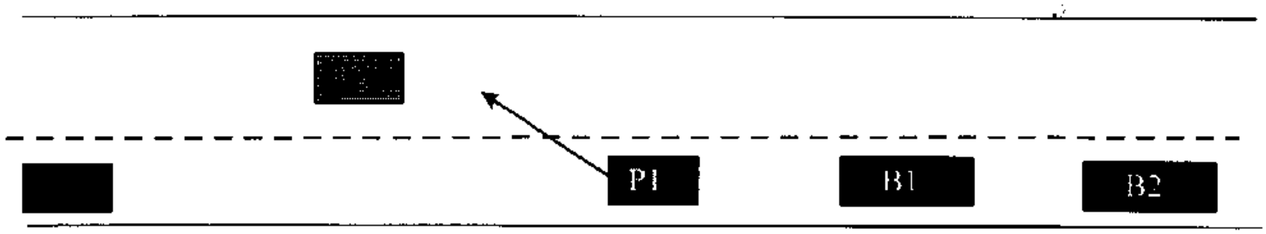

Figure 2.1.1-7b Obstacle Detection and Avoidance-Segment 7

Segment 8: Finish
P2 detected an obstacle in the right lane and slowed to a stop. P1 detected that P2 was slowing and did the same. P3, B1 and B2 came to a coordinated automated stop.

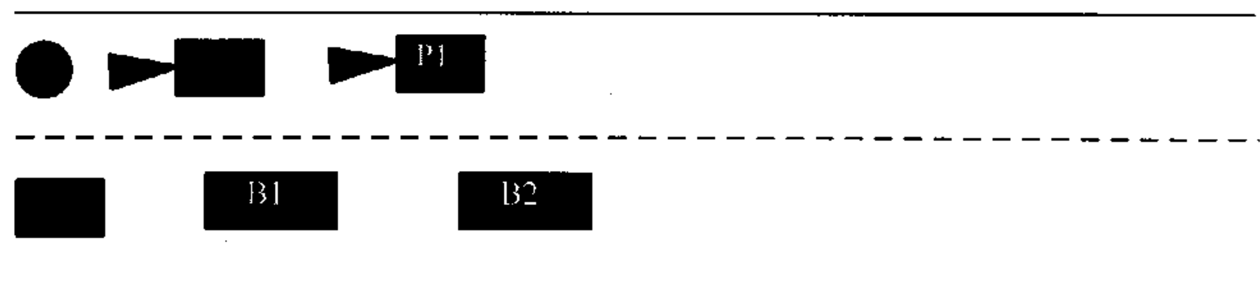

Figure 2.1.1-8 Finish-Segment 8

2.1.2 Platoon Scenario - (University of California - Berkeley PATH Program)

The Platoon Scenario demonstration system included eight Buick LeSabre sedans instrumented with radios for vehicle-to-vehicle communication, radar for measuring the distance between vehicles, magnetic sensors for measuring the vehicle's lateral position relative to the lane center, drive-by-wire steering, throttle and brake actuators, and a Pentium computer. The vehicles also had special interface features, including buttons for the driver to turn the automatic control systems on and off and display screens to illustrate what was happening at each stage of vehicle operations, plus a head-up display to provide information to the driver while he was watching the road and the vehicle in front.

The roadway was instrumented with magnetic markers buried along the centerline of each lane at 4 foot spacing. The magnetic markers enabled the vehicle to detect its lateral position and, by alternating the polarities of the magnetic markers, they also transmitted roadway characteristics such as upcoming road geometry information, milepost, entrance and exit information to the vehicle.

The vehicles traveled with approximately 20 feet of separation at 65 miles per hour, and demonstrated functions including lane keeping, (lane-changing), close spacing longitudinal control, platoon split and join maneuvers. The scenario is described below.

Scenario Description
The vehicles with two passengers each entered the lanes and positioned themselves in a closely spaced single file. The vehicles entered the right express lane of Interstate-15 (with respect to direction of travel) under manual control, and transferred to automated control.

After transferring to automated control, separation distances were reduced to about 5 meters.

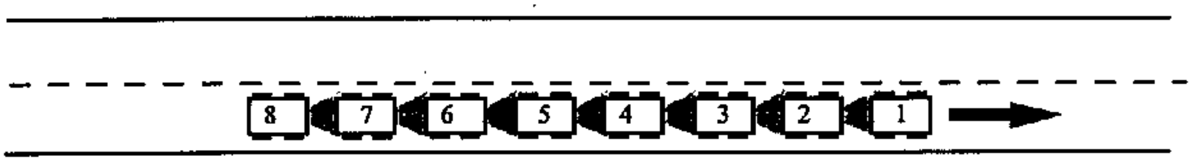

Figure 2.1.2-1 Initiate Platoon Operation

As they proceeded, the single large platoon split between the first and second and second and third vehicles. The split separation distance is approximately 30 m (100 feet).

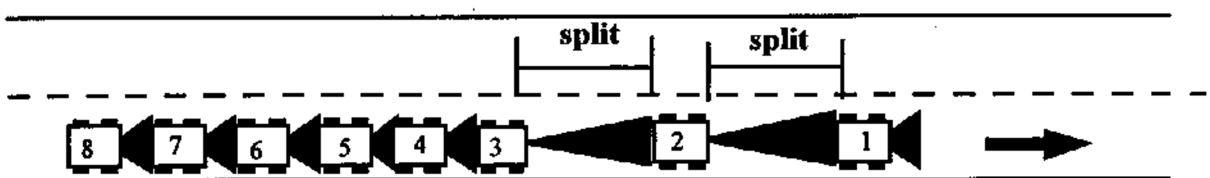

Figure 2.1.2-2 Platoon Split

After traveling about a mile the second vehicle conducted a lane change maneuver to the left lane.

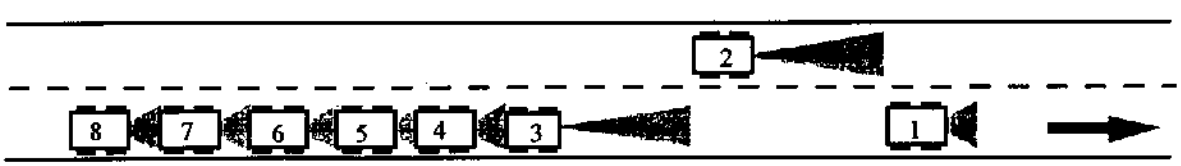

Figure 2.1.2-3 Platoon Lane Change

Vehicles 3 through 8 closed the gap and rejoined vehicle 1 again.

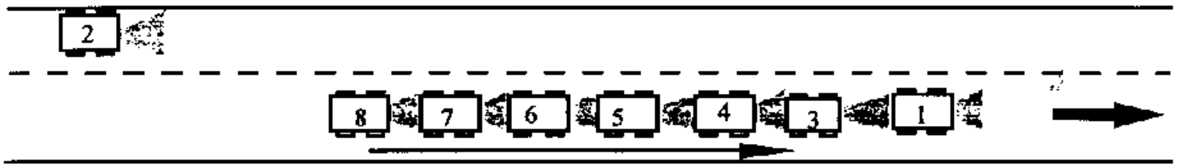

Figure 2.1.2-4 Platoon Join

The former vehicle 2, now new vehicle 8, executed a lane change maneuver from the left lane to the right lane to join platoon.

Figure 2.1.2-5 Platoon Lane Change and Join

At the far end, the vehicles stopped and then were returned to manual control to be driven to the NSA or SCY..

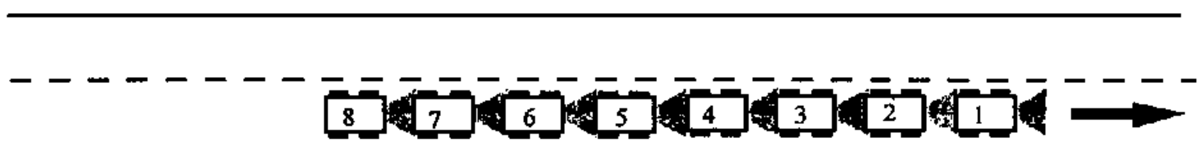

Figure 2.1.2-6 End Platoon Operation

2.1. 3 Maintenance Scenario - Lockheed Martin and California Department of Transportation (Caltrans)

The Maintenance Scenario demonstrated the ability to automate maintenance and inspection of the future smart transportation system know as the AHS. The demonstration targeted two specific goals: 1) system operational status interrogation and 2) obstacle detection/removal. This scenario illustrated simple AHS infrastructure inspection and performance verification without impacting the traffic throughput. The demonstration consisted of two vehicles; the Obstacle Removal Vehicle (ORV), was a manually driven Ford truck specially equipped with a robotic "manipulator" arm. The second vehicle in the scenario was the Infrastructure Diagnostic Vehicle (IDV) which was a 1996 Chevrolet Lumina mini-van equipped with three magnetometers for magnetic reference marker detection, a vision-based lateral control system, and conventional speed (cruise) control that was tied into the on-board computer to permit velocity profile following. The IDV was also equipped with an on-board diagnostic payload capable of detecting and locating electronic and non-electronic maintenance requirements on the infrastructure and communicating that information to a maintenance center for future use.

In this demonstration a faulty or missing marker was scripted; the IDV identified the location of the marker, notified the observing passengers on-board and also communicated this information to the Demonstration Presentation Center (DPC) at the Exposition Center, in near real-time. Also, the IDV operator detected debris on the edge of the road; the automatic location and tracking system (ALTS) logged the location information into the geographical information system (GIS) database and transmitted the location to the DPC which dispatched the ORV. The manually driven ORV picked up the obstacle with a robotic "manipulator" arm and continued in the same direction as the IDV.

Scenario Description
The scenario shown in Figures 2.1.3-1 and -2, was as follows:

- IDV vehicle traveled with lateral control and cruise control in the right lane.
- Driver identified debris on the shoulder of the road and logged debris onto ALT system. ALT system automatically informed the DPC which, in turn, simulated calling for a Caltrans ORV to remove problem.
- The ORV departed after the IDV on a pre-set time delay and picked up the debris.

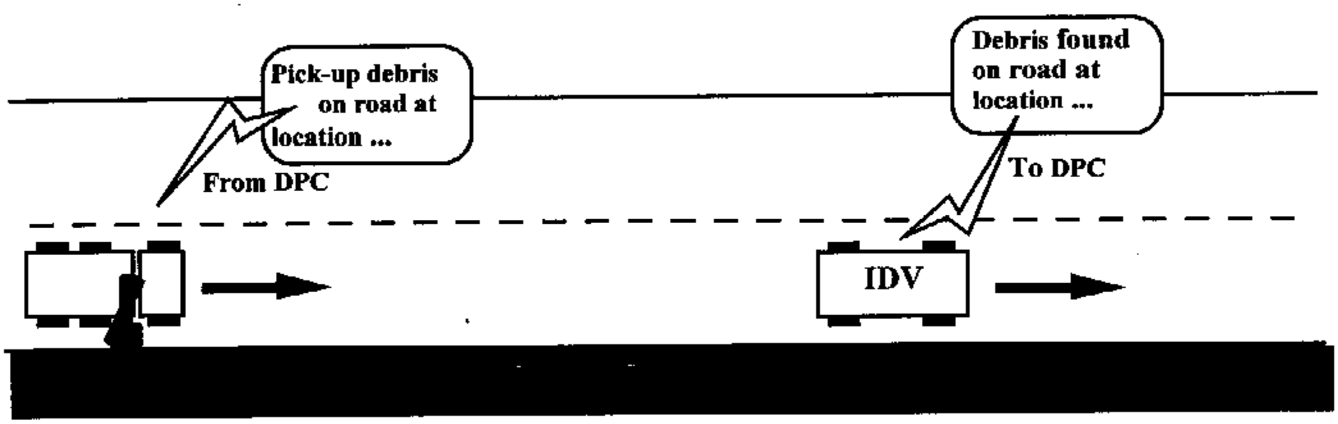

Figure 2.1.3-1 Debris Location and Removal

- IDV vehicle traveled in right lane. The interrogative electronics checked and verified the location and the strength of the magnetic markers.
- One or two marker were simulated as missing or were found to be malfunctioning and the IDV vehicle recorded the location for future maintenance.
- ALTS transmitted error information to the DPC.

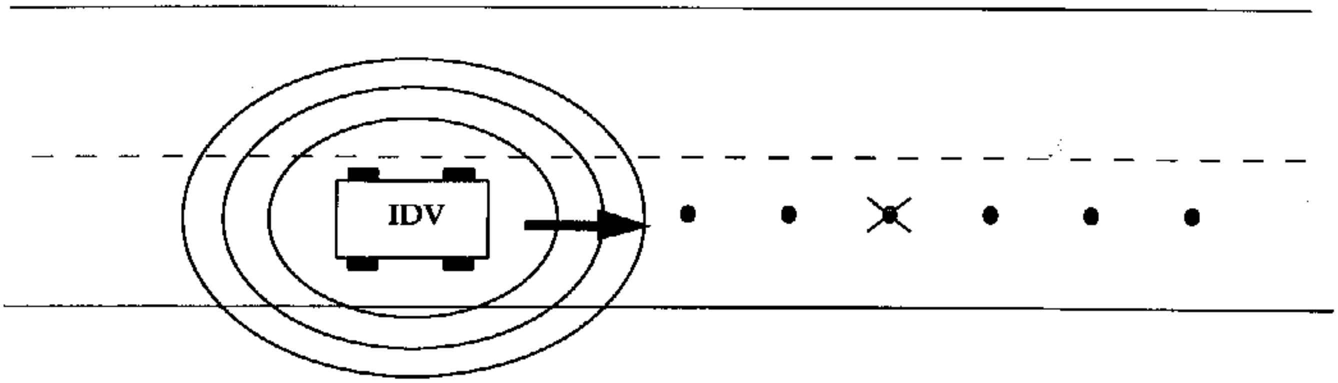

Figure 2.1.3-2 Faulty Magnetic Marker Detection and Location

2.1.4 Evolutionary Scenario - (Toyota Motor Corporation Japan)

The Evolutionary Scenario consisted of four vehicles, two automated and two manual. The two automated vehicles were 1996 Toyota Avalon sedans equipped with vision and laser systems. The two manual vehicles in the scenario were 1997 Toyota Camry sedans. The Evolutionary scenario demonstration consisted of two parts. The first part demonstrated four driver-support functions designed to assist drivers on regular as well as automated highway systems. These functions were lane departure warning and control, adaptive cruise control, blind spot warning, and automatic longitudinal control in stop and go traffic. The second part demonstrated four fully automated driving functions that could also be employed on regular, as well as, automated highway systems. These functions were lane keeping, automatic lane change for obstacle avoidance, cooperative vehicle following, and automatic stopping for obstacle avoidance. The scenario and its segments are described below.

Part 1 - Driver Support Functions

Segment #1 - Lane Departure Warning & Control

The scenario began with all 4 vehicles in the staging area, manual vehicle #1 (herafter designated as MV1 left the staging area first, traveling in the left lane, which was followed in the left lane, at a spacing of 100 meters, by automated vehicle #1 (hereafter designated as AV1); which was followed in the right lane, at a spacing of 100 m, by automated vehicle #2 (hereafter designated as AV2); which is followed in the right lane, at a spacing of 100 m, by manual vehicle #2 (hereafter designated as MV2). Once the vehicles entered the Interstate-15 express lanes and stabilized at a speed of approximately 100 km/hr, the demonstration began with Segment #1. During Segment #1, MV1 and MV2 maintained their speed and spacing in preparation for Segment # 2.

Lane departure warning and control was demonstrated as follows:
The drivers of AV1 and AV2 maintained the position of their vehicles specified during the staging operation (left lane spaced 100 m apart) as they entered the Interstate-15 express lanes and maintained a speed of approximately 100 km/hr. The drivers changed from their respective lane to the opposite lane and back to their original lane. No lane departure warnings occurred. Once stabilized in the left lane, the drivers released the steering wheel and allowed the vehicle to drift towards the lane boundary. As the vehicles approached the lane boundary, the lane departure warning occurred and the steering actuator was activated to steer the vehicles back into the proper lane.

- Driver initiated lane change (no warnings)
- Driver released the steering wheel
- Lane departure warning occurred
- Driver manually returned to lane
- Lane keeping by steering actuator

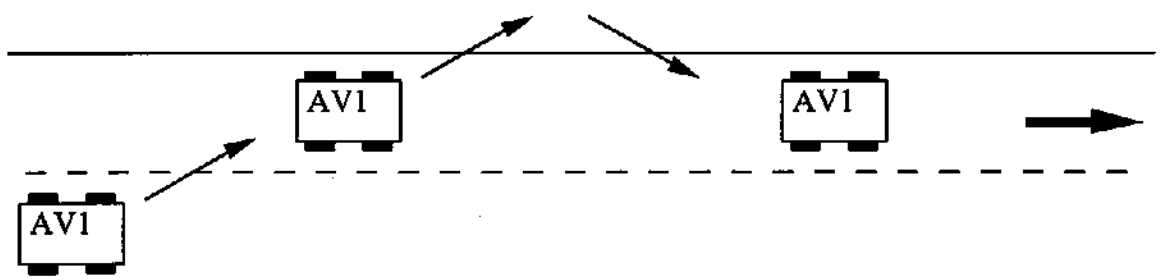

Figure 2.1.4-1 Lane Departure Control-Segment 1

Segment #2A - Adaptive Cruise Control
The second segment demonstrated the smooth automatic control of vehicle spacing when the preceding vehicle's speed varied. Once all the vehicles had stabilized, and the drivers had reassumed manual control of steering, the vehicles continued traveling in the left lane. With the vehicles' speed at approximately 100 km/hr, with AV1 and AV2 traveling one behind the other with a gap of approximately 100 m, the drivers of AV1 and AV2 activated their vehicle's Adaptive Cruise Control (ACC). The vehicles then approached MV1 from the rear. MV1 was also in the left lane and its speed varied between 60 km/hr and 80 km/hr. AV1 and AV2 autonomously adjusted their speed to that of MV1 and maintained a headway of approximately 50 m.

- All vehicles were steered manually
- AV1 approached MV1 in left lane
- AV1 slowed and maintained a safe following distance

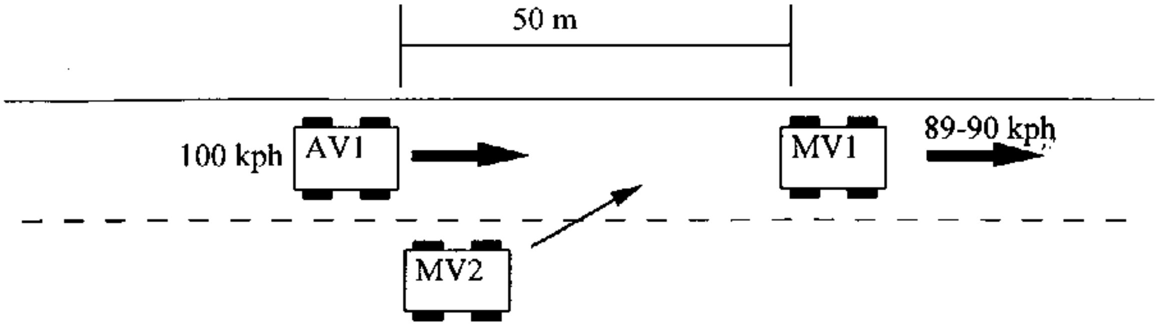

Figure 2.1.4-2 Adaptive Cruise Control-Segment 2A

Segment #2B - Headway Maintenance
During this segment headway maintenance was demonstrated. MV2 passed AV2 and AV1 and after passing the automated vehicles, MV2 changed lanes, cutting into the 50 m gap between the AV1 and MV1. AV1, realizing its headway had been decreased by the cut in of MV2, autonomously increased the headway back to the initial 50 m.

- All vehicles were steered manually
- MV2 approached from the rear in the right lane and cut into the gap between the two vehicles in the left lane
- AV1 and AV2 slowed to accommodate the vehicle which cut in
- At this point MV1 had finished its portion of the demonstration. MV1 then continued on to the end of the HOV lanes.

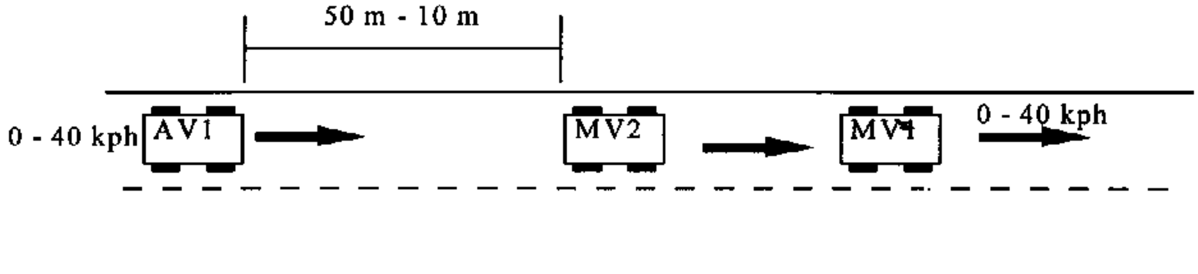

Figure 2.1.4-3 Headway Maintenance-Segment 2B

Segment #3 - Automated Control in Stop & Go Traffic
This segment demonstrated the abilities of automated vehicles in congested stop and go traffic. With the vehicles stabilized in the left lane (vehicle order is: MV2 at the lead, followed by AV1, followed by AV2) at a speed of approximately 80 km/hr, the lead vehicle, MV2, slowed to a stop, pause for 2 - 3 seconds, and then accelerated to 40 km/hr. This cycle was repeated two times (total of three stop and go maneuvers). AV1 and AV2 autonomously decelerated and

accelerated based on the actions of MV2. During the stop & go portion of this segment, a gap of about 6 - 10 m was maintained between the vehicles, dependent upon the speed of the vehicles.

- At this point MV1 had finished its portion of the demonstration. MV1 then changed to the right lane and slowed to allow the other vehicles to pass. MV1 then followed the other vehicles to the end of the scenario.
- AV1 and AV2 followed MV2 at a distance of about 50 m at a speed of about 40 kph
- MV2 slowed to a stop then accelerated back to 40 kph.
- AV1 and AV2 automatically slowed to a stop at a distance of about 10 m then accelerated back to 40 kph
- This process was repeated two more times

Staging for Fully Automated Driving
At the end of Segment #3, the vehicles came to a stop approximately 4.2 km into the route. Once the vehicles had come to a complete stop and the drivers had confirmed that all systems aboard all vehicles worked properly, and the autonomous vehicles had established vehicle-to-roadside-to-vehicle communications, the second part of the demonstration began. Once the vehicles had confirmed that they were ready for the second part of the demonstration, the vehicles left the staging area in the following sequence: AV1 positioned itself in the right lane and left the staging area, followed at a distance of approximately 200 m by the AV2, also in the right lane. The vehicles accelerated to 100 km/hr.

At this point MV2 had completed it's portion of the demonstration. MV2 then followed AV1 and AV2 at a safe distance as they completed the demonstration.

Part 2 - Fully Automated Driving

Segment #4 - Lane Tracking Based on Machine Vision
This segment demonstrated lane tracking. Once the vehicles had stabilized at a speed of approximately 100 km/hr, AV1 and AV2 followed the lane autonomously.

- Vehicles engaged vision based lateral control

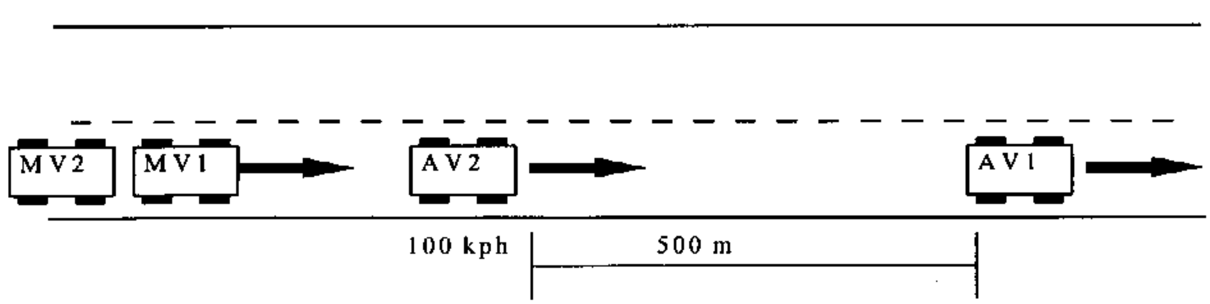

Figure 2.1.4-4 Lane Tracking Based on Machine Vision-Segment 4

Segment #5 - Automatic Lane Change & Return for Obstacle Avoidance
This segment demonstrated the ability to detect an obstacle, notify other following near-by automated vehicles of the obstacle's location, and automatically change lanes to avoid the obstacle. AV1 was traveling in the right lane at approximately 100 km/hr, followed at a distance of approximately 200 m by AV2. The lead vehicle, AV1, detected an obstacle (highway construction barrel with reflective tape) in the right lane. AV1 then communicated the presence of the obstacle to AV2 via vehicle-to-roadside-to-vehicle communications system, and simultaneously checked its surroundings for other vehicles and changed lanes to the left lane to avoid the obstacle. AV2, after receiving and processing the data from AV1, checked for vehicles around it, and then executed a lane change to the left lane to avoid the obstacle. As the automated vehicles passed the obstacle, the vehicles confirmed that the obstacle had been passed and the automated vehicles changed lanes again to return to the right lane.

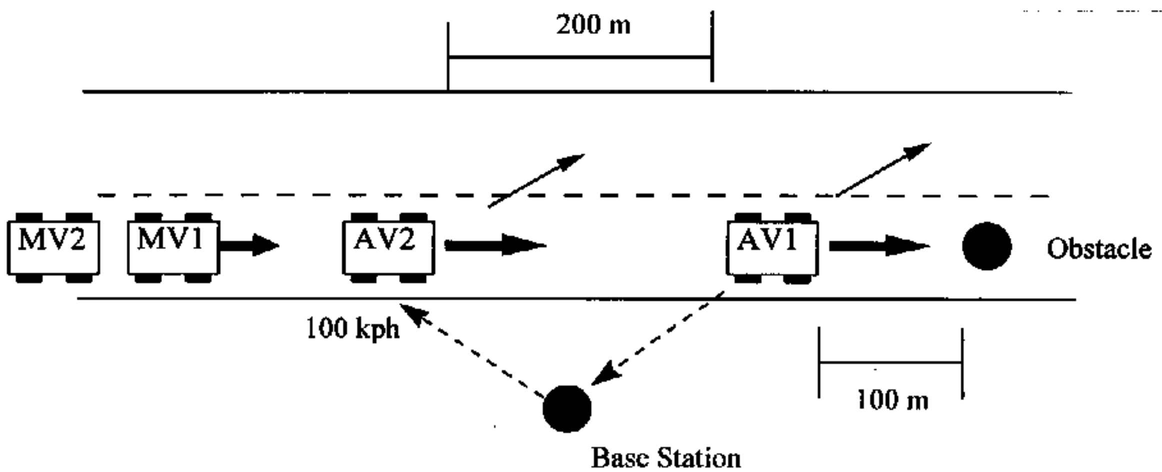

Figure 2.1.4-5 Automatic Lane Change & Return for Obstacle Avoidance-Segment 5

Segment #6 - Cooperative Vehicle Following
This segment demonstrated cooperative vehicle following. AV1 decreased its speed and AV2 maintained its speed of 100 km/hr until the gap between the two vehicles had been decreased to approximately 100 m. At that time, AV1 and AV2 maintained their positions in the right lane and set their speeds to 80 km/hr. Once the automated vehicles had stabilized, AV2 decreased the gap between itself and the lead vehicle, AV1, and began the cooperative vehicle following, while maintaining a headway gap of approximately 30 m.

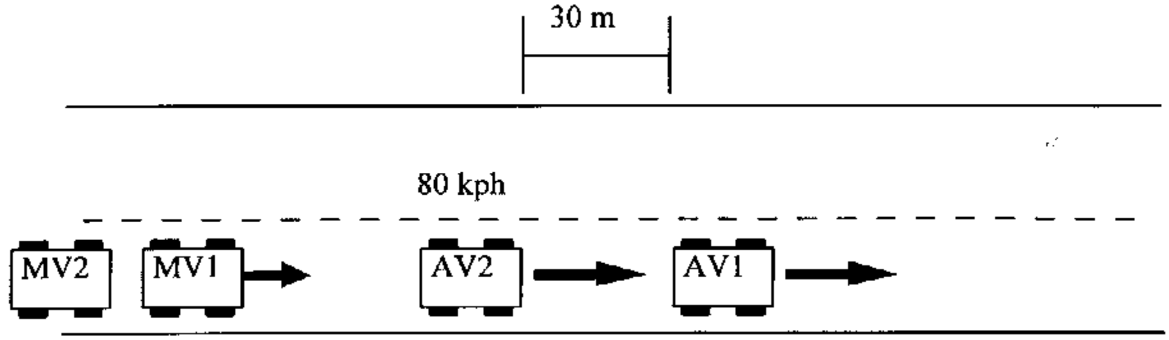

Figure 2.1.4-6 Cooperative Vehicle Following-Segment 6

Segment #7 - Rapid Deceleration for Obstacle Avoidance
This segment demonstrated rapid deceleration to avoid striking an obstacle. After the automated vehicles had stabilized, they continued in the right lane at approximately 80 km/hr separated by a gap of 30 m. AV1 detected obstacles (highway construction barrels with reflective tape) in both lanes and began a rapid deceleration to a stop to avoid striking the obstacles. After detecting AV1's illuminated brake lamps, the decreasing relative distance and increasing relative speed, AV2 initiated braking and decelerated to a stop behind AV1.

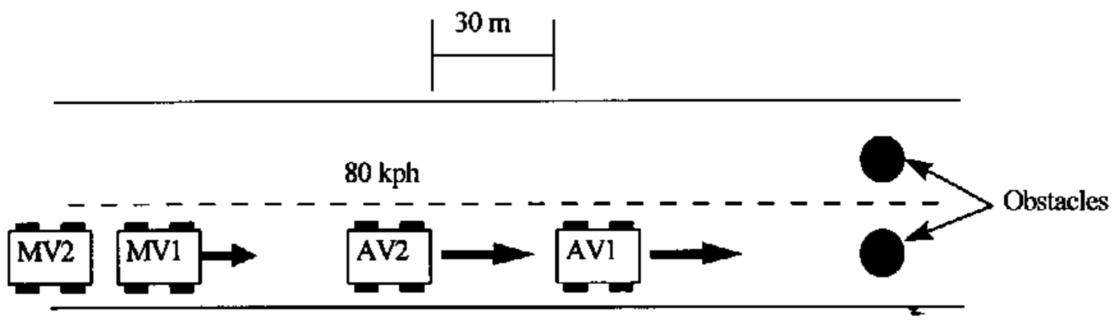

Figure 2.1.4-7 Rapid Deceleration for Obstacle Avoidance-Segment 7

Wrap-up
After the automated vehicles had completed Segment #7, the driver of AV1 communicated via voice communications to the other drivers that the demonstration had been successfully completed and for the other vehicles to proceed to the end of the course.

2.1.5 Control Transition Scenario - (Honda R&D North America)

The Control Transition Scenario objectives was to demonstrate two different kinds of lateral control sensing technologies and to demonstrate how both free-agent and a platoon operation could co-exist as parts of a layered approach to deployment and operation. This scenario illustrated lane keeping and road following using a vision system which is characteristic of a free agent concept and embedded magnetic following using magnetometers as would be found in urban areas where roadways are equipped for precise lateral control. The scenario also demonstrated both the free agent and platoon (That is, close headway) concepts of operation. Lasers were use for obstacle detection and avoidance functions.

The vehicles used in the Control Transition Scenario demonstrations included two 1996 Honda Accord LX sedans. Each vehicle was equipped with vision control, magnetometers and laser systems for lateral and longitudinal control. These segments are depicted in Figures 2.1.5-1 through 2.1.5-4.

Scenario Description
Two cars entered the freeway under manual control with several hundred feet of separation. After the vision system detected the freeway boundaries, the vehicles switched to automated control using the vision system as the primary sensor. The magnetic sensors were not operating at this point. Both vehicles drove in the right hand lane of the Interstate-15 for about a mile.

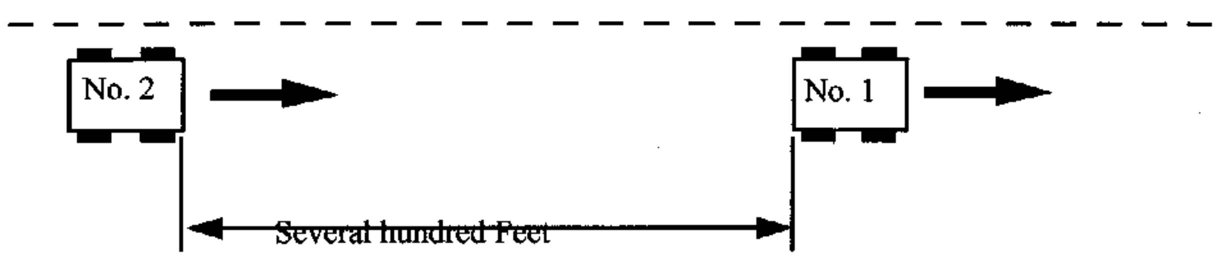

Figure 2.1.5-1 Freeway Lane Tracking-Segment 1
(Lateral Control-Vision; Longitudinal Control-Laser and Stereo Vision)

At this point, the cars encountered an obstacle in their lane. Each vehicle independently detected the obstacle and performed a lane change to avoid the obstacle.

Independently, Vehicle No. 1 detected obstacle and performed lane change.

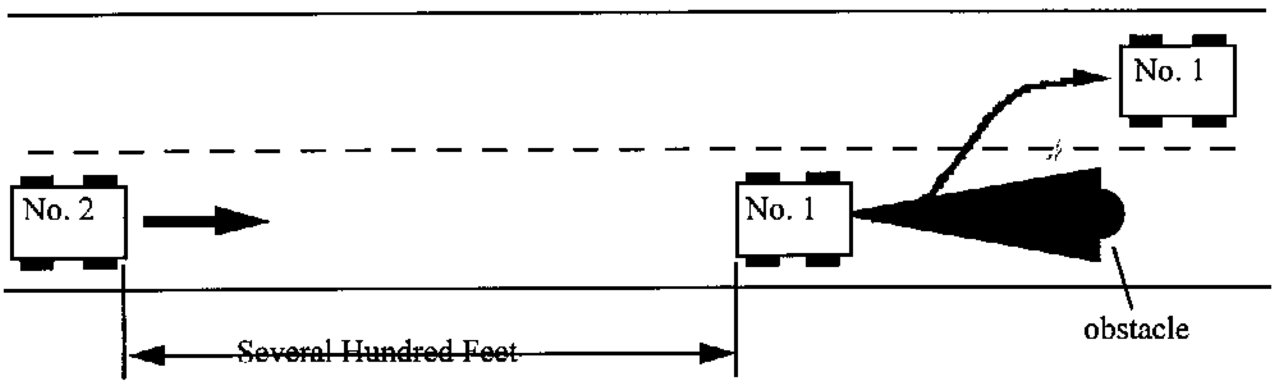

Figure 2.1.5-2A Obstacle Detection/Avoidance-Segment 2
(Lateral Control-Vision; Longitudinal Control-Laser and Stereo Vision)

Independently, Vehicle No. 2 also detected obstacle and also performed lane change.

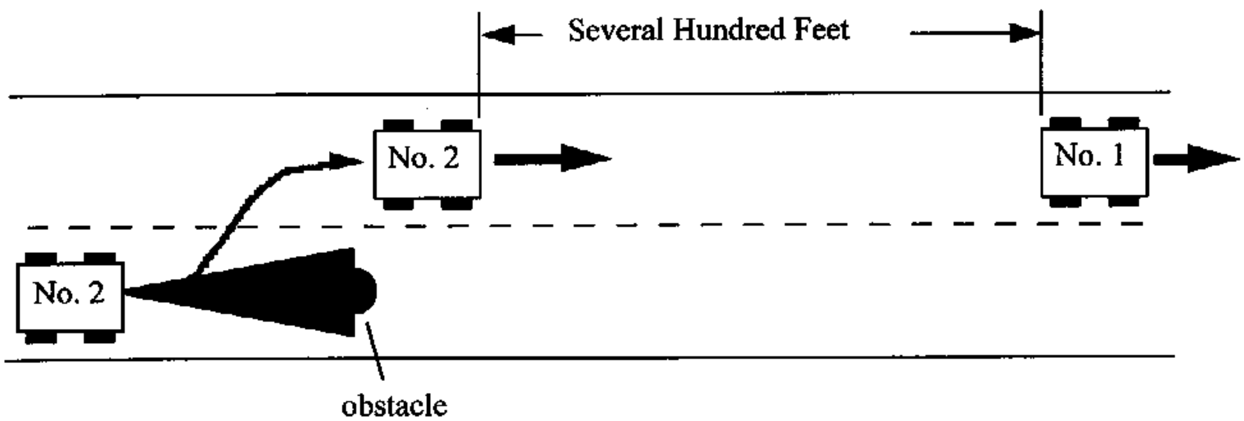

Figure 2.1.5-2B Obstacle Detection/Avoidance-Segment 2
(Lateral Control-Vision; Longitudinal Control-Laser and Stereo Vision)

Under autonomous control, Vehicle No. 1 set a speed of approximately 80.5 kph (50 mph) and Vehicle No. 2 set a speed of approximately 104.6 kph (65 mph). Vehicle No. 2 closed in on Vehicle No. 1 until the following distance was a moderate to long spacing. The vehicles maintained this spacing for about one and one half kilometers.

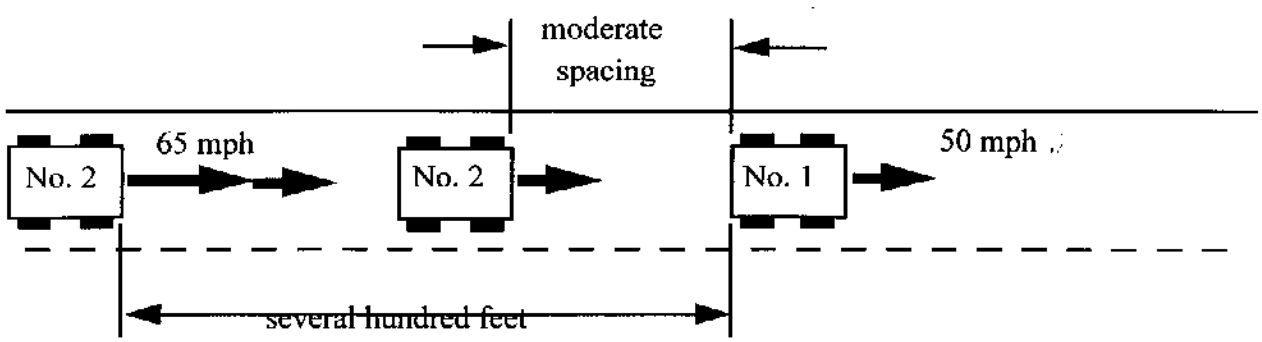

Figure 2.1.5-3 Non-Cooperative Adaptive Cruise Control-Segment 3
(Lateral Control-Vision; Longitudinal Control-Laser)

The scenario then simulated the vehicle entering an urban AHS corridor. Upon entering the "corridor" the vehicle controls switched from the vision based system to magnetic marker and radar as the primary sensors. The trailing vehicle then closed to approximately 15 meters and the vehicles continued for about one and one half kilometers.

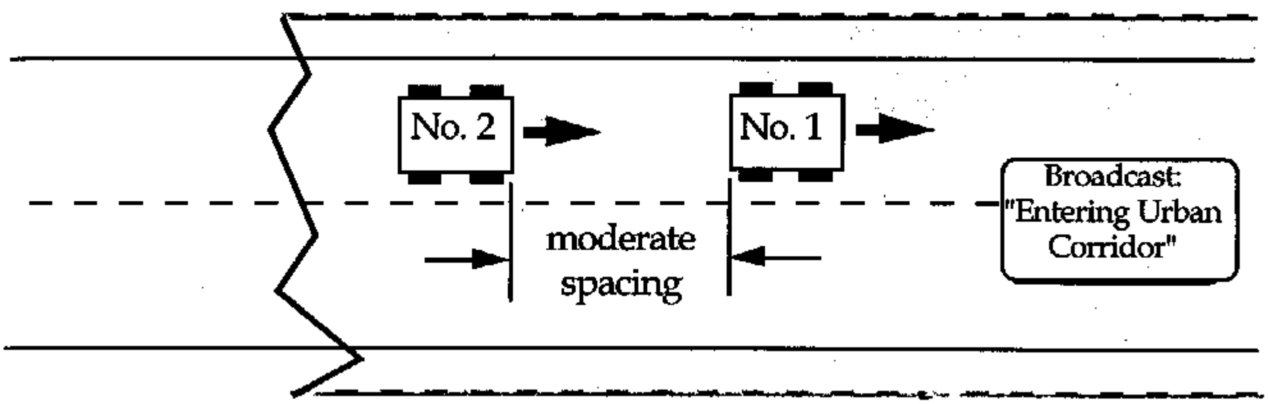

Figure 2.1.5-4A Cooperative Adaptive Cruise Control-Segment 4
(Lateral Control-Magnetic Nail; Longitudinal Control-Laser)

Vehicles No. 1 and No. 2 switched from vision control to magnetic marker-following control. Vehicle No. 2 closed on Vehicle No. 1 reducing headway, establishing vehicle to vehicle communications and demonstrating platooning. At this point the scenario ended.

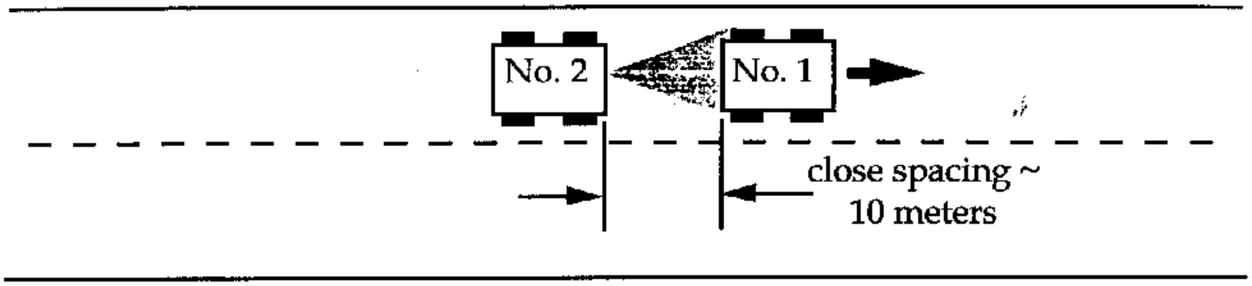

Figure 2.1.5-4B Cooperative Adaptive Cruise Control-Segment 4
(Lateral Control-Magnetic Nail; Longitudinal Control-Laser)

2.1.6 Alternative Technology Scenario - (The Ohio State University [OSU])

The primary unique feature of the Alternative Technology Scenario was the use of radar reflective stripe technology. In this technology, there was a minimal amount of impact on the infrastructure—i.e., special radar reflective stripes were laid down the middle of the lanes or at the edge of the lanes where lane divider markers were typically provided.

The Alternative Technology Scenario used two automated and one conventional 1996 Honda Accord LX sedans. The major features of the automated vehicles were: (1) their "control-by-wire" brakes, throttle, and steering systems and, (2) their radar laser and vision based control systems. The radar laser and vision based control systems served as the eyes and brains of the vehicle during automated operation. The "control-by-wire" brakes, throttle, and steering systems acted as the "hands" and "feet" of the automated driver.

The Alternative Technology Scenario demonstrated intelligent cruise control, obstacle detection, warning and/or avoidance, and lane departure warning and/or intervention.

Special radar sensors and control systems on-board the vehicle used radar reflective stripes to automatically guide the vehicle though basic driving maneuvers such as driving the vehicle in the center of the lane and executing a double-lane change passing maneuver.

Other key features of the Alternative Technology Scenario were the demonstration of a combination of vehicle control technologies (e.g., radar, vision, and laser) to provide special flexibility and back-up capacity. This fusion of technologies was especially important to (1) accommodate a variety of mixed traffic situations and, (2) provide extra control redundancy for improved safety. [The term mixed-traffic as used here refers to situations in which automated and non-automated vehicles can share a common roadway—a feature which many see as a key to success in the initial deployment of AHS vehicles and technologies.]

Scenario Description

This scenario, as depicted in Figures 2.1.6-1 through 2.1.6-3 was executed as follows: Vehicle No. 1 (manual) followed by Vehicle No. 2 (automated) traveled along the highway at approximately 64.4 kph (40 mph). Separation distance was approximately 12.2 m (40 feet). Vehicle No. 2 initially used vision for lane guidance and a laser system for headway maintenance. After reaching the radar reflective stripe, Vehicle No. 2 switched from vision guidance to its stripe guided radar system for lateral control.

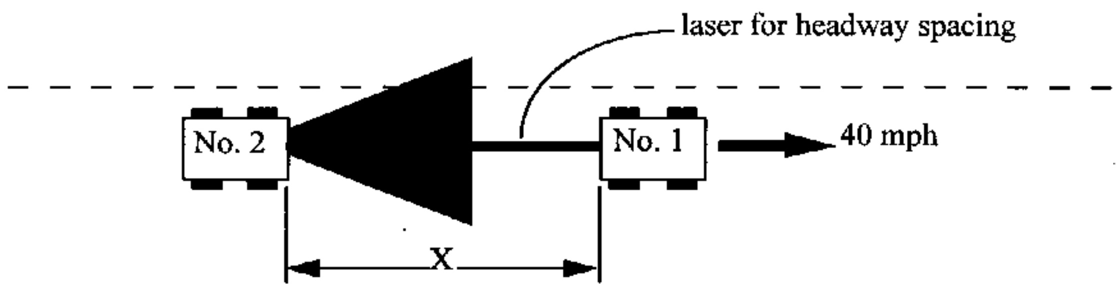

Figure 2.1.6-1a Alternative Technology Scenario-Segment 1a

Vehicle No. 3 (automated) staged in the right lane and further back, approached Vehicles No. 2 and No. 1, which were traveling slower. When Vehicle No. 3 caught Vehicle No. 2, Vehicle No. 3 adapted to Vehicle No. 2 speed and followed Vehicle No. 2 at a distance of about 12.2 m (40 feet).

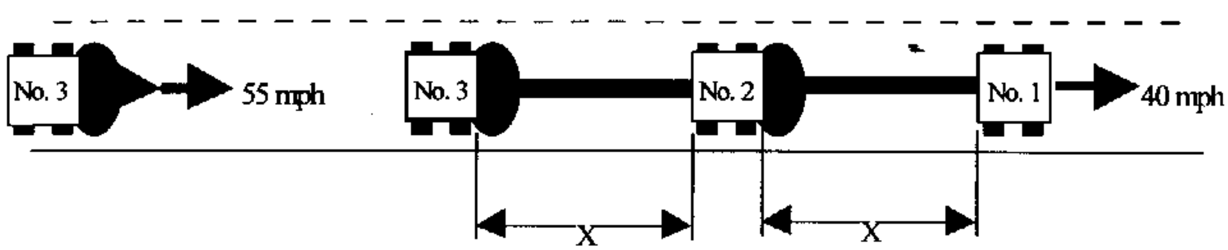

Figure 2.1.6-1b Alternative Technology Scenario-Segment 1b

After about .8 km, Vehicle No. 2 executed a lane change maneuver to pass Vehicle No. 1. Vehicle No. 3 then closed the gap to Vehicle No. 1 to a distance of about 12.2 m (40 feet).

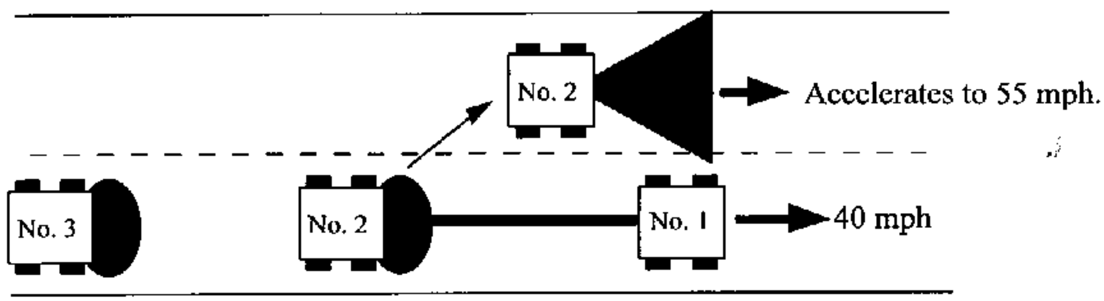

Figure 2.1.6-2a Alternative Technology Scenario-Segment 2a

After another mile of travel Vehicle No. 2 then returned to its original lane using the vision based system.

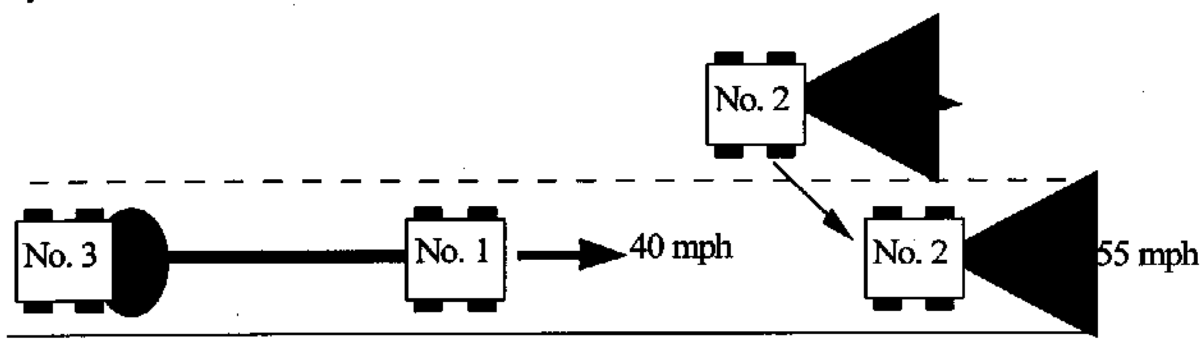

Figure 2.1.6-2b Alternative Technology Scenario-Segment 2b

Vehicle No. 3 and No. 2 changed back to vision/laser lane-guidance system.

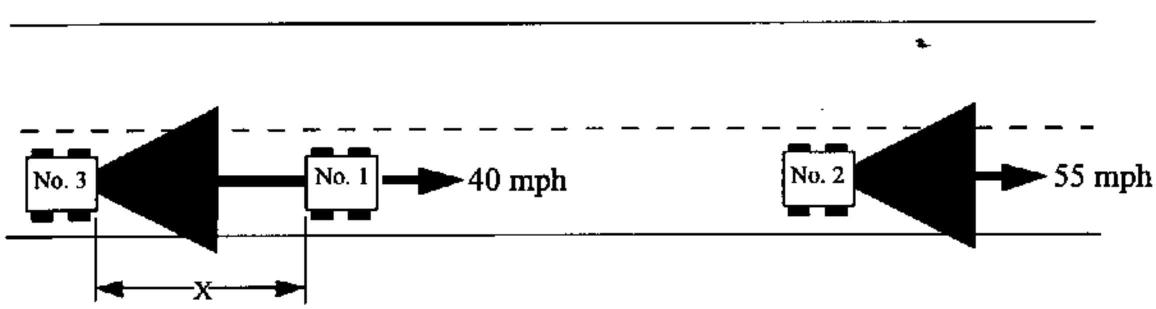

Figure 2.1.6-3 Alternative Technology Scenario - Segment 3

2.1.7 Commercial Vehicle (Truck) Scenario - (Eaton VORAD Technologies)

The Commercial Vehicle Scenario consisted of a Class 8 tractor (Freightliner) with trailer and one passenger (1994 Chevrolet Corvette) vehicle. The scenario was divided into three segments. Segment 1 demonstrated a creep alert feature on the truck at the beginning of the demonstration.

As both vehicles moved on the lanes, the forward collision warning system (FCWS) was demonstrated reporting at a three-second alert (242 ft), a two-second alert (161 ft) and, a one-second alert (81 ft). Segment 2 incorporated passing maneuvers and forward collision warning system interaction between the two vehicles in this scenario. Segment 3 concluded the Truck Scenario with the SmartCruise(TM) speed and headway demonstration.

Scenario Description
Figures 2.1.7-1 through -7 depicts each of the segments. The starting configuration for the truck scenario was as follows:

- First Vehicle = Vehicle B (Passenger Car)
- Second Vehicle = Vehicle A (Class 8 Tractor and Trailer)

Segment 1
The truck and car started the scenario at the control yard or staging area location. Both the car and truck started in the right lane. The car started the scenario ahead of the truck by 15 ft. The truck released service brake and crept forward. Truck observed Creep Alert. The car accelerated to 65 mph to approximately 350 feet ahead of the truck. The truck accelerated to 55 mph and the car decelerated to 50 mph.

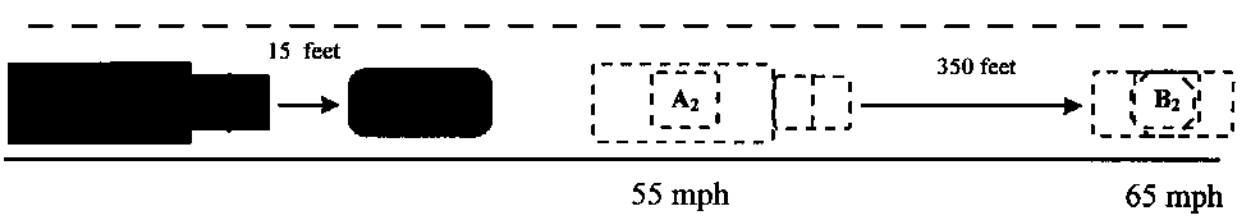

Figure 2.1.7-1 Creep Alert

As the truck closed the spacing on the car, the truck driver observed forward collision warning system (FCWS) reports at a 3 second alert (242 ft), a 2 second alert (161 ft), a 1 second alert (81 ft).

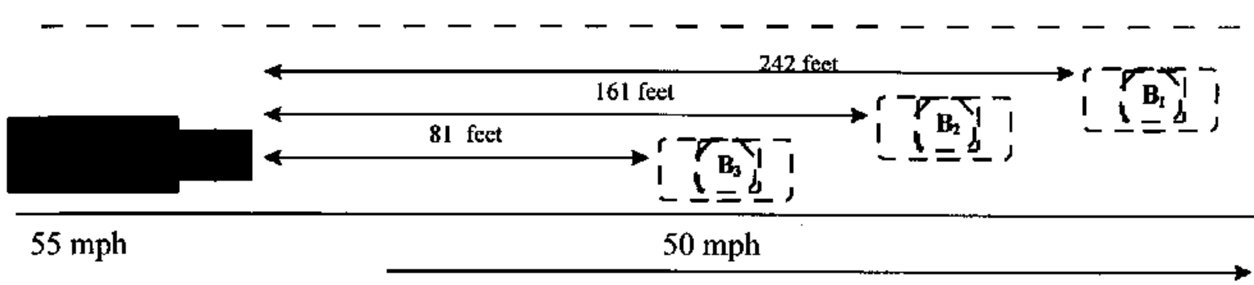

Figure 2.1.7-2 Forward Collision Warning

Segment 2

The car accelerated to 65 mph to approximately 350 feet ahead of the truck. The car then decelerated to 35 mph. The truck moving at 55 mph, approached the slower moving car at a 20mph differential. The truck driver observed a FCWS 3 second report.

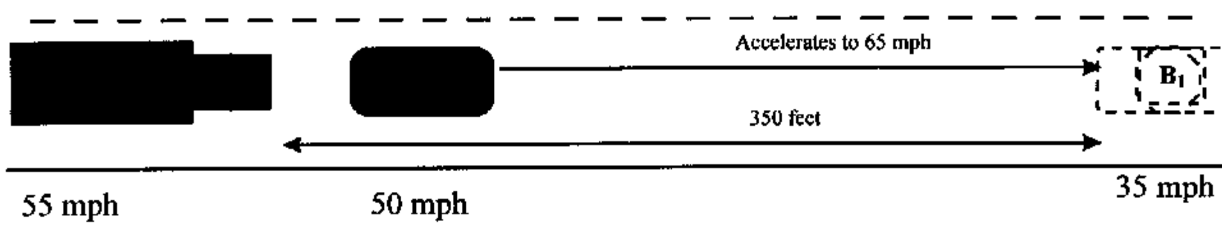

Figure 2.1.7-3 Forward Collision Warning

The truck driver executed a lane change to left lane to avoid the car. The car waited for the truck to pass, then the car accelerated to approximately 55 mph in right lane and stayed in the truck's blind spot. The truck driver observed the blind spot alert.

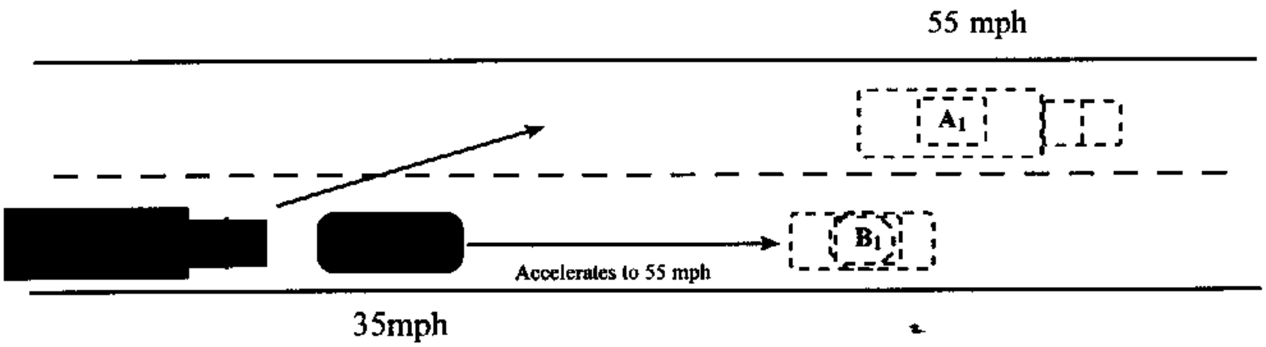

Figure 2.1.7-4 Blind Spot Alert

The car accelerated to 65 mph in the right lane and pulled ahead of the truck approximately one quarter mile. The truck returned to the right lane at approximately 45 mph. The car came to a stop, activated hazard warning lights, the truck driver observed the FCWS report and moved to left lane to avoid the stopped car.

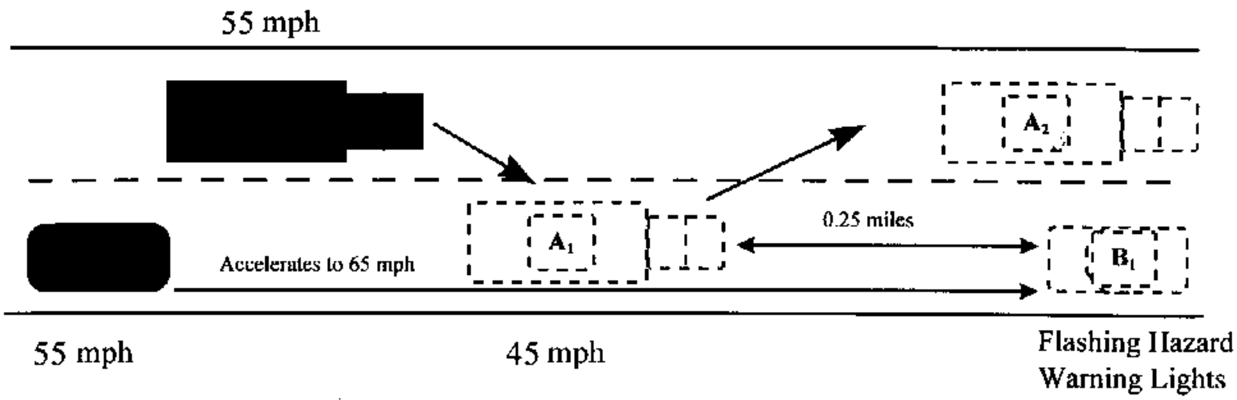

Figure 2.1.7-5 Forward Collision Warning

Segment 3

The truck driver executed a lane change maneuver to the right lane and proceeded at approximately 55 mph. The truck driver set SmartCruise(TM) speed and headway. The car accelerated to 65 mph, moved to left lane and passed the truck. The car then moved to right lane in front of truck. The truck driver observed the FCWS yellow light but took no action because the car was moving away from the truck.

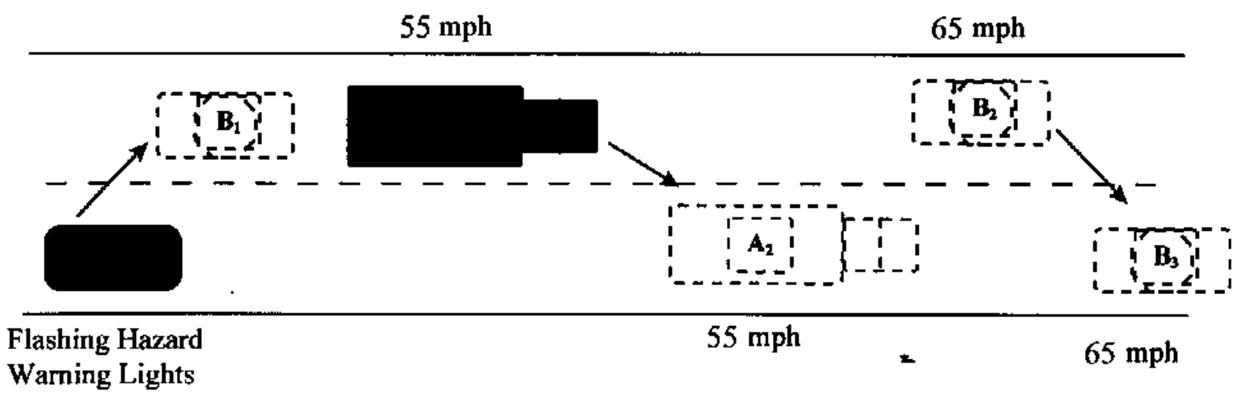

Figure 2.1.7-6 SmartCruise(TM)

The car slowed to 45 mph. As the truck approached the car the truck's SmartCruise(TM) matched speed and preset headway. The car accelerated to 50 mph, the truck SmartCruise(TM) matched the change in speed of target car and maintained preset headway. The truck driver changed headway setting. The car accelerated to 65 mph. The truck's SmartCruise(TM) returned to driver's preset cruise speed.

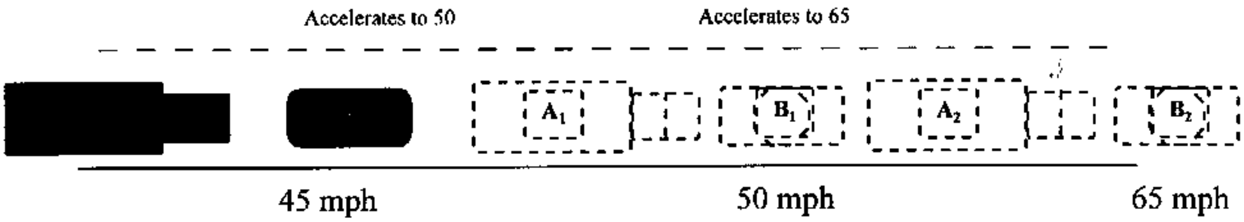

Figure 2.1.7-7 SmartCruise(TM)

The car and truck returned to Control Yard

2.1.8 Vehicle Demonstration Scenario Safety Considerations

Appendix D, Demonstration Safety Plan and Appendix C, Safety and Performance Certification Procedure, were used to ensure all vehicles and scenarios met certain safety requirements before they were allowed to participate in the Demonstration.

It should be recognized that all vehicles, other than the Platoon vehicles, in the demonstration relied on the driver to ensure the final level of safety during automated operation. The Platoon vehicles were unique. They operated at highway speed in combination with a relatively small vehicle-to-vehicle spacing, so they had to rely on computer controlled fault management and drivers for safely responding to malfunctions. In addition, to help prevent accidents, the following operational safety procedures were implemented.

- The scenario proceeding the Platoon Scenario acted as a sweeper to see that there was no road debris in front of the Platoon Scenario. If road debris was encountered, the Platoon Scenario would be warned and taken out of automated control.
- Personnel were stationed on each overpass to ensure nothing was dropped on the roadway.
- Police intensely patrolled the Interstate-15 lanes adjacent to the HOV lanes to ensure that occupants of any stopped or stalled vehicles did not jump the barriers into the HOV lanes. When a vehicle stopped adjacent to the HOV lanes, the demonstration was stopped until the police, or some other authority, arrived to monitor the stopped vehicle.
- Tow trucks were on immediate standby to quickly remove any stalled vehicles adjacent to the HOV lanes.

2.1.9 Summary

All scenarios, except the Commercial Vehicle Scenario, were carefully scripted; that is, they were controlled by distance from the start, magnetic marker number or global positioning system (GPS) location. Hence at all times vehicles knew where they were and what they should be doing. Obstacles were carefully selected for size and carefully placed in favorable locations. Drivers had to be vigilant in monitoring the vehicles at all times. The next extension of an AHS feasibility demonstration would be to operate the vehicle on highways that meet certain requirements, but were not previously traveled on by test vehicles.

2.2 Mini-Demos (Small Demonstrations)

The mini-demos were conceived as a way to allow a broader audience to have the opportunity to ride in a functioning automated vehicle during Demo '97. The mini-demos were demonstrations held on smaller demonstration test tracks adjacent to the Exposition Center. Bechtel and Caltrans took an active role in the construction and management of the mini-demo area. Some logistics support was provided by National Trade Productions (NTP) such as canopies, furniture, electricity, signage and grandstands. Visitors to the mini-demo site were able watch and ride in three fully automated cars and one partially automated car (which demonstrated warning and communication devices).

The mini-demo area included a main track for PATH, 3M, and OSU demonstrations. Honda set up a separate track. The Society of Automotive Engineers (SAE) was given an area for outdoor displays. In addition, one remote controlled construction vehicle and three unmanned ground vehicles developed by university students from across the United States were on display and provided the attendees the opportunity to see additional automated vehicle technology functions.

The four demonstration tracks were situated adjacent to a large viewing area (referred to as Mini-Demo Central).

Test Track A was a half mile run featuring two main tangents and one main curve, surrounded by a K-Rail barrier. Test Track A was utilized by University of California - Berkeley PATH Program, Ohio State University (OSU), and 3M to demonstrate a variety of automated technologies, including: magnets, radar, vision systems, and tapes.

The University of California - Berkeley PATH Program Buick LeSabre used in this demonstration, was the same car used in the Interstate-15 vehicle demonstration Platoon Scenario. The vehicle demonstrated fully automated control (i.e. steering, acceleration, braking). Lane keeping was accomplished by utilizing magnetic markers embedded along the 1.1 kilometer test track. This car traveled autonomously at speeds up to 40 mph and also demonstrated how the vehicle could maintain automated control while driving backwards.

The Ohio State University (OSU) Honda Accord demonstrated a combination of technologies. During the first 200 yards of the run, the OSU car utilized a special radar reflective tape as a reference to maintain lateral control. For the latter portion of the course, the vehicle switched over to a vision system for lateral control.

The 3M mini-van relied on a "Smart Tape" system to communicate information to this partially automated vehicle. The 3M team described this vehicle as "transitional," meaning it demonstrated many of the spin-off technologies that resulted from AHS research that could be fitted to existing cars in the very near future. 3M's systems also demonstrated the application of

"Smart Signs" which could effectively communicate to a driver things such as: gas, food, and lodging information located at upcoming exits, along with hazards or construction that the driver might be approaching.

Test Track B was constructed for the express use of Honda R & D North America, Inc. This track was a small elliptical course that featured several curves, similar in shape to a "peanut." Honda's vehicle operated under full automated control and followed a painted white line utilizing a vision based lane keeping system for lateral control.

Test Track C was a confined 100' X 80' rectangular area wherein the Advanced Highway Maintenance and Construction Technology (AHMCT) team demonstrated the functional uses of a remote controlled front-end loader. This vehicle had two independent control systems which were appropriate for different scenarios. One consisted of a chest pack and the other, a stand alone panel that could be placed within proximity of a job or maintained on the back of a pick-up truck.

Test Track D was an area designed to test the fully automated vehicle technologies developed by students from Ohio State University (Columbus), Virginia Tech University (Blacksburg), Oakland University (Rochester, Michigan), and the University of Colorado (Denver). Each of the universities' unmanned ground vehicle went through a series of twists, turns, obstacles and even over a bridge utilizing vision systems. The vehicles were completely autonomous and did not require the support of infrastructure or tethers to complete their rounds.

2.3 Demonstrated Technologies

Most of the components demonstrated in Demo '97 were components that were either in the R&D laboratories of the Core or Associate Participant, or were available in the market but were being applied in the unique automated vehicle control environment. Two notable exceptions were (1) the collision warning products demonstrated by Eaton Vorad on the class 8 truck; these products are on truck fleets today; and (2) the adaptive cruise control system from Toyota that is a product in Japan.

The components and systems were tuned specifically for daytime operation on the Interstate-15 HOV lanes as equipped for the test, with dry weather. Within those restrictions, the systems operated safely and effectively during the demonstration operations.

Near-term practical technologies that were demonstrated included:

- Millimeter wave radar for longitudinal control and obstacle detection
- Microwave Radar for obstacle detection
- Laser radar for longitudinal control and obstacle detection
- Magnetic markers for lateral control
- Radar Reflective Stripe for lateral control
- Image processing for lateral control
- Image processing for lane departure warning and blind spot monitoring

- Vehicle-to-vehicle data communications
- Vehicle-to-roadside data communications
- Real time data processing

Conceptual approaches to vehicle highway automation that were demonstrated included:

- Evolutionary approach:
    - Warning systems
    - Partial automation
    - Full automation
- Operating Environments:
    - Mixed vehicle platforms
    - Free agent
    - Platoon

The technologies listed above were used in a variety of ways in the different scenarios. This is shown in Table 2.3.1.

Table 2.3-1 Demonstrated Technologies - Scenario Comparison

	FA	PT	MV	EV	CT	AT	TRK
Technology							
Millimeter wave radar for longitudinal control and obstacle detection	X	X					
Microwave Radar for obstacle detection	X					X	X
Laser radar for longitudinal control and obstacle detection				X	X	X	
Magnetic markers for lateral control		X			X		
Radar Reflective Stripe for lateral control						X	
Image processing for lateral control	X		X	X	X	X	
Vehicle-to-vehicle data communications	X	X		X	X		
Vehicle-to-roadside data communications	X	X	X				
Real time data processing	X	X	X	X	X	X	X
Conceptual approaches to vehicle highway automation:							
Evolutionary approach:							
Warning systems	X			X			X
Partial automation	X		X	X			X
Full automation	X	X		X	X	X	
Operating Environments:							
Mixed vehicle platforms	X						
Free agent	X		X	X	X	X	X
Platoon		X			X		

FA - Multi-Platform Free-Agent
PT - Platoon
MV - Maintenance
EV - Evolutionary Deployment
CT - Control Transition
AT - Alternative Technology
TRK - Commercial Vehicle

3.0 DEMO '97 PLANNING AND DEVELOPMENT

There were seven live vehicle demonstrations--or vehicle scenarios--as part of Demo '97. Each scenario was comprised of a set of vehicles working together to demonstrate the various technologies currently available. This section describes the planning and activities that went into preparation for these vehicle scenarios and the Demo '97 Exposition Center. The planning, development and execution of Demo '97 was accomplished by the organization shown in Figure 3-1.

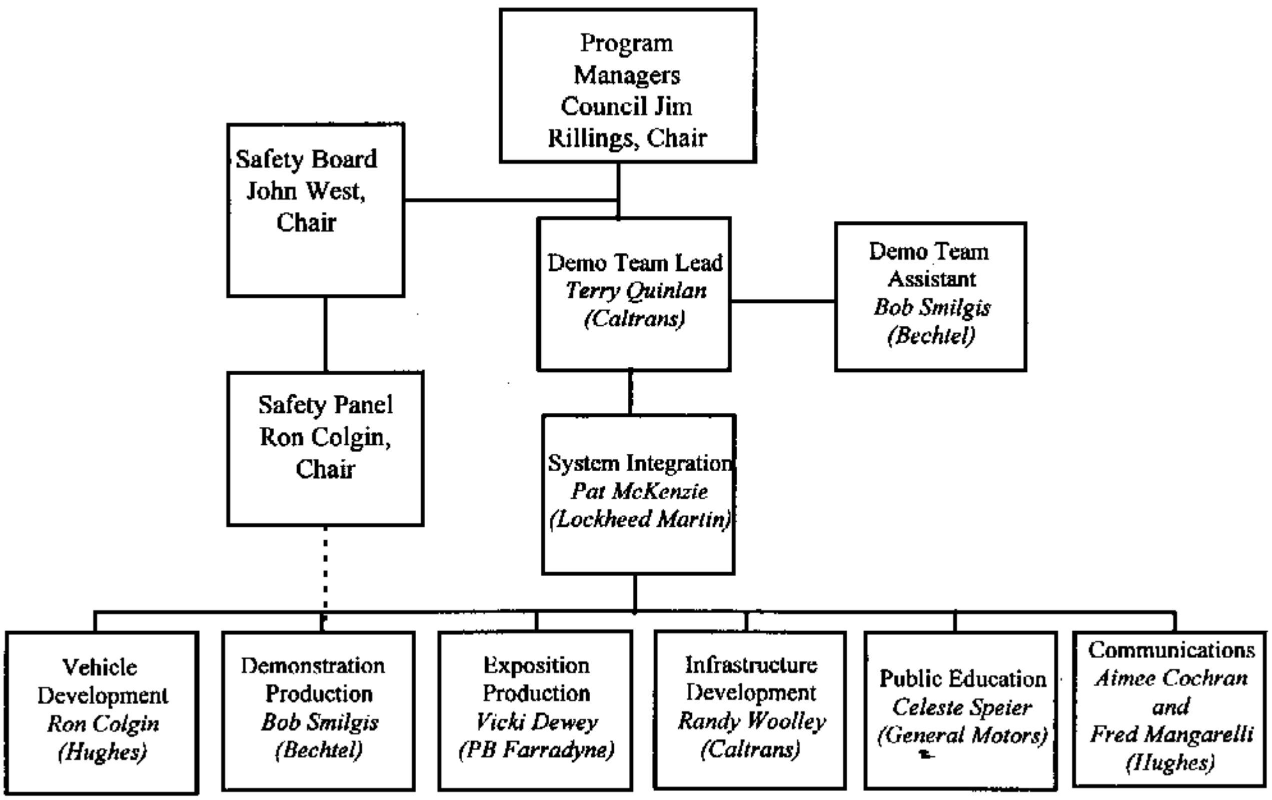

Figure 3-1 Demo '97 Team Organization

3.1 System Integration

The System Integration function was responsible for ensuring that all preparations were made for the successful execution of the Demonstration. That responsibility included:

- providing technical demonstration overall systems integration
- tracking Demo '97 planning and development schedules
- allocating resources
- performing risk assessment, management and mitigation
- providing primary interface for Associate vehicle developers regarding Demo '97

- developing the Demo '97 System Specification
- ensuring demo requirements were adequately covered by related test procedures
- including safety requirements as they are developed
- developing and maintaining a system level Interface Control Document
- developing and publishing a coordinated communications operating guideline for Demo '97
- monitoring demonstration vehicle safety performance
- coordinating pre-certification, certification test, dry runs and dress rehearsals on Interstate-15 lanes.
- directing and coordinating any test support provided by Associate NAHSC members
- developing and executing the Demonstration Presentation Center

3.2 Vehicle Development

Each Core Participant vehicle developer developed their own vehicle specification document which specified actuator, power, cooling, and vehicle sensing requirements along with computing, communications, and user interface requirements. Within each scenario several vehicle development milestones were established for each vehicle development team. The Associate Participant vehicle developers established their own vehicle development designs within general guidelines provided by the Demo team. Vehicle development milestones were coordinated with the Demo team periodically.

The vehicle development milestones for the Core Participant scenarios - Multi-Platform Free Agent, Platoon, and Maintenance are provided below.

3.2.1 Multi-Platform Free Agent

For the Multi-Platform Free Agent scenario the following milestones were established:

Vehicle Design and Build - During this period, the vehicle developer (GM) designed and built the first free agent vehicle using the requirements set forth in the vehicle specification document. Interaction between the vehicle developers and the Demo team for clarification of requirements set forth in the vehicle specification document was performed. Monthly progress reports from the vehicle developers to the Demo team was performed to ensure that contingencies could be accomplished if the schedule slipped.

Computing/Sensing Platform Design and Build - During this period, the Computing/Sensing Platform (CSP) designers developed the computing hardware and sensing package required for successful completion of the free agent scenario. The design was based on the specifications set forth in the vehicle specification document. This process included designing the system, acquiring computing and sensing components, and assembling the first unit. CMU was responsible for all facets of this task except those relating to broadcast communications technology, and voice radios.

User Interface Design - GM built the passenger vehicles for CMU. CMU installed their equipment on these vehicles and Delco performed the user interface design in cooperation with vehicle builders (GM), integrators (CMU), and the Demo team.

Obstacle Detection and Headway Maintenance Systems Integrated and Demonstrated On Free Agent Vehicles - Assessed radar with respect to obstacle detection and avoidance. Sent one vehicle to the 1997 free agent test site in San Diego, California to do limited tests designed to verify that the environmental assumptions built into the application modules were correct and that vehicle performed as expected. Special emphasis were placed on determining problem area at the site for items like radar, vision and communications.

Trial Demo Preparation - This demo was an early showcase of the capabilities of the free agent vehicles and provided a preview of what could be expected in Demo '97. It also allowed the Demo team to become familiar with the expected integration effort which would be required for the 1997 Free Agent demonstration. The goal of this demo was to show integrated vision based lateral control, obstacle detection and avoidance, and headway maintenance. Check in and entry procedures were included.

Execute the Trial Demo - The demo was conducted and documented and the results were assessed. As a result, it was determined which areas needed the most attention and focus for further efforts.

Preparation Specific to the Free Agent Scenario - Using the results from the Trial Demo, work was concentrated on deficiency areas and remaining system software was developed and tested. Integration continued with an emphasis on determining which technologies were ready for demonstration. Near the end of this period, development work slowed and effort was concentrated on integration and testing.

Finalization of Free Agent Scenario - The Free Agent scenario was finalized, based on the current state of maturity of the component technologies.

3.2.2 Platoon Scenario

The vehicle development milestones for the Platoon scenario included:

Sensor Development - This phase included improving the sensing scheme for extended range, purchasing new magnetometers, testing the new magnetic sensing scheme, improving the radar, testing an alternative ranging sensor, and developing an observer using motion sensors for dead reckoning.

Design Lateral Control Algorithms - This milestone included modeling the new test vehicle (from the perspective of lateral dynamics and tire cornering force), verifying the vehicle lateral dynamic model through open loop tests, modifying the existing lane keeping control algorithm, developing a robust lane keeping control algorithm, developing a merge and lane change control algorithm, simulating the new control algorithm using the verified dynamic model, debugging lateral control algorithm (intermediate experiments performed locally at Richmond Field Station and Crows Landing) and performing experiments on lateral control algorithm (performed on I-15).

Design Longitudinal Control Algorithm - This scenario vehicle development phase included modeling the new vehicle (from the perspective of engine dynamics and tire friction), verifying the vehicle dynamic model through open loop tests, improving the current space regulation algorithm (including split and join), developing strategy and protocols for merge and diverge, simulating the space regulation control algorithm using the verified vehicle dynamic model, debugging the longitudinal control algorithm and performing experiments on Interstate -15 HOV lanes in San Diego.

Combine the Lateral and Longitudinal Control Algorithms - This milestone included software development for additional drivers and supporting algorithms, designing additional control logic necessary for combined lateral control algorithm such as merge, using a simulation of a combined lateral and longitudinal control model, software integration, debugging the combined control algorithms and performing experiments on Interstate -15 HOV lanes in San Diego.

Vehicle Development (First 2 Vehicles) - This milestone accomplished the first phase of the vehicle assembly for the Platoon scenario and included procuring components, designing, developing and installing the steering and throttle actuators, developing the inner-loop controller for the steering and throttle actuators, designing, developing and installing the brake actuators, performing the wiring, installing the human interface and debugging all installed components.

Develop the Communication Link - This milestone of the Platoon scenario vehicle development included finalizing the communications specifications between PATH and Hughes, developing/integrating the radio, developing the communications protocols, developing message format for platooning and merge/lane change maneuvers, installing communications link on the vehicle and finally performing on-vehicle communications link debug and tests.

Vehicle Volume Build - This milestone of the Platoon scenario vehicle development was performed primarily by GM. After the system build documentation, consisting of Demo vehicle content and interfaces between AHS components, validation requirements for added AHS components, vehicle packaging, and interfaces to the Demonstration Presentation Center functions were prepared, GM started the vehicle volume build for 10 vehicles. The build sequence was to develop Demo vehicle requirements, perform system analysis of the vehicle components to meet vehicle requirements, perform power system analysis of the vehicle to meet vehicle requirements, perform health check system of the vehicle to meet vehicle requirements, check system interfaces of the vehicle components to meet vehicle requirements, perform system validation test of the vehicle to meet vehicle requirements.

As with all other vehicle builds, modifications and refinements were required through each of the following vehicle development milestones: Trial Demo Preparation, Execution of the Trial Demo, Preparation Specific to the Platoon Scenario and Finalization of Platoon Scenario.

3.2.3 Maintenance Scenario

The Maintenance Scenario vehicle development process involved GM, Lockheed Martin and Caltrans. Lockheed Martin integrated a steering actuator (provided by GM), cool air ducting into the trunk, a power bus running into the trunk (provided by GM), a LMC vision-based navigation system and a maintenance diagnostic payload (Caltrans provided) into the maintenance vehicle (GM Chevrolet Lumina mini-van). The vehicle development process included checking the steering actuator, installing the electronics and VME rack into the van (including low level CPU, servo amps, power conditioner, A/D, D/A, wire bundles, interface for upper level CPU (Sparc)), mounting a video camera, magnetometer, frame grabber, and upper level CPU, integrating lateral control software, performing component, subsystem and system tests of navigation and performance of maintenance vehicle, integrating payload (Infrastructure Diagnostics and ALTS system including GPS) and checking out payload performance.

As with all other vehicle builds, modifications and refinements were required to the vehicle build through each of the following vehicle development milestones: Trial Demo Preparation, Execution of the Trial Demo, Preparation Specific to the Maintenance Scenario and Finalization of Maintenance Scenario.

3.3 Safety Board / Safety Panel

An independent Safety Board was convened to ensure the safety of the live vehicle demonstration. It was chaired by John West of Caltrans, chair of the PMOC, and included the NAHSC Program Manager and Technical Director; and safety experts from the NHTSA location at the Transportation Research Center where extensive vehicle testing occurs, the GM Proving Ground where GM vehicle testing occurs, and Lockheed Martin's Littleton Colorado facility where military project testing occurs.

The Board formed a Safety and Certification Panel to directly oversee the vehicle teams' design, development and testing. The Panel reported to the Board only. It included people with multiple disciplines including highway design, system engineering, software engineering, vehicle design and testing, and communications. The chair of this Panel was also on the Board.

The Panel developed an extensive safety and certification procedure. After Board approval, the Panel visited each demonstration team site in March and April for a one-day, rigorous pre-certification test that identified and documented shortfalls and issues. The Panel then performed certification testing of each demonstration in June and July on I-15. All pre-certification problems had to be corrected and the rigorous certification testing had to be passed for a demonstration team to be approved for participation in the Demo '97. Eventually, all teams passed.

3.4 Demonstration Production

Each of the seven live vehicle demonstration teams originated a scenario to showcase their automated techniques of highway operation. Each scenario was presented to the Demonstration Team which approved it or ask for some modifications.

Each vehicle developer established their own vehicle performance requirements, and designed their hardware and software components to enable the performance of their respective scenarios. For the most part, scenarios and vehicle components were drawn from experience and existing technologies familiar to the development team. Components were purchased or designed and built by the vehicle developers. Also software to integrate the components, control the vehicles and control the scenarios were all integrated into the respective vehicle platforms.

Thorough testing of the systems was required. Testing included component and subsystem testing, individual vehicle testing, integrated testing of multiple vehicles including their interactions, and integrated testing of the scenario at the Interstate-15 test location. Pre-certification of the scenario was conducted by the Safety and Certification Board primarily at the development team's site; final certification testing to qualify the demonstration for participation in Demo '97 was conducted at the Interstate-15 location.

- Scenario pre-certification - This consisted of running a preliminary certification procedure with the Safety and Certification Panel to ensure that vehicles and their scenario passed certain safety and performance robustness criteria.
- Scenario dry runs on Interstate-15 - Once scenarios had been tested at the developer's facilities, they were transferred to the Interstate-15 demonstration facility for dry running and final refinement of the scenarios on the actual Interstate-15 demonstration facility.
- Scenario certification - The vehicles and scenarios were subjected to a final certification by the Safety and Certification Panel which had to be passed in order for the scenario to be included in the demonstration.

Full rehearsals of all the scenarios had to be run to ensure the total demonstration could be run successfully and safely. In order to do this, optimization of the sequence in which the scenarios would be run was done. This included taking into account how long a scenario would be on the HOV express lanes, as well as, the placement and timely removal of obstacles. In addition, the handling crews for the vehicle and facilities had to have an opportunity to practice as a full demonstration team. Finally, passenger scheduling, transportation, loading and unloading was practiced.

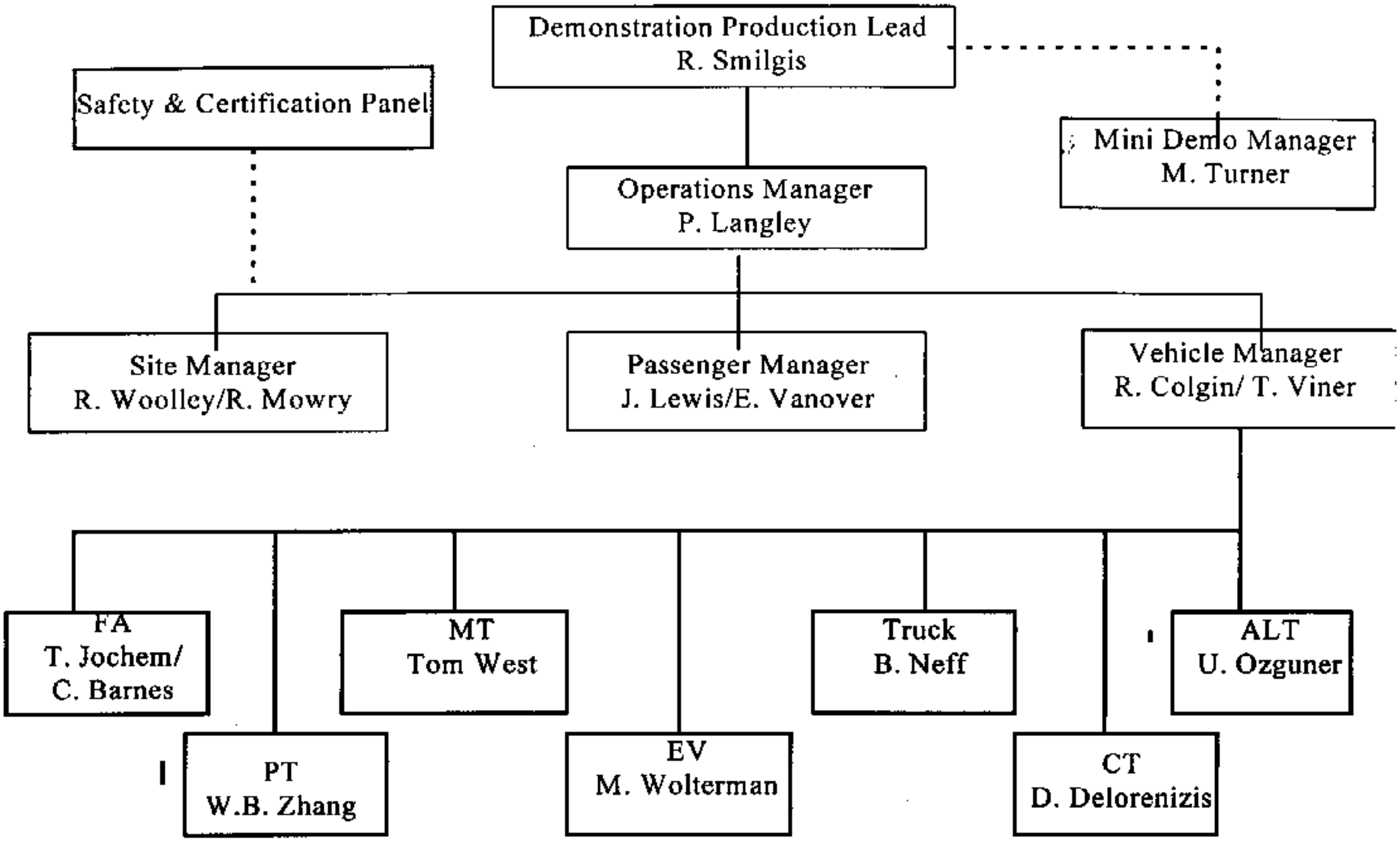

Figure 3.4-1 Vehicle Demonstration Production Organization

3.4.1 Operations

The Caltrans site safety officer (Tarbell Martin) approved the lanes and staging areas for operation at the beginning of the day and turned the facilities over to the Control Center. Unless there was a problem, the Control Center had no further contact with the Caltrans site safety officer until the end of the day. The Caltrans site manager, vehicle manager, passenger manager then executed their respective procedures to prepare the vehicles, facilities, and passengers. Once all procedures were completed and the Caltrans site manager and site vehicle manager gave their approval, the operations manager gave the go-ahead to begin the sequence. The vehicle manager directly notified the appropriate dispatcher to release the scenario. The dispatcher then released all vehicles in the scenario as needed. Figure 3.4.1-1 shows the individuals located in the Control Center, as well as the relationship between individuals. As the procedures were completed, the operations manager updated a hard copy of the procedures. The scheduler updated an electronic copy of the procedure and relayed shuttle bus information to the operations manager. The vehicle manager tracked the progress of each scenario and obstacle vehicle on a white board.

A listing of procedures monitored by the operations manager are contained in the Demonstration Planning Document, Appendix A to this report.

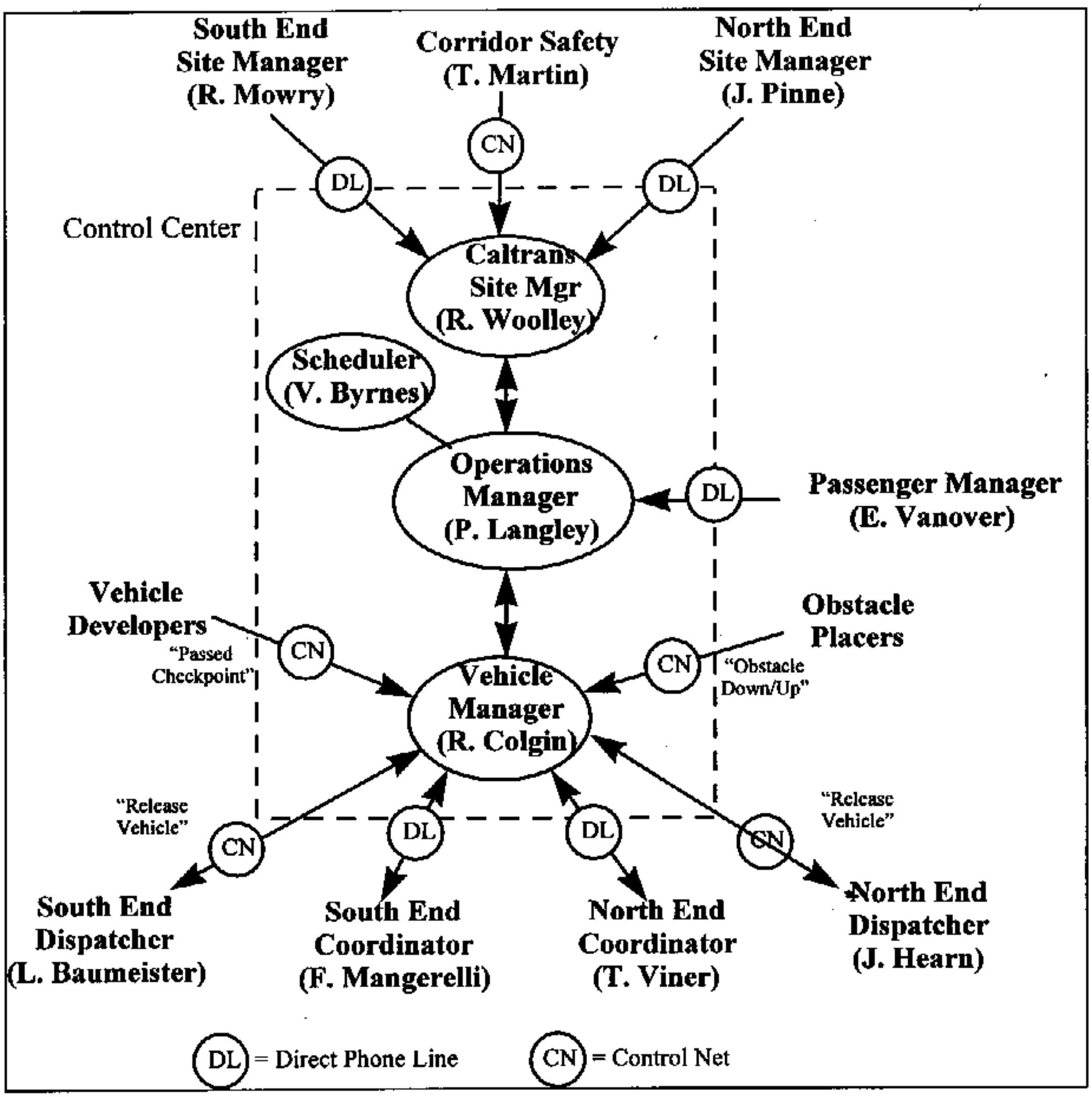

Figure 3.4.1-1 Control Center Roles

3.4.2 Passenger Management

All passengers participating in the "vehicle demonstration rides" on Interstate-15 started and finished the ride in the Passenger Staging Area (PSA) at Miramar College (*See Figure 3.4.2-1*

Miramar College - General Location Map). Shuttles transported passengers to and from the South Control Yard and North Staging Areas (*See Figure 3.4.2-2 Area Map*). The Passenger Management Team operating at the PSA, including roles and responsibilities, are summarized in the Demonstration Planning Document, Appendix A to this report. The process for addressing passenger management functions during Demo '97 considered the following:

- All VIP's registered at the Exposition "Distinguished Guest" booths where registration material and name badges were provided
- VIP database was used as source for identifying the "VVIP" or "Distinguished Guests"
- VIPs were directed to Passenger Staging Area (PSA) as follows:
  - "Pre-assigned-VIP" were advised to check-in at PSA 20-30 minutes before shuttle loading time.
  - If VIP had no ride assignment, they were directed to PSA where ride requests were accommodated through stand-by, walk-on, etc.
- At the passenger check-in area:
  - Preassigned VIPs signed-in, and obtained "boarding pass"
  - VIP walk-ons could:
    - Sign-up for next open ride slot
    - Get on standby list for next available ride
    - Get on waiting list for ride on later Demo days
- The PSA functioned as a VIP waiting area (*See Figure 3.4.2-3 Passenger Staging Area Layout*) and included:
    - Video display - general AHS briefing
    - Refreshments
    - AHS displays distributed throughout room
    - Mentors (~6) to meet/greet and answer questions
- Passenger manager announced when scenarios were loading
  - Passengers escorted to shuttle loading area
- Shuttles identified by scenario color and linked to color coded boarding pass (See *Figure 3.4.2-4 Boarding Pass*)
- Shuttles transported passengers to staging areas
  - Narrator provided briefings
    - General safety briefing
    - Scenario briefing
- Passengers dropped off at north or south staging areas
- Passengers loaded into Demo vehicles and took "vehicle demonstration ride" on Interstate-15
- Passengers picked up at other end and shuttled back to Exposition site
- Total time to ride (from check-in at Exposition to unload at Exposition) was approximately 1 1/2 hours

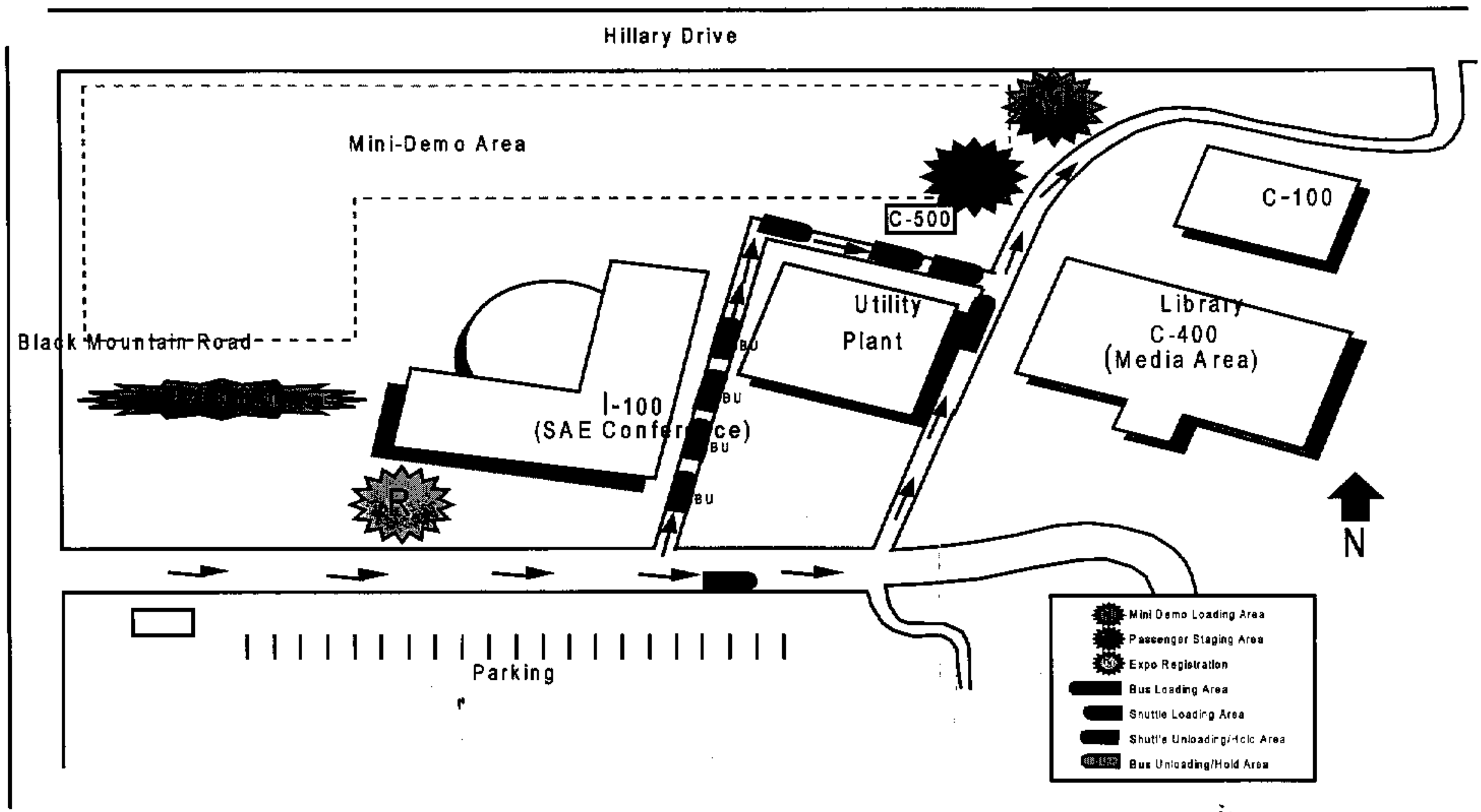

Figure 3.4.2-1 Miramar College - General Location Map

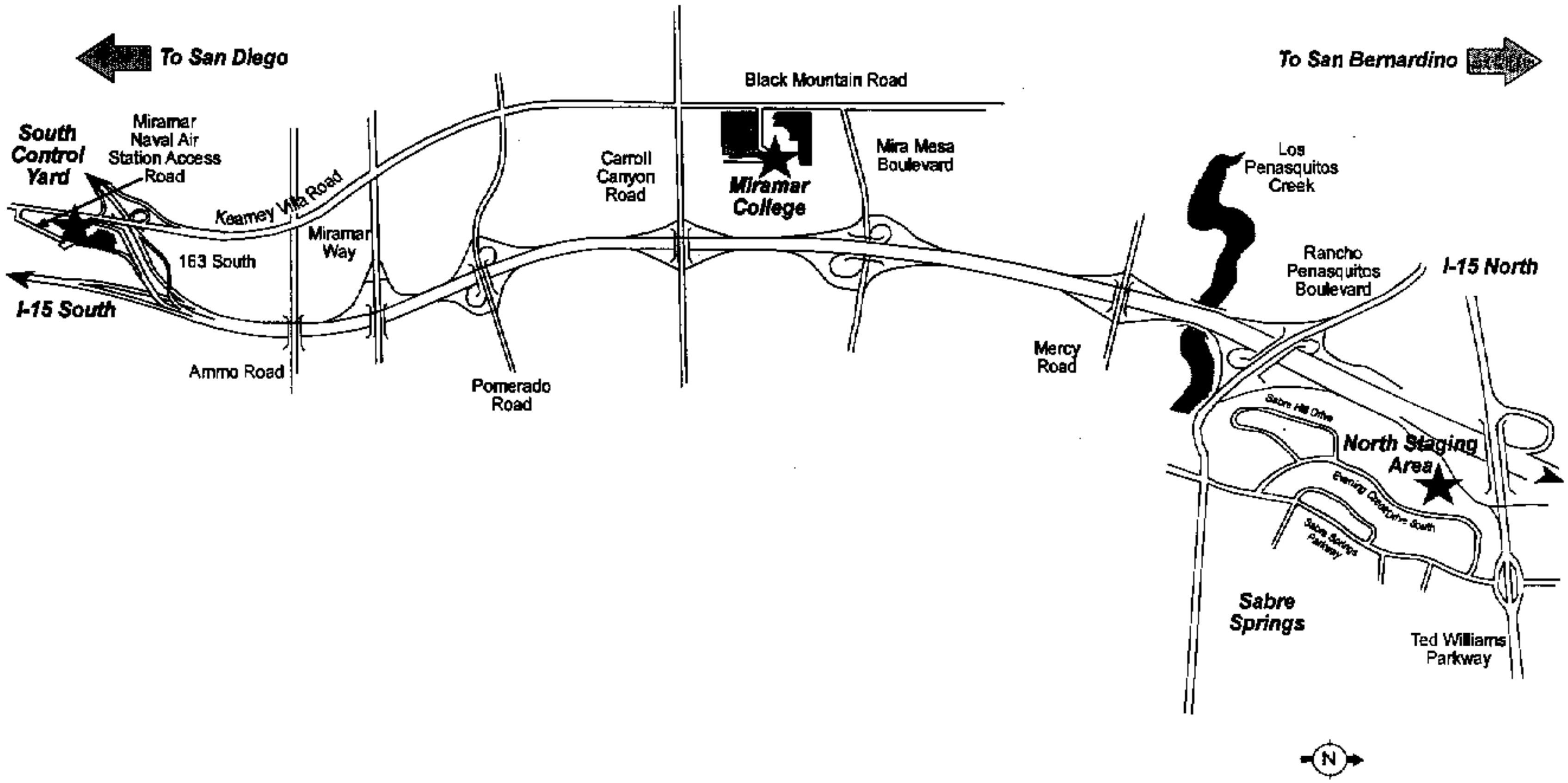

Exhibit 3
Area Map

Figure 3.4.2-2 Area Map

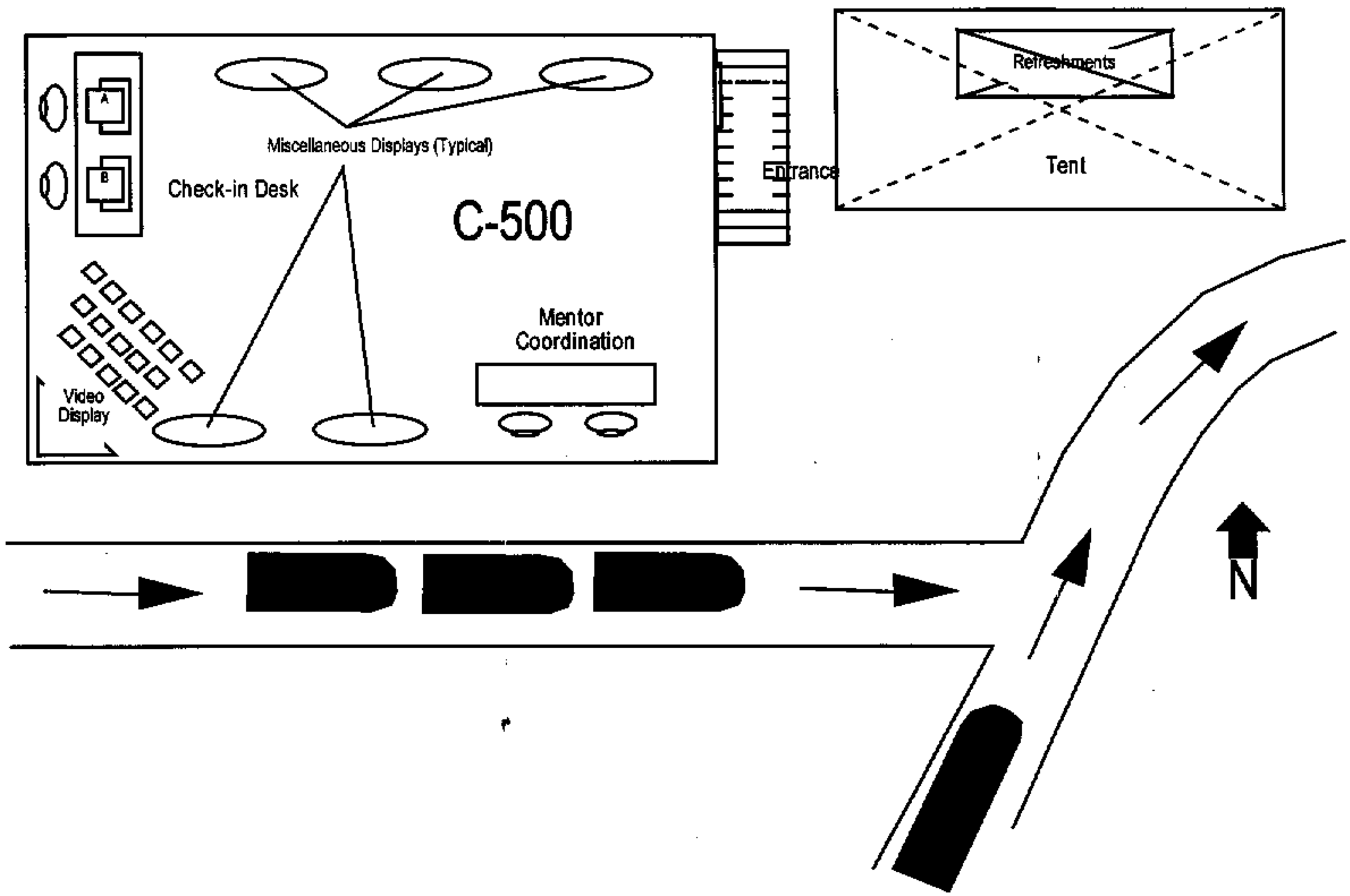

Figure 3.4.2-3 Passenger Staging Area Layout - (Enlarged)

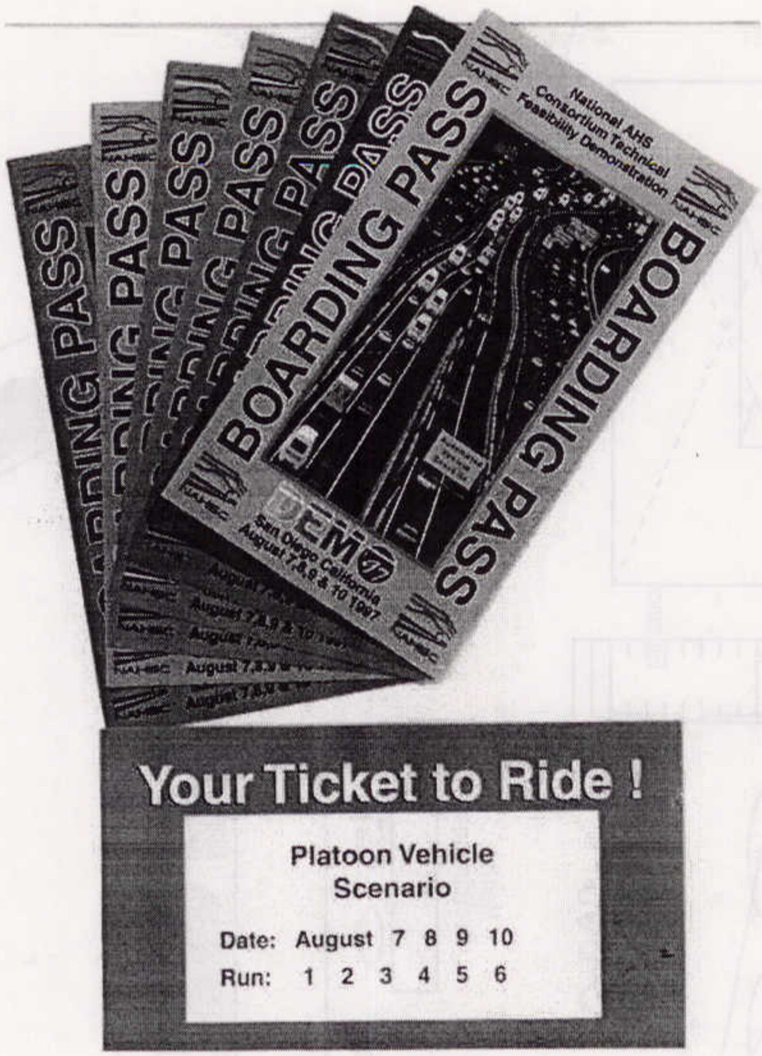

Figure 3.4.2-4 Boarding Pass

3.4.2.1 Shuttle Management Plan

There were seven vehicle scenarios as part of Demo '97. Each scenario was comprised of a set of vehicles working together to demonstrate the various technologies currently available. Each scenario serviced a different number of passengers. To aid in coordination of the many planning functions, each scenario had a designated color. Scenario information is summarized in Table 3.4.2.1-1.

Table 3.4.2.1-1 Scenario Summary

Scenario	Color Code	Maximum Number Passengers
Evolutionary	**Gray**	4
Free Agent, Multi-Platform	**Red**	34
Control Transition	**Blue**	4
Maintenance	**Orange**	2
Platoon	**Green**	16
Heavy Truck	**Purple**	3
Alternative Technology	**Tan**	4

During the demonstration, the vehicle scenarios demonstrated on Interstate-15 were deployed in the order shown and repeated several times throughout the day. The group of seven scenarios was considered one complete "run". The total number of demonstration runs with passengers is summarized in Table 3.4.2.1-2.

Table 3.4.2.1-2 Live Vehicle Demo Schedule (Planned Runs with Passengers)

Date	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Runs Per Day	Maximum Passengers Per Run	Maximum Total Daily Passengers
August 7, 1997	X	X	X	X			4	67	268
August 8, 1997	X	X	X	X			4	67	268
August 9, 1997	X	X	X	X	X	X	6	67	402
August 10, 1997	X	X	X	X	X	X	6	67	402
TOTALS							20		1340

Shuttle requirements are summarized in Table 3.4.2.1-3, based on 5 minute departure times, and utilizing separate shuttles for each scenario. Two separate "Teams" of shuttles were required, as indicated.

Table 3.4.2.1-3 Shuttle Requirements

Scenario	Shuttle ID	Shuttle Type	Maximum Shuttle Passenger Capacity
TEAM A			
Evolutionary	Gray A	Chevy Venture Mini-Van	4
Free Agent, Multi-Platform	Red A	Bus	40
Control Transition	Blue A	Chevy Venture Mini-Van	4
Maintenance	Orange A	Chevy Venture Mini-Van	4
Platoon	Green 1A	Chevy Express Van	10
Platoon	Green 2A	Chevy Express Van	10
Heavy Truck	Purple A	Chevy Venture Mini-Van	4
Alternative Technology	Tan A	Chevy Venture Mini-Van	4
TEAM B			
Evolutionary	Gray B	Chevy Venture Mini-Van	4
Free Agent, Multi-Platform	Red B	Bus	40
Control Transition	Blue B	Chevy Venture Mini-Van	4
Maintenance	Orange B	Chevy Venture Mini-Van	4
Platoon	Green 1B	Chevy Express Van	10
Platoon	Green 2B	Chevy Express Van	10
Heavy Truck	Purple B	Chevy Venture Mini-Van	4
Alternative Technology	Tan B	Chevy Venture Mini-Van	4

NOTES:
1. Team A served passengers on Run Numbers 1, 3 and 5. Vehicles traveled from Miramar College to South Control Yard to North Staging Area to Miramar College.
2. Team B served passengers on Run Numbers 2, 4 and 6. Vehicles traveled from Miramar College to North Staging Area to South Control Yard to Miramar College.

Shuttle management responsibilities included the following:
- Developing shuttle schedules for each Demo Day
- Driver training and coordination (Driver checklist is included in the Demonstration Planning Document, Appendix A of this report.)
- Shuttle storage, cleaning, and fueling
- Shuttle contingency plans to address shuttle breakdowns, passengers missing shuttles, etc.
- Developing shuttle main and alternate routes
- Shuttle communications during demonstration

3.5 Exposition Production

Located at Miramar College, adjacent to the Interstate-15 on-lane demonstrations, the Exposition Center offered an in-depth look at innovative technologies and products. In addition to the on-lane demonstrations, the Exposition Center provided visitors with an opportunity to learn how an automated highway system (AHS) could significantly improve highway travel. The Exposition Center included an Exposition Hall, outdoor displays and a complex of closed road courses for mini-demonstrations of automated vehicle technologies.

3.5.1 Exposition Hall

At the entry of the 33,000 square foot Exposition Hall, the National AHS Consortium hosted a 4,000-square-foot "Welcome to AHS" area designed to educate and inform the public and stakeholders about the history of AHS, the workplan of NAHSC, and the value of AHS as one component of a national transportation strategy. The exhibit included a time line tracing the history of the development and execution of the AHS concept; mini-booths focused on specific issues and NAHSC activity areas; videos on AHS systems testing, discussion of benefits, and discussion of applications; computer simulations; descriptions of activities occurring at Demo '97; NAHSC and Demo '97 literature; and live-feed video from the demonstration lanes and Outdoor Technology Demonstrations. The exhibit also included a seating area for meetings, discussion and relaxation. Specific subject areas, addressed via mini-booths in the exhibit, were:

- Solving Users' Problems (User Needs)
- Partnerships Lead Us Forward (Public and Private Partnerships)
- Driving Toward the Future (Future of AHS)
- Meeting Needs of Communities (Case Studies)
- Everyone Benefits (Benefits of AHS)

The NAHSC exhibit was staffed by more than 20 members of various NAHSC Core and Associate Participants. These individuals shared their knowledge and experiences with an estimated 1,500 visitors over the course of the four day demonstration. Visitors ranged from school children to Members of Congress. They were also able to see how the showcased technologies could significantly reduce the transportation problems that plague motorists today and threaten the safe and efficient travel of tomorrow.

Within the main section of the Exposition Hall more than 35 exhibitors showcased their latest products and technologies. The exhibitors were:

- 3M Intelligent Transportation Systems
- Advanced Cruise-Assist Highway System Research Association (AHSRA)
- Air Force Development Test Center (AFDTC/DRX)
- American Honda Motor Co. Inc.
- Barrier Systems, Inc.
- Bechtel
- C.J. Hood Company, Inc.
- Caltrans
- Cohu Inc., Electronics Division
- dSpace, Inc.
- Dynamic Technology Systems Inc.
- Eaton VORAD Technologies
- Enerdyne Technologies, Inc.
- Federal Highway Administration

- General Motors
- Hodges Transportation Inc.
- Houston Metropolitan Transit Authority
- Inbound Logistics Magazine
- ITS America
- ITS World Magazine/GPS World
- Lockheed Martin
- Massachusetts Institute of Technology
- Minnesota Guidestar
- National Highway Traffic Safety Administration
- National Safety Council
- Navigation Technologies
- Ohio State University Center for ITS
- Parsons Brinckerhoff / Farradyne Inc.
- Raytheon E-Systems
- Rijkswaterstaat Verkeer en Vervoer
- Roads and Bridges Magazine
- Toyota Motor Corporation
- Traffic Technology International
- Transport Technology Publishing
- Transportation Research Board
- Transportation Research Center, Inc.

Additionally, the Exposition Hall included the Demonstration Presentation Center (DPC), where live and pre-recorded scenes of the live vehicle demonstrations as well as technical information associated with highway and vehicle automation were presented. Outside exhibits also featured displays of test vehicles and their AHS-related technologies. Figure 3.5.1-1 depicts the layout of the Exposition Hall.

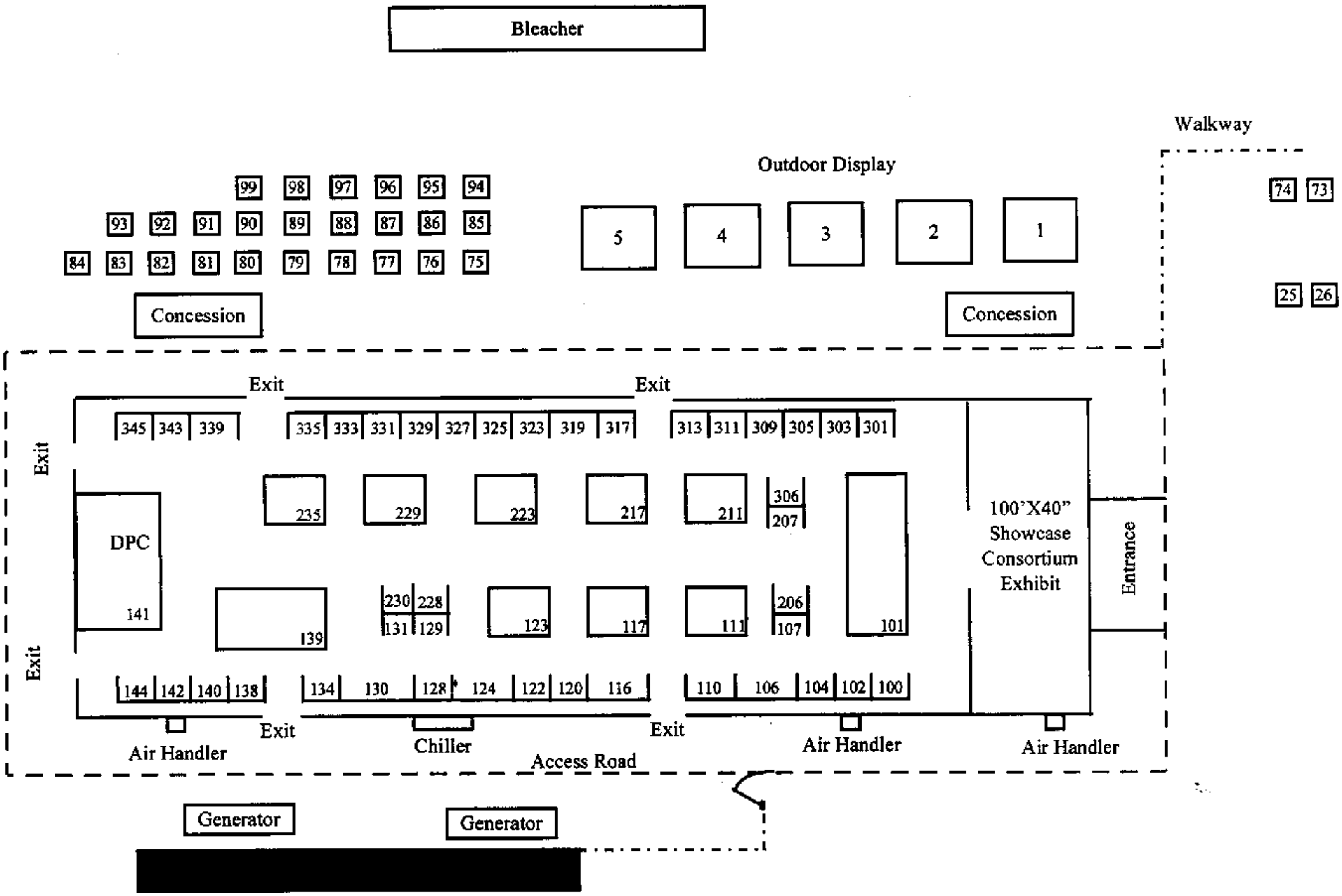

Figure 3.5.1-1 Demo '97 Exposition Hall Layout

3.5.2 Outdoor Technology Presentations and Displays

In addition to the technical displays in the Exposition Hall, the following key exhibitors showcased their latest products and demonstrated advanced vehicle control systems (AVCS) in action, using more than 180,000 square feet of outdoor area.

Demo '97 Exposition Center Outdoor Technology Presentations:

- 3M
- General Motors/University of California - Berkeley - PATH
- Honda
- The Ohio State University
- Caltrans/University of California - Davis
- Unmanned Ground Vehicle Student Competition

Demo '97 Exposition Center Outdoor Displays:

- Houston Metro
- National Highway Traffic Safety Administration
- The Ohio State University
- Caltrans/University of California - Davis

3.5.3 Demo '97 Exposition Center Sponsors

Some of the sponsors of the Exposition Center included:
Buick Motor Division – Corporate Sponsor,
Barco Visual Systems – Visual Equipment for the Demonstration Presentation Center,
Enerdye Technologies Inc. – Decompressor Equipment and,
Hewlett-Packard Company – Computer Equipment.

3.5.4 Mini-Demonstration Track

Adjacent to the Exposition Hall was a half-mile demonstration track where hundreds of attendees got first-hand experience riding in several automated vehicles. A specially equipped Buick LeSabre, Honda Accord and vehicles sponsored by 3M and The Ohio State University demonstrated two key AHS functions -- automatic steering control and lane departure warning -- for a wide variety of curious attendees. The mini-demonstrations, which were held outside on adjacent, test tracks, are described in Section 2.2 of this report.

3.5.5 Demonstration Presentation Center (DPC)

The DPC was an integral part of the Exposition Hall, which provided a platform to allow the Exposition attendees to participate in Demo '97. The DPC provided live video coverage of the Interstate-15 high-occupancy lanes vehicle demonstrations, generated map displays tracking vehicle positions, allowed playback of pre-recorded video and supported speakers with an audio visual platform to describe the Demo '97 activities.

The DPC was derived from several NAHSC Core Participants' experience in deploying Transportation Management Systems (TMS) with the additional functionality to support the production and presentation aspects of Demo '97. While a TMS is a computerized system for detecting and displaying field traffic conditions and providing control over resources that can improve the flow of traffic, the DPC was restricted from controlling any aspect of the live vehicle demonstrations on the Interstate-15 HOV lanes.

The DPC was one of many venues at the Exposition Center through which the public could better understand the Demo '97 and the technology represented. The DPC introduced AHS concepts in a setting which was familiar and comfortable to many of the stakeholders in attendance. It also provided the ability to showcase the live vehicle demonstrations for thousands of Exposition attendees who might not have had the opportunity to actually experience an automated vehicle scenario first hand.

The DPC live video coverage of the Interstate-15 vehicle demonstrations was facilitated by live video and communications links including field cameras, video encoder/decoders, telephone line interconnections, voice radio, and telemetry equipment. Field cameras were installed at locations along the Interstate-15 HOV route which provided good visibility and power/telephone connectivity. Nine cameras were installed at the following locations:

1) State Route 163 and Interstate-15 #1
2) State Route 163 and Interstate-15 #2
3) Ammunition Road Via Duct
4) Pomerado Road Via Duct
5) Mira Mesa Boulevard Via Duct
6) South Mercy Road
7) Poway Road Via Duct
8) State Route 56 and Interstate-15 #1
9) State Route 56 and Interstate-15 #2

Each installation included a pole mounted camera with auto-iris, pan/tilt, and zoom drivers, camera control unit, and video encoder. Video was encoded to motion JPEG digital standards and transmitted over telephone T-1 circuits. Video frame rates of about 13-15 frames per second were achieved. The video was transmitted to the DPC in the Exposition Hall and the South Control Yard adjacent to Interstate-15.

Three to six live vehicle demonstration scenarios were highlighted each day. If a live vehicle demonstration scenario could not be highlighted as it occurred on the Interstate-15 HOV lanes, the scenario team was provided an opportunity to present those scenarios from pre-recorded video. When scenarios were not presented, the DPC provided a platform for presentation of related pre-recorded audio-video clips and in an "infomercial" format.

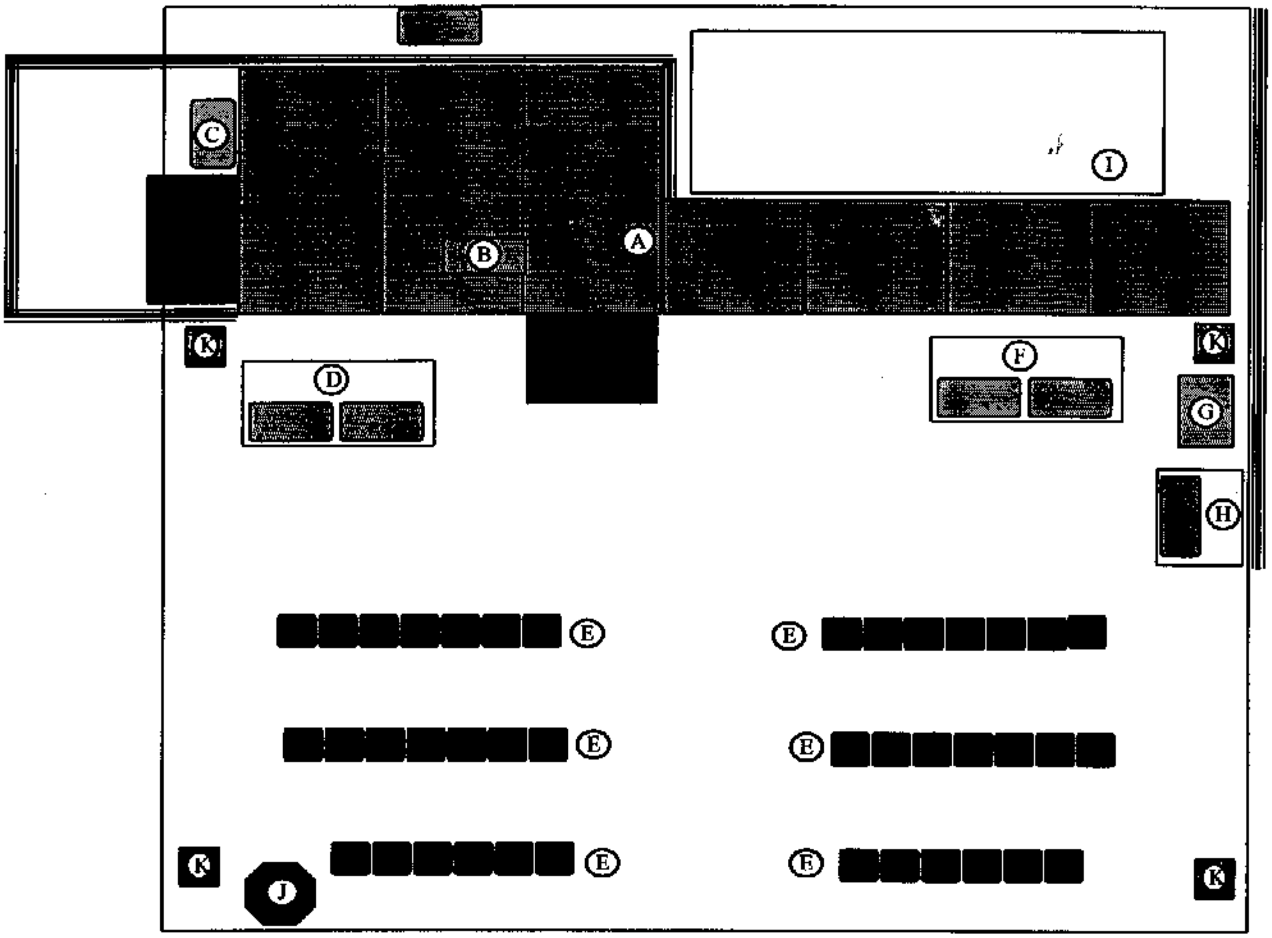

Figure 3.5.5-1 Demonstration Presentation Center Layout

The DPC included computers, video wall, video processing and an audio system. Key features of the DPC included:

A. Stage (8' x 28', elevated 36" with a video wall cut-out)
B. Podium workstation with flat panel touch screen to facilitate slide presentation
C. Sound workstation with amplifiers, balancers and mixers. (Operator with headset)
D. Tracking and telecommunications workstations. (Two operators with headsets)
E. Audience seating for 40 people.
F. Production and video workstations. (Two operators with headsets)
G. Video decoding and switching racks
H. Recording/playback workstation operated by production manager.
I. Video wall with 3' x 2' screens (Composite total 8' high x 13.5' wide, screen bottom 5' above the floor)
J. Kiosk for Exposition attendees to query information on Demo '97
K. Loud speaker stands. Lower left stand with 2 CCTV cameras
L. The Management Information System for Transportation (MIST)

MIST has been developed by PB Farradyne Inc. (PBFI). to provide a platform from which customized traffic management and Intelligent Transportation Systems can be produced.

The design of the DPC application by PBFI included a SQL database for vehicle identification, location, time stamp and check-in/out logging. The operator interface included open GL graphics with a 3D viewing feature which could show the actual vehicle locations in real time on a scaled drawing of the I-15 demonstration site. The system also included a simulation of regional traffic congestion with appropriate colors and symbols and a changeable message sign control interface and true display of messages for the DPC. The operating system software was Windows NT 4.0.

For the development and testing of the system, PBFI developed data tables which emulated each of five specific vehicle scenarios which provided an accurate simulation display.

3.6 Infrastructure Development

The Infrastructure development function ensured that all Demonstration facility were developed, available, and safe to execute Demo '97. Responsibilities of this function included: development of the South Control Yard, North Staging Area, HOV lanes, site communications, site logistics, site services, site security, and vehicle storage.

3.6.1 South Control Yard

The South Control Yard (SCY) was located on a parcel of land adjacent to the entrance ramp to Route 163 from Kearny Villa Road. The SCY had entrances at the south end, via a military roadway to which an easement was acquired, and the north end providing bi-directional, barrier-protected access to the high occupancy vehicle (HOV) lanes. This was the primary location where vehicle servicing takes place. The SCY was comprised of a temporary service building, where offices, workshops, and garage facilities were located, and a temporary storage structure, which was used for overnight storage of the vehicles, as well as the loading area for passengers. Associate Participants had space available to them to set up temporary vehicle servicing and storage facilities.

The perimeter of the SCY was completely fenced. Native landscaping was also placed around the perimeter of the yard. A 5,000 square foot service building was built to accommodate the required maintenance, vehicle equipment testing, and to house the Command Center. The service building provided laboratory space, office space, storage space, vehicle work bays, two hydraulic vehicle lifts, and compressed air.

A double-wide conference trailer was leased to accommodate the daily vehicle briefings and other meetings at the SCY. An office building trailer was leased to accommodate the 24 hour security functions at the SCY. Space was allocated for Core and Associate Participants to set up temporary office building trailers.

3.6.2 North Staging Area

At the north end of the lanes was the North Staging Area (NSA). A parcel of land adjacent to the Interstate-15 exit ramp to Ted Williams Parkway was leased to develop as a staging area at the north end of the HOV lanes. This area was the focal point for exposure of the demonstration vehicles to the media during the demonstration days. This was also the principal hospitality area (on the lanes) for the Very Important Persons (VIPs). The area contains a hospitality tent, a media tent, and a driver break area.

Caltrans contracted for the paving of the NSA, complete fencing, yard lighting, and electrical power and telephone service. The NSA contained areas for participant vehicle parking (between demonstration runs), display tents, a restroom trailer, and a single-wide office trailer. The Caltrans contract also provided for a 24-hour security guard at the NSA. In order to provide access to the NSA, a detour exit ramp was constructed from the Interstate-15 mainline lanes. This temporary ramp enabled mainline traffic to exit to Ted Williams Parkway beyond the driveway to the NSA allowing the original exit ramp to be closed. Demonstration vehicles were then able to exit the HOV lanes directly into the NSA without encountering public traffic.

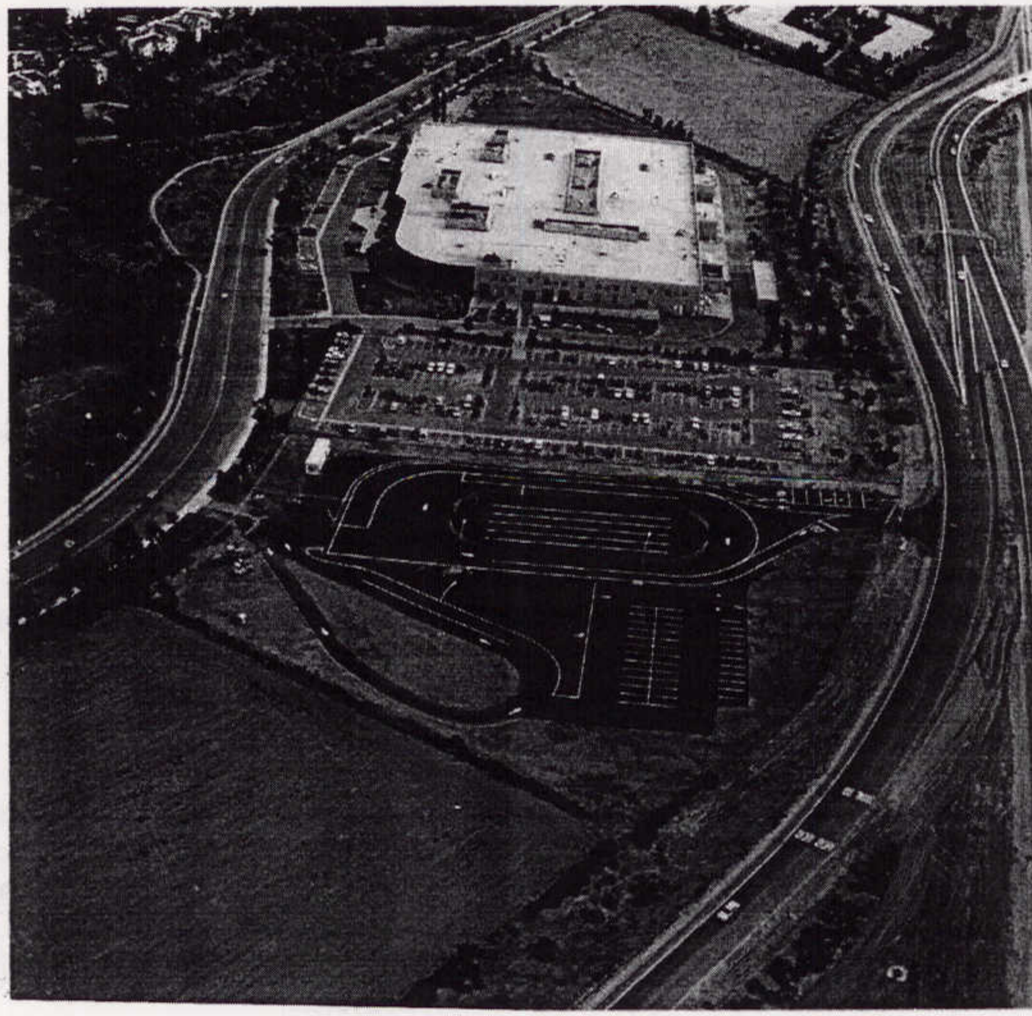

Figure 3.6.2-1 North Staging Area

3.6.3 HOV Express Lanes

Magnetic markers were installed into the concrete pavement in both lanes for 16 lane miles at 1.2 meter spacing along the center of the traveled way to support the PATH lateral guidance technologies. Single cylindrical magnets were approximately one inch in diameter by one inch long. In most locations, four ceramic magnets were installed together. On bridge structures, one rare earth magnet, far stronger and more costly than the ceramic magnets, was installed. This was to avoid drilling a five-inch-deep hole into the structural section. The magnets will remain in place for future testing and development.

While most of the length of the HOV lanes were separated from the mainline lanes by concrete barrier, a two mile portion was chain-link fence only. In order to create an environment where

AHS vehicles were 100% isolated from public traffic, a temporary concrete barrier was installed on the shoulder of the HOV lanes along this two mile section.

Nine Closed Circuit Television (CCTV) cameras were installed along the length of the HOV lanes. These cameras facilitated live monitoring of the Demo by the Command and Control Center at the SCY and by the Demonstration Presentation Center at the Exposition site. The cameras remained in place for use after Demo '97 by Caltrans Traffic Operations in the Transportation Management Center.

The radar-reflective traffic striping tape was installed (provided by 3M corporation) along a three mile length of the HOV lanes. Four miles of tape was installed - two miles in each lane, with one mile of overlapping (installed in both lanes at the same location). The radar-reflective tape was in support of the Ohio State University scenario. The tape was removed during post-demo restoration work.

To prepare the lanes aesthetically, Caltrans contracted to restripe and remarker the entire length of the HOV lanes. Caltrans maintenance forces provided litter pick-up, weed removal, sweeping and graffiti removal along the corridor.

3.6.4 Communications

A 50-pair telephone trunk line was purchased to feed the South Control Yard. A portion of this telephone trunk line was made available for activation for Associate Participants (including Toyota, Honda R&D, Ohio State University, and Houston Metro) and Core Participants operations. Telephone line uses included voice, file transfer and facsimile functions. A 24-line capacity telephone access point was provided for at the North Staging Area for multiple users (operations and media). Seven telephone lines were activated .

Eleven T1-grade lines were activated to accommodate the video data communication functions required to send live video from the vehicle demonstration facility to the Demonstration Presentation Center and to the Command Center. Caltrans installed, operated, and maintained the live video system. Mobilization of the video system equipment from the operations center to the Demonstration Presentation Center for the demonstration period took place over a very short time frame. This entailed extensive troubleshooting and regular monitoring once the system was operable.

The State of California Office of Emergency Services provided 44 hand-held radios with three local site direct frequencies for production staff working within each staging area. A UHF radio repeater for voice communications was installed and 32 hand held radios for operations personnel including California Highway Patrol (CHP), Traffic Management Center (TMC), tow service, and ambulance were furnished. The radio repeater provided a dedicated channel with continuous coverage for demonstration personnel along the corridor. All vehicles participating in the demonstration were required to be equipped with radios capable of communicating through the dedicated repeater.

A gasoline powered back-up power supply for the radio repeater was provided.

3.6.5 Site Logistics

3.6.5.1 Vehicle Test Management

Caltrans staff managed the corridor during the vehicle test periods. Vehicle test managers coordinated with the Traffic Management Center (TMC) and the California Highway Patrol (CHP) to conduct vehicle testing for Core and Associate Participants. The testing could only take place when the corridor was normally closed to public traffic. This left mid-day on week days, night time, and weekends available for vehicle testing. The test manager had to first verify that the corridor was clear and then proceed to secure the corridor (i.e. close the gates and set up any required traffic control devices). The test manager would then supervise the testing activities, provide coordination between multiple test parties, maintain appropriate communication with the TMC and CHP, and maintain a safe operating corridor, free from intruders.

Caltrans provided at least seven utility trucks for corridor operations. Five staffed trucks were dedicated for vehicle demonstration scenario obstacle placement.

3.6.5.2 Fueling

Participants were not allowed to store fuel on-site. On-site fueling arrangements were initially facilitated by Caltrans. A particular vendor was solicited and given the contact information for each of the participants and visa versa. Participants collaborated to schedule on-site fuel deliveries. The Participants handled their individual billings with the vendor.

Maintaining an on-site fueling vendor became difficult. This was probably due to legality regarding the requirement for an approved vapor recovery system. Apparently none of the vendors were equipped with such a system. Over the course of the testing period, dress rehearsals, and demonstration period, several vendors were used.

After reliable fuel service became an issue, the installation of a temporary on-site fuel storage system was considered. The process for funding and approval to install a temporary storage system was not pursued due to the cost, time, and coordination involved at that juncture. Therefore, vendor fueling continued as scheduled service.

3.6.5.3 Toilet and Servicing

A self-contained restroom trailer was purchased and erected at the South Control Yard. The restroom required water delivery and waste removal service, provided by Caltrans. Timing the service calls to satisfy the actual usage proved to be challenging. Ultimately, the service frequency was increased to exceed the demand at a higher cost. A self-contained restroom trailer was rented and put in place at the North Staging Area. The cleaning and servicing of that restroom facility was accomplished by an included service contract.

3.6.5.4 Food Services

Staff would typically have meals off-site. Drinkable water and disposable cups were provided on-site. The NAHSC provided meals on-site during the dress rehearsals and the demonstration. An effort was made to schedule a food truck for on-site purchases, but due to the available testing time being between 9:30 AM and 1:30 PM, an acceptable time for everyone was not found and the service did not last long. Small snacks were available for purchase in the main lobby of the service building at the South Control Yard.

3.6.5.5 Medical Teams

An ambulance company was contracted to maintain a standby unit at either end of the live vehicle demonstration facility during the demonstration period and part of the dress rehearsals. Each ambulance unit provided two emergency medical technicians.

3.6.5.6 Tow Service

AAA sponsored several standby tow units at either end of the live vehicle facility and at the Exposition site during the demonstration period. One tow unit was stationed at each end of the live vehicle facility during the dress rehearsals. Houston Metro contracted a bus tow service during the demonstration period.

3.6.5.7 California Highway Patrol

Several units from the California Highway Patrol (CHP) were on hand to assist with maintaining lane closures and patrolling the outside perimeter of the live vehicle facility during the dress rehearsals and the demonstration period. The CHP frequently assisted by responding to sightings of stopped vehicles, potential pedestrian encroachments, and other mainline traffic incidents which might have caused delays to the demo.

3.6.5.8 Security

While demonstration vehicles were on-site at the SCY, Caltrans provided multiple 24-hour security guards to safeguard NAHSC vehicles and equipment. Both staging areas were physically secured with fencing. Security personnel logged staff and visitors in and out of the facility at a single access point.

3.6.5.9 Janitorial

A company was contracted to provide daily cleaning service for the restroom, office buildings, and operations center.

3.6.5.10 Equipment and Supplies

The following equipment and supplies were provided:
- Paper copiers, facsimile, and paper products
- Two floor mounted vehicle lifts and exhaust extraction blowers in the temporary service building
- Barrels/drums to represent roadway obstacles during the demonstration
- Hard hats and orange vests required for anyone working on the highway right of way.
- Four hundred fifty (450) orange cones for lane delineation at Miramar College mini-demo area.
- A back-up generator for the SCY.
- Miscellaneous rental equipment needed for the dress rehearsals and demonstration including tents, tables, umbrellas, chairs, stanchions, refrigerator, microwave, NSA restroom trailer and servicing, landscaping, etc..
- Informational signage.

3.7 Public Education

This section describes the strategy employed in planning for the public-education portion of the Demo '97 including preparations for the event, media events, communications materials, and a summary of a post-demonstration Congressional briefing on Demo '97.

The public education portion of the Demo '97 team helped plan the events to maximize communications and to ensure that the substance of the event was explained accurately and completely to all interested parties. The objectives of the public education effort were to:
- Communicate that Demo '97 met the Congressional mandate to demonstrate the technical feasibility of vehicle-highway automation, and emphasize the event's history-making aspects
- Increase the awareness of automated highway system technologies and the projected benefits to the stakeholders
- Explain the need for continuing NAHSC research

A large part of Demo '97 involved educating key stakeholders about AHS, the Consortium and the potential benefits of vehicle-highway automation. The stakeholders translated into the following targeted audience for the event:
- Federal government officials, congressional representatives and their staffs, and the U.S. Department of Transportation
- State and local transportation policy makers
- AHS-related (stakeholder) industry management/policy makers

- International, national and local print and broadcast media -- both general and technical
- The technological community including academia, the intelligent transportation systems (ITS) industry and most of the stakeholder category industries: automotive, electronics, construction, engineering design, insurance and the legal profession
- Transportation Users: Commercial fleet and private vehicle drivers and future drivers. Also user associations/groups such as the American Automobile Association
- International government and transportation officials, the global technical community and international (stakeholder) industries

3.7.1 Public Education Preparations

The public relations team was responsible for, and developed plans for, media relations and general public education. The strategy followed was to:

- Mobilize the Participant network to create a "multiplier effect," ensuring effective dissemination of key messages to target audiences.
- Organize various press events, building to Demo '97. Communicate strategic messages proactively and provide a range of coverage opportunities to the media.
- Develop informational materials that could be used to fulfill the numerous and wide ranging inquiries by different stakeholder groups.

Each (Core and Associate Participant organization that was demonstrating was asked to assign one public relations representative. This representative was responsible for getting organization-specific information, including graphics, to the Consortium and sending information about the Consortium to their internal and external publics. This network of PR representatives ensured consistent messages across all Participant organizations and each served as a distribution point to extended target audiences.

Each of the representatives provided key visuals to the Consortium's photo and video library as well as providing public relations support, including executive spokespeople, signage and organization-specific literature at the Demo press events.

The NAHSC Public Education team sent "multiplier effect" packages to each Participant Public Relations representative prior to the Demo, enabling consistent, accurate and streamlined two-way communications whenever possible.

The packet was sent in June, containing:

- Demo '97 Public Education calendar of events
- NAHSC media events plan
- NAHSC demo-specific key messages
- NAHSC press kit
- Demo '97 media contact guidelines
- Media contact report form
- Press event notification form

- Speaker's bureau Information form
- Consortium style guide
- Electronic and camera-ready hard copies of the NAHSC Demo '97 logo
- Demo '97 overview video
- NAHSC Demo '97 team contact list

The media contact guidelines, media contact report form, press event notification form and style guide were developed to streamline the communications process and ensure that the public education team was aware of all AHS-specific plans and communications disseminated by each of the Participant organizations.

In March, 1997, a meeting of Participant public relations representatives was held to explain the public education plans and begin the "multiplier effect." A slogan was developed and a potential crisis brainstorming session was held in preparation for full crisis plan development. The contracting public relations agency and all Participant public relations representatives were introduced. Initial information packets were handed out.

A Calendar of Events was created and distributed to all members of the Demo Team (including the Participant PR representatives.). The purpose of this calendar was to coordinate all of the Demo '97 main and ancillary events, helping spokespeople, PR representatives, etc., build these events into their schedules.

The Public Education team was tasked with keeping the Demo Team network updated on public education campaign plans, including the long-lead and short-lead media days. A memo outlining plans and events was sent via mail, e-mail and fax to each of the representatives and the vehicle development teams several weeks prior to the respective events.

The NAHSC and each Participant organization developed key message documents and forwarded key still and video photography to create the Demo '97 libraries. Messages and photography drawn from these libraries formed the basis for the communications materials described elsewhere in this report.

Several task forces were created within the public education team to focus on specific priority tasks. Among those formed: Messages and Materials; Ancillary Events; Invitations; Web Page; Exhibit Booth and Regional Campaign. Below are examples of the activities of these task forces:

- **Messages and Materials** - This task force was formed to create Demo-specific key messages, the event's slogan, a version of the NAHSC logo specific to the Demo and plan the content and production of all communications materials, incorporating Participant messages and visuals. A complete list of materials developed is detailed later in section 5.3.
- **Ancillary Events** - The Society of Automotive Engineers (SAE) Future of Transportation Technology conference, NAHSC welcome reception at the Presidio, August 8th reception

sponsored by the California Alliance for Advanced Transportation Systems (CAATS) and several sight-seeing trips were coordinated by this task force.

3.7.2 Media Events

The Consortium held three days of pre-Demo '97 press events, providing each of the public relations representatives with several opportunities to publicize organization-specific messages during these press events. In addition, Honda, Ohio State University and Buick/U.C.-Berkeley PATH (two events) each held separate press events where they provided invited guests and the media with an opportunity to ride in their demonstration vehicles on a test track and learn about their vehicles' technologies and their involvement in Demo '97.

3.7.2.1 Long-Lead Media Day

A long-lead event was held to accomplish two objectives: First, the Public Education team wanted to be able to accommodate media outlets that would need more time to compile their stories (i.e., monthly magazines). The team also wanted to invite top-notch media to an early event so their coverage would interest additional media to cover the Demo.

Long lead was a two-day event (with three scenarios running on the first day and the other four scenarios running on the following day) in which invited members of the press had the opportunity to ride in the scenarios, interview representatives from the NAHSC and each of the technical teams, shoot footage with their correspondents on-site and (often) in-vehicle.

Each of these days began with a background briefing about the NAHSC, AHS technologies and Demo '97, followed by rides in the demo vehicles and interview opportunities. The schedule was as flexible as safety and operations allowed, so that the various coverage needs of the media could be met.

The media boarded scenarios at the South Control Yard (SCY) and did one run to the North Staging Area (NSA). Once at the NSA, they unloaded and had additional opportunities to visit each of the technical teams who had set up displays showcasing their scenario in separate tents. Refreshments and general /NAHSC displays were set up in another separate tent.

Once the last scenario arrived at the NSA, the media then reloaded for a second ride back to the SCY. After additional opportunities for interviews and lunch, the event concluded. A total of 24 media representatives attended both days.

3.7.2.2 Short-Lead Media Day

The short-lead media day was structured similarly to the long-lead days, with changes due to more than triple the number of media representatives in attendance and tighter timing due to all seven scenarios running on one day.

The Consortium provided each vehicle development team with a display table where they provided information about their AHS scenario. Each of the public relations representatives were invited to the press briefing and asked to brief the media about their scenarios, prior to the media's selection of scenario. The public relations representatives were also given the opportunity to invite an executive spokesperson from their organization to attend the event for interview opportunities. All 15 of the Participants had an executive spokesperson attend this event.

A ticketing process was created to place media representatives in the demo vehicles. After the press had an opportunity to talk to each of the technical teams about specific technologies being showcased, they proceeded to a ticket table to receive a ticket for their scenario of choice. This process helped to ensure every media representative got at least one ride in a demo vehicle. Seventy-six media representatives attended this media day.

3.7.2.3 Demo Days

Each of the organizations were invited to hold a press conference on the opening day of the Demo, detailing their organization's involvement in the demonstration. The Consortium provided the press conference room including podium, head table, chairs, a/v equipment, refreshments and promotion of the conferences on the press room bulletin board, in the Demo '97 daily newsletter and in media alerts. Six press conferences were held and the majority of the press present that day attended one or more conference. The total number of press that attended Demo Days was 80.

A press work room was provided for members of the press to work during the Demo. The room was located in the Miramar College Library and offered access to a fax machine, computer modem, copy machine, literature table and work supplies. A secluded room was available for the press representatives to conduct one-on-one interviews with NAHSC spokespeople or executive spokespersons from Participant organizations. In addition, each of the Participant organizations placed media information and displays in the press work room.

3.7.2.4 Opening Ceremony

Fifteen executive-level representatives from each of the demonstrating Participant organizations and five from the local Participants were on hand for the opening ceremony held the morning of the first Demo Day. A Marine color-guard began the official opening and a ceremonial ribbon printed with the Demo slogan "Where the Research Meets the Road" was cut by the group. Congressman Rod Packard was driven to the stage in an automated Buick LeSabre. He and Congressman George Brown spoke to the audience of approximately 300, followed by remarks by Terry Quinlan, NAHSC Test and Demonstration manager, Program Manager Jim Rillings and the deputy mayor of San Diego. A video taped message from Rodney Slater was also shown to the group via large-screen monitor.

3.7.3 Communications Materials

A range of literature was produced to communicate the details of Demo '97; each featured a similar look but ranged in size and content. The distribution of communications material is reflected in Table 5.3-1 NAHSC Demonstration '97 Communications Distribution Summary

Table 3.7.3-1 NAHSC Demonstration '97 Communications Distribution Summary

COMMUNICATION FORMAT/SUBJECT	CONTENT DESCRIPTION	METHOD(S) OF DISSEMINATION	DISSEMINATION DATE(S)/TIME(S)	TARGETED RECIPIENTS
Senator Rides - News Release	Sen. Chafee rides in PATH demo car in San Diego	fax w/ phone follow up	3/27/97	D.C.-based print media
Post-USA Today Interview Op Notice	Notification, summary of article in USA Today, interview op. w/spksppl.	fax	4/9, 4/10	electronic press (TV, radio)
USA Today Editorial Response Letter	Response to negative letter from H. Dittmar	placement in USA Today	4/15	USA Today "Letters to Editor" editor and J. Healey
(Pre-) Memorial Day News Release	AHS as solution to traffic congestion ppl. Encounter trying to get out-of-town	fax	5/22	national media, media in cities w/ traffic congestion
ITS America Annual Meeting News Briefing	Demo '97 details	fax media alert wk. before; follow-up calls day before; spksppl. remarks, Q & A	5/27, 6/3	ITS trade press and D.C. transportation/automotive correspondents
NAPS Article	Demo '97, AHS concept, NAHSC mission/vision	through NAPS dist.	6/9	small town dailies/weeklies
Media Alert - Long Lead Media Days	Opportunity for media to test-ride AHS at event	fax w/ phone follow-up	7/7	top 75 national media
Demo '97 Press Kit	Kit with background, Demo '97 details	mass-mailing	7/28, 29	top 200 from media list
Media Alert - Short Lead Media Day	Short-lead media days info./invitation	fax w/follow-up calls	7/28, 8/4	key national and S. Cal. media (brdcst./print)
Demo '97 News Release	Demo '97 details, descript. of AHS technologies	PR Newswire placement	8/7	U.S. media, primarily newspapers
Video News Release	AHS as solution to highway probs., Demo '97 bkgrnd.	Medialink-national release, follow-up fax, calls	8/7	U.S. TV networks/local news
Radio News Release	AHS as solution, Demo '97 bkgrnd., Slater bite	notification and follow-up by North America Network	8/7	U.S. radio stations that produce their own news
Demo '97 Opening Ceremony/NAHSC Press Briefing	Congressmen, local and NAHSC remarks, Demo '97 as historic event	staged ceremony, remarks, Slater video taped remarks at Exposition Center	8/7	400+ Demo '97 attendees
Demo '97 Results News Release	Congressional mandate met, successful event, total numbers (ppl./miles driven)	fax	8/18, 8/21	media attendees, then top 200 media from list

3.7.3.1 Information/Press Kit

An information/press kit was distributed at media events, conferences, meetings, display booths and in response to individual inquiries requesting information about the NAHSC, AHS and Demo '97. The kits included:

- Lead press release (outlining the objectives of the Demo '97 as well as giving an overview of what technologies will be showcased)
- Exposition press release (gave information on what type of events would be held at the Exposition Center at Miramar College)
- AHS fact sheet
- Historical background of AHS
- Specific to the press kit:
  - Photos with cut-lines
  - Slides with reference sheet

3.7.3.2 Brochures and Inserts

A variety of brochures were developed for the attendees and the media:

- Demo Brochure - A color, tri-fold piece, detailing Demo '97 scenarios, frequently-asked questions, AHS technologies, schedule of events, etc.
- "What is an AHS?" brochure - A smaller, color tri-fold brochure explaining the basics of the AHS concept and vision in a question-and-answer format. It also listed general contact information.
- Information booth brochures - each of the information booths in the entry gallery had brochures that supported the message of the booth.
- A multi-page, tabloid-size, color newspaper insert was produced and widely distributed with details about Demo '97. Advertisements were sold to Participants, in which each explained their involvement with the NAHSC and their commitment to Demo '97.

3.7.3.3 Video

Video materials were available to selected media representatives to help explain the AHS message:

- Demo '97 overview video -- gave the "big picture," detailed short-term AHS technologies and long-term vision, history of AHS and interviews with key NAHSC spokespeople
- B-roll -- nearly 10 minutes of video footage on beta formatted tape was provided to broadcast media. Footage content included aerial shots of Interstate-15, in-vehicle and exterior running shots of the various demo cars, buses and tractor-trailer truck

3.7.3.4 Web Site

Both the public and password-protected sides of the NAHSC Web site were dramatically updated in anticipation of increased traffic due to Demo '97. Both sides were given a graphics facelift to make the pages more pleasing to look at and make the information more engaging. Also, each of the locators were checked to make sure the page had an easy-to-follow flow and the most pertinent information was obvious and easy to get to. The information content was fortified and updated.

An extensive Demo-specific section was developed and added to the NAHSC site where interested site guests could register to exhibit, attend and get the latest information about Demo '97.

The total number of NAHSC web site "hits" exceeded 34,000 from August 5 - September 3, 1997.

3.7.4 Regional Public Education

This Public Education team task force lead the preparations in the San Diego area, giving one-on-one and large-group presentations detailing plans for Demo '97, explaining the potential of AHS and the consortium goals, etc. More than 100 of these presentations/meetings were given to key San Diegans in a one-year time span, using a presentation kit (slides, interactive CD) developed by the task force. This wide-spread outreach effort gained a good deal of positive awareness and support for Demo '97 in the San Diego area, early-on. As a result, Demo '97 was well received in the Southern California area. See Appendix H - San Diego Regional Public Education & Marketing Actions of this report for a summary of the actions taken.

3.7.5 Post-Demonstration Congressional Briefing Summary

In early October a briefing on Demo '97 was held in the Capital Building for members of Congress. The program featured Gloria Jeff, acting federal highway administrator, who described her AHS experiences at Demo '97 and provided her views on progress to date and key next steps. Congressman Jay Kim, a member of the Transportation and Infrastructure Committee, gave an update on the process and progress of ISTEA successor legislation. NAHSC Program Manager Emeritus Jim Rillings briefed attendees on the structure and mission of NAHSC and touched on the highlights of Demo '97.

In impromptu remarks, Senator Lautenberg, ranking democrat on the Environment and Public Works Committee, talked about how ISTEA helped advance ITS/AHS and how the technologies could be applied to a variety of transportation needs, including the congested highways of his state, New Jersey. Frank Purcell of Congressman Cunningham's office conveyed his boss' excitement about AHS and pleasure at having hosted Demo '97 in his district.

Before and after speeches, the updated NAHSC video and a "best-of" collection of TV news stories on Demo '97 were shown. In addition, an exhibit of a variety of visual displays, including a montage of Demo '97 photos showing Senators Chafee and Boxer and Representative Packard, blow-ups of print media stories, including Representative Cunningham's op-ed letter in the San Diego Union-Tribune, as well as participant and Consortium logos and other AHS visuals.

3.7.5.1 Capitol Hill Attendance

The Capitol Hill attendance was solid; those who came were the audience the consortium had hoped would attend to learn about the various aspects of Demo '97. Seven senior committee or personal staff members attended:

- Senator Frank Lautenberg, ranking minority member, Senate Environment and Public Works Committee
- Senator Dirk Kempthorne, Senate Environment and Public Works Committee
- Representative Jay Kim, House Transportation and Infrastructure Committee
- Representative John Cooksey, House Transportation and Infrastructure Committee
- Brian Waidman, Chief of Staff, Senator Kempthorne
- Matt Andrews, Chief of Staff, Representative Kim
- Dan Matthews, Legislative Director, Representative Kim
- Frank Purcell, Legislative Director, Representative Duke Cunningham, Appropriations Committee
- Rosalyn Millman, Transportation Economist, House Transportation and Infrastructure Committee
- Jeff Grove, Professional Staff Member for Transportation Policy, House Science Committee
- Dana Gresham, Legislative Assistant for Transportation Policy, Representative Bud Cramer, House Transportation and Infrastructure Committee

3.7.5.2 Administration Attendance

The event enjoyed strong attendance from key Administration officials. These included:

- Mortimer Downey, Deputy Secretary, US Department of Transportation
- Gloria Jeff, Acting Administrator, Federal Highway Administration
- Christine Johnson, Director, ITS Joint Program Office, Federal Highway Administration
- Dick Bishop, AHS Program Manager, Federal Highway Administration
- Bob Clarke, Policy Planning, Office of the Secretary, US Department of Transportation
- Caitlan Hughes, Office of the Deputy Secretary, US Department of Transportation
- Joe Ann O'Hara, National Highway Traffic Safety Administration
- Kevin Dopart, Mitretek (USDOT)

3.7.5.3 NAHSC Staff and Members

- Steve Carlton, Lockheed Martin, Interim Program Manager

- Jim Rillings, General Motors and Program Manager Emeritus
- Bill Spreitzer, General Motors
- Gene McCormick, Parsons Brinckerhoff
- George Percivall, Hughes
- Bill Cune, Hughes
- Catherine Conner, Parsons Brinckerhoff
- Maureen McFalls, Carnegie Mellon University

3.7.5.4 Friends of AHS/NAHSC

Finally, the event was well attended by friends of AHS
- Jim Costantino, President, ITS America
- Lyle Saxton, Chair, Transportation Research Board AHS Task Force
- Mark Johnson, Staff Attorney, ITS America
- Jerry Bastarache, Director of Communications and Outreach, ITS America
- Don Knight, Publications Editor, ITS America
- Regina DeCoster, Membership Specialist, ITS America

3.8 Communications

The communications effort was led by Hughes. Hughes was responsible for the specification and integration support of communications associated with automated highway system functions, including vehicle-to-vehicle and vehicle-to-infrastructure data links. Hughes also specified hardware and support integration of communications providing telemetry data transfer from the vehicles to the Demonstration Presentation Center. Hughes also performed technical evaluation of voice communications requirements. Hughes provided technical consultation as required to related working groups, such as the infrastructure, integration, production, and Demonstration Presentation Center (DPC) teams.

The communications effort included evaluation of interference between each communications system. Integrated tests were performed prior to the live-demo dress rehearsals to verify operational compatibility among various systems. Potential interference sources such as video broadcast, news press communications, local short-wave radios, adjacent microwave systems, and cellular telephone traffic were considered. A design review was conducted to verify the integrated communication systems design. Communications system integration included verification of functional performance and subsystem compatibility. The communications systems included on associate vehicles was evaluated by the communications group to identify incompatibility and interference issues.

3.8.1 Vehicle-Vehicle Communications

Hughes developed a wireless communications system to support vehicle to vehicle transfer of control system data. The link access protocol supported the coordination of vehicle maneuvers required to demonstrate close-following modes such as platooning. The system specification was derived from the control loop update rates and message transmit opportunity requirements necessary to implement longitudinal control algorithms for a ten vehicle platoon. The communication system was based on existing commercial hardware with software modifications. The software based design allowed the flexibility to support independent vehicle communications, including requirements for free agent or truck scenarios.

Spread spectrum radios in the 902-928MHz unlicensed band were mounted in each vehicle. The vehicle-vehicle link allowed vehicles to coordinate position control functions within a cooperative group of vehicles (platoon). The vehicle-vehicle link supported transfer of information such as velocity and acceleration data within the platoon. This communication link also allowed coordination of merge, separation, lane change, enter, and exit maneuvers. The risks of operating in the unlicensed bands and relative performance in the presence of interference from adjacent bands such as cellular telephone was considered. The specific tasks performed by this group are listed below.

- Define communication system requirements.
- Write communication system specification.
- Document vehicle control system interface.
- Evaluate COTS hardware and make vendor selection.
- Develop vehicle-vehicle link test plan and procedures.
- Develop lab and mobile test simulation.
- Design network protocol.
- Test radio to host computer interface in lab environment.
- Test communication system in mobile environment.
- Support on site integration with two PATH demo vehicles.
- Support on site test and evaluation.

3.8.2 Vehicle-Infrastructure Maneuver Coordination Communications

Vehicle-roadside communications (VRC) was provided to demonstrate the role of infrastructure support in AHS operations. The check-in functions were used to illustrate the coordination of vehicle entry using two-way vehicle-infrastructure communications.

The Delco/Hughes tag/beacon system was implemented to support transfer of check-in information and vehicle status between roadside processors and the vehicles. Roadside readers (beacons) were located at the check-in points. An radio frequency transponder (tag) was mounted in each vehicle. The VRC link allowed the infrastructure to poll the vehicle for current status at the check-in points, the vehicle to respond with self-test data, and the infrastructure to provide a go/no-go message to the vehicle.

The scope of the tag/beacon demonstration focused on check-in and was not intended to provide continuous communication between the infrastructure and the vehicles over the entire Interstate - 15 route. The check-in functions were integrated with the Delco human-machine interface

(HMI) in the vehicle. Delco provided the control interface to support generation of vehicle messages for transfer to the infrastructure reader. Delco also generated HMI messages consistent with the data transferred to the transponder from the reader. Hughes was responsible for developing the infrastructure instrumentation necessary to support the check-in and check-out scenarios. Specific activities are listed below.

Evaluate reader and transponder capabilities.

- Document check-in script based on marketing and production inputs.
- Identify interface requirements.
- Develop vehicle-infrastructure link test plan and procedures.
- Support on site integration with demo vehicles.
- Support on site test and evaluation.

3.8.3 Vehicle-Infrastructure Data Transfer

Transfer of data from vehicles at the demonstration site to an off site location was not implemented. Transfer of digital data was possible along the entire length of the demonstration route. Connectivity was provided from the vehicles to the Demonstration Presentation Center (DPC) to support transfer of vehicle status updates for display or processing by the DPC integration team.

Data transfers included current vehicle position and automated subsystem status. The limited quantity of data and the non-safety critical nature of its use for display purposes made this communication link a good candidate for a commercial wireless service such as cellular telephone or CDPD (cellular digital packet data). Local service providers were surveyed to determine the most cost effective approach to supporting this function. Specific activities are listed below.

- Define data capacity requirements.
- Document interface specification.
- Define hardware requirements.
- Identify and select service provider.
- Coordinate hardware procurement and installation.

3.8.4 Site Voice Communications

SMR band (800-860 MHz) mobile radios were mounted in each vehicle to provide a voice link with Demo safety personnel. The voice radios provided connectivity from the vehicles anywhere on the Interstate - 15 HOV lanes to the staging area at the south control yard and the Kearny Mesa Caltrans TOC. The voice radios were standard mobile voice radios compatible with existing Caltrans equipment. Hughes specified radio models and coordinated the radio purchase, where required. Hughes also provided technical support for a survey of voice radio site coverage and evaluated the need for a repeater.

A site survey conducted in December 1995 determined that a repeater was required to provide continuous coverage of the lanes. Radio coverage was achieved by using a dedicated repeater along the Interstate -15 HOV lanes with the Caltrans Soledad repeater as a contingency repeater. The primary repeater location was selected and a set of tests were run in February 1996 to verify RF coverage. Caltrans was responsible for the design of the repeater mounting, and will perform wiring and installation of the infrastructure instrumentation. The selected repeater location provided reliable voice communication for command and control of the demonstration, and allowed radio communication with the Caltrans TOC. Specific activities are listed below.

- Support demonstration site evaluation.
- Specify voice communication hardware.
- Support repeater simulation tests.
- Document site evaluation results.
- Coordinate procurement of mobile voice radios.

3.8.5 Integrated Communications

The demonstration scenarios required independent communication systems for the vehicle-vehicle control loop, vehicle-infrastructure check-in/check-out, vehicle-infrastructure data transfer, and voice. The communication systems were in adjacent bands, raising the issue of compatibility or mutual interference. An integrated test of the overall functionality was performed to verify individual system performance with each system operating concurrently. The performance of each system was evaluated with each of the other systems operating. The location and polarization of antennas was an important consideration. Specific activities are listed below.

- Evaluate system interoperability requirements.
- Develop communication system test plan.
- Perform lab test and evaluation of overall communication system.
- Support demo system integration effort.
- Document demonstration results.

3.8.6 Infrastructure Processing

A processor was installed at the check-in stations. The processor location was coincident with the reader location for the tag/beacon VRC system. The roadside processors was used to perform real-time control over connected signals and changeable message signs (CMS).

A changeable message sign was used at the check-in stations to provide a text message indicating the result of the check-in process. The roadside processor provided a serial interface to control the changeable message sign.

The roadside processors passed information received from the vehicles over the communications interface to the DPC. There was no existing wired (fiber/telephone) or wireless (microwave) connectivity to the Interstate - 15 HOV lanes. Connectivity between the check-in points and the DPC was made using commercial wireless services such as cellular. This approach supported the low data rates and non-critical nature of the data transfer requirements with little investment in hardware or infrastructure.

The marketing and production team provided input to the infrastructure team concerning the location of the check-in locations. The CMS entry signal/message selection was performed by Caltrans. Procurement and installation of the CMS, was performed by Caltrans. Design of the processor cabinet mounting location was performed by Bechtel. Specific activities performed by Hughes are listed below.

- Define processor performance requirements.
- Write processor specification.
- Document processor interface specification.
- Coordinate processor procurement.
- Develop processor software.

4.0 DEMO '97 RESULTS

The NAHSC held the congressionally mandated demonstration to show how cutting-edge technologies can help to solve the growing transportation problems in the U.S. The event proved to be the biggest automated highway system (AHS) event in history.

More than 3,500 people attended Demo '97 and nearly 9,000 automated miles were driven on the Interstate-15 lanes and on the mini-demo track.

U.S. Secretary of Transportation Rodney Slater was among those who rode in one of the 21 automated vehicles that did the driving during Demo '97. Secretary Slater visited the demonstration site prior to the opening ceremony and was able to experience how transit buses would work in an automated highway system.

Following his ride on one of two automated Houston Metro New Flyer buses, the Secretary stated that the Consortium had successfully met the challenge Congress had mandated in the ISTEA legislation.

The number of attendees at Demo '97 were within the range of what had been planned when the invitation list was compiled. Media attendance slightly exceeded expectations, especially the media day just before the start of the Demo.

From across the country, the NAHSC Demo Team was made up of employees and volunteers from more than 20 different organizations – and all joined together to form a cohesive team to successfully (and safely) make this unique, multi-faceted event possible.

4.1 Lessons Learned

This section addresses the lessons learned from Demo '97 in the perspective of what the objectives were and what was and was not accomplished.

The objectives for the demonstration are described in Section 2; in summary they were:
- Demonstrate a variety of technologies that could be used in automated vehicle control and highway automation
- Demonstrate more near term partial automation services that could act as stepping stones to full-automation AHS
- Show the stakeholders and the public that vehicle and highway automation has applicability to relieving many of the nation's highway transportation problems
- Give the visitors a sense for what automated highway travel may be like in the twenty-first century

These objectives had to be met in a little over 30 months after the Consortium was formed. To accomplish this, the demonstration had the following characteristics:

- Technologies employed already had to exist in a laboratory; the challenge was applying what existed to AHS--the Consortium's research and development efforts could only minimally contribute
- What was shown were staged demonstrations of the technologies to give the visitors a sense of how the technologies could be applied to AHS; in many cases the technology components had to be supplemented with special supporting tools (e.g., computers on laps) and human backup (driver ready to take over instantly); the vehicles and systems were not even prototype designs, with the exception of the Eaton-VORAD forward collision warning system which is a commercial product
- The various systems were not engineered for reliability, robustness, or to meet the full needs of highway driving; consequently, the demonstration did not provide a basis for making sound comparisons of technologies and/or system designs

Nevertheless, there were many valuable lessons learned from Demo '97. These lessons learned are described below in three categories-- Demonstration Preparation, Engineering Lessons Learned, and Public Reaction.

4.1.1 Demonstration Preparation

Preparations for the demonstration began as soon as the Consortium was formed. Below are a few of the major lessons learned as part of that preparation

- Planning - The top three items of importance are planning, planning and planning--at a detailed level to address possible contingencies.
- Site Selection - If any changes at all are required for the infrastructure, early selection of the site is critical; changes to a public roadway takes a great deal of planning and approval.
- Teaming - The local, regional and state transportation agencies must be an integral part of the planning and preparation, and must be fully committed to the effort. All parties whose direct support is needed must also be part of the team (possibly including the state police). Fortunately for the NAHSC, Caltrans is a Core Participant.
- Coordination - All parties who may be affected by the demonstration must be informed and allowed to voice their opinions; this includes the public and communities affected; in San Diego, it included a military installation.
- Competition - Having live vehicle demonstration from multiple vehicle manufacturers and having parallel teams working with different technologies lent an air of competition to the event that synergistically added to the quality of the demonstrations and their impact
- Safety - It was emphasized that the two most important goals of the demonstration were that there be no crashes and that nobody gets hurt; either of these happening could have erased virtually all the public and outreach benefits of the demonstration. It is important that safety issues not be compromised in future demonstrations.
- Rehearsals - These brought together all of the various aspects of a very complex demonstration; because of them, the demonstrations looked easy and relaxed--that was not true for the first rehearsal.

- Audience - The event must be large enough that the key stakeholders and policy-makers are willing to attend; these key individuals must be invited and special arrangements must be made so that they are given an opportunity to clearly observe the event; show and tell events seem to be more attractive.

4.1.2 Engineering Lessons Learned

Even though the live vehicle demonstrations were staged demonstrations of technology and not prototype designs, this gave the engineers the opportunity (in some cases the first opportunity) to apply these technologies to vehicle-highway automation with hands-on engineering. Consequently, some significant engineering lessons were learned.

During the demonstration, some of the technologies seemed to perform better than others. Some of the variations were due to problems in the specific design used for the demonstration. One problem was due to the basic physics of the technology. For example, vision systems can be blinded by the sun, and tend to lose tracking when passing beneath overpasses where the shadow was in great contrast to the sun on the road surface. In these cases, engineering design may solve the problem, so meaningful comparisons cannot be drawn. Below are some of the findings:

- Processors - The processing power required for the demonstration was significantly less than had been predicted; for example, both PATH and CMU had space for two Pentium processors in the trunks, but in both cases only one processor (equivalent to a personal computer) was needed. The processing power for automated vehicle control is now available; in 1989, an automated ground vehicle developed by Martin Marietta and CMU required a U-Haul trailer-size container full of processing equipment.
- Communications - Reliable communications was a problem during the demonstration for a variety of reasons; however, it was satisfactory for the demonstration for two reasons: (1) the control systems were designed to accommodate occasional dropouts; and (2) if a communications link failed, the scenario could fall back to a less ambitious operation (for example, the vehicles in a platoon could move further apart). Interference is one of the fundamental problems with communications--in the highway environment, its source can be public, private, and/or military. More work is needed on vehicle-to-vehicle communications that is not affected by these and other conditions. Cellular data communications worked generally well, but reliability is not sufficient to provide the required level of safety for vehicle control.
- Actuators - Tying into the vehicle actuators seemed to be easily accomplished; however the steering and brake actuator movements (authority) were restricted for safety reasons. The newly designed quick-actuation brake actuators used in the Platoon scenario required some field debugging. For some demonstrations, tying in the processor through a local bus created integration problems.
- Algorithms - Algorithms for control of the vehicles varied considerably from early testing to final demonstration as they matured; as these designs continued to mature and as algorithms were developed to handle various system failures, automated operation became much smoother, and many more failures were handled by the system rather than the driver as backup. In short, many hours of development time are still required for the algorithms to sufficiently mature.

- Safety Design - In the demonstration, an independent watchdog safety process was used to guard the vehicle's operation from software errors; in addition, as noted above, physical restrictions were placed on the actuators so that if a potentially dangerous command slipped through (e.g., steer hard left at 60 mph), it was not possible for the vehicle to execute that command . It was assumed that software errors would occur. Future control software needs to be subjected to a more rigorous safety design since the demonstration's actuator restrictions will not be possible in normal driving situations.
- Longitudinal Control Sensors - The technologies tested included radar, laser and vision. All of the sensor technologies had some shortfalls. During preparations for the demonstration, none were able to distinguish all conditions at all times; however, system designs must be tailored to the need--by tailoring the systems for the Interstate-15 test track environment, all worked satisfactorily during Demo '97.
  - Longitudinal control using laser radar appeared to be quite effective. The standard plastic construction barrel (when arranged two side-by-side) appeared to present an adequate radar cross section for detection as far away as 100 meters, albeit the weather conditions were benign. Adequate detection range of other vehicles was not a problem. Since the lasar radars have such narrow azimuth and elevation beam-widths, alignment of these sensors was the largest source of problems.
  - The microwave radar used for other vehicle detection worked quite well. The millimeter wave radar was used to detect a standard plastic construction barrel, augmented with a flasher (the flasher light was not used - the additional metal and battery used to construct the flasher added to the barrel radar cross section). The detection range of the millimeter radar was only about 80 meters for the augmented barrel, but had at least a 100 meters detection range for other vehicles.
  - Some of the problems encountered were due to the specific designs used for the demonstration or operating conditions; for example, it was found that dirt on the laser aperture caused its range to be reduced. In other cases, the problems represent limitations of the basic technology itself.
  - At least for the near term, sensor systems that provide input to the vehicle's control should use two different kinds of sensors employing different phenomenologies, and/or the roadway needs to be designed to aid the sensors in distinguishing targets from clutter. Sensor systems need to be self-checking so that if they fail, they can warn the system and driver.
  - False returns are a problem for obstacle detection systems; obstacle detection in the demonstration was accomplished under very controlled circumstances. Radar sensor systems that only warn the driver help eliminate false returns by blocking out non-moving objects; these systems assume that the driver is fully alert all times and would be able to distinguish stopped vehicles ahead from bridge abutments.
- Lateral Control Sensors - Vision systems, embedded magnets and radar-reflective strips were used for lateral control; that is, sensing the lane and roadway boundaries so that vehicles could stay in their lane of travel, change lanes or warn of possible roadway departure. All worked fine during the demonstration.
  - Lateral control using magnetic markers was very robust and accurate. At no time did the vehicles using magnetic markers have a lane departure or otherwise fail to accurately follow

the road during the demonstration, including the demanding mini-demo. Magnetic markers were equally effective when operating at night. The Platoon vehicles were not yet programmed to transfer from manual to automated operation while moving; consequently, the vehicles had to be properly aligned with the magnetic markers at the start of the scenario. It was found that the magnets must be accurately located when embedding them in the roadway to avoid noticeable lateral vehicle motion.

  - Vehicles using vision systems for lateral control required tuning to avoid lane departures; but once the systems were tuned to the Interstate-15 environment, they worked satisfactorily. Some of the variations that caused problems were (1) shadows from overpasses; (2) changes in shoulder-to-main lane contrast over bridges; (3) blinding; (4) change in camera angle due to passengers in the back seat for one system; and (5) for some systems, inability to operate at night or during times of unfavorable contrasts due to evening lighting conditions. The vision systems, while not as robust or as accurate, do have the advantage of not requiring infrastructure modifications other than distinguishable lane markers. More instrumentation to augment vision systems (e.g. accelerometers, inclinometers, ride height and passenger load measuring devices) are needed for better lane keeping.
  - The Radar Reflective Stripe demonstration was limited. The stripe was relatively short and installed on a straight section of the demonstration lanes. It worked satisfactorily during the demonstration; this was its first application.

- Lateral Position Sensors - Radar and laser systems were used to detect vehicles in the adjacent lane when attempting to change lanes. These systems tended to have a high rate of false alarms . Eventually, roadway characteristics such as shoulder width, and vehicle characteristics may have to be designed to help the sensors distinguish between roadside objects, such as guardrails, and vehicles.
- Lane Change Maneuvers - The lane change was the most difficult maneuver to perform by all vehicles regardless of their lateral control system. Every scenario which had an automated lane change experienced an overshoot and lane departure incident during preparation for the demonstration; however, in all cases the trained driver was able to take manual control of the vehicle and prevent an accident. All of the lane change events during the demonstration itself were satisfactory.
- Infrastructure Improvements - Vision based control systems had problems with lack of consistency in lane and shoulder widths, markings and shoulder-to-lane contrast. Bott's dots are hard for vision systems to see. A broken or solid line would be better. Also, road surfaces need to be smoother or the vision system must be designed to handle the variations. Bumps and dips need to be removed or adjusted for so that cameras scenes do not bound as much. Finally there were a lot of sensor false alarms caused by infrastructure objects such as "cats-eyes", signs, K-rail reflectors and beams used in the construction of overpasses.
- Measures of Effectiveness - Even though the demonstration system designs could not reasonably be compared because of their immaturity, it was possible to begin identifying the measures of effectiveness by which future, more mature designs and technologies can be compared. The demonstration gave vehicle developers a chance to showcase their technologies in an atmosphere of friendly competition which became an informal measure of effectiveness. It should be

remembered that the demonstration was a beginning, not the end. A demonstration is not real life. There are a number of long term technology application issues such as:

- Systems that do not have predictable infrastructures are problematic. Before and during the demonstration the Interstate-15 lanes were probably the best maintained roads in the world. But even minor variations in road characteristics will cause all but the most sophisticated (and expensive) systems to exhibit unacceptable consumer level behavior.
- Obstacles were large, obvious and placed in the middle of a lane. Real life obstacles (such as old tires on wet roads, ladders, etc.) are small, obscure and difficult to assess as hazards.
- Practical considerations, such as environmental; EMI; infrastructure cost, uniformity, maintenance and repair; and fail safe operational requirements, are suspended during demonstrations.

• Keys to Success - Core technologies must work; bells and whistles can be added later as designs mature. Goals can be met with precise development requirements and schedules, technology performance requirements, practice and willingness to accept mistakes. Flexibility is paramount to success. This is best accomplished with small, accountable, integrated and focused vehicle development teams. From a demonstration production standpoint, demonstration requirements must be locked in early with contingency plans. This is necessary to ensure continued corporate support, budget approvals and manpower approvals. Things that would improve vehicle performance and quality in the future are:

- Implement a single Vehicle Build Center
  a) Moving vehicles from place to place for assembly was hard to manage
  b) Getting design information and components took too long
  c) Quality assurance was also hard to manage

- Vehicle Requirements
  a) Only some top level requirements were known by all
  b) How some components worked was not completely known by the Vehicle Leads
  c) Insufficient documentation was provided for long term support

- Vehicle Integration and Test
  a) Component and subsystems should have been "bought off" prior to assembly in vehicles
  b) Component developers should have been on hand for early vehicle development testing

4.1.3 Public Relations Lessons Learned

Overall, the demonstration gave the stakeholders and public their first opportunity to experience what highway travel may be like in the future. It also gave visitors an opportunity to see some of the more near-term partial automation services that may provide a stepping stone to the full AHS of the 21st century. Based on the post-demo surveys and comments received, the public's reaction was far more positive than virtually anyone in the Consortium had predicted, albeit the attendees were not a typical cross-section of the American public. It appeared that the attendees' acceptance of all forms of AHS was positive. Below are some of the specific lessons learned:

- Riding is Believing - Envisioning an automated vehicle control service and experiencing it are two entirely different things. The visitors who were able to ride in one of the live vehicle demonstrations were overwhelmingly positive about the experience.
- Evolution Portrayed - There have been many attempts to explain how early partial automated vehicle control services could act as stepping stones for fully automated operation. The Evolutionary and Free Agent demonstrations allowed the riders to experience first hand how the services could evolve.
- Vehicle Types - Creating a venue for competitors to jointly show-off enhances visibility. By viewing different vehicle types in the demonstration, visitors could better relate the technology to today's roadways where buses and trucks share the highways with light vehicles, and where maintenance vehicles operate.
- Concept Types - The typical visitor was probably vaguely aware that a variety of AHS concept types were be demonstrated, but was not able to actually compare them. Most visitors were only able to ride on one live vehicle demonstration; and the refinements of magnets versus vision versus radar-reflective strips was probably not apparent.

4.2 Statistics

4.2.1 Attendees

The attendees can be divided into four main categories: 1.) Those invited to both the Exposition Center and to ride in demonstration vehicles; 2.) Those who attended the Exposition Center only; 3.) Participant organization workers and exhibitors, and; 4.) Members of the media.

The number of those invited to ride on Interstate-15 was carefully calculated, using demo vehicle capacities and HOV lane hours as the guide. Just over 2,000 of these invitations were mailed in May. Each of the targeted groups were well represented. Overall attendance was at the level expected.

Registration for Exposition Center attendance began in early April. The fee was waived for early registration (before July 14). Guests were able to purchase tickets at the door, as well, for $50 each.

Media attendees were invited to one of three on-lane media days. During Demo Days most of the media in attendance covered the demonstration from the Exposition Center, getting demonstration rides on the mini-demo test track.

General Attendee Summary
Public - 989 (Sunday Only)
Press - 141 (including pre-Demo Days media events)
VIP guests - 1400

General Industry - 1000 (Includes 400 SAE)
Total - 3500

Members of Congress Attendees
Senator Barbara Boxer
Senator Diane Feinstein
Senator John Chafee (Pre-Demo)
Congressman Ron Packard
Congressman George Brown
Congressman Jay Kim
Congressman Bob Filner

U.S. Department of Transportation Attendees
Secretary of Transportation Rodney Slater
Deputy Secretary Mort Downey
Acting FHWA Administrator Tony Kane
Acting FHWA Administrator Gloria Jeff
ITS Joint Program Office Director Christine Johnson
FHWA Leadership Team (regional administrators)

Media
Long Lead - 24
Short Lead - 76
Demo Days - 80
other (dress rehearsal) days - 10
Total Media Outlets Represented - 120

A detailed list of media attendees is provided in Appendix I of this report.

Table 4.2.1-1 List of Attendees provides a summary of Demo '97 attendees by category.

Table 4.2.1-1 List of Attendees

Attendees (invited to both Exposition Center and Interstate-15 demo rides):	
NAHSC Core Participants - (Ten from each Core Participant organization not including NAHSC Demo Team)	95
NAHSC Associate and Outreach Participants -(Approximately five from each organization)	250
U.S. DOT - (In addition to the Core which will be from the FHWA Research Center, guests are expected from the Office of the Secretary, JPO, NHTSA, Federal Transit Administration, Office of Motor Carriers, etc.)	125
Other U.S. Executive Branch - (DOE, Commerce, PNGV, DOD, Executive Office of the President)	35
U.S. Legislative Branch - (Senate and House of Representatives elected and Congressional Staff and applicable home district staff)	25
California State Government - (Officials and staff from the Department of Business, Transportation and Housing Agency, the Calif. Highway Patrol, Caltrans Headquarters and District Officials, Office of the Governor, State Assembly and Senate, Air Resources Board)	125
Local Government - (SANDAG, MPOs County Government - Board of Supervisors, School Boards, Board of Regents, Commissions, Transit Agencies - Metropolitan Transit Development Board, North County Transit, Orange County Transit, City Staff)	155
Other Government Officials - (State DOTs, Turnpike Authorities, Executive Staff)	140
Local Business Leaders - (Members of Chamber of Commerce, Economic Development Commission, Regional Technology Alliance, Regional Transportation Technology Alliance, business owners and executives)	160
International Dignitaries - (VERTIS, ERTICO, Ministers of Transportation, manufacturers representatives and executives)	115
Intelligent Transportation Society - (Board of Directors, Coordinating Council, support and technical staff)	135
SAE Conference Attendees	200
University Researchers and Faculty	150
Attendees - General Industry (Exposition Center only)	800
Public (on Public Day - Sunday, August 10)	990
TOTAL	**3,500**

4.2.2 Exposition Center

Exposition Booths - 50
Outdoor Displays - 10
Student Competition Participants- 4
Mini Demos (on the four test tracks adjacent to the Exposition Center) - 5
Exhibitors - 200
Exposition Staff - 100

4.2.3 Interstate-15 Demo

Interstate-15 Staff - 200
Total Vehicles - 26
Total Automated (longitudinal and/or lateral control) - 21
Platforms - 2 trucks, 2 buses, 22 cars
Automated Types - 1 truck, 2 buses, 18 cars
Automated Makes - Freightliner, New Flyer, Buick, Oldsmobile, Pontiac, Honda, Toyota
Scenarios - 7 (NAHSC, Houston Metro, Ohio State Univ., Honda, Toyota, Eaton VORAD)
Demo Runs - 20 (entire sequence of scenarios run one direction)
Trial runs - 8 (entire sequence of scenarios run one direction prior to Demo Days)
Total Automated Vehicle Runs - 588 = [(20 + 8) x 21]
Total Automated Miles Run During Demo - 4468 = (588 x 7.6)
Dress Rehearsal runs (entire sequence of scenarios run three weekends prior to demo) - 22
Total Automated Miles Run During Dress Rehearsal - 3511 = [(22x21) x 7.6)
Total Automated Miles Run During Dress Rehearsal and Demo - 7979

Passengers
Number of available rides: (The Available Seats column assumed all scenario runs at full capacity; 4 runs on Thursday/Friday, 6 runs on Saturday/Sunday; did not include spare passenger seats)

Available Seats Information

Date	Day	Available Seats
August 7	Thursday	268
August 8	Friday	268
August 9	Saturday	402
August 10	Sunday	402
Total		**1340**
Total		

Rides Taken Information

Interstate-15 Runs	Rides
Demo Day (Thursday)	250
Demo Day (Friday)	250
Demo Day (Saturday)	425
Demo Day (Sunday)	425
	1350
Dry Run Trails	500
Dress Rehearsals	1000
	2850

4.2.4 Mini Demos (At the Exposition Center)

Total Vehicles - 5
Total Automated (longitudinal and/or lateral control) - 3
Types - 1 tractor (front loader), 4 cars
Automated - 3 cars
Automated Makes - Buick, Honda
Scenarios - NAHSC, Honda/PATH, Ohio State Univ., 3M, Caltrans/UC-Davis AHMCT
Total Automated Vehicle Runs - 144
Total Automated Miles Run During Mini Demo - 180
Grand Total of Automated Miles: 8,159

Passengers
During the course of Demo Days, the following number of mini-demo rides were provided:

PATH:	1,100 passengers
OSU:	200 passengers
3M:	600 passengers
Honda:	1,200 passengers

Combined Totals for all Mini-Demo Rides: 3,100 passengers

4.2.5 Press Coverage

Media coverage of Demo '97 was extensive. The majority of news stories were, for the most part, positive and accurate.

Highlights include:

- To-date, the Demo '97 story generated 879 stories in 12 countries on five continents. In the United States, 648 different newspapers reported the story, generating 763 stories.
- A good deal of the blanket coverage came from the long-lead press event in July. The strategy to first engage prime "feeder media" worked well. For example, gaining the attendance of both an Associated Press (AP) reporter and photographer was extremely effective in getting the AHS story out to communities across the U.S. The AP photo of platooning Buick LeSabres was above-the-fold news not only throughout the U.S. but as far afield as Britain, China and New Zealand.
- In addition, the New York Times and Los Angeles Times stories ran on their wires and were picked up by scores of additional papers across the country. (Another example of "feeder" media.)
- The story ran in all 50 states and the District of Columbia. The national average per state was thirteen papers.
- More than one-fifth of tracked national newspapers covered the story on two or more occasions. Chicago's two largest papers, the Chicago Tribune and Sun Times reported the story *six* times.

- Seventy five different papers in California alone covered the AHS story.
- Estimated total circulation in the U.S. exceeded 75 million.

Broadcast coverage of Demo '97 included:
- MSNBC, "The Site" (live) -- 7/22
- CNN/Headline News -- 7/23
- ABC World News Now – 7/23
- NBC News at Sunrise/Nightside – 7/23
- CNBC "Power Lunch" -- 7/23
- Late Night with David Letterman (monologue joke about good for Calif. drivers) -- 7/23
- The Osgood File - CBS Radio (synd.) -- 7/23
- CBS Evening News -- 8/6
- CBS This Morning -- 8/6
- National Public Radio, "All Things Considered" -- 8/6
- CBS This Morning -- 8/7
- News Hour with Jim Lehrer -- 8/8
- More than 220 affiliate/local TV and cable stations presented the AHS Demo '97 story during July and August

Print exposure included:
- Associate Press (coverage in more than 1,000 newspapers) – 7/23
- USA Today – 7/23
- Wall Street Journal – 7/24
- Business Week – 8/4
- New York Times 8/7 (New York Times News (wire) Service with high-profile pick-up including the Chicago Tribune)
- Washington Post – 8/9
- San Diego Union-Tribune – 8/3, 7, 8 and 11

Refer to Demo '97 Media Coverage Summary and Sample, Appendix E for examples of print coverage and the radio and TV broadcast summaries.

4.3 Survey Results

The Consortium effectively reached the target publics, engaging them with interactive communications and in every case possible, by providing first-hand experience with automation technologies. Several Members of Congress traveled to Demo '97 to see it for themselves. Questions were answered and stakeholder feedback was captured. Those not able to attend the demonstration were informed about it by a wide variety of media that covered the event. Each attendee or news watcher was able to get a better understanding of research efforts in the U.S. to solve mounting surface transportation problems. Automated Highway Systems became a much more widely known and supported concept.

Demo '97 was a newsworthy event and therefore an opportunity to educate the public at-large, giving the story and first-hand experience of AHS technologies and their potential benefits to the media, and through them to the general public. The public around the world received news of the automated highway demonstration via television (broadcast and cable), radio (local and syndicated), and through printed publications such as newspaper wire services and specialized magazines.

In addition, it was an ideal opportunity to capture stakeholder feedback, given the stated mission of the NAHSC to achieve national consensus and the unique opportunity to give attendees the actual experience of riding in a variety of automated vehicles.

4.3.1 Surveys

Two surveys were taken to capture stakeholder feedback. Both were supervised by the contracted PR firm, Strat@comm, based in Washington, D.C. The first was administered prior to the Demo and the second took place during the four Demo Days. Both measured awareness and support levels for AHS technologies and projected benefits.

4.3.1.1 Pre-Demo '97 Survey

Prepared by Wirthlin Worldwide, a well-respected opinion research company, the results of the pre-demonstration survey of NAHSC key publics indicated that a good level of awareness and support of AHS technologies existed before Demo '97. This survey was administered via telephone and was taken early in the summer, well before most of the Demo '97 media coverage had taken place.

Some noteworthy findings:

- Key audiences are very aware of AHS: 88 percent responded that they are aware of automated highway systems. Fifty-seven percent were able to correctly identify AHS among a list of intelligent transportation system (ITS) technologies. Familiarity was nearly twice as high among state/local and Administration officials than with Congress and the media.
- Eighty-six percent of respondents favored the continuation of AHS research.
- Significantly, a statistically identical 82 percent of respondents felt the federal government should continue to help fund AHS research.
- Safety was deemed the most important among six listed attributes (safety, economy, environment, mobility, realistic, adaptable). On a scale of 1-5, safety scored 4.1, while the other benefits scored 3.4 - 3.6.

For a complete report of this survey's findings, see AHS Key Publics Survey, Appendix F of this report.

4.3.1.2 Demo Days Survey

A one-on-one, face-to-face survey of Demo '97 attendees was taken during all four Demo Days, just before and just after attendees rode in the automated vehicles.

Highlights of this survey's findings:

- Overall, responses were very favorable. The survey audience clearly believes AHS will provide tangible safety and efficiency benefits and will begin doing so in the next five years.
- Test riders cited cost (pre-ride: 39 percent; post-ride: 40 percent), public acceptance (pre-ride: 30 percent; post-ride: 33 percent) and liability issues (pre-ride: 25 percent; post-ride: 22 percent) as barriers that may hinder AHS implementation.
- Approximately 95 percent of Demo attendees surveyed believed AHS technologies would be helpful or somewhat helpful in solving our nation's most pressing transportation problems.
- An overwhelming number of attendees (more than 95 percent) responded that AHS technologies would be helpful or somewhat helpful in improving highway safety.
- Before and after results show that about 90 percent of attendees think that AHS technologies will provide congestion relief.
- For most questions the pre-and post-ride response variances were small. This shouldn't be surprising, given the high level of awareness in the sample.
- A notable exception to this uniformity was found on the issue of cost. After their test-ride, a high number of individuals indicated their willingness to pay more for a car that is AHS equipped.
- Scarcely any respondents (two percent) noted that their AHS ride experience was negative. In fact, 96 percent described the ride as impressive, educational and exciting.
- Similarly, when asked to characterize the test ride description/narration, 96 percent of respondents remarked that it was clear and informative.

The statistical significance of these findings show that current AHS initiatives have been well received by the survey audience and provide a clear warrant for continued development.

For a complete summary of this survey, see Demo Days Survey, Appendix G.