Development of Human Factors Guidelines for Advanced Traveler Information Systems and Commercial Vehicle Operations

RESOURCE MATERIALS

ATIS and CVO Development Objectives and Performance Requirements

ITI TOOLBOX

U.S. Department of Transportation
Federal Highway Administration

Publication No. FHWA-RD-95-109
September 1995

FOREWORD

This report is one of a series of nine reports produced as part of a contract designed to develop precise, detailed human factors design guidelines for Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO). Among the other topics discussed in the series are functional description of ATIS-CVO. comparable systems analysis, task analysis of ATIS/CVO functions, alternate systems analysis, identification and exploration of driver acceptance, and definition and prioritization of research studies.

This report documents ATIS and CVO system objectives and performance requirements. It provides basic information regarding the range of ATIS and CVO operational capabilities. a survey of ATIS and CVO systems, a preliminary set of ATIS and CVO scenarios, and a. summary of system performance requirements.

Copies of this report can be obtained through the National Technical Information Service (NTIS). 5285 Port Royal Road. Springfield, Virginia 22161, telephone (703) 4874650. fax (703) 321-8547.

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Office of Safety and Traffic
Operations Research and Development

NOTICE

Technical REport Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No
FHWA-RD-95- 109		

4. Title and Subtitle	5. Report Date
Development of Human Factors Guidelines for Advanced Traveler Information Systems and Commercial Vehicle Operations: ATIS and CVO Development Objectives and Performance Requirements	September 1995
	6. Performing Organization Code
7. Author(s) 41. McCallum. J. Lee, T. Sanquist. W. Wheeler	8. Performing Organization Report No.
9. Performing Organization Name and Address Battelle 4000 41st Street NE Seattle, Washington 98 105	10. Work Unit No (TRAIS) 3B4c
	11. Contract or Grant No. DTFH6 I -92-C-00 102
12. Sponsoring Agency Name and Address Office of Safety and Traffic Operations R&D Federal Highway Administration 6300 Georgetown Pike, McLean, VA 22 101-2296	13. Type cf Report and Period Covered Resource Materials 10/92 - 7/96
	14. Sponsoring Agency Code

15. Supplementary Notes

Contracting Officer's, Technical Representative (COTR) - Joseph Moyer. HSR-30

16. Abstract

The document type is resource materials.

This working paper documents Task B of the present project, Identify Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO) System Objectives and Performance Requirements. The goal of Task B is to define the transportation community's current conceptualization of ATIS and CVO, providing a baseline of information for subsequent tasks. Information was obtained from a literature review. conducted as the first task of the project, and by interviewing and surveying government and private representatives of the ATTS and CVO development community. The results of this report have supported subsequent project tasks by:

- Providing basic information regarding the range of operational capabilities to be included in ATIS and CVO systems for use in the more specific definition of system functions and features during the conduct of Task C, Define Functions.
- Providing a survey of ATIS and CVO systems currently developed, or under development. in support of Task D, Comparable Systems Analysis.
- Providing a preliminary set of ATIS and CVO scenarios that can be further elaborated during the conduct of Task E, Task Analysis.
- Providing a summary of performance requirements currently identified by the transportation community for subsequent incorporation in project research. (Tasks H, K. and M)

17. Key Words	18. Distribution Statement
Advanced Traveler Information System (ATIS); Commercial Vehicle Operations (CVO); Intelligent Vehicle-Highway Systems (IVHS)	No restrictions. This document is available to the public through the National Technical Information Service, Springfield. VA 22 16 I

19. security Class (of this report)	20. Security Classif. (Of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	96	

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To FInd	Symbol
	LENGTH			
in	inches	26.4	millimeters	mm
fl	feet	0.305	meters	m
yd	yards	0.914	meters	m
ml	miles	1.61	kilometers	km
	AREA			
in	square inches	645.2	square millimeters	
ft2	square feet	0.093	square meters	
yd2	square yards	0.636	square meters	
ac	acres	0.405	hectares	
mi2	square miles	2.69	square kilometers	
	VOLUME			
ft oz	tluid ounces	29.57	milliliters	
gal	gallons	3.765	liters	
ft2	cubicfeet	0.028	cubic meters	
yd2	cubic yards	0.765	cubic meters	

NOTE: Volumes greater than 1000 I shall be shown in m2

Symbol	When You Know	Multiply By	To FInd	Symbol
	MASS			
oz	ounces	26.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or 'metric ton)	Mg (or "t"
	TEMPERATURE (exact)			
oF	Fahrenheit temperature	5(F-32)/9 or (F-32)/1 .8	Celcius temperature	oC
	ILLUMINATION			
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m*	cd/m2
	FORCE and PRESSURE or STRESS			
lbf	poundforce	4.45	newtons	N
lbf/in2	pourldrorce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To FInd	Symbol
	LENGTH			
mm	millimeters	0.039	Inches	in
m	meters	3.26	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
	AREA			
	square millimeters	0.0016	square inches	in*
	square meters	10.764	square feet	ft2
	square meters	1.195	square yards	yd2
	hectares	2.47	acres	ac
	square kilometers	0.386	square miles	mi2
	VOLUME			
	milliliters	0.034	fluid ounces	ft oz
	liters	0.264	gallons	gal
	cubic meters	35.71	cubic feet	ft3
	cubic meters	1.307	cubic yards	yd3
	MASS			
g	grams	0.035	ounces	oz
kg	kilograms	2202	pounds	lb
Mg (or "t")	megagrams (or 'metric ton')	1.103	short tons (2000 lb)	T
	TEMPERATURE (exact)			
oC	Celcius temperature	1.8C + 32	Fahrenheit temperature	oF
	ILLUMINATION			
lx	lux	0.0929	foot-candles	fc
cd/m2	candela/m2	0.2919	foot.Lamberts	fl
	FORCE and PRESSURE or STRESS			
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in2

• Si is tha symbol for the international System of Units. Apptoprlale rounding should bo made to comply with Section 4 of ASTM E380

(Revised September 1993)

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LIST OF ABBREVIATIONS

ACS	Automated Clearance Sensing
ATIS	Advanced Traveler Information System
ATMS	Advanced Traffic Management Systems
AVC	Automated Vehicle Classification
AVI	Automated Vehicle Identification
AVL	Automated Vehicle Location
Caltrans	California Department of Transportation
CI	Confidence Interval
CVO	Commercial Vehicle Operators
DOT	Department of Transportation
EC	Electronic Credentials
FHWA	Federal Highway Administration
GPS	Global Positioning System
IMSIS	In-vehicle Motor Services Information Systems
IRANS	In-vehicle Routing and Navigation Systems
ISIS	In-vheicle Signing Information Systems
IVHS	Intelligent Vehicle Highway System.
IVSAWS	In-Vehicle Safety Advisory and Warning System.;
NHTSA	National Highway Transportation and Safety Administration
OBC	On-Board Computer
PCD	Personal Communications Device
R&D	Research and Development
TARIF	Trucks At Rest In Fog
TTD	Telecommunications Device for the Deal
TWC	Two-Way real-time Communications
WIM	Weigh In Motion

I. INTRODUCTION

Components of the Intelligent Vehicle-Highway System (IVHS) are currently at various stages of research, development. and implementation. Several private firms are modifying products developed in Europe and Japan. or developing new systems to support their product development objectives. At the same time, the U.S. Department of Transportation (DOT) is Supporting research and development (R&D), system architecture development, operational tests, institutional and policy projects, and deployment projects through the national IVHS program as a means of stimulating the development of systems that will meet institutional and consumer objectives.

Two major areas of IVHS development are Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO). These types of systems will provide the primary means by which private and commercial vehicle drivers will interact with IVHS. Thus, determination of the system characteristics that will enhance acceptance and usability of these systems is critical to the success of the IVHS initiative. In recognition of this human factors challenge in developing ATIS and CVO systems, the Federal Highway Administration (FHWA) initiated the present project, which is being conducted to develop human factors guidelines for the design of ATIS and CVO systems. This project will address the impacts of driver interfaces, information type, behavioral factors. and user demographics on the development of specific information subsystems.

This working paper documents Task B of the present project, Identify Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO) System Objectives and Performance Requirements. The goal of Task B is to define the transportation community's current conceptualization of ATIS and CVO, providing a baseline of information for subsequent tasks. Information was obtained from a literature review, conducted as the first task of the project, and by interviewing and surveying government and private representatives of the ATIS and CVO development community. The results of this report are intended to support future project work by:

- Providing basic information regarding the range of operational capabilities to be included in ATIS and CVO systems for use in the more specific definition of system functions and features during the conduct of Task C, Define Functions.
- Providing a survey of ATIS and CVO systems currently developed, or under development, in support of Task D, Comparable Systems Analysis.
- Providing a preliminary set of ATIS and CVO scenarios that can be further elaborated during the conduct of Task E, Task Analysis.
- Providing a summary of performance requirements currently identified by the transportation community for subsequent incorporation in project research.

The remainder of this working paper describes the methods and results of the Task B analyses. Section II. METHOD describes the interview participants. procedures and materials, and analyses. Section III. ATIS TECHNOLOGY OVERVIEW provides a description of ATIS architecture and assumptions adopted in conducting this task, and an overview of ATIS and CVO system capabilities. Section IV. DEVELOPMENT OBJECTIVES AND PERFORMANCE REQUIREMENTS identifies the performance requirements of ATIS and CVO systems associated with five general objectives. Section V. SCENARIO OVERVIEW describes the approach taken in developing the 12 private and 14 CVO scenarios included in this paper. Sections VI through IX describe the operational capabilities, projected benefits and performance requirements, and operational scenarios as they relate to private vehicle and CVO, for each of the four major ATIS subsystems: In-vehicle Routing and Navigation Systems (IRANS), In-vehicle Motor Services Information Systems (IMSIS) In-vehicle Signing Information Systems (ISIS), and In-vehicle Safety Advisory and Warning Systems (IVSAWS). Section X describes the operational capabilities, projected benefits and performance requirements, and operational scenarios as they relate to CVO-specific IVHS development.

II. METHOD

Information used in the identification of ATIS and CVO development objectives and performance requirements was obtained from two general sources: First, the literature review working paper and supplement (Dingus. Hulse, Alves-Foss, Confer, Jahns, Rice, Roberts. Hanowski. & Sorenson, 1993) provided background information regarding published reports discussing ATIS and CVO system configurations, functions, and objectives. Second, a series of interviews were conducted with government and private industry members of the transportation community to solicit their views regarding ATIS and CVO development objectives, performance requirements, and related topics. Following are descriptions of the interview participants, procedures and materials. and analyses employed during the conduct of this task.

INTERVIEW PARTICIPANTS

A total of 49 individuals from the public and private sectors of the transportation community who are directly involved in ATIS development projects were interviewed to solicit their views regarding ATIS and CVO development objectives. Table 1 provides a summary of the number of interview participants from the government and R&D sectors, divided by their primary focus of either private vehicle applications of ATIS and other IVHS technologies, or both private and commercial vehicle applications of IVHS. The reader should note that a very limited sample of individuals representing either truck manufacturers or commercial transport firms participated in the interviews due to difficulties encountered in identifying the appropriate points of contact and scheduling interviews. To obtain an adequate representation of CVO perspectives, participants from the government and R&D sectors with knowledge of CVO requirements were classified as representing both private and commercial vehicles. As indicated in table 1, 23 of the 49 participants were judged by the research team to have an adequate knowledge and involvement in CVO issues to be categorized as "Both Private and Commercial Vehicles". This group of 23 participants provided the input upon which CVO findings in this report are based.

Table 1. Summary of interview participants.

PARTICIPANT FOCUS	PARTICIPANT SECTOR		TOTALS
	Government	R&D	
Private Vehicles	5	21	26
Both Private and Commercial Vehicles	13	10	23
Totals	18	31	49

The interview participants were identified in an iterative manner, using membership lists of IVHS America technical committees as a starting point and expanding the list of participants, based upon discussions with previous contacts. The final set of individuals contacted represented a substantial segment of the ongoing ATIS and CVO projects currently under way. The Federal Government's programmatic approaches towards ATIS and CVO development were discussed with several representatives of both the FHWA and the National

Highway Traffic Safety Administration (NHTSA). Information regarding program objectives evaluation issues, performance objectives. operational capabilities, and guiding scenarios were obtained in discussions with members of operational test efforts, including Pathfinder. TravTek, ADVANCE, Genesis, Travel Aid. and FAST-TRAK. Additional interviews were conducted with individuals representing ATIS initiatives within automobile manufacturing and original equipment manufacturing to obtain the system developer's perspective. Discussions with two major data base suppliers provided the perspective of both data base development constraints and requirements of other original equipment manufacturers. Discussions with representatives from a State highway patrol provided inputs regarding law enforcement issues related to ATIS and CVO. Finally, representatives from two professional transportation associations provided their perspectives.

INTERVIEW PROCEDURES AND MATERIALS

Interviews were conducted in person by a team of two project staff. The interviews folloued a semi-structured format. Twenty-nine separate interview sessions were held with individuals, or small groups of individuals. from the same organization. Interviews typically lasted for a period of approximately 2 hours, although several interview sessions took 4 hours or more.. Interviews were generally divided into four phases. The first phase consisted of a presentation by an interviewer of the current project, definitions of the major components of IVHS, definitions of those subsystems within the scope of the interviews (IRANS, IMSIS. ISIS. IVSAWS, and CVO), a summary of the basic objectives for IVHS defined by IVHS America (Intelligent Vehicle Highway Society of America, 1992), and an overview of interview objectives and format. The IVHS objectives identified in the IVHS America document were decreased traffic congestion. improved safety, increased and higher quality mobility, improved environmental quality and energy efficiency, and improved economic productivity.

During the second phase, participants were asked to provide an overview of their role in the ATIS and CVO, to include their responsibilities within their organization, and the specific ATIS or CVO projects with which they were associated. At this point, it was determined whether the discussion should'focus upon private vehicle applications, CVO. or both. Included in this phase were tours of facilities and demonstrations of products, as appropriate. Additional documents were obtained at this time, including publications not identified in the literature review, unpublished reports, working papers. and information brochures. Finally. other points of contact within the transportation community were identified during this phase.

The third phase of the interviews consisted of a discussion of ATIS and CVO development. Discussions generally focused upon specific system development objectives, operational test objectives and associated performance requirements, and issues related to systems under development. During this phase, the interviewers made specific queries concerning development objectives. performance criteria, scenarios, and system characteristics. as the discussion allowed. Both interviewers kept extensive written notes during the course of this phase of the interviews.

The final phase of the interviews involved the completion of 14 separate series of ratings by participants. Seven series of ratings addressed private vehicle applications and a matched set of seven series of ratings addressed commercial vehicle applications. Most of these series of ratings were used to obtain judgments regarding the relative importance of the four ATIS subsystems in fulfilling general ATIS development objectives for either private vehicle or commercial vehicle applications. The remaining series of ratings were used to obtain ratings of the importance of the five general ATIS development objectives in meeting the very general objectives of ATIS development for private vehicle or commercial vehicle applications. Rating forms and instructions were designed to obtain ratio-scale ratings. Participants were given the following general instructions:

> *Assume you are determining the future R&D budget* ***for*** *your organization and that the following importance ratings will be used to determine the money that will be spent researching and developing alternative designs.*

Step-by-step written instructions for performing this rating task were also provided to participants. To ensure that participants understood the ratio-scale nature of the rating task. further instructions stated that:

> *A score of "50" is "one-half" of "100". That is, in determining an R&D budget, an alternative assigned a score of "50" would have one-half the budget of an alternative with a score of "100".*

In most cases, participants were requested to complete the questionnaire during the final period of the in-person meeting. However, 10 respondents were unable to complete the questionnaire at the time of the interview, due to time constraints, and were left a copy of the survey. Completed questionnaires were received from 8 of these 10 participants.

ANALYSIS PROCEDURE

Three separate analyses of the information obtained from the interviews were conducted. First, both of the interviewers reviewed their notes and independently prepared a summary of the discussions organized on the basis of ATIS and CVO subsystems, development objectives. performance requirements, and scenarios. Second, the additional written materials obtained from interview respondents were reviewed and summarized, following the same format used for the interview notes. Finally, questionnaire responses were entered into a computer data base and statistically analyzed to determine mean importance ratings, along with 95% Confidence Intervals (CI), for each separate set of questionnaire ratings.

In parallel with the analysis of interview information, a selected review of literature identified in Task A was conducted. Information from these documents was also summarized under specific headings of ATIS and CVO subsystems, development objectives, performance requirements, and scenarios. Taken together, the resulting summaries provided the basis for the remainder of this report.

III. ATIS TECHNOLOGY OVERVIEW

This section provides an overview of the assumptions regarding ATIS technology architecture adopted for the purposes of the present working paper. ATIS subsystems considered, portable ATIS technologies under development, and CVO systems considered. More detailed discussions of ATIS subsystems and CVO systems are provided in sections VI through X.

ATIS ARCHITECTURE ASSUMPTIONS

A system architecture describes the communication modes and protocols among interrelated systems and subsystems. In the DOT *IVHS* Strategic Plan: *Report* to *Congress* (Department of Transportation, 1992), the importance of a standardized IVHS technology architecture is stressed. Recent contracting initiatives by FHWA in system architecture have demonstrated the DOT's commitment to providing leadership and guidance in establishing a unifying system architecture. The approach of the present working paper is to minimize the assumptions regarding the specific ATIS architecture by considering a wide range of possibilities. Four interrelated ATIS architecture issues that were specifically considered in developing this strategy are briefly discussed below, followed by a summary of the ATIS assumptions adopted for the present working paper. The issues are:

- Data flows between ATIS and Advanced Traffic Management Systems (ATMS).
- Distribution of ATIS functions.
- Data flows among ATIS subsystems.
- IVHS and ATIS technologies maturity.

The data flows between ATIS and ATMS could be either one-way or two-way. A one-way link from ATMS to ATIS would provide the basis by which ATIS could incorporate real-time information regarding traffic conditions, roadway congestion, alternate routes, parking, locations of accidents, weather conditions, optimal routes, recommended speeds, and lane restrictions. Such data would then be available to support the route planning, route guidance, and the safety advisory and warning functions. A Two-Way real-time Communications (TWC) link between ATIS and ATMS would allow the vehicle to serve as a traffic sensor, as well as to send and acknowledge vehicle-specific communications, such as mayday requests and acknowledgments. For the purposes of the present working paper, it is being assumed that TWC data flows between ATMS and ATIS could be employed in ATIS. However, more limited capabilities that do not rely upon such data flows are also considered.

The degree of ATIS data processing distribution has been discussed in terms of a continuum ranging from vehicle-based to infrastructure-based architectures. The infrastructure-based architecture emphasizes the interdependence between ATMS and in-vehicle components by employing centralized data bases, route planning, and vehicle positioning that rely upon the infrastructure for frequent updates. The vehicle-based architecture emphasizes autonomous functioning of an ATIS, with in-vehicle data bases. route planning, and vehicle positioning.

The discussions-in this working paper do not assume any specific architecture with regard to this issue Rather, it is assumed that an effective ATIS technology will meet minimum Standards of information accuracy, timeliness, and value, regardless of the extent to which such functions are implemented in either an infrastructure-based or vehicle-based architecture.

Data flows among the major ATIS subsystems —TRANS IMSIS ISIS. and IVSAWS — have a significant effect upon many of the ATIS capabilities, For example, linking IRANS and IMSIS would allow the identification of a destination in IMSIS, which could then be used as a destination in planning a route with IRANS. However, full exchange of data between ATIS subsystems does not allow for more stand-alone ATIS components that would be lower in cost. A number of respondents interviewed during Task B argued for the importance of introducing less complex systems that only included limited subsets of ATIS subsystems, as a means of reducing cost to the consumer and providing an initial introduction of technology to consumers. The present working paper has tried to consider both fully integrated and stand-alone systems in describing capabilities and defining preliminary scenarios.

The maturation of the IVHS technology was discussed by Rillings and Betsold (1991) and later addressed in the *Strategic Plan for Intelligent Vehicle-Highway Systems in the United* States (Intelligent Vehicle Highway Society of America, 1992). The three phases, defined as the *information stage, advisor?, stage, and coordintrtion stage,* represent an evolution from autonomous, vehicle-based systems, through real-time exchange of data between ATMS and ATIS, to a fully integrated (coordinated) ATMS-ATIS technology. The present working paper provides discussions that are consistent with all of these stages of evolution. Again. the intent is to provide descriptions compatible with earlier, more limited systems representing the *information stage,* while not ignoring the future capabilities that are compatible with the more advanced stages.

The preceding discussion provides a very general discussion of ATIS architecture issues that have a substantial impact upon the development objectives, capabilities, and performance requirements considered. As outlined above, the present working paper attempts to consider the full spectrum of system alternatives. The intent in this approach is to allow consideration of more limited systems, while stili considering the more advanced capabilities of fully integrated, mature systems. Following is a summary of the architecture assumptions adopted in the present working paper:

- Data flows between ATIS and ATMS technologies — for the purposes of the present working paper, it is being,assumed that TWC data flows between ATMS and ATIS could be employed in ATIS. However, more limited capabilities that do not rely upon such data flows are also considered.

- Distribution of ATIS functions — the discussions in this working paper do not assume any specific vehicle-based or infrastructure-based architecture. Rather. it is assumed that an effective ATIS technology will meet minimum standards of information accuracy, timeliness. and value, regardless of distribution of ATIS functions.

- Data flows among ATIS subsystems — the present working paper has tried to consider both fully integrated and stand-alone systems in describing capabilities and defining preliminary scenarios.

- IVHS and ATIS technology maturity — this paper discusses capabilities and related scenarios that are compatible with earlier, more limited systems representing the *information stage,* as well as the more advanced advisory and *coordination* stages.

BASIC ATIS SUBSYSTEMS

Perez and Mast (1992) identify and define the four ATIS subsystems (IRANS. IMSIS ISIS, and IVSAWS) that have been adopted by the present project. The following definitions, based on the Perez and Mast paper, were used in the series of Task B interviews:

- In-vehicle Routing and Navigation Systems (IRANS) — provide drivers uith information about how to get from one place to another. When integrated with an ATMS. IRANS provides information on recurrent and non-recurrent traffic congestion, and is capable of calculating, selecting, and displaying optimum routes based on real-time traffic data.

- In-vehicle Motorist Services Information Systems (IMSIS) — provide motorists with commercial logos and signing for motels, eating facilities, service stations. and other signing displayed inside the vehicle to direct motorists to recreational areas, historical sites, etc.

- In-vehicle Signing Information Systems (ISIS) — provide non-commercial routing, warning, regulatory, and advisory information that is currently depicted on external roadway signs inside the vehicle. ISIS is distinguished from IVSAWS on the basis of the relative permanence of the information displayed by this system. ISIS provides information that could be displayed on permanent roadway signs.

- In-vehicle Safety Advisory and Warning Systems (IVSAWS) — provide warnings of unsafe conditions and situations affecting the driver on the roadway ahead. IVSAWS provides sufficient advance warning to permit the driver to take remedial action. IVSAWS provides messages related to relatively transient conditions, requiring modifications to the messages at irregular intervals. It should also be noted that mayday systems have been subsumed under IVSAWS for the purposes of the present discussion. IVSAWS does not encompass in-vehicle warnings of imminent danger requiring immediate action (e.g., collision avoidance devices).

Following the interview discussions. Task B respondents were asked to judge the importance of these four subsystems in supporting, what they considered to be the overall ATIS technology objectives for private vehicle applications and commercial vehicle operations. Figure 1 depicts the mean importance ratings and 95% CI (represented by vertical bars) for private vehicles -and commercial vehicles. In this and other comparisons of the survey results. the entire respondent sample of 49 who completed questionnaires was used in calculating statistics for private vehicles, since all respondents reported to be involved in this aspect of ATIS development whereas the subset of 33 respondents who reported involvement with commercial applications was used in calculating statistics for the commercial vehicle applications. Review of this figure demonstrates the central role that IRANS is judged to have in meeting ATIS objectives for both private and commercial applications. For both the private and commercial applications, the mean importance rating for IRANS was significantly higher than for the remaining three subsystems. which were not significantly different from one another, based on a comparison of 95% C1 Summary tables providing the mean ratings and 95% CI for all survey items are provided in appendix A of this working paper. Table 35 (see appendix A) provides the specific means and 95% CI depicted in figure 1.

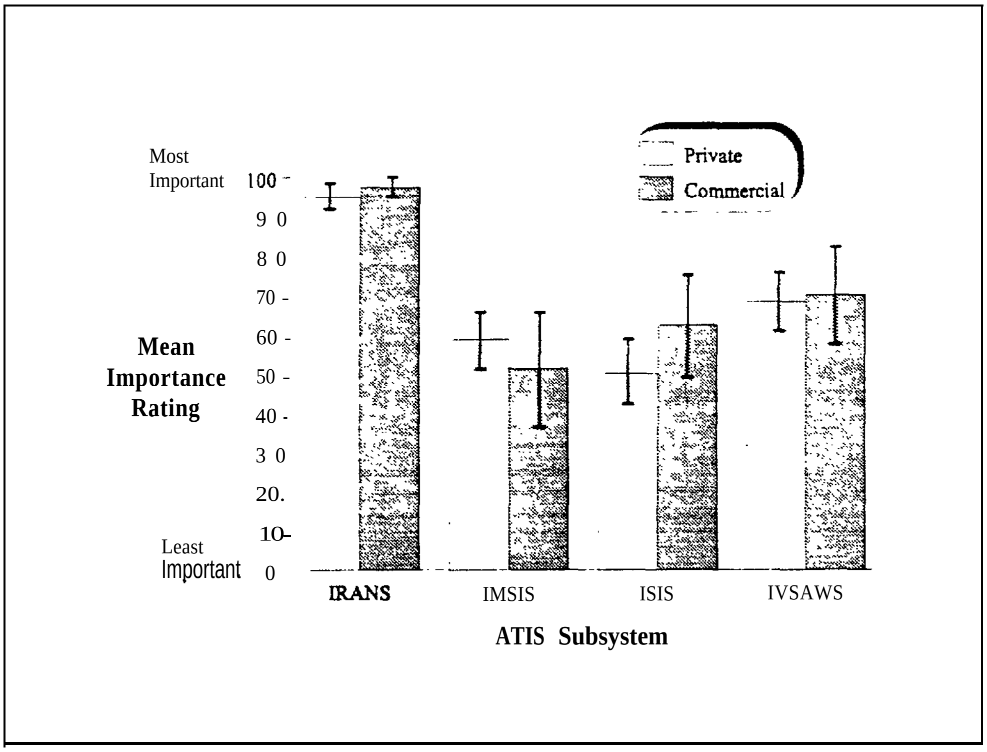

Figure 1. Mean importance ratings for ATIS subsystems in supporting the overall ATIS technology objectives for private vehicle and commercial vehicle applications.

PORTABLE ATIS TECHNOLOGIES

In several discussions with Task B respondents, the topic of portable ATIS technologies was introduced by respondents. Such systems were frequently cited as a quickly emerging technology that could possibly obtain relatively widespread consumer acceptance prior to the introduction of dedicated in-vehicle systems. Minnesota DOT is currently leading the Genesis project. which centers on the development and operational testing of such systems. A recent project report (Minnesota Department of Transportation, 1993) proposes the development of a portable digital personal communications device (PCD) that could support the following functions:

- Incident reports.
- Trip planning with dynamic reminder alert.
- Transit schedule information.
- Parking avaiiability information.
- Planned event, road construction, and road maintenance information.
- Weather-related roadway information.
- Dynamic carpool matching.
- Request for roadside services.
- Request for paratransit services.

A review of the above list indicates a substantial overlap of the functions supported by in-vehicle systems and such portable systems. Although the present project deals explicitly with in-vehicle systems, portable systems should be considered in the future when addressing the scope of in-vehicle human factors guidelines. Several Task B respondents raised the possibility of such systems providing an efficient means of having a "transportable" system that could be used either at home for trip planning or in the vehicle to provide in-vehicle ATIS functions. Such a system could be viewed as residing in a "gray area" between PCDs and in-vehicle ATIS technologies in terms of their overall use. However, when used in the vehicle, they would pose the same user interface challenges as a dedicated in-vehicle system.

CVO SYSTEMS

Commercial vehicle operations include fleets of trucks, buses, vans, taxis, and emergency vehicles. The scope of the present project is to consider both in-vehicle and out-of-vehicle CVO applications. In-vehicle CVO applications include both the application of the basic ATIS subsystem capabilities, as outlined in section III. ATIS TECHNOLOGY OVERVIEW, BASIC ATIS SUBSYSTEMS, as well as additional supporting capabilities specific to CVO requirements. Out-of-vehicle applications center around various support functions that can be provided by commercial vehicle dispatchers. The IVHS Strategic *Plan for intelligent Vehicle-Highway Systems in the United States* (Intelligent Vehicle Highway Society of America, 1992) provides relatively comprehensive coverage of potential CVO technologies and applications. Technologies cited as those that will "enable" specific CVO applications are:

- Automated Vehicle Identification (AVI).
- Automated Vehicle Classification (AVC).
- Automated Vehicle Location (AVL).

- Automated Clearance Sensing (ACS).
- Weigh-In-Motion (WIM).
- On-Board Computer (OBC).
- Two-Way real-time Communications (TWC).
- Digital real-time traffic broadcasts.
- Dynamic network routing and scheduling.
- Roadside beacons.

In addition to identifying these enabling technologies, the IVHS America *Strategic Plan for Intelligent Vehicle-Highway Systems in the United States* (Intelligent Vehicle Highway Society of America, 1992) also identifies CVO-specific systems under development or consideration. These systems include:

- Real-time safety monitoring of drivers and vehicles.
- Hazardous material information systems.
- Site-specific highway warning systems for trucks.
- Automated mayday capabilities.
- Electronic Credentials (EC).
- Automated credential and weight checking.
- Real-time information systems.
- Advanced fleet planning.
- Electronic log book.
- Automated (electronic) toll collection.
- Stolen vehicle alarm capability.

IV. SYSTEM DEVELOPMENT OBJECTIVES AND SYSTEM PERFORMANCE OBJECTIVES, MEASURES, AND REQUIREMENTS

This section presents the transportation community's perspective regarding the more general system development objectives for ATIS and CVO, as well as the more specific system performance objectives, performance measures. and performance requirements. The term *development objective* is used to refer to general factors or benefits envisioned to result from ATIS and CVO development. The term *performance objective* is used to refer to a specific objective that is related to ATIS or CVO performance, but that does not include the specification of particular measures of system performance. The term *performance measure* is used to refer to a quantifiable index of system effectiveness. The term *performance requirement* is used to refer to specific quantitative values of individual measures that serve as goals or requirements for system performance. The primary goals in ascertaining the transportation community's views on these topics are:

- To convey the underlying objectives for system development.
- To help ensure that subsequent project work maintains a perspective that is consistent with the transportation community.
- To provide an initial basis upon which to develop dependent measures to be employed in the subsequent research phases of this project.

IVHS-wide development objectives have been stated in very broad, institutional terms in the *Strategic Plan for Intelligent Vehicle-Highway Systems in the United States* (Intelligent Vehicle Highway Society of America, 1992) as summarized below:

- Improved safety.
- Reduced congestion.
- Increased and higher quality mobility.
- Reduced environmental impact.
- Improved energy efficiency.
- Improved economic productivity.
- Development of a viable U.S. IVHS industry.

For the purposes of the present discussion, we have combined the objectives of "reduced environmental impact" and "improved energy efficiency." These two objectives were combined because of their commonality of goals and performance objectives. Additionally. we have not systematically considered the objective of "development of a viable U.S. IVHS industry". Although this objective is an important and pervasive goal, it has limited relevance to the scope of the present project.

The general IVHS objectives cited in the *Strategic Plan fur Intelligent Vehicle-Highway Systems* in *the* United *States* tend to be repeated with only minor variations throughout the transportation community when referring to either IVHS or ATIS development. This consistency is due to the guiding role that has been played by the government-industry team represented by IVHS America. However, there are differences in the relative importance of these objectives when private and commercial applications are considered. Figure 7 depicts the mean importance ratings and 95% CI (represented by vertical bars) of the importance of five development objectives in meeting overall ATIS technology objectives for private and commercial vehicle applications. Review of this figure suggests that for private applications, *traffic* congestion, safety, and *mobility* are all considered to be relatively more important than *environment* & *energy* and *economic productivity.* Review of the 95% CI for these data (see appendix A, table 36) indicate substantial variability among the ratings, resulting in significant differences between only *traffic congestion* and *environment* & *energy,* even though the trend indicated by review of the figure is supported by statistical analysis. Review of the ratings for commercial applications reveal that the least important objective for private applications, *economic productivity,* was rated the most important for commercial applications. However. we again find that *environment* & *energy* are given the lowest ratings for commercial applications. Review of CI indicates that there was also substantial variability among respondents' ratings of commercial applications, resulting in *economic productivity* receiving significantly higher ratings than all groups, and safety being rated significantly higher than *environment* & *energy*.

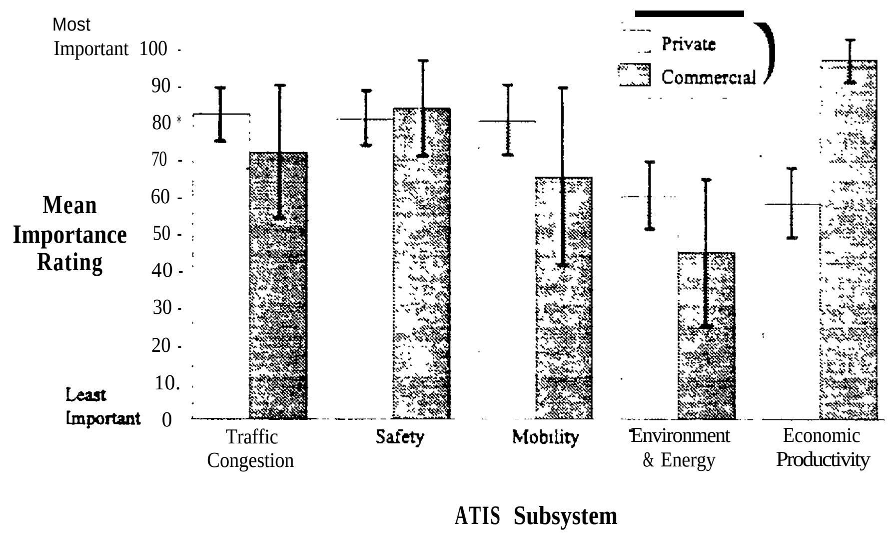

Figure 2. Mean importance ratings for five development objectives in meeting overall ATIS technology objectives for private and commercial vehicle applications.

The five general-development objectives identified above provide a very useful focus for government and industry in the current effort to develop a common framework for IVHS development. These objectives can be associated with various performance objectives, measures. and requirements that can be used to assess the overall effectiveness of IVHS, ATIS, and CVO systems. For example, the development objective of *traffic congestion* can be associated with several performance requirements which generally address such factors as increased traffic volume and reduced excess travel. Such performance objectives represent broad institutional benefits from system development. However, as pointed out in many of the interviews, including all interviews with private industry representatives, the perspective of the individual consumer must also be specifically considered in identifying performance objectives, measures, and requirements. As noted repeatedly by interview respondents, the individual consumer will ultimately determine the success or failure of ATIS technologies. Respondents noted that the individual consumer has a limited concern for traffic volume. The individual's concerns associated with *traffic congestion* revolve around reducing personal travel times and minimizing traffic delays personally experienced. These two perspectives are both associated with *traffic congestion,* and it is likely that correlations between the two measures will be found to be substantial when large-scale operational tests are conducted. However, the distinction is important, in terms of recognizing the relative roles of institutional and individual performance objectives, measures, and requirements associated with the separate development objectives. This distinction will be explicitly addressed throughout this section.

CVO system development objectives are also associated with both institutional and individual user performance objectives, measures, and requirements. However, as pointed out by CVO representatives during project interviews, the CVO community is quite heterogeneous in terms of its concerns regarding the separate performance benefits. Two important factors in considering CVO system objectives are the type of service being provided and the size of the commercial operation responsible for the vehicles. For the purposes of the present paper, CVO services have been divided into three categories: public service, local commercial, and interstate trucking. Each of these types of operations have substantially different operational requirements, which can be translated into ATIS and CVO system performance objectives, measures, and requirements. The size of the commercial operations can generally be categorized as large operations, with 100 or more vehicles owned by the operation; smaller operations, with less than 100 vehicles; and individual owner/operators.

When considering the basic ATIS objective of providing the traveler with more complete and accurate information, many commonalities and differences can be seen in comparing private and commercial vehicle operations. Much of the information ATIS will be designed to provide can be useful to all drivers, regardless of the type of vehicle they use. However, CVO drivers require more specialized information. For example, interstate trucks cannot be operated on all roads for various reasons, such as low clearances, restrictive geometry, hazardous materials limitations, and bridge weight restrictions. Therefore, interstate truck operators require accurate, detailed information about any changes to their normal routes or unfamiliar routes.

The remainder-of this section is divided into five subsections, each of which discusses one of the five broad development objectives: *traffic congestion. safety mobility, environment & energy.* and *economic productivity.* Each of these subsections is further divided into an introduction and three brief discussions. The introductions include a consideration of the relationship between ATIS subsystems and the development objective; and provide an overview of the specific performance objectives, measures, and requirements found to be associated with each general development objective within the transportation community. The sets of three brief discussions address the sources and types of specific performance objectives, measures, and requirements that correspond to the goals of government institutions, private vehicle drivers, and commercial vehicle operators.

DECREASED TRAFFIC CONGESTION

The IVHS America *Strategic Plan for Intelligent Vehicle-Highway Systems in the United States* (Intelligent Vehicle Highway Society of America, 1992) identifies decreased traffic congestion as a primary objective of IVHS. Major benefits cited include better utilization of roadway capacity by shifting traffic from overcrowded routes to those with excess capacity.. This basic strategy is seen as a means of increasing traffic volume without increasing congestion, to provide broad, institutional economic benefits associated with more effective use of roadways. Benefits to both private and commercial vehicle operators are seen as directly related to reduced travel time. Decreased traffic congestion is also seen as resulting from ATIS technologies that provide travelers with information regarding alternative modes of transportation, including bus, rail, air, and ride-sharing. Several interrelationships between decreased traffic congestion and the other general development objectives were identified in the literature and by respondents. In discussing the objective of decreased traffic congestion during Task B interviews, many respondents pointed out the interrelationship between the objectives of traffic congestion and improved safety. It was frequently noted that reducing traffic congestion also reduces speed changes along major roadways, which, in turn, reduces the frequency of accidents. A California Department of Transportation (Caltrans) program plan (California Department of Transportation, 1991) notes the interrelationship between the congestion and safety objectives, stating that accident rates on freeways under congested conditions are three times those in uncongested conditions, while more than half of all highway traffic congestion is caused by accidents and other incidents.’ Decreased congestion was seen as a means of improving energy efficiency through reducing the variability of travel speeds. which was also closely related to improved energy efficiency. It is assumed that decreased congestion could also improve the mobility of private and commercial vehicles by providing extended periods during which travelers could avoid heavy congestion. Finally, decreased congestion was seen as a means of improving economic productivity by reducing vehicle operating costs, as well as reducing trip times.

Interview respondents were asked to rate the relative importance of each of the four ATIS subsystems in meeting the traffic congestion objectives for private and commercial applications. The results of these analyses. shown in figure 3, indicate the central role of

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1 The reader should note that this Caltrans program plan was intended as a policy document and did not cite the source of its Statements, nor did it define “congested” and “uncongested.”

TRAN in decreasing traffic congestion. A representative of a map data base company estimated (on the basis of his recall of past published research) that approximately 10% of travel is the result of errors in navigation, and that a routing and navigation system would have a substantial potential for reducing this unnecessary travel. A similar argument was made by Rillings and Betsold (1991) who used King and Mast's (1987) estimate that 6% of all driving results from an incorrect choice of route. Review of figure 3 suggests that similar expectations may be shared among the respondents with regard to the role of ATIS subsystems in achieving decreased congestion.

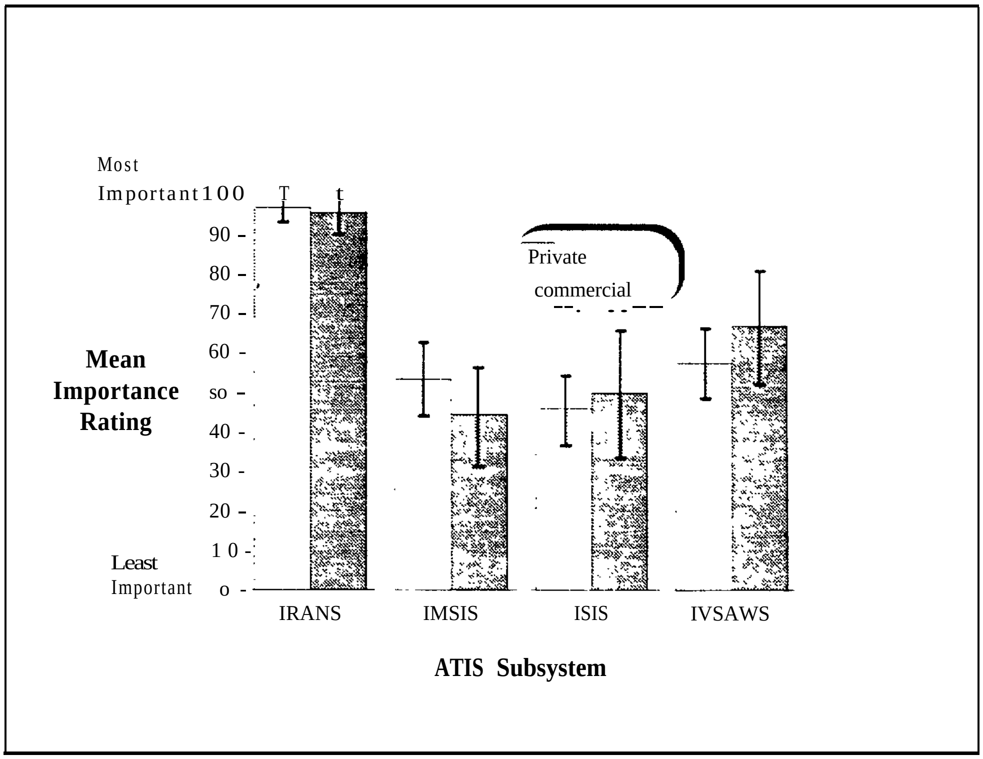

Figure 3. Mean importance ratings for ATIS subsystems in meeting the objective of decreasing traffic congestion for private and commercial vehicle applications.

The TRANS technologies were rated very high, followed by moderate ratings for IVSAWS. Review of 95% CI (see appendix A, table 37 for specific values) indicates that for both private and commercial applications, TRANS was rated significantly more important than all other subsystems. Ratings for the remaining three subsystems were not significantly different from one another for either private or commercial application.

Table 2 provides an overview of performance objectives, measures, and requirements identified through the review of operational test plans, strategic plans, and interview notes that were found to be associated with the development objective of decreased traffic congestion within the transportation community. The first column of this table identifies the specific performance objective, measure, or requirement. The second column identifies the sources of these performance objectives, measures, and requirements. Twelve separate sources were reviewed in compiling table 2 (as well as rhe remaining tables in this section).

Table 2. Decreased traffic congestion objectives, measures, and performance requirements.

PERFORMANCE OBJECTIVES, MEASURES, AND REQUIREMENTS	SOURCES	TYPE
Institutional Performance Objectives, Measures, and Requirements		
Reduced congestion level	Genesis. FAST-TRAC	Objective
Reduced congestion costs	IVHS America DOT	Requirement
Increased vehicle occupancy rates	DOT IVHS America, Caltrans	Objective
Increased volume of people	GOV-Private. GOV-Both	Objective
Increased volume of goods	IVHS America. DOT, Caltrans. GOV-Both	Objective
Reduced excess travel caused by navigational problems	IVHS America. PRIV-Both	Objective
increased use of alternative transportation modes	GOV-Both	Objective
Increased parking availability	Genesis	Measure
Private Vehicle Driver Performance Objectives, Measures, and Requirements		
Reduced delay of a vehicle on a given route	FAST-TRAC, TravTek. GOV-Both	Measure
Reduced variance in travel time on a given route	FAST-TRAC	Measure
Reduced travel time	ADVANCE. FAST-TRAC, Genesis. TravTek. Mobility 2000 R&D-Private, R&D-Both	Measure
Perceived benefit of ATIS in decreasing level of congestion experienced	TravTek	Measure
CVO Performance Objectives, Measures and Requirements		
Reduced delay of a vehicle on a given route	FAST-TRAC	Measure
Reduced variance in travel time on a given route	FAST-TRAC	Measure
More accurate prediction of travel times	R&D-Ptivate. R&D-Both	Objective

Four operational test plans were reviewed: TravTek (Fleischman. 1991); ADVANCE (Bolezak) Salwin, and McHale, 1992); FAST-TRAC (Underwood, 1993); and Genesis (Minnesota Department of Transportation, 1993). Four strategic plans were reviewed: the Mobility 2000 Operational Benefits report (Mobility 2000, 1990); IVHS America (Intelligent Vehicle Highway Society of America, 1992); Caltrans (California Department of Transportation, 1991); and the DOT *IVHS Strategic Plan: Report to Congress* (Department of Transportation, 1992). Responses by interview participants were classified into four categories:

- *GOV-Private* Interview respondents from the government sector representing private vehicle concerns exclusively.

- *GOV-Both* Interview respondents from the government sector representing both private and commercial vehicle concerns.

- *R&D-Private* Interview respondents from the R&D sector representing private vehicle concerns exclusively.

- *R&D-Both* Interview respondents from the R&D sector representing both private and commercial vehicle concerns.

The final column in table 2 indicates whether the sources were recommending a specific performance objective, performance measure, or performance requirement. In cases where respondents recommended several *Types* the most specific Type is listed. Performance requirements are more specific than performance measures, and performance measures are more specific than performance objectives.

Review of table 2 indicates that only one performance requirement associated with the development objective of decreased traffic was identified. Seven separate performance measures and seven performance objectives were identified. The following discussions address the institutional, private vehicle, and CVO performance objectives, measures, and requirements associated with the general ATIS development objective of decreased traffic congestion.

Institutional Performance Objectives, Measures, and Requirements

A recent research project summary by Caltrans (California Department of Transportation, 1991) provides a good summary of the institutional perspective with regard to decreased traffic congestion:

> *By the year 2005, traffic congestion in California would increase by 200 percent over current levels, with average freeway speeds during peak periods dropping from 35 m.p.h. to I I m.p.h. Fuel waste and lost productivity associated with traffic congestion are estimated at more than $5 billion annually in California. With projected congestion trends, this cost would increase to nearly $20 billion (1990 dollars) by the year 2005.*

There is a general consensus within the Federal, State, and local transportation agencies that traffic congestion is a major problem, and that decreasing congestion would result in broad economic benefits. This leads to the general goal of increasing the capacity and operational efficiency of the surface transportation system. From the traffic engineering perspective, this requires a balancing of traffic across the traffic network and across time, which could result in a lower peak level of congestion during rush hour in urban and suburban settings. Balancing of travel is commonly considered to include diversion of travelers to modes other than single-occupant automobiles, in the case of private applications. One State agency emphasized the importance of reducing congestion to meet requirements of non-commuting travelers, such as tourists. One local agency, representing a smaller urban setting, stressed the value of increasing the number of trips, assuming that all “induced trips” have social and economic benefits that outweigh the costs.

In reviewing institutional performance objectives, measures, and requirements associated with the development objective of decreased traffic congestion, it is important to note that many of these goals are tied to the broad implementation of IVHS. There are very few objectives stated specifically for ATIS. The institutional performance objectives, measures, and requirements associated with decreased traffic congestion are summarized below:

- *Reduced congestion level* - the Genesis project, under management of Minnesota DOT, plans on measuring congestion level. Similarly, the FAST-TRAC program intends to assess congestion level by obtaining measures of mean number of vehicle stops per trip, vehicle speed variance, and corridor volume variance, based on the outputs of models (Underwood, 1993).

- *Reduced congestion costs* - the *Strategic Plan **for** Intelligent Vehicle-Highway Systems in the United States* (Intelligent Vehicle Highway Society of America, 1992) defines this performance requirement in terms of phases of IVHS development, with specific goals of reducing congestion costs by 10% in a significant number of metropolitan areas by 2001, and by 15-20% in a substantially increased number of metropolitan areas by 2011.

- *Increased vehicle occupancy rates* - the DOT *IVHS Strategic Plan: Report to Congress* (Department of Transportation, 1992), the *Strategic Plan for Intelligent Vehicle-Highway Systems in the United States* (Intelligent Vehicle Highway Society of America, 1992), and the *Caltrans Program Plan* (California Department of Transportation, 1991) identify the specific objective of increasing the average vehicle occupancy rate, but more specific performance measures or performance requirements were not identified.

- *increased volume **of** people* - increasing the absolute volume of people traveling on existing facilities and corridors was cited as a performance objective by several government participants during interviews related to reduced congestion.

- *Increased volume **of goods*** - an institutional performance objective directly tied to CVO is the increase in commercial goods transported on existing facilities and corridors. This objective was recommended by IVHS America (Intelligent Vehicle Highway Society of America, 1992), in the DOT *IVHS Strategic Plan: Report to Congress* (Department of Transportation, *1992),* in the *Caltrans Program Plan* (California Department of Transportation, 199 l), and by respondents from the government sector.

- *Reduced excess travel caused by navigational problems* - directly addressing the issue of reducing travel associated with navigational errors was identified as a performance objective in the *Strategic Plan **for** Intelligent Vehicle-Highway* Systems in the *United States* (Intelligent Vehicle Highway Society of America. 1992) and by interview participants from the government sector.

Increased use of alternative transportation rnodes a number of representatives from State agencies noted the performance objective of demonstrating increased use of bus, rail, and ride-sharing travel modes associated with ATIS use.

Increased parking availability - the Minnesota Department of Transportation has specifically identified increased parking availability, as measured by parking vacancies and time required to fill parking lots, as an evaluation measure for the Genesis project (Minnesota Department of Transportation, 1993).

Private Vehicle Driver Performance Objectives, Measures, and Requirements

For the private vehicle driver, the development objective *of decreased traffic congestion* is more appropriately revised to *avoidance of traffic congestion*. In considering this topic. the majority of interview respondents noted that the basic issues for the private vehicle driver are related to decreased travel time and decreased variability in travel times. The performance objectives and measures found to be associated with decreased traffic congestion for the private vehicle driver are summarized below:

- *Reduced delay* of *a vehicle on a given route* - several variations of this measure were identified during the course of Task B. A general measure of reduced delay is decreased travel time between an origin and a destination, which was included in the TravTek evaluation. The number of stops per trip is another measure included in the FAST-TRAC evaluation plan (Underwood, 1993). Finally, a more elaborate measure suggested by one State agency interview participant is the average deceleration and acceleration rates.

  Reduced variance in travel time 0" *a given route* - the FAST-TRAC evaluation plan (Underwood, 1993) identifies the measure of speed variance experienced by individual drivers traveling between the same two points on a regular basis.

- *Perceived benefit of ATIS in decreasing level of congestion experienced* - from the industry perspective, the driver's perception of ATIS benefits is critical to the future success of such systems. Thus, the TravTek project evaluated drivers' judged value of the system in congestion avoidance as well as whether vehicle owners demonstrated a willingness to equip their automobiles with ATIS devices.

CVO Performance Objectives, Measures, and Requirements

As in the case of private vehicle performance objectives, measures, and requirements, those of CVO center on the avoidance of traffic congestion. Although the majority of CVO objectives are most closely tied to productivity, one performance objective and two measures can be linked to congestion, as summarized below:

- *Reduced delay of a vehicle on a* given *route* - as in the case of private vehicles. measures of travel time between an origin and a destination: number of stops per trip; and average deceleration and acceleration rates could be applied here. Two potentially important areas for employing such measures would be in emergency vehicle response times, and commercial passenger vehicle (taxis and buses) travel times. This measure was included in the FAST-TRAC evaluation plan (Underwood, 1993).

- *Reduced variance in travel time will a given route* - when standard delivery points are being traveled to, reduced travel time variance would translate into better scheduling of the pick-up and delivery of goods. This measure was also included in the FAST-TRAC evaluation plan (Underwood, 1993).

More accurate prediction of travel times - more accurate travel time prediction is commonly associated with economic productivity, providing a means of improving "just-in-time" production efficiencies. Several interview respondents from the R&D sectors identified this performance objective. These discussions focused on the value of accurately predicting travel times as a means of facilitating the "just-in-time" approach to manufacturing. Assuming more accurate travel time prediction is used to support "just-in-time" manufacturing. reductions in production slowdowns and parts storage could be obtained.

IMPROVED SAFETY

In general, IVHS technology is seen as providing an opportunity to improve safety by reducing crashes, rather than the traditional approach of increasing "crashworthiness". The basic strategies identified for improving safety center around avoiding areas of congestion. being warned of hazards, and reducing levels of congestion (that are associated with a higher incidence of accidents). As noted in section IV. SYSTEM DEVELOPMENT OBJECTIVES AND SYSTEM PERFORMANCE OBJECTIVES, MEASURES, AND REQUIREMENTS, DECREASED TRAFFIC CONGESTION, decreased congestion and improved safety are closely linked. Congested traffic conditions have a higher incidence of crashes; thus, by decreasing congestion, the general level of exposure to crashes is reduced on the roadway.

In discussions with respondents from industry, rhe high priority of safety was stressed. A theme that was frequently addressed in addition to reduced exposure to unsafe conditions was the need to avoid increasing driver mental workload. Specific concerns cited included avoiding directing drivers down one-way streets in the wrong direction; reducing the time spent by drivers in monitoring the roadway; and reducing reaction time to unanticipated hazards, due to high levels of mental workload. A specific concern with in-vehicle ATIS technology introduction is excessive mental workload requirements in the case of heavily instrumented commercial vehicles, especially emergency vehicles, Another specific safety concern was the use of portable and hand-held systems that were not specifically designed to be operated concurrently with the driving task. On the positive side, it was noted that ;t properly implemented ATIS technology could reduce driver workload by providing required information and warning drivers of potentially hazardours conditions. Another possible positive aspect of having an in-vehicle device that was identified by respondents would be the reduction in frequency of drivers simultaneously holding a map while driving a vehicle.

In comparing the role of ATIS subsystems in supporting the objective of improving safety in private vehicle and CVO applications, a consistent view was obtained across participants. Figure 4 depicts the mean importance ratings and 95% CI for ATIS subsystems, indicating a consistent ranking of: (I) IVSAWS, (2) IRANS (3) ISIS, and (4) IMSIS. The safety advisory and warning system was rated as significantly higher than all other ATIS subsystems for private applications, whereas the difference in ratings between IVSAWS and TRANS was only marginally significant in the case of commercial applications. IMSIS was rated significantly lower than all other subsystems by respondents when considering both private and CVO applications (see appendix A, table 38, for specific rating means and 95% confidence limits).

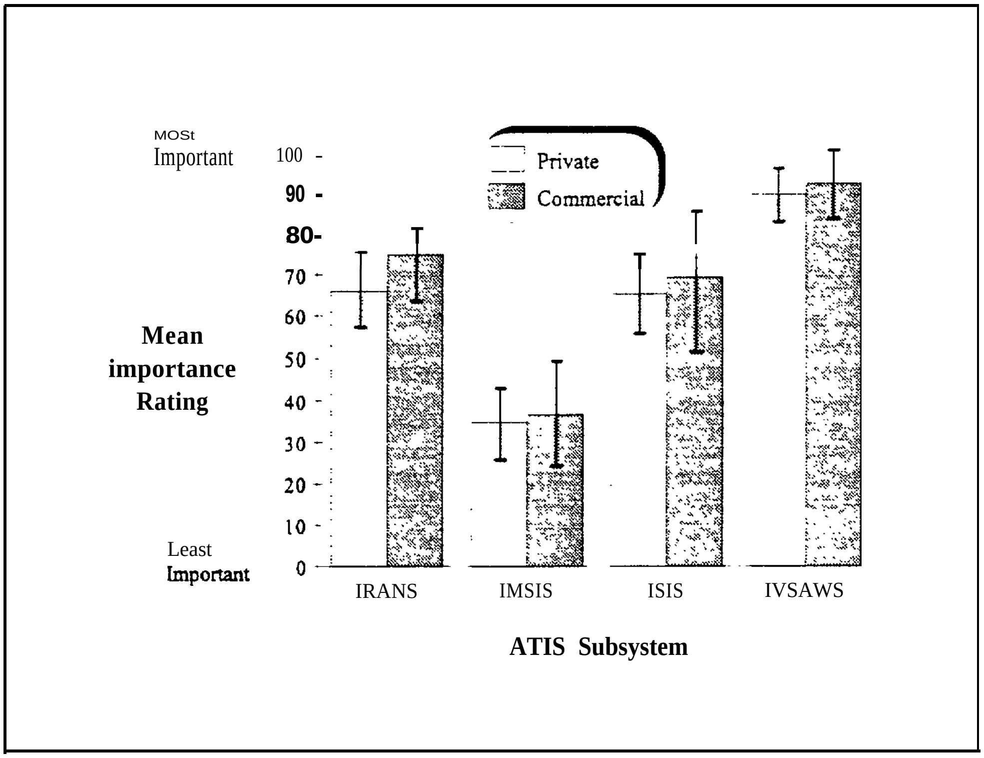

Figure 4. Mean importance ratings for ATIS subsystems in meeting the objective of improved safety for private and commercial vehicle applications.

Table 3 provides an overview of performance objectives, measures, and requirements identified through the review of operational test plans (Fleischman, 1991; Bolczak et al., 1992; Underwood, 1993; Minnesota Department of Transportation, 1993), strategic plans (Mobility 2000, 1990; Intelligent Vehicle Highway Society of America, 1992; California Department of Transportation, 1991; Department of Transportation, 1992), and interview notes. Review of this table indicates that 2 performance requirements, 1 performance measure, and 13 performance objectives were identified. The following discussions address these performance objectives, measures, and requirements in terms of their applications to institutional, private vehicle, or CVO concerns.

Table 3. -Improved safety objectives, measures, and **performance requirements.**

PERFORMANCE OBJECTIVES, MEASURES, AM) REQUIREMENTS	SOURCE	TYPE
Institutional Objectives, Measures: and Performance Requirements		
Reduced deaths	IVHS America. DOT	Requirement
Reduced injuries	DOT	Objective
Reduced mix of commercial and private vehicles	GOV-Both	Objective
Reduced travel on residential roads	GOV-Both	Objective
Private Vehicle Objectives, Measures, and Performance Requirements		
Reduced deaths	IVHS America DOT	Requirement
Reduced injuries	DOT	Objective
Reduced crashes	DOT	Objective
Increased security	IVHS America. GOV-Both	Objective
Increased attention to driving task	R&D-Pnvate. R&D-Both	Objective
CVO Objectives, Measures, and Performance Requirements		
Reduced deaths	DOT	Objective
Reduced injuries	DOT	Objective
Reduced crashes	DOT	Objective
Improved conformance with CVO safety regulations	GOV-Both	Objective
Reduced emergency response times	Mobility 2000 GOV-Both. R&D-Both	Measure
Decreased public exposure to hazardous materials	IVHS America. GOV-Both	Objective
Increased attention to driving task	R&D-Private. R&D-Both	Objective

Institutional Performance Objectives, Measures, and Requirements

Institutional concerns regarding improved safety center around a reduction of crash fatalities and accidents. Specific institutional performance objectives, measures, and requirements associated with this development objective are summarized below:

- *Reduced deaths* - several respondents identified a reduction in the number of driving-related deaths as a primary performance requirement of improved safety. Both absolute levels and rates per miles traveled provide useful measures. The *Strategic Plan for Intelligent Vehicle-Highway Systems in the United States* (Intelligent Vehicle Highway Society of America, 1992) provides a specific target of reducing the number of annual fatalities by 8% by 2011 (which would be equivalent to 3300 annual deaths).

- *Reduced injuries*- the performance objective of reducing injuries was specifically identified in the DOT *IVHS Strategic Plan: Report to Congress* (Department of Transportation, 1992).

- *Reduced crashes* - reduced numbers and rates of crashes is an additional objective specified by the DOT *IVHS Strategic Plan: Report to Congress* (Department of Transportation, 1992).

- *Reduced mix of commercial and private vehicles* - law enforcement officials who were interviewed identified the segregation of commercial and private vehicles in a way that would not degrade CVO effectiveness as a safety requirement, due to the over-representation of private vehicle deaths in commercial vehicle-related crashes. This was a performance objective, not stated in terms of a measure or performance requirement.

- *Reduced travel* on *residential roads* - an interview participant from a government agency identified the objective of minimizing unnecessary travel on residential roads, which is associated with a substantial crash rate and pedestrian fatality level.

Private Vehicle Driver Performance Objectives, Measures, and Requirements

The one private vehicle performance requirement and three specific objectives have substantial overlap with those identified under institutional concerns, and also address the additional topics of traveler security and driver mental workload:

- *Reduced deaths* - obviously, reduced overall deaths and death rates would translate into a decreased likelihood of fatal accidents among drivers of ATIS-equipped vehicles. The IVHS America performance requirement (described in section IV. SYSTEM DEVELOPMENT OBJECTIVES AND SYSTEM PERFORMANCE OBJECTIVES, MEASURES, AND REQUIREMENTS, IMPROVED SAFETY, Institutional Performance Objectives, Measures, and Requirements, also applies here.

- *Reduced injuries* - Reduced likelihood of injuries in ATIS-equipped private vehicles would represent an objective to which the individual driver would relate. This objective was derived from the DOT *IVHS Strategic Plan: Report to Congress* (Department of Transportation, 1992).

- *Reduced crashes* - expected likelihood of crashes and near-misses represent important objectives related to occupant'safety derived from the DOT *IVHS Strategic Plan: Report to Congress* (Department of Transportation, 1992).

- *Increased security* - the *Strategic Plan for Intelligent Vehicle-Highway Systems in the United States* (Intelligent Vehicle Highway Society of America, 1992) identifies increased personal security as an objective. Interview respondents from the law enforcement sector noted that increased security includes the availability of mayday devices to call for help in case of emergency, as well as providing warnings of high-crime areas in urban settings.

- *Increased attention to driving task* - increased attention to the driving task was identified as an objective linked to safety by several interview participants in the R&D sector.

CVO Performance Objectives, Measures, and Requirements

The basic set of CVO objectives and measures associated with improved safety are the same as those for private vehicles, relating to deaths, injuries, and accidents. Decreased workload is also an appropriate objective in the case of CVO. Improved conformance with CVO safety regulations would also be associated with CVO safety objectives. Finally, improved emergency vehicle response times and decreased exposure of the public to hazardous materials would also provide safety-related performance measures and objectives for CVO. Following is a summary of the performance objectives and measures associated with improved CVO safety:

- *Reduced deaths* - reduced deaths involving CVO operations are analogous to the objective for private vehicles, derived from the DOT *IVHS Strategic Plan Report to Congress* (Department of Transportation, 1992).

- *Reduced injuries* - reduced injuries are also a performance objective derived from the DOT *IVHS Strategic Plan: Report to Congress* (Department of Transportation, 1992).

- *Reduced crashes* - reduced commercial vehicle crashes provide a further objective derived from the DOT *IVHS Strategic Plan: Report to Congress* (Department of Transportation, 1992).

- *Improved conformance with CVO safety regulations* - an increased rate of vehicles conforming to CVO safety regulations on the road was cited as a performance objective by representatives from Washington State DOT during the interviews. Examples of specific measures could include the percentage of vehicles with brakes that do not meet established safety standards, and the number of drivers operating vehicles for longer shifts than allowed under established safety standards.

- *Reduced emergency response times* - this performance measure was identified in the Mobility 2000 report, as well as by interview respondents from both the government and private sectors. Reduced emergency vehicle response time is assumed to be associated with reduced fatalities at emergency sites being serviced, as well as quicker alleviation of congestion, resulting in reduced exposure of the general public to unsafe traffic conditions.

- *Decreased public exposure to hazardous materials* - the objective of applying ATIS technologies in CVO to reduce the public's exposure to hazardous materials was identified in the IVHS America *Strategic Plan for Intelligent Vehicle-Highway Systems in* the *United States* (Intelligent Vehicle Highway Society of America, 1992); and was also noted by interview respondents from the government sector.

- *Increased attention to driving task* - increased attention to the driving task by commercial vehicle operators was identified as an objective of interview participants from the R&D sector.

INCREASED AND HIGHER QUALITY MOBILITY

The objective of increased and higher quality mobility is used to refer to a broad range of associated performance objectives and measures that address the traveler's well being, comfort, enjoyment, and access to travel. These performance objectives and measures range from reducing the general level of stress while driving to increasing access to scenic and recreation areas. Access to travel objectives include both improved automobile access, as well as improved access to alternative modes of travel. Finally, this general objective is commonly referred to when noting the specific objective of increasing the mobility of the elderly, disabled, and economically disadvantaged segments of the population.

The objective of increased mobility is considered to be closely related to that of decreased congestion. Decreased traffic congestion is expected to result in increased availability of acceptable periods of travel for non-commuting needs. These needs would include driving by tourists, the elderly, and commercial vehicles. With regard to both tourism and CVO, several respondents noted the interrelationship between improved mobility and increased economic productivity.

Respondents' ratings of the importance of the four basic ATIS subsystems in meeting the objective of improved mobility resulted in somewhat different priorities for private and commercial application. Figure 5 depicts the mean ratings by the two groups of respondents who provided private and commercial vehicle ratings. Review of the mean importance ratings for private applications indicates a very high priority for TRANS, followed by a moderate rating for IMSIS, and relatively low ratings for ISIS and IVSAWS. Comparison of 95% CI for private applications (see appendix A, table 39, for specific values) indicates that IRANS was rated significantly higher than all other subsystems, IMSIS was rated significantly higher than the remaining two subsystems, and ISIS and IVSAWS were rated at comparable levels. TRANS also received significantly higher ratings for commercial applications. However, for commercial applications, ratings for IMSIS, ISIS, and IVSAWS were not significantly different from one another. This difference between private and commercial ratings points to the broader focus of private applications, which include IMSIS directories that could be used to assist in identifying points of destination, thereby improving the level of mobility.

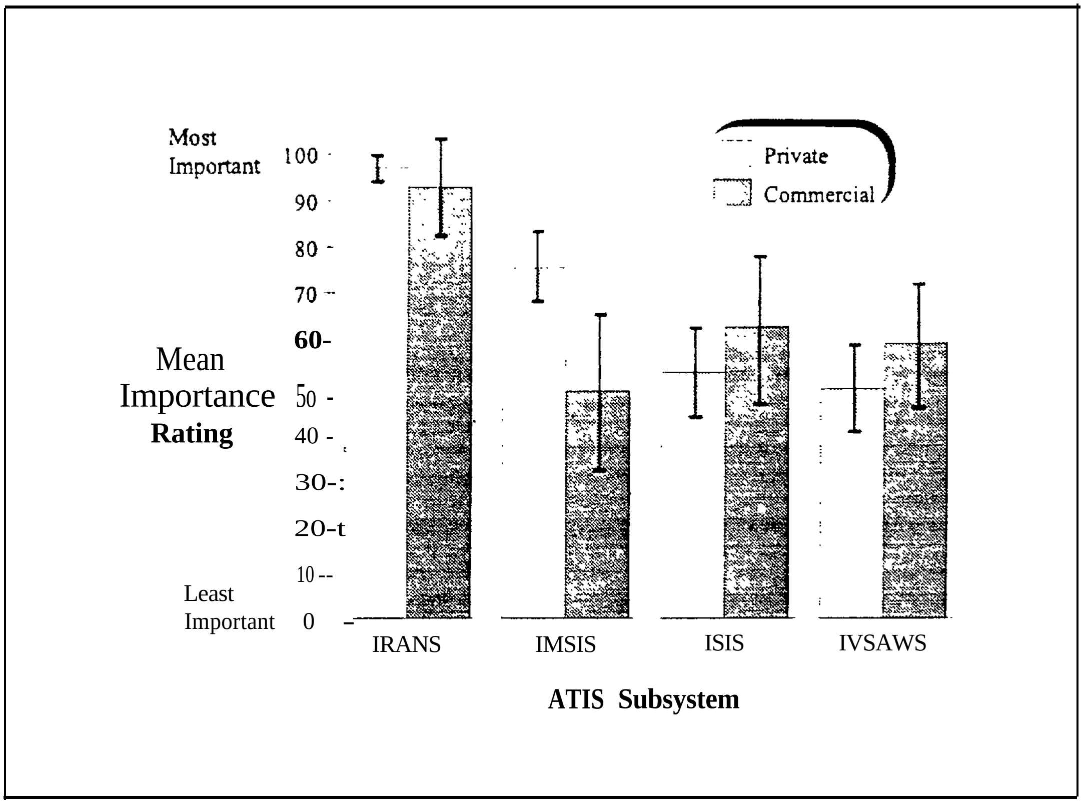

Figure 5. Mean importance ratings for ATIS subsystems in meeting the objective of increased and higher quality mobility for private and commercial vehicle applications.

Table 4 provides an overview of objectives and measures identified through the review of operational test plans, strategic plans, and interview notes. Review of this table indicates that no performance requirements directly associated with the general objective of increased and higher quality mobility were identified. Additionally, only three sets of measures and seven specific objectives were identified.

Table 4. Increased and higher quality mobility objectives, measures, and Performance requirements.

PERFORMANCE OBJECTIVES, MEASURES, AND REQUIREMENTS	SOURCE	TYPE
Institutional Performance Objectives, Measures, and Requirements		
Improve information regarding public transportation alternatives	GOV-Both	Objective
Improve responsiveness of public transportation to traveler requirements	GOV-Both	Objective
Improve information about travel links (flights, ferries, parking)	GOV-Both	Objective
Private Vehicle Performance Objectives, Measures, and Requirements		
Increased range of traveler destinations and routes	Mobility 2000 R&D-Both	Objective
Reduced level of stress and fatigue associated with travel	IVHS America, DOT. FAST-TRAC. R&D-Private	Objective
Increased periods of time in which trips are made	FAST-TRAC, R&D-Private	Measure
Increased use of alternative transportation modes	GOV-Both	Objective
Decreased travel times	ADVANCE, TravTak FAST-TRAC	Measure
Decreased travel distance	ADVANCE, Genesis	Measure
Increased travel time predictability	IVHS America, Mobility 2000 DOT, GOV-Both, R&D-Both	Objective
CVO Objectives, Measures, and Performance Requirements		
NA	NA	NA

NA = not applicable

Institutional Performance Objectives, Measures, and Requirements

The objective of increased and higher quality mobility focuses primarily upon the private vehicle operator, rather than upon CVO or institutional issues, However, ATIS applications related to public transportation point to three institutional performance objectives, as summarized below:

- *Improve information regarding public transportation alternatives* - increasing the general knowledge of public transportation alternatives, by making that information more accessible through ATIS, is a performance objective identified by interview participants from the government sector that is closely linked to Advanced Public Transportation Systems.

- *Improve responsiveness of public transportation to traveler requirements* - ATIS applications in transit fleets, especially transit and paratransit systems, could improve fleet management and routing, thereby improving the responsiveness to traveler requirements. This, which was also identified by an interview participant from the government sector, could be assessed using measures addressing wait time and travel time of travelers.

- *Improve information about travel links* - several representatives of State transportation agencies identified the objective of applying ATTS to improve the availability of information about the separate links of travel, including flight information, ferry schedules and delays, and parking availability.

Private Vehicle Driver Performance Objectives, Measures, and Requirements

Improving the mobility of private vehicle operators was considered central to the concept of ATIS. Specific performance objectives and measures address an increased range of destinations and routes, reductions in stress and fatigue, increased periods of travel, reductions in travel time and distance, and increased travel time predictability, as well as increased use of alternative travel modes:

- *Increased range of traveler destinations and routes* - this objective was included in the Mobility 2000 document and was identified by government sector interview participants. The objective is associated with increased availability of information regarding alternative destinations (including businesses and recreation areas) and the routes to those destinations. including such aspects as selecting more scenic routes and routes that avoid tolls.

- *Reduced level of stress and fatigue associated with travel* - a decrease in the overall stress associated with travel is an objective that was identified in several of the published sources reviewed, including IVHS America (Intelligent Vehicle Highway Society of America, 1992), the DOT *IVHS Strategic Plan. Report to Congress* (Department of Transportation, 1992), the FAST-TRXC evaluation plan (Underwood, 1993), and the Mobility 2000 *Operation Benefits* report (Mobility 2000, 1990). This objective is associated with a number of factors, including reducing the overall workload required for navigation, improving travelers' ability to find their destinations, improving the confidence of travelers in being able to find their destination, and improving the confidence of travelers that their destinations can be found quickly.

- *Increased periods of time in which trips are made* - in some areas of the country, non-commuting travel times are limited, due to current levels of congestion. Both the FAST-TRAC evaluation plan (Underwood, 1993) and interview respondents from the R&D sector identified use of this measure, which would be associated with increased periods when travel was not restricted by congestion, or with providing alternative routes that avoid congestion.

- *Increased use of alternative transportation modes* - in areas where alternative transportation modes resulted in improved mobility, this performance objective, identified by interview respondents from the government sector, would apply to private vehicle operators.

- *Decreased travel times* - decreased travel times were frequently cited as an appropriate measure of ATIS performance. This measure was employed in the TravTek evaluation, andhas been proposed for use in the ADVANCE (Bolezak et al., 1992) and FAST-TRAC (Underwood, 1993) operational tests.

- *Decreased trave; distance* - the measure of travel distance is being planned for use in both the Genesis (Minnesota Department of Transportation, 1993) and ADVANCE (Bolczak et al., 1992) operational tests. In both cases, it is being hypothesized that travel distances will be reduced as a result of better information regarding travel alternatives and routes.

- *Increased travel time predictability* - reducing the uncertainty regarding travel times is an objective that was identified in strategic pians and by interview participants from both the government and R&D sectors.

CVO Performance Objectives, Measures, and Requirements

The benefits of increased mobility for CVO were expressed in terms of their contribution co increases in productivity among the Task B respondents who addressed CVO issues. This topic is discussed below in subsection IMPROVED ENVIRONMENTAL QUALITY AND ENERGY EFFTCTENCY, CVO Performance, Objectives, Measures, and Requirements.

IMPROVED ENVIRONMENTAL QUALITY AND ENERGY EFFICIENCY

Environmental quality and energy efficiency are closely linked to one another. Among the Task B respondents interviewed, energy efficiency was seen as directly tied to improvements in environmental quality. Environmental quality, however, was not limited solely to improved energy efficiency, and included such additional issues as reduced noise pollution. reduced travel, and shifts in the mode of travel. The *Strategic Plan for Intelligent Vehicle-Highway Systems in the United States* (Intelligent Vehicle Highway Society of America, 1992) states that the objective of improved environmental quality and energy efficiency will be accomplished by decreasing traffic congestion; diverting travelers from single-occupancy vehicles; accommodating smoother, more evenly distributed traffic flow; and could possibly include demand-based road pricing.

Environmental quality and energy efficiency are closely related to the objective of decreased traffic congestion. The following excerpt from the *Transportation Technology Development for California: Program and Policy Review* (California Department of Transportation, 199 1) illustrates the relationship between congestion and energy efficiency:

> *The Energy Commission recognizes that congestion contributes significant& to fuel efficiency losses. When average speeds drop from 30 m.p.h. to 10 m.p.h., fuel consumption (in gallons per mile) increases 100% Corigestion in California is wasting about 750 million gallons of fuel each year. This could increase to nearly 2 billion gallons by the year 2005.*

Congestion is also seen as a primary factor in environmental quality. The *Transportation Technology Development for California: Program and Policy Review* (California Department of Transportation, 1991) notes research findings indicating that when freeway speeds are reduced from average speeds of 5.5 to 20 mi/h (88.5 to 32.2 km/h), hydrocarbon emissions increase approximately 250%.

A commonly expressed concern in the literature reviewed and among interview respondents is that ATIS technologies may increase traffic through-put, thereby having a negative environmental impact. Again, there is a complex relationship between vehicle-miles traveled and vehicle emissions, depending upon the flow of traffic. Two components of IVHS that were commonly identified when issues of increased vehicle emissions resulting from ATIS introduction were considered were electronic tollways and congestion pricing. Electronic tollways have a substantial potential for reducing congestion at current tollways by allowing traffic to flow by at normal speeds, while individual vehicles are debited according to roadway usage. Electronic tollways would represent a specific IVHS capability that could be integrated with an ATIS display. Similarly, if congestion pricing were implemented as a means of reducing trips, ATIS devices could provide information regarding current tolls.

Ratings by Task B respondents of the importance of the basic ATIS technologies in meeting the objective of improved environmental quality and energy efficiency were very similar for the private and commercial applications, as shown in figure 6. In both case, IRANS was rated significantly higher than the other subsystems, as determined by 9.5% CI (see appendix A, table 40, for detailed values), and none of the remaining three subsystems were rated as significantly different from one another. This finding reinforces that the objective of improved environmental quality and energy efficiency is seen as closely related to the reduction of congestion, which, in turn, is seen as influenced primarily by IRANS capabilities.

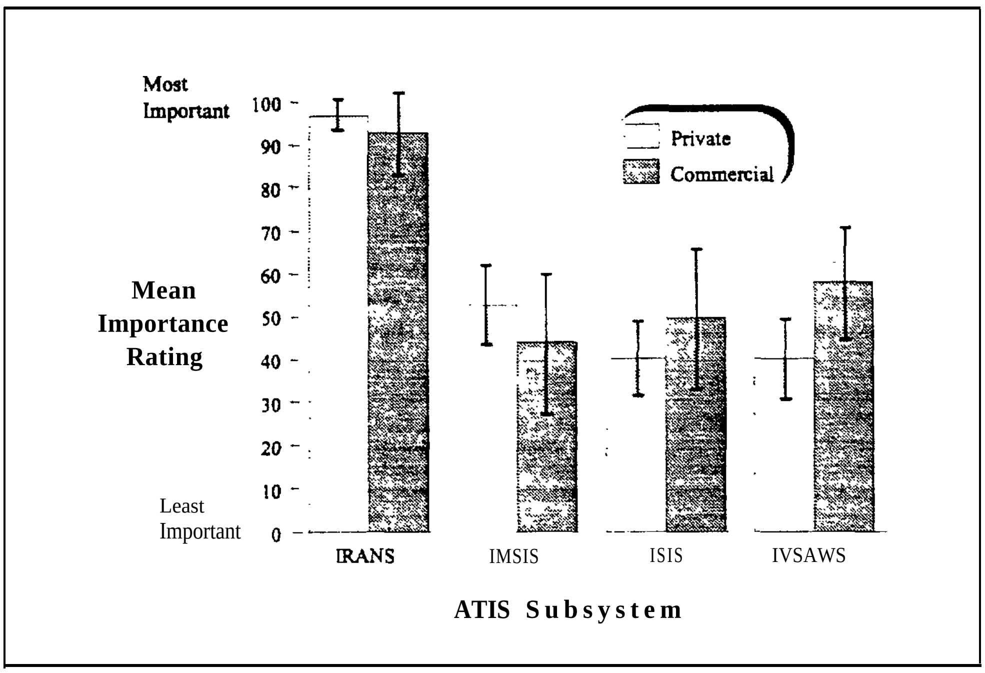

Figure 6. Mean importance ratings for ATIS subsystems in meeting the objective of improved environmental quality and energy effkiency for private and commercial vehicle applications.

Table 5 provides an overview of the objectives and measures identified through the review of operational test plans, strategic plans, and interview notes. No performance requirements were identified within the transportation community. and only two objectives and two measures were identified.

Table 5. Improved environmental quality and energy efficiency objectives, measures, and performance requirements,

PERFORMANCE OBJECTIVES, MEASURES, AND REQUIREMENTS	SOURCE	TYPE
Institutional Performance Objectives, Measures, and **Requirements**		
Reduced energy consumption	IVHS America, DOT., FAST-TRAC. Mobility 2000. GOV-Both	Objective
Decreased air pollution	IVHS Xmenca. Trav Tek FAST-TRAC. Genesis. Mobility 2000	Measure
Decreased noise pollution	FAST-TRAC	Objective
Private Vehicle Performance Measures and Requirements		
Reduced energy consumption	IVHS America. Mobility 2000. DOT, FAST-TRAC	Measure
CVO **Performance Objectives,** Measures, **and** requirements		
NA	NA	NA

NA = not applicable

Institutional Performance Objectives, Measures, and Requirements

The performance objectives and measures associated with improved environmental quality and energy efficiency are predominantly institutional in nature.

- *Reduced energy consumption* - reductions in surface transportation energy consumption were identified in several of the documents reviewed (see table 5) and by interview participants from the government sector. Suggested measures for assessing ATIS with respect to this objective include fuel usage per vehic!e-mile and per passenger-mile traveled.

- *Decreased air pollution* - decreases in harmful emissions from the total mix ot' surface transportation modes were addressed as both an objective and a measure by several of the sources used in the present survey. Measures frequently refer to the use of such variables as vehicle acceleration and deceleration, trip length, and number of trips.

- *Decreased noise pollution* - ATIS could contribute to decreased noise pollution. The FAST-TRAC evaluation plan (Underwood, 19931 identifies this as a test objective, but does not specify a particular measure.

Private Vehicle Driver Performance Objectives, Measures, and Requirements

As noted above, Task B interview respondents identified the present objective as primarily institutional in nature. One interesting exception to this was in California, where it was suggested that reduced pollution is seen as a general "quality of life" issue that influences individual consumption patterns. The other more prevalent aspect of private vehicle performance concerned reduced private vehicle energy consumption.

- Reduced *energy consumption* - reductions in vehicle energy consumption represent the primary private vehicle measure associated with the general ATIS objective of improved environmental quality and energy efficiency. Along with more general objectives identified in strategic plans, the FAST-TRAC evaluation plan (Underwood, 1993) proposed a specific measure of gasoline consumption. Contributing factors to this requirement would include average miles per gallon, private vehicle miles traveled, and reductions in trips resulting from the selection of alternative transportation modes.

CVO Performance Objectives, Measures, and Requirements

CVO concerns with this objective are most directly linked to improved economic productivity, as discussed in the following section.

IMPROVED ECONOMIC PRODUCTIVITY

The *Strategic Plan for Intelligent Vehicle-Highway Systems in the United States* (Intelligent Vehicle Highway Society of America, 1992) cites improving productivity of individuals, organizations, and the economy as a whole as a basic objective of IVHS. From the institutional perspective, this objective can be achieved by reducing total institutional expenditures for the transportation infrastructure. From the individual and CVO perspective, improved economic productivity relates to specific gains by individuals and commercial operators. A closely related objective is improved energy consumption, which translates into cost savings for all components of the economy. Mean ratings and 95% CI for the importance of ATIS subsystems in meeting the objective of improved economic productivity in private and commercial applications is depicted in figure 7. Mean ratings for IRANS are near maximum for both private and commercial applications and, in both cases, review of 95% CI (see appendix A, table 41, for detailed values) indicates that IRANS was rated significantly higher than all other subsystems. This finding represents the common view that improved route selection and navigation will be the central capability supporting improved economic productivity. In the case of private applications, IMSIS was rated significantly higher than the remaining two subsystems, reflecting the view that increased access to commercial listings would serve as an economic stimulus to drivers of private vehicles. In contrast, IMSIS, ISIS, and IVSAWS ratings were not significantly different from one another for commercial applications.

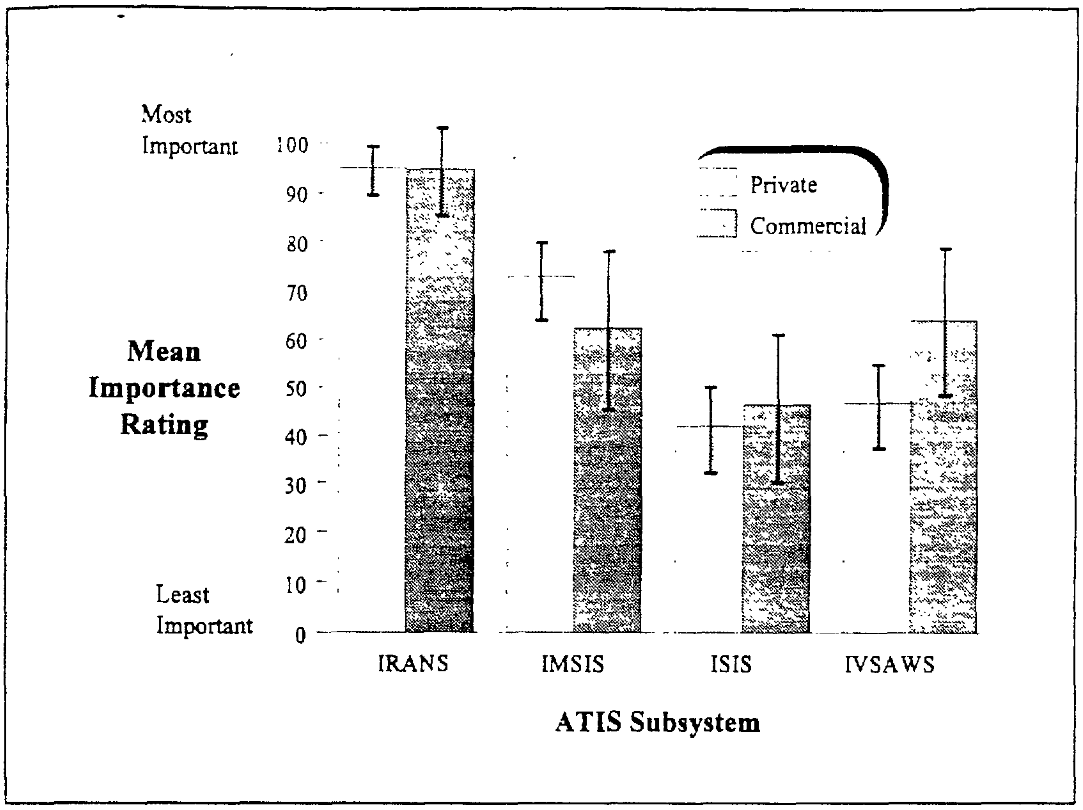

Figure 7. Mean importance ratings for ATIS subsystems in meeting the objective of improved economic productivity for private and commercial vehicle applications.

Table 6 provides an overview of the performance objectives and measures associated with the general ATIS objective of improved economic productivity that were identified through the review of operational test plans, strategic plans, and interview notes. No performance requirements were identified within the transportation community. Three performance measures and seven performance objectives were identified, as described below.

Table 6. Improved economic productivity objectives, measures, and performance requirements.

PERFORMANVR OBJECTIVES, MEASURES, AND REQUIREMENTS	SOURCE	TYPE
Institutional Performance Objectives, Measures, and Requirements		
Reduced new road constriction costs	DOT, GOV-Both	Objective
Improved efficiency of roadway operations and maintenance	GOV-Both	Objective
Improved efficiency in public service vehicle operations	GOV-Both	Objective
Improved efficiency of transportation planning	DOT, GOV-Both, IVHS America	Objective
Private Vehicle Perfrmantion Objectives Measures, and Requirements		
Reduced private vehicle operating costs	FAST-TRAC, Mobility 2000	easure
CVO Performance Objectives, Measures, and Requirements		
Reduced vehicle operation costs	R&D-Both. Mobility 2000	Objective
Increased vehicle service coverage	R&D-Both	Objective
Increased efficiency of dispatch operations	R&D-Both	Measure
Improved timeliness of delivery	Gov-Both. R&D-Both. Mobility 2000	Objective
Reduced vehicle maintenance costs	R&D-Both	Objective ,

Institutional Performance Objectives, Measures, and Requirements

Institutional goals addressing improved economic productivity were limited to four performance objectives. These objectives address reductions in new road construction costs, efficiencies in public service vehicle operations, efficiencies in roadway operations and maintenance, and improvements in transportation planning.

- *Reduced new road construction costs* - reductions in new roadway construction costs were identified as an objective in the DOT *IVHS Strategic Plan: Report to Congress* (Department of Transportation, 1992) and by interview respondents from the government sector. This performance objective is seen as being attained as a result of increased roadway traffic volume.

- *Improved efficiency of roadway operations and maintenance* - ATIS was seen by some interview respondents from the government sector as one component of the IVHS technologies that would provide improved data to more efficiently manage roadway maintenance and operations requirements. One specific application area is in electronic toll collection, which could result in reduced tollway collection costs.

- *Improved efficiency in public service vehicle Operations* - this objective was identified by interview respondents from the government sector. Application of advanced fleet management capabilities (including automated fleet vehicle location; computer-aided dispatch: and integrated scheduling, routing, and navigation systems) provide the potential for increasing the productivity of public service vehicles. This could result in reduced numbers of vehicles required to provide a given level of service coverage.

- *Improved efficiency of transportation planning* - a final performance objective is to reduce the costs associated with and improve the quality of data collected for transportation planning, operations management, roadway construction and maintenance services, and user fee purposes. This objective was identified by government interviewees and in the IVHS America (Intelligent Vehicle Highway Society of America, 1992) and DOT *IVHS Strategic Plan: Report to Congress* (Department of Transportation, 1992).

Private Vehicle Driver Performance Objectives, Measures, and Requirements

- *Reduced private vehicle operating costs* - this performance measure would provide an indicator of cost savings to private vehicle operators. This requirement is closely related to energy efficiency and reduced travel miles. The measure was identified in the Mobility 2000 Operation Benefits report (Mobility 2000, 1990) and the FAST-TRAC evaluation plan (Underwood, 1993).

CVO Performance Objectives, Measures, and Requirements

CVO performance objectives and measures associated with economic productivity include various aspects of operational efficiency and effectiveness, as summarized below.

- *Decreased vehicle operation costs* - fuel efficiency savings are a very important requirement associated with improved productivity. One interview respondent from the R&D sector noted that even very small improvements in fuel efficiency represent a significant level of operations costs reductions.

- *Increased vehicle service coverage* - for any delivery vehicle that must travel through congested areas, increased service coverage for vehicles represents a basic measure of productivity. This is represented by the measures of reduced travel time for long-haul activities and increased numbers of deliveries for local delivery operations. These measures were identified by interview respondents from the R&D sector.

- *Increased efficiency of dispatch operations* - the efficiency of complex commercial vehicle dispatch operations could be increased through the application of advanced fleet management capabilities (including automated fleet vehicle location: computer-aided dispatch; and integrated scheduling, routing, and navigation systems). These benefits could be measured by staff hours required to support these operations.

- *Improved timeliness* of *deliver* - improved efficiency of commercial vehicle operations also translates into productivity gains by the client when more timely service is provided, as determined by client delays. This performance objective was identified by several respondents familiar with the CVO environment, as well as 'by the Mobility *2000 Operational Benefits* report (Mobility 2000, 1990).

- *Improved vehicle maintenance costs* - in-vehicle CVO devices provide the capability to monitor truck performance, which can be used to improve the efficiency and effectiveness of vehicle maintenance. This performance objective of reduced costs was identified by an interview respondent from the R&D sector.

SUMMARY

This section presented the transportation community's perspective regarding the general development objectives for ATIS and CVO systems, as well as more specific performance. objectives, measures, and requirements. This information was obtained and compiled to help ensure that subsequent project work maintains a perspective that is consistent with the transportation community, and to provide an initial basis upon which to develop dependent measures to be employed in the subsequent research phases of this project. The preceding discussion provides a substantial amount of detail regarding the development objectives and performance requirements of ATIS and CVO systems. Major topics and findings can be summarized as follows:

- For private vehicle applications, the development objectives of *decreased traffic congestion, improved safety,* and *increased and higher quality mobility* were considered by respondents to be relatively more important than *improved environment & energy* and *improved economic productivity.*

- For CVO applications, the development objective of *improved economic productivity* was considered to be most important, *improved safety* was considered to be the second most important, and *improved environment & energy* was judged to be the least important.

- For both private and CVO applications, IRANS was judged to be the most important ATIS subsystem in meeting the development objectives of *decreased traffic congestion, increased and higher quality mobility, improved environment & energy,* and *improved economic productivity.*

- Performance requirements associated with each general development objective can be seen as addressing institutional, private vehicle, or CVO concerns. Where applicable, the performance requirements addressing each category of concern identified during Task B are briefly described under the corresponding development objective.

V. SCENARIO OVERVIEW

This section provides an overview of the scenarios developed as part of the Task B effort. Scenarios have been developed to aid in the identification of ATIS features and functions (Task C), as well as support the task analysis effort (Task E). The scenarios are not based on comprehensive analyses of ATIS features and functions, nor on a comprehensive analysis of the task of driving with the aid of an ATIS During Task C, the scenarios will be analyzed to determine if they provide a comprehensive representation of ATIS features and functions. During Task E, the scenarios will be revised and elaborated as necessary to support the analysis of driver requirements. However, they do represent a broad sample of the scenarios encountered within the transportation community during the course of Task B work. The remainder of this section provides a summary of input pertinent to ATIS scenarios obtained from the transportation community, followed by an overview and summary of the scenarios developed in conducting this task.

TRANSPORTATION COMMUNITY INPUT PERTINENT TO ATIS SCENARIOS

Information pertinent to ATIS scenarios was developed from a review of the literature, including published evaluation plans, strategic plans, and discussions of IVHS capabilities: a review of available marketing materials collected from trade shows; and interviews with members of the transportation community. Types of information used in developing the preliminary set of scenarios presented in this report included system developmental issues. capabilities, functions, and features. The following summary of transportation community input is divided in accordance with the separate ATIS categories. However, it is important to note that specific issues, capabilities, functions, and features address multiple ATIS subsystems. Additionally, certain system capabilities and functions require the integration of two or more subsystems.

IRANS Scenario Input

Following are selected issues, capabilities, functions, and features pertinent to IRANS operational scenarios that were identified during the course of the Task B interviews and literature reviews:

- The TravTek driver evaluation questionnaire asked drivers to indicate whether or not they thought TravTek would be useful in the following settings: (1) at-home daily driving, (2) out-of-town vacation driving, and (3) out-of-town business trips.

- Several interviewees cited the theme of a business visiting a client and knowing the commute time.

- A current user of a prototype IRANS technology uses it in his own neighborhood to help identify the correct turn among several similar-looking intersections. This reduces glances away from the roadway, especially in the dark or other sub-optimal conditions (e.g., rain or fog), and thereby increases safety. This could serve as a special advantage for older drivers with poor acuity and poor night vision, where more legible navigation support can be provided with an in-vehicle system.

- A brochure for a recently developed prototype system identifies the value of IRANS when driving in an unfamiliar area. This was described as a potentially frustrating scenario. It noted the requirement to plan a route to a destination in advance of travel as a difficult effort that often ends by asking someone on the way for directions The product is described as one that can be relied upon to deliver drivers to their destination no matter how complicated the path.

- A data base developer cited the apparent value of TravTek to real estate and other local sales persons as good examples of uses of route guidance and location features.

IMSIS Scenario Input

Very few issues, capabilities, functions, and features specific to IMSIS were identified during the course of Task B interviews. IMSIS was generally viewed as a useful tool for both individuals driving in an area where they had some familiarity, but were seeking a specific service, as well as supporting drivers unfamiliar with their setting, such as business travelers and tourists. A few points of information follow:

- A data base developer noted the value to local residents of using IMSIS to select a restaurant in their city.

- An ATIS technology developer noted that IMSIS could provide parking information, although this would be a substantial technical challenge.

ISIS Scenario Input

ISIS issues, capabilities, functions, and features received limited attention from interviewees. although, again, it was considered to be a viable subsystem concept. The following information pertinent to scenarios was obtained from the interviews:

- A researcher noted that ISIS would provide drivers with information on conditions where there are no other, more obvious cues.

- An automobile manufacturer noted that ISIS could be valuable on roads with high snow piles, where roadside signs were obscured by plowed snow.

- A State government representative who is active in the development of an ISIS-type system operational test noted that ISIS could provide a means of displaying speed limits under driving conditions where the speed limits were variable, depending upon mountain road conditions.

IVSAWS Scenario Input

Information pertinent to IVSAWS scenarios was seldom generated during Task B interviews. The following provides a sample of possibilities identified from discussions and prototype descriptions:

- An IVSAWS development brochure cites normal commuting as a useful scenario for IVSAWS alerts concerning traffic congestion.

- A researcher noted that IVSAWS would provide timely alternative route information in strange environments, where the driver is not familiar with the alternatives.

- Law enforcement respondents described a possible situation where by a vehicle is being pursued and IVSAWS could be used to isolate the vehicle by directing other vehicles in an area to stop. so that a "nail strip" could be laid on the highway to disable the vehicle under pursuit.

- Law enforcement respondents noted the value of an IVSAWS mayday function in providing additional security and support to disabled drivers in the event of a mishap

- Law enforcement respondents noted the value of an IVSXWS mayday function in rural settings, where assistance could be difficult to obtain.

CVO-Specific Scenario Input

Interview respondent input pertinent to CVO scenarios was more closely tied to the specific capabilities that CVO-specific systems would provide. Such capabilities are more explicitly addressed in section X. CVO OPERATIONAL CAPABILITIES AND SCENARIOS. However, a few general issues and capabilities that focused on CVO-specific systems were mentioned during Task B interviews and identified in documents that are summarized below,:

- Law enforcement respondents noted the case of a current program called Trucks-At-Rest-In-Fog (TARIF) that is used to stop trucks, then convoy them through fog in the fog-prone areas. A CVO-specific IVSAWS technology could be used to differentially route trucks, then have them wait for a TARIF convoy..

- Law enforcement respondents noted the value of being able to review vehicle safety status information (brakes, tire condition, etc.) while vehicles continue to travel..

- The *Strategic Plan for Intelligent Vehicle-Highway Systems in the United States* (Intelligent Vehicle Highway Society of America, 1992) notes the value of automatic vehicle identification technology embedded in advanced traffic management systems in the handling of hazardous material transport and transport incidents. The plan notes that either the fleet dispatcher, or the traffic control center, or both could identify hazardous cargo by individual vehicle; direct the driver through the appropriate route; and track the vehicle along the route. The plan notes that if an incident were to occur, such a system could facilitate detection and emergency response.

- A data base developer noted the capability to dispatch emergency vehicles on the basis of their predicted response time, rather than their relative location to the scene requiring emergency service.

- Several respondents noted the scenario involving meeting "just-in-time" delivery requirements, based upon the accurate prediction of travel time.

SUMMARY OF PRELIMINARY SCENARIOS DEVELOPED FOR THE PRESENT PROJECT

This section identifies the factors considered during the development of the preliminary private vehicle and CVO scenarios presented in this working paper (sections VI through X). and provides separate tables summarizing the extent to which the preliminary scenarios represent these different factors. The scenarios that are described in the remainder of this report are categorized on the basis of ATIS subsystems. Private vehicle scenario categories are IRANS, IMSIS ISIS, and IVSAWS. Commercial vehicle scenario categories are in-vehicle IRANS, IMSIS ISIS, EVSAWS, EC and WIM and out-of-vehicle IRANS. However, the scenarios are based upon the assumption that many ATIS functions in both private vehicle, and CVO applications are facilitated by interaction of system capabilities that cross these subsystem boundaries. For example, use of IMSIS is assumed to be facilitated by interaction with IR.\NS capabilities. In looking for restaurants near one's location, it would be helpful if the IMSIS could determine the current location of the vehicle using the IRANS functions. Additionally, following the selection of a restaurant destination, it would be helpful if that destination could be passed from the IMSIS subsystem to the IRANS subsystem for route planning.

Private Vehicle Scenarios

Table 7 provides a summary of the 12 private vehicle scenarios, labeled Pl through P12 in the table. Three private vehicle scenarios were developed for each of the four ATIS subsystems. Additional factors considered in the development of the scenarios were: driver age (young, medium, and older), driving experience (low and high), trip category (local travel, sales, business travel, and leisure travel), scenario setting (urban, suburban, and rural), the level and type of traffic congestion (uncongested, recurrent congestion, and non-recurrent congestion), and the weather (clear daytime, clear nighttime, and heavy rain or snow) In developing the scenarios summarized in table 7. an attempt was made to maximize the representation of each level of the separate factors (such as driver age. etc.). However. a formal effort to optimize sample coverage was not made.

Table 7 Summary of private vehicle scenarios

SCENARIO FACTORS/SCENARIO SUBSYSTEM	IRANS			IMSIS			ISIS			IVSAWS		
SCENARIO	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**
Driver Age												
Young				•			•					
Medium	•	•			•			•		•		
Older			•			•			•		•	
Driving Experience												
Low			•				•					•
High	•	•		•	•	•		•	•	•	•	
Trip Category												
Local Travel			•	•						•	•	
Sales		•										
Business Travel					•			•				
Leisure Travel	•					•	•		•			•
Scenario Setting												
Urban	•			•						•		
Suburban		•	•		•			•			•	
Rural						•	•		•			•
Traffic Congestion												
Uncongested			•		•	•	•		•			•
Recurrent Congestion	•							•				
Non-recurrent Congestion		•		•						•	•	
Weather												
Clear Daytime	•				•	•	•			•		
Clear Nighttime			•	•							•	
Heavy Rain or Snow		•						•	•			•

Commercial Vehicle Operations Scenarios

Table 8 provides a summary of the 14 CVO scenarios. labeled Cl through Cl4 in the table. Different numbers of scenarios were developed for the separate CVO capabilities of in-vehicle IRANS. IMSIS ISIS, IVSAWS, EC and WLM. and out-of-vehicle IRANS Additional factors considered in the development of the CVO scenarios were operator age (young and medium); operator experience with the current route (low and high); vehicle category (public service. local fleet, and interstate trucking); scenario setting (urban, suburban, and rural); the level and type of traffic congestion (uncongested, recurrent congestion, and non-recurrent congestion); and the weather (clear daytime, clear nighttime, and heavy rain or snow). It should be noted that it was assumed that young drivers had a limited number of driving hours, while medium-aged drivers had a relatively high number of driving hours. As in the *case* of the private vehicle scenarios, an attempt was made to maximize the representation of each level of the separate factors (such as driver age, etc.). However, a formal effort to optimize sample coverage, was not made.

Table 8. Summary of commercial vehicle operations scenarios.

	In-Vehicle IRANS			IMSIS	ISIS		IVSAWS				EC & WIM	Out-of-Vehicle IRANS		
Scenario	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**
Operator Age														
Young		•	•	•	•		•			•			•	•
Medium	•					•		•	•		•	•		
Operator Experience														
Low Experience with Route		•	•	•	•		•			•			•	•
High Experience with Route	•					•		•	•		•	•		
Vehicle Category														
Public Service	•						•					•		
Local Fleet		•			•			•					•	
Interstate Trucking			•	•		•			•	•	•			•
Scenario Setting														
Urban		•						•				•		
Suburban	•				•								•	
Rural			•	•		•	•		•	•	•			•
Traffic Congestion														
Uncongested				•		•				•	•			•
Recurrent Congestion		•			•				•				•	
Non recurrent Congestion	•		•				•	•				•		
Weather														
Clear Daytime		•						•	•				•	
Clear Nighttime	•			•	•						•	•		
Heavy Rain or Snow			•			•	•			•				•

VI. IRANS OPERATIONAL CAPABILITIES AND SCENARIOS

This section provides a summary of IRANS operational capabilities and descriptions of the preliminary IRANS scenarios developed during this task. The operational capabilities of IRANS represent an initial summary of capabilities, which will be refined and elaborated during Task C. The preliminary scenarios will be modified, elaborated. and refined during Task E.

OPERATIONAL CAPABILITIES OF IRANS

In-vehicle Routing and Navigation Systems (IRANS) provide drivers with information about how to get from one place to another. When integrated with an ATMS, IRANS provides information on recurrent and non-recurrent traffic congestion and is capable of calculating, selecting, and displaying optimum routes based on real-time traffic data. A sample of potential IRANS capabilities identified through interviews and a review of the iiterature is provided below. These capabilities will be refined, elaborated, and presented as specific IRANS functions and features in the upcoming Task C report. Basic capabilities of IRANS include:

- Providing drivers with route guidance information (how to get from one place to another).
- Providing drivers with navigation information (where they are in relation to their destination).
- Providing information on recurrent and non-recurrent traffic congestion.
- Calculating, selecting, and displaying optimum routes based on real-time traffic data.

Some additional capabilities common among IRANS prototypes and emerging systems include:

- Turn-by-turn guidance (visual and voice displays).
- Notification of driver error.
- Recommended modifications in-route, due to traffic conditions or driver error.
- Selection of multiple-scale maps by the driver.

A number of variations of the basic requirement to develop a route, including multiple destinations, were cited in the literature and by Task B respondents. This capability has several applications for both private vehicles and CVO. Variations of this capability include:

- Planing a route for an extended vacation.
- Planning a route for a series of local deliveries.
- Planning a route for a business trip with several stops.

Several existing prototype and emerging IRANS technologies allow the driver to select from multiple criteria prior to the determination of a route to a destination. Some such criteria include fastest route, shortest route, route avoiding tollways. most scenic route, and route avoiding complex intersections.

Private industry representatives who have been involved in a recent IRANS technology development effort noted information that would be difficult to implement, but useful, including:

- Location of turn bays.
- Number of lanes.
- Exit numbers.
- Landmark information.
- Location of toll booths.
- cost of tolls.

An IRANS technology developer noted that providing lane recommendations for highway exits could reduce last-minute lane changing, thereby increasing safety. A government official working on an operational test program noted that TRANS could reduce traffic on residential streets by reducing the priority of such routes, when possible. This would have the advantage of reducing traffic where accident rates are relatively higher. A representative of a major automobile manufacturer suggested considering the use of voice input, but recognized the technical problems associated with extraneous discussions. A representative of another major automobile manufacturer suggested that when re-routing occurs due to an accident in an unfamiliar area, safety is increased when a map (versus simple route guidance) is available, allowing drivers to orient themselves. A brochure for a recently developed prototype system identifies the following capabilities:

- Display of one-way streets.
- Display of the destination address.
- Highlighting of progress along the defined route.
- Alerting of missed turn.
- Driver-initiated recalculation of route while driving.

An IRANS technology developer noted that it was important to provide drivers with the capability to build their own, customized set of destinations in system memory. An IRANS technology developer noted that ATIS could be re-configured for younger and older drivers. An automobile manufacturing representative noted that the driver needs information concerning the spill backup, not simply the site of an accident. Information that would be useful to the driver includes both: (1) the current and forecasted extent of congestion (rather than simply incident information), and (2) recommended alternate routes. The point made by this interview. participant was that the incident is not the concern of the driver so much as the extent of congestion and available routes to avoid the congestion. Another capability stressed by an automobile manufacturer was the need to provide route guidance for multiple quick maneuvers, such as traffic circles, multiple road intersections, complex exits from interstate highways, and branching exits. A government sponsor of an operational test program noted that additional information that should be available on IRANS includes the type of roadway (highway, arterial, or residential), public transportation options, and shared riding oppoutunities, In discussions with several interview respondents, a concept was identified that involved ATIS providing a real-time notification of the time at which current congestion would allow a travel time that is within a pre-set range. In all cases, the respondents were referring to a portable computer that would function as both a desk-top and in-vehicle ATIS by employing some type of docking system in the vehicle. Several Task B respondents mentioned the importance of providing accurate and reliable real-time information. These respondents' concerns focused on private vehicle drivers' tolerances for congestion data that was out of date. Several developers pointed to a need to decrease the current time between the occurrence of congestion and the incorporation of that information into in-vehicle systems. One respondent suggested that providing confidence levels for estimated travel times could help. Another respondent pointed to the general strategy of providing the driver with the data upon which alternate routes are recommended, rather than simply specifying the recommended route. Some capabilities identified in a project report of an IRANS technology concept included:

- Continuous alerts of changes or recommended alternate routes if new conditions (such as incidents) occur.
- Continuous and updated estimated time of arrival.
- An alert at the proper time to leave work, based on current congestion and roadway conditions.
- An alert at the necessary time to catch a bus from work so that the traveler can be home at the required time.

A data base firm representative noted that the geographic data base used by CVOs could be tailored to their specific clientele. providing detailed locations for loading docks and other points of service.

OPERATIONAL SCENARIOS FOR IRANS

Private Vehicle Scenarios

The remainder of this section provides descriptions of preliminary IRANS operational scenarios representing private vehicle and CVO applications. Each of the separate scenarios is presented via a brief narrative description, followed by a table that provides a general timeline of events related to the condition of the vehicle and roadway, driver information requirements, driver actions, and ATIS information display. These scenarios are provided for the purpose of defining the general system capabilities and scenario conditions that should be considered in future analytic and research phases of this project. It is likely premature to provide specifics concerning display content and format prior to a more complete analysis of driver information requirements, capabilities, and constraints.

P1: Preliminary Scenario for Tasks C and E

A middle-aged man vacationing with his family in an urban setting has arrived in the daytime and has rented a car with an IRANS device installed. The family's plan is to go directly to their hotel located in the city 10 mi (16.1 km) from the airport. The weather is good, but there is a substantial level of congestion on the major highways between the airport and the hotel, due to normal commuting traffic. After receiving a brief orientation to the IRANS at the rental office, the driver identifies his destination on the IRANS and requests the fastest route. The IRANS recommends a route that the driver accepts and he begins his trip to the hotel. Table 9 summarizes scenario Pl.

Table 9. Timeline of scenario Pl events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t0	Vehicle in PARK	IRANS procedure for selecting hotel as destination	Request system help	Procedure instructions
t_1			Select hotel as destination	Selection feedback
t2		IRANS procedure for planning routes	Request system help	Procedure instructions
t3		Fastest route to hotel	Select fastest route criterion	Selection feedback
t_4				Recommended route
t_5			Accept route	Route acceptance feedback
t_6		Overview of route to hotel	Request large area map	Large area map Route to hotel Areas of congestion
t_7		Detailed route out of airport	Request small area map	Small area map
t8	Vehicle in DRIVE	Route guidance	Normal driving	Small area map Voice guidance

P2: Preliminary Scenario for Tasks C and E

A real estate salesperson is meeting a couple at their residence. She plans on showing them several houses in a suburban area of a major city. She has selected houses in several different neighborhoods, spaced around one side of the city. The neighborhoods can be reached by either highways or arterials. It is evening, there is a heavy rain, and there is an accident on one of the highways that could be taken. Two neighborhoods that would be reasonable starting points for the evening's viewings are approximately equidistant from the clients' current residence. The salesperson would like to go to the neighborhood that can be most easily reached first. Prior to picking up her clients, sne enters the addresses of all of the houses in the IRANS During her drive to her clients' house, she monitors the traffic congestion in the planned area of travel. When she arrives at the clients' residence, she requests a comparison of travel times, and selects the route that is predicted to take the least time. She then reviews current traffic congestion. Finally, she picks up her clients and drives them to the first house. Table 10 summarizes scenario P2.

Table 10. Timeline of scenario P2 events.

TIME	**VEHICLE & ROADWAY** CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t_0	Vehicle in PARK		Enter residences "for sale" as destinations	Selection feedback
t1	Vehicle in route between office and clients' residence	Traffic conditions	Dnve vehicle	Large area map Traffic congestton areas
t_2	Vehicle is driven to clients' house and placed in PARK	Travel times to the two alternative initial destinations	Request route plannmg	Route planning functton activated
t_3			Select route comparison option Specify destinations for comparison	Predicted travel times for alternative routes
t4			Select destination with fastest travel time	Selection feedback
t5		Current traffic congestion areas	Request large area map	Large are3 map
t6	Vehicle in DRIVE	Route gutdance	Normal driving	Small area map Voice guidance

P3: Preliminary Scenario for Tasks C and E

An elderly woman has recently begun driving again after several years of very limited driving. She is driving home in a suburban area from a relative's house at night. She is driving on arterials; there is little congestion and the weather is good. Since returning to driving, she has made regular use of her IRANS for all but the shortest trips. She enters her home as her destination and the IRANS technology guides her along the route. Table 11 summarizes scenario P3.

Table 11. Timeline of scenario P3 events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t0	Vehicle in PARK	Route to home	Request route to home	Large area map with route
t1	Vehicle in DRIVE	Advance warning of upcoming road conditions requiring driver action	Normal driving	Small area map Upcoming intersections and other route conditions Turn-by-turn route guidance
t,	Vehicle parked and IGNITION OFF			

Commercial Vehicle Scenarios

C1: Preliminary Scenario for Tasks C and E

A team of two, experienced, middle-aged emergency vehicle operators are working their nighttime shift. They are dispatched to an accident on a freeway in a suburban area approximately 10 mi (16.1 km) from their base station. The accident has stopped traffic on the road that would normally be taken to the accident site. After receiving their call. the driver begins to travel towards the location of the accident on a major arterial. At this time. the ATIS operator enters the location of the accident in the IRANS, obtains a recommended route, and relays directions to the driver. Table I2 summarizes scenario C1.

Table 12. Timeline of scenario C1 events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	ATIS OPERATOR ACTIONS	ATIS INFORMATION DISPLAY
t_0	Vehicle in PARK Emergency dispatch received	Fastest route to accident site Congestion in vicinity of route	Acknowledge dispatch Activate IRANS route guidance function	Route guidance function activated
t_1	Vehicle in DRIVE traveling towards site	Limited amount of information to allow route guidance. while dnving at high speed through traffic	Enter accident site location Request route	Large area map Current vehicle location Accident site selection feedback
t_2				Recommended route Congestion in vicinity of route Next turn on route
t_3			'Provide driver verbal guidance for route Provide driver verbal alert of upcoming congestion	
t_4	Vehicle arrives at accident site			

C2: Preliminary Scenario for Tasks C and E

A young technician with limited driving experience is operating a one-person vehicle that provides on-caIl air conditioning system service to its clients in an urban area. The technician is paged while providing service at one client's business. She returns the call and learns that the next service stop is across town. There are several alternative major roadways that can be taken to reach the next client's business. It is late afternoon and the daily traffic congestion is beginning to. develop on many of the roadways. After completing the current job, the technician gets into her vehicle, enters the location of the next client's business on the IRANS obtains route guidance, and is provided navigation aid during the drive. Table 13 summarizes scenario C2.

Tabie 13. Timeline of scenario C2 events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t0	Vehicle in PARK	Fastest route to client's location Congestion in vicinity of route	Activate IRANS route guidance function	Route guidance function activated
t1			Enter client location Request route	Large area map Current vehicle location Client site selection feedback
t2				Recommended route Congestion in vicinity of route
t3			Accept route	Route acceptance feedback
t4	Vehicle in DRIVE	Route guidance	Normal driving following route guidance	Small area map Navigation guidance

C3: Preliminary Scenario for Tasks C and E

A young inexperienced interstate truck operator is driving on a rural highway in a heavy rainstorm. The driver comes to a roadblock where he is informed by the highway patrol that there is a mud slide that has blocked the roadway 20 mi (32.2 km) ahead. The driver pulls over, indicates the road blockage on the IRANS, and determines an alternate route that is compatible with the road restrictions placed on his truck. He obtains a recommended route revision and continues his trip. Table 14 summarizes scenario C3.

Table 14. Timeline of scenario C3 events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t_0	Vehicle in PARK	Shortest route around road blockage compatible with truck restrictions	Activate IRANS route guidance function	Destination menu
t_1			Specify road blockage	Road blockage specification feedback
t_2			Request new route	Large area map Current vehicle location Recommended route
t_3		Any vehicle restrictions along route		Vehicle restrictions along route
4	Vehicle in DRIVE	Navigation guidance	Normal driving on highway	Large area map Navigation guidance

VII. IMSIS OPERATIONAL CAPABILITIES AND SCENARIOS

This section provides a summary of IMSIS operational capabilities and descriptions of the preliminary IMSIS scenarios developed during this task. The operational capabilities of IMSIS represent an initial summary of capabilities, which will be refined and elaborated during Task C. The preliminary scenarios will be modified. elaborated and refined during Task E.

OPERATIONAL CAPABILITIES OF IMSIS

In-vehicle Motorist Services Information Systems (IMSIS) provide motorists with commercial logos and signing for motels, eating facilities, service stations, and other signing displayed inside the vehicle to direct motorists to recreational areas, historical sites, etc. IMSIS provides routing information for local destinations. A sample of specific IMSIS capabilities identified through interviews and a review of the literature is provided below. These capabilities will be refined, elaborated, and presented as specific IMSIS functions and features in the upcoming Task C report. A brochure for a personal computer-based system highlights the following capabilities:

- Provides a source for a city's best hotels, restaurants, and just about all other vital services.
- Provides routing information.
- Provides routing for any means of transportation — walking, driving, bus, train, and ferry.

Several Task B respondents noted the value of having selection criteria available to aid the user in selecting restaurants, hotels, and other services. Restaurant selection criteria could include location, price range, type of food, and review rating. Hotel selection criteria could include location, price range, types of rooms, guest amenities, and review rating. A commonly discussed capability is that of being able to make reservations or purchases with a cellular phone link integrated with the IMSIS device. Although IMSIS provides local routing information, closer integration with IRANS would provide additional capabilities by allowing selected services to be used as destinations in more sophisticated route guidance functions. Some means of integrating ATIS with public transit is desirable, and IMSIS provides an appropriate platform for this. Specific information that could be provided includes transit schedules, paratransit opportunities, costs, trip times, and dependable departure and arrival times.

OPERATIONAL SCENARIOS FOR IMSIS

The remainder of this section provides descriptions of preliminary IMSIS operational scenarios representing private vehicle and CVO applications. Each of the separate scenarios is presented via a brief narrative description, followed by a table that provides a general timeline of events related to the condition of the vehicle and roadway, driver information requirements. driver actions, and ATIS information display. These scenarios are provided for the purpose of defining the general system capabilities and scenario conditions that should be considered in future analytic and research phases of this project. It is likely premature to provide specifics concerning display content and format prior to a more complete analysis of driver information requirements, capabilities, and constraints.

Private Vehicle Scenarios

P4: Preliminary Scenario for Tasks C and E

A young couple has just attended a weekend sporting event at a sports dome in a major city. Traffic resulting from the sporting event is substantial. The couple would like to drive to a nearby restaurant for an informal dinner prior to going home. The couple get into their car. select two alternative restaurants from the IMSIS directory, and compare travel times for the two restaurants using the IRANS. They then select one restaurant, based on travel time. Table 15 summarizes scenario P4.

Table 15. Timeiine of scenario P4 events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t0	Vehicle in PARK	Local inexpensive seafood restaurants	Activate IMSIS restaurant guide	IMSIS restaurant guide Listing of restaurant selection criteria
t_1			Request listing of seafood restaurants	Listing of seafood restaurants
t_2			Request listing in inexpensive price range	Listing of inexpensive seafood restaurants
t_3			Request listing in area near sports dome	Listing of inexpensive seafood restaurants near sports dome
t_4		Travel times to two preferred restaurants	Access IRANS route planning function	IRANS route planning activated
t_5			Request route comparison Specify restaurants for comparison	Predicted travel times for alternative routes
t_6			Select restaurant with fastest travel time	Selection feedback
t_7		Overview of route to restaurant	Request large area map	Large area map Route to restaurant
t_8		Detailed route out of sports dome parking lot.	Request small area map	Small area map
t9	Vehicle in DRIVE	Route guidance	Normal dnving	Small area map Voice guidance

P5: Preliminary Scenario for Tasks C and E

.A middle-aged business traveler has a series of meetings in a large suburban area, The man has some time between appointments and decides to go to a service station to get gasoline and to a restaurant for lunch before his appointment. The traveler uses the IMSIS directory to select a restaurant near his present location. He then enters the restaurant and the next client's location on the IRANS and requests the location of a service station on this route. Table 16 summarizes scenario P.5.

Table 16. Timeline of scenario P5 events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t0	Vehicle in PARK	Restaurants serving lunch near route to next appointment	Access IRANS route to next client	IRANS route to client
t1			Access LMSIS restaurant guide	IMSIS restaurant listings Restaurant selection criteria menu
t_2			Select Italian restaurants	Listing of Italian restaurants in area
t_3			Select moderate lunch price range	Locations of moderately priced Italian restaurants in area Restaurant selection criteria menu
t_4			Select restaurant on route	Selection feedback
t_5		"Acme" service stations on selected route	Access IMSIS service station guide	IMSIS service station guide Service station selection criteria menu
t_6			Select "Acme" service stations	Listing of "Acme" service stations in area
t_7			Select service station on route	Selection feedback
t8	Vehicle in DRIVE	Route guidance	Normal driving	Small area map Voice guidance

P6: Preliminary Scenario for Tasks C and E

A retired couple is on an extended driving vacation. They have stopped for some midday sightseeing approximately 50 mi (80.5 km) from their destination and would like to review motel options for this evening at their destination. They access the IMSIS directory for the town they will be staying in, review several alternative motels that fit their criteria, and select several motels in one area to look at when they arrive. Table 17 summarizes scenario P6.

Table 17. Timeline of scenario P6 events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t0	Vehicle in PARK	Alternative motels at destination	Access IMSIS hotel/motel guide	IMSIS hotel/motel guide
t1			Request hotels at planned destination	Hotels and motels at destination Hotel/motel selection criteria
t2			Select motels in moderate price range	Listing of motels in moderate price range
t_3		Locations of alternative motels with respect to route	Access IMSIS/IRANS map display	Map display
t4			Select display of alternative motels on map	Planned route and motels on large area map
t_5			Select four motels	Selection feedback
t_6		Route to closes& motel	Select closest motel as next destination on IRANS	Revised route
t_7	Vehicle in DRIVE	Route guidance to first motel	Normal driving	Small area map Voice guidance

Commercial Vehicle Scenarios

C4: Preliminary Scenario for Tasks C and E

A young interstate truck operator has been diverted from his normal route, due to a road closure. just prior to a planned refueling. Now traveling at night on an unfamiliar detour route, the driver uses his IMSIS to determine the nearest service station on the new route. Table 18 summarizes scenario C4

Table 18. Timeline of scenario C4 events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t0	Vehicle in DRIVE on detour route	Location of nearest service station on detour route	Stop vehicle	
t1			Access XMSIS technology	IMSIS display
t_2			Select truck service station guide	Truck service station guide
t3			Enter geographical area of Interest	Area of interest entry feedback Listing of truck service stations in area of interest
t_4		Routing information to service station	Request routing information	Routing output
t_5	Resume trip, putting vehicle in DRIVE			

VIII. ISIS OPERATIONAL CAPABILITIES AND SCENARIOS

This section provides a summary of ISIS operational capabilities and descriptions of the preliminary ISIS scenarios developed during this task. The operational capabilities of ISIS represent an initial summary of capabilities, which will be refined and elaborated during Task C. The preliminary scenarios will be modified, elaborated, and refined during Task E.

OPERATIONAL CAPABILITIES OF ISIS

In-vehicle Signing Information Systems (ISIS) provide non-commercial routing, warning, regulatory, and advisory information that is currently depicted on external roadway signs inside the vehicle. ISIS is distinguished from IVSAWS on the basis of the relative permanence of the information displayed by this system. ISIS provides information that could be displayed on permanent roadway signs. A sample of specific ISIS capabilities identified through interviews and a review of the literature is provided below. These capabilities will be refined, elaborated, and presented as specific ISIS functions and features in the upcoming Task C report.

The basic capability of ISIS is that of warning of conditions requiring the driver's attention prior to the conditions being easily determined by the driver without such a warning. Several Task B respondents concerned with CVO noted the potential capability of providing information specific to the characteristics of a particular vehicle. Such information could include:

- Curve speed for specific vehicle sizes.
- Braking requirements for specific grades.
- Routing restrictions for specific vehicle cargoes.

ISIS could respond to a limited set of queries by the driver to repeat messages that were not initially comprehended or attended to by the driver. Displays could be provided in a manner that could reduce the time spent by the driver looking away from the roadway. ISIS could provide more detailed instructions than are practical on roadway signs. ISIS could display information reliably under adverse weather conditions. ISIS displays could be optimized for use by elderly drivers, resulting in better information transfer than would be possible with external roadway signs. Specific capabilities would involve displays that could be better read at night and displays that avoid the problem of limited visual acuity.

OPERATIONAL SCENARIOS FOR ISIS

The remainder of this section provides descriptions of preliminary ISIS operational scenarios representing private vehicle and CVO applications. Each of the separate scenarios is presented via a brief narrative description followed by a table that provides a general timeline of events related to the condition of the vehicle and roadway driver information requirements, driver actions, and ATIS information display. These scenarios are provided for the purpose of defining the general system capabilities and scenario conditions that should be considered in future analytic and research phases of this project. It is likely premature to provide specifics concerning display content and format prior to a more complete analysis of driver information requirements, capabilities, and constraints.

Private Vehicle Scenarios

P7: Preliminary Scenario for Tasks C and E

A young inexperienced driver is staying in a mountain resort with his friends for a weekend of skiing. He is unfamiliar with the 20-mi (32.2 km) road between the lodge where they are staying and the ski area. The roads have been recently plowed and are bare, but many roadway signs are obstructed by the plowed snow. On one stretch of road, there are several changes in the speed limit due to roadside businesses and an area of tight turns. The driver receives advance ISIS notification of each transition in speed limit. Table 19 summarizes scenario P7.

Table 19. Timeline of scenario P7 events.

TIME	VEHICLE ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DIAPLAY
t0	Vehicle in DRIVE on bare straight -away road with 55-mi/h (88.5-km/h) speed limit	Advance warning of upcoming road conditions requiring driver attention and action	Normal driving	ISIS display activated
t1	Vehicle approaching local business area	Actions required in response to business area	Driver alerted	"Business area" message Reduced speed limit message
t2	Vehicle travels through business area		Reduce speed and drive through business area	
t3	Vehicle leaves business area and resumes 55 mi/h (88.5 km/h)		Normal driving	
t4	Vehicle approaching series of sharp curves with reduced speed limit	Actions required in response to curve warning	Driver alerted	"Approaching curve" message Reduced speed message
t5	Vehicle travels through curves		Reduce speed and drive through curves	
t6	Vehicle resumes 55 mi/h (88.5 km/h)		Normal driving	

P8: Preliminary Scenario for Tasks C and E

A middle-aged business traveler is in the suburbs of a major city that he is not familiar with. during a heavy rainstorm. He has a 20-mi (32.2-km) drive from his hotel to his first appointment. He has selected a route that is.predominantly on arterial roads, The heavy rain is making visibility very poor. During the drive, the ISIS technology in his car provides advance warning of an "exit only" for the right-hand lane and a school zone. Table 20 summarizes scenario P8.

Table 20. Timeline of scenario P8 events.

TIME	VEHICLE ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t_0	Vehicle in DRIVE on wet road at 40 mi/h (64.4 km/h	Advance warning of upcoming road conditions requiring driver attention and action	Normal driving	IMSIS display activated
t_1	Vehicle approaching "exit only" lane		Driver alerted	"Right lane exit only" message
t_2		Actions required in response to "exit only" lane		Change lane if continuing message
t_3	Vehicle changing lane		Change lane	
t_4	Vehicle continues past lane restriction		Normal driving	
t_5	Vehicle approaching school zone		Driver alerted	"School zone" message
t_6		Actions required in response to school zone		Reduced speed message
t_7	Vehicle travels through school zone at reduced speed		Reduce speed and drive through school zone	
t_8	Exit school zone		Resume normal driving	

P9: Preliminary Scenario for Tasks C and E

An older couple is on vacation driving on a mountain pass during heavy rain at night. Visibility is very poor. The road has several curves with reduced speed limits, a section of road where the extra right-hand lane has very slow moving trucks, and a point where the truck lane merges with the other lanes. The ISIS technology provides advance warning of each condition and provides recommended driver actions. Table 21 summarizes scenario P9.

Table 21. Timeline of scenario P9 events.

TIME	VEHICLE ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t_0	Vehicle in DRIVE on wet mountain road at night traveling at 50 mi/h (80.5	Advance notice of upcoming road conditions requiring driver attention and action	Normal driving	ISIS display activated
t_1	Vehicle approaching series of sharp curves with reduced speed limit		Driver alerted	"Approaching curves: message
t_2		Actions required in response to curve warning		Reduced speed message
t_3	Vehicle travels through curves		Reduce speed and drive through curves	
t_4	Vehicle leaves curves and resumes 50 mi/h (80.5 km/h)		Normal driving	
t_5	Vehicle approaching slow truck lane		Driver alerted	"Slow trucks ahead" message
t_6		Actions required in response to truck lane		"Faster vehicles move left" message
t_7	Vehicle changes lane		Maintain speed and change lane	
t_8	Vehicle approaches truck lane merge		Driver alerted	"Approaching merging lane" message
t_9	Vehicle travels past merging lane		Driver looks for merging trucks and continues normal driving	

Commercial Vehicle Scenarios

C5: Preliminary Scenario for Tasks C and E

A young inexperienced interstate truck operator is driving a tanker from a refinery to service stations in a suburban area that has several road restrictions on the transport of flammable materials. Prior to reaching a stretch of roadway that does not allow flammable cargoes, the driver receives.an ISIS notification of the restriction, along with the recommended alternative route. Table 22 summarizes scenario C5.

Table 22. Timeline of scenario C5 events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t_0	Vehicle in DRIVE on route	Advance warning of upcoming road conditions requiring driver action	Normal driving	ISIS display activated
t_1	Vehicle approaching roadway closed to trucks carrying flammable materials		Driver alerted	Roadway restriction warning
t_2		Actions required in response to road restrictions		Recommended alternate route
t_3		Verification of recommended route	Request message to be repeated	Warning and recommended route repeated
t_4	Vehicle on alternate route		Driver diverts to alternate route	

C6: Preliminary Scenario for Tasks C and E

An experienced interstate truck operator is on a rural roadway with several low overpasses that require him to exit the freeway and drive over the overpasses. The driver is very familiar with the route; however, there is a rainstorm that is severely limiting visibility, Prior to reaching each of these overpasses, the driver receives ISIS notification of the low clearance, along with advice to exit. Table 23 summarizes scenario C6.

Table 23. Timeline of scenario C6 events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t_0	Vehicle in DRIVE on route	Advance warning of upcoming road conditions requiring driver action	Normal driving	ISIS display activated
t_1	Vehicle approaching low overpass		Driver alerted	Low overpass warning
t_2		Actions required in response to low overpass		Recommended exit
t_3	Vehicle exits, takes overpass, and returns to highway		Driver takes recommended exit	
t_4			Normal driving	

IX. IVSAWS OPERATIONAL CAPABILITIES AND SCENARIOS

This section provides a summary of IVSAWS operational capabilities and descriptions of the preliminary IVSAWS scenarios developed during this task. The operational capabilities represent an initial summary of capabilities. which will be refined and elaborated upon during Task C. The preliminary scenarios will be modified, refined, and elaborated upon during Task E.

OPERATIONAL CAPABILITIES OF IVSAWS

In-Vehicle Safety Advisory and Warning Systems (IVSAWS) provide warnings of unsafe conditions and situations affecting the driver on the roadway ahead. IVSAWS provides sufficient advance warning to permit the driver to take remedial action. IVSAWS provides messages related to relatively transient conditions, requiring modifications to the messages at irregular intervals. It should also be noted that mayday systems have been subsumed under IVSAWS for the purposes of the present discussion. IVSAWS does not encompass in-vehicle warnings of imminent danger requiring immediate action (e.g., collision avoidance devices.). A sample of specific IVSAWS capabilities identified through interviews and a review of the literature is provided below. These capabilities will be refined, elaborated, and presented as specific IVSAWS functions and features in the upcoming Task C report. A basic capability of IVSAWS is that it is not limited simply to warnings of conditions. Advisory messages could also include recommended actions. It is important to note that IVSAWS, like ISIS, could have the capability of transmitting multiple messages, with only a subset of messages appropriate for any class of vehicles. This has particular value to CVO, where truck-specific warnings could be provided for the following:

- Steep downgrades.
- Tight ramps and intersections.
- Railroad-grade crossings with limited sight distances.

Two separate state DOTS noted that IVSAWS could provide the capability of dynamic speed limits, which could facilitate trip smoothness (dynamic speed limits are currently used in Germany). Law enforcement respondents foresaw the capability of IVSAWS transmitters being installed on rolling hazards, such as emergency vehicles and school buses, providing an additional mode for warning signals. Law enforcement respondents also noted the value of having portable transmitters available for their use in case of accidents. Finally, law enforcement respondents noted the value of mayday functions for deaf drivers, who are unable to use a cellular telephone without Telecommunications Device for the Deaf (TDD). This could provide a cost-effective means of improving personal security for this population. Several documents discuss the potential for automatic mayday systems that would be triggered by unusual events, such as a rollover or extreme deceleration of the type that would trigger airbags. The capability of linking a mayday system with a Global Positioning System (GPS) was identified as advantageous by several Task B interview respondents. Law enforcement respondents noted that the mayday function should provide feedback to the user that action is being taken and how long it will be before help arrives. An IVSAWS technology could be integrated with ATMS. or a more limited system of sensors and data processing capabilities, to provide dynamic messaging based upon prevailing conditions. One brochure for a prototype system extends the capability of an IVSAWS device to providing real-time congestion information.

OPERATIONAL SCENARIOS FOR IVSAWS

The remainder of this section provides descriptions of preliminary IVSAWS operational scenarios representing private vehicle and CVO applications. Each of the separate scenarios is presented via a brief narrative description. followed by a table that provides a general timeline of events related to the condition of the vehicle and roadway, driver information requirements, driver actions, and ATIS information display. These scenarios are provided for the purpose of defining the general system capabilities and scenario conditions that should be considered in future analytic and research phases of this project. It is likely premature to provide specifics concerning display content and format prior to a more complete analysis of driver information requirements, capabilities, and constraints.

Private Vehicle Scenarios

P10: Preliminary Scenario for Tasks C and E

A middle-aged woman is on her regular 10-mi (16. l-km) commute across town to her workplace in a medium-sized city. Roadway and weather conditions are good. During the drive, an emergency vehicle approaches her from behind and she comes to a school bus boarding children. She receives advance warning by her IVSAWS technology. Table 24 summarizes scenario P10.

Table 24. Timeline of scenario P10 events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t_0	Vehicle in DRIVE at 40 mi/h (64.4 km/h)	Advance warning of upcoming road conditions requiring driver action	Normal driving	IVSAWS display activated
t_1	Emergency vehicle approaching vehicle from behind		Driver alerted	"Emergency vehicle approaching" warning
t_2		Action required in response to approaching emergency vehicle		Pull over into right lane and stop recommendation
t_3			Pull over to allow emergency vehicle to pass	
t_4	Emergency vehicle passes		Resume normal driving	
t_5	Vehicle approaching school bus boarding children		Driver alerted	"School bus" warning
t_6		Action required in response to school bus warning		Reduce speed and come to stop at bus message
t_7			Reduce speed and stop at bus	
t_8	School bus completes boarding and vehicle resumes travel		Normal driving	

P11: Preliminary Scenario for Tasks C and E

An older, experienced driver is traveling alone on suburban arterials in the morning to his health club. It is a cold winter morning and traffic is unusually slow due to the poor weather conditions. As he approaches a bridge, he receives an IVSAWS warning of ice on the bridge. Later on the drive, he receives warning of slow-moving road equipment on the roadway, Table 25 summarizes scenario P11.

Table 25. Timeline of scenario Pll events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t_0	Vehicle in DRIVE on road at 40 mi/h (44.4 km/h)	Advance warning of upcoming road conditions requiring driver action	Normal driving	IVSAWS display activated
t_1	Vehicle approaching icy bridge		Dnver alerted	"Ice on bndge ahead" warning
t_2		Actions required in response to warning		Recommended reduced speed message
t_3			Reduce speed	
t_4	Vehicle on bndge		Drive over bridge	
t_5	Vehicle past bridge		Resume normal driving	
t_6	Vehicle approaching road equipment		Driver alerted	"Road equipment" warning
t_7		Actions required in response to warning		Recommended reduced speed message
t_8			Reduce speed. drive past road equipment	
t_9	Vehicle past road equipment		Resume normal driving	

P12 Preliminary Scenario for Tasks C and E

A young inexperienced driver is traveling late at night on icy rural roads. He has received IVSAWS warnings of ice on the roadway, but hits some ice at an excessive speed and runs off of the road. He uses the mayday function of the IVSAWS to call for help. Table 26 summarizes scenario P12.

Table 26. Timeline of scenario P12 events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t_0	Vehicle in DRIVE on road at 60 mi/h (96.6 km/h)	Advance warning of upcoming road conditions requiring driver action	Driving at excessive speed	IVSAWS display activated
t_1	Vehicle approaching icy roadway		Driver alerted	"Ice on road ahead" warning
t_2				Recommended reduced speed of 20 mi/h (32.2 km/h) message
t_3			Reduces speed to 50 mi/h (80.5 km/h)	
t_4	Vehicle starting to lose control on ice		Step on brakes and turn wheel	
t_5	Vehicle skidding out of control		Continues to apply the brakes	
t_6	Vehicle goes into snow filled ditch at 40 mi/h (64.4 km/h)	Several. including means to call for assistance	Check self for injuries Listen to IVSAWS message	IVSAWS message providing options for assistance call
t_7	Vehicle in ditch		Activates IVSAWS control calling road service	
t_8	Road-service vehicle arrives			

Commercial Vehicle Scenarios

C7: Preliminary Scenario for Tasks C and E

A young inexperienced medical-aid vehicle operator is transporting a passenger, who has suffered a heart attack, to a hospital in a rural area during a severe rain storm. The major arterial on which the vehicle is traveling is flooded between the vehicle's current location and the hospital. Prior to reaching the flooded area, the driver receives an IVSAWS notification of the flooded roadway and is provided guidance regarding an alternate route. Table 27 summarizes scenario C7.

Table 27. Timeline of scenario C7 events.

TIME	VEHICLE ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t_0	Vehicle in DRIVE on wet road	Advance warning of upcoming road conditions requiring driver action	Driving at highest possible safe speed	IVSAWS display activated
t_1	Vehicle approaching flooded area		Driver alerted	"Flooded roadway" warning
t_2		Required response to warning		Recommended alternate route
t_3		Verification of alternate route	Request repeat of message	Warning and alternate route messages repeated
t_4	Vehicle on alternate route		Driver diverts to alternate route	

C8 Preliminary Scenario for Tasks C and E

An experienced driver of a delivery vehicle is making a scheduled delivery at an airport. The driver is en route on a freeway through a major city. The driver receives an IVSAWS notification that there is a multiple-vehicle accident on the freeway ahead and an alternate route is recommended. Table 28 summarizes scenario C8.

Table 28. Timeline of scenario C8 events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t_0	Vehicle in DRIVE en route to airport	Advance warning of upcoming road conditions requiring driver action	Normal driving	IVSAWS display activated
t_1	Vehicle approaching site of accident		Driver alerted	"Accident ahead" warning
t_2		Actions required in response to warning		Recommended alternate route
t_3		Verification of alternate route	Request repeat of message	Warning and alternate route message repeated
t_4	Vehicle on alternate route		Driver diverts to alternate route	

C9: Preliminary Scenario for Tasks C and E

An experienced interstate truck operator is traveling on a rural highway late at night. The driver sees a private vehicle accident, stops, and determines that medical and highway patrol assistance is required. The driver uses the mayday function of the truck's IVSAWS technology to call for help. Table 29 summarizes scenario C9.

Table 29. Timeline of scenario C9 events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t_0	Vehicle in DRIVE on highway		Normal driving	IVSAWS display activated
t_1	Vehicle approaching site of private vehicle accident	Private vehicle requirements for assistance	Pull over truck	
t_2	Vehicle in PARK at accident site		Inspects accident and determines need for medical and highway assistance	
t_3			Returns to truck	
t_4			Access IVSAWS mayday function	IVSAWS mayday interface
t_5			Select Emergency medical aid calling option	Emergency medical aid call feedback
t_6			Select Highway patrol aid calling option	Highway patrol aid call feedback
t_7		First aid assistance that can be provided prior to arrival of an emergency aid vehicle	Return to accident site and provide first aid	
t_8	Emergency medical aid arrives at scene			
t_9	Highway patrol aid arrives at scene			

C10: Preliminary Scenario for Tasks C and E

An experienced interstate truck operator is driving on a mountain pass in ice and snow. A strong gust of wind pushes the vehicle on the icy roadway and the vehicle rolls over. The rollover automatically triggers the mayday function in the truck, alerting the highway patrol of a rollover accident and the location of the truck. Table 30 summarizes scenario C10.

Table 30. Timeline of scenario Cl0 events.

TIME	VHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	ATIS INFORMATION DISPLAY
t_0	Vehicle in DRIVE on highway	Advance warning of upcoming road conditions requiring driver action	Normal driving	IVSAWS display activated
t_1	Vehicle approaching ice and snow on roadway		Driver alerted	"Ice and snow on roadway" warning "Strong winds" warning Recommended reduced speed
t_2	Vehicle speed reduced		Vehicle speed reduced	
t_3	Vehicle on ice and snow			
t_4	Strong gust of wind pushes vehicle into rollover		Unsuccessful attempt to regain vehicle control	IVSAWS mayday technology detects rollover and requests response from driver
t_5			Driver unable to respond to IVSAWS	IVSXWS mayday technology automatically alerts highway patrol of incident and vehicle location
t_6	Highway patrol arrives at Scene of accident			

X. CVO OPERATIONAL CAPABILITIES AND SCENARIOS

This section provides a summary of operational capabilities unique to CVO and descriptions of the preliminary scenarios representing a sample of these capabilities. The CVO operational capabilities represent an initial summary of capabilities, which will be refined and elaborated during Task C. The preliminary scenarios will be modified, elaborated, and refined during Task E.

OPERATIONAL CAPABILITIES SPECIFIC TO CVO

CVO systems cover a broad spectrum of capabilities that have been identified to meet specific operational requirements. The scope of the present review has excluded crash avoidance systems, such as automatic clearance sensing, but has included on-vehicle status monitoring systems. Following is a sample of CVO-specific system capabilities identified through interviews and a review of the literature. These capabilities will be refined, elaborated, and presented as specific CVO functions and features in the upcoming Task C report.

Much of the technology being proposed for CVO-specific system development is currently available and implemented in limited degrees. This has allowed the transportation community an opportunity to become quite familiar with alternative capabilities. This familiarity resulted in a consistently high level of knowledge regarding these topics among the Task B interview respondents. It has also resulted in a well-developed set of descriptions for these capabilities in the *Strategic Plan for intelligent Vehicle-Highway Systems in the United States* (Intelligent Vehicle Highway Society of America, 1992). Because of the excellent, comprehensive nature of the strategic plan, it serves as the primary reference in the following discussion. Specific capabilities identified and described in that report are excerpted below:

- *Electronic Credentials (EC)* - would enable a motor carrier to electronically file for, obtain, and pay for all required licenses, registrations, and permits. An electronic record of the credential could be sent to the motor carrier's headquarters or other desired location.

- *Hazardous material information systems* - could provide enforcement and incident management response teams with timely, accurate information on cargo contents, enabling them to react properly in emergency situations.

- *Automatic Vehicle Classification (AVC)* - employs EC technology to provide a readable, electronic record of vehicle type and contents.

- *Automated Vehicle Location (AVL)* - employs GPS, or other triangulation technologies, to provide real-time information regarding the location and status of vehicles.

- *Driver/vehicle real-time safety monitoring* - could include records of duty logs, medical qualifications data, and commercial driver's license information. Vehicle-related elements could include operational data and conditional information (such as status of brakes, lights, tires, and steering).

- *Electronic* log *book* - could replace the manual trip log typically prepared by the motor carrier. The fuel tax rates for each state and the number of vehicle-miles traveled within each state could be recorded electronically if electronic beacons were provided aft all site boundaries.

- *Automated Vehicle Classification/Identification* (AVC/AVI)- would allow uninterrupted movement of the vehicle through inspection or weighing stations.

- *Weigh in Motion* (WIM) - allows motor carriers equipped with special transponders to proceed on the highway at normal speeds through instrumented weigh stations as their weight is electronically inspected by in-pavement scales and readers.

- *Automated (electronic) toll collection* - is accomplished by applying the same technologies as those used in automated credential checking.

- *Two-Way real-time Communications (TWC)* - would provide ATIS and ATMS information to drivers or dispatchers concerning congestion, incidents, and optimum routing.

- *Advanced fleet management* - would apply advanced vehicle routing algorithms employing real-time congestion information. as well as balance routes and loads, based on predicted travel times.

OPERATIONAL SCENARIOS FOR CVO-SPECIFIC CAPABILITIES

The remainder of this section provides descriptions of preliminary CVO-specific operational scenarios. Each of the separate scenarios is presented via a brief narrative description. followed by a table that provides a general timeline of events related to the condition of the vehicle and roadway, driver information requirements, driver actions, and ATIS information display. These scenarios are provided for the purpose of defining the general system capabilities and scenario conditions that should be considered in future analytic and research phases of this project. it is likely premature to provide specifics concerning display content and format prior to a more complete analysis of driver information requirements, capabilities. and constraints.

in-vehicle Scenarios

C11: Preliminary Scenario for Tasks C and E

An experienced interstate truck operator is passing between two states at night. Prior to reaching the inspection point, her WIM system advises her to move to the right-hand lane, where her vehicle is weighed while traveling at normal speeds. Simultaneously, a sensor reads the truck's EC to validate safety records and debit the trucking company's account for road taxes. The driver receives notification that all transactions have been performed successfully and she proceeds at normal speed past the inspection point. Table 31 summarizes scenario Cl1.

Table 31. Timeline of scenario C11 events.

TIME	VEHICLE & ROADWAY CONDITION	DRIVER INFORMATION REQUIREMENTS	DRIVER ACTIONS	CVO SYSTEM INFORMATION DISPLAY
t_0	Vehicle in DRIVE on highway	Advance warning of upcoming road conditions requiring driver action	Normal driving	EC and WIM systems activated
t_1	Vehicle approaching inspection point	Actions required, if any. and inspection point		"Upcoming EC and WIM site ahead" message Recommend move to right hand lane
t_2			Truck moved to tight-hand lane	
t_3	Vehicle passing WIM and EC sensors at normal speed			"Successful WIM message "Successful safety record check" message "Successful road tax debit" message
t_4	Vehicle leaving inspection point at normal speed Slow-moving trucks ahead that will be stopping at inspection point		Driver changes lane to avoid delay and continues driving	

Out-of-Vehicle Scenarios

C12: Preliminary Scenario for Tasks C and E

A central dispatcher for medical aid vehicles in a large metropolitan area is working her normal nighttime shift. She receives two emergency calls for aid required at a freeway accident and a private residence. It is during rush hour and there is major congestion on many of the roadways. The dispatcher enters the locations of the emergencies into her routing system and the system determines the appropriate medical aid vehicle stations to call and the appropriate routes to take, based on the fastest predicted travel time under current traffic conditions. Table 32 summarizes scenario C12.

Table 32. Timeline of scenario Cl2 events.

TIME	DISPATCHER INPUT	DISPATCHER INFORMATION REQUIREMENTS	DISPATCHER ACTIONS	CVO SYSTEM INFORMATION DISPLAY
t_0		Status of all emergency vehicles	Review vehicle status	Large area map Vehicle status display
t_1	Emergency call for site #1 received by dispatcher	Vehicle to dispatch to site #I Routes to be taken to emergency site #1	Enter location of emergency site #l	Site #l location INPUT feedback
t_2	Emergency call for site #2 received by dispatcher	Vehicle to dispatch to site #2 Routes to be taken to emergency site #2	Enter location of emergency site #2	Site #2 location input feedback
t_3			Request routes from stations with vehicles available	Route request acknowledgment
t_4				Large area map Vehicle station and route to site #1 Vehicle station and route to site #2
t_5		Confirmation of dispatches from vehicles Status of vehicles	Dispatch vehicle to site #I	Large area map Vehicle status display
t_6	Confirmation from vehicle station for site #I dispatch		Dispatch vehicle to site #2	
t_7	Confirmation from vehicle station for site #2 dispatch			
t_8		Status of all emergency vehicles	Review vehicle status	Large area map Vehicle status display

C13: Preliminary Scenario for Tasks C and E

A central dispatcher coordinates the progress of 20 separate vans that provide door-to-door airport transportation in one suburban section of a major metropolitan area. Service is provided on demand, so calls are responded to within a specified period of time. If the caller is not picked up within the time they are told, the cost of the ride is reduced by 50% and a report must be filed by the driver and dispatcher. Dispatchers are also rewarded for making the maximum use of available vans, as determined by the fleet routing system. Table 33 summarizes scenario C 13.

Table 33. Timeline of scenario Cl3 events.

TIME	DISPATCHER INPUT	DISPATCHER INFORMATION "REQUIREMENTS	DISPATCHER ACTIONS	CVO SYSTEM INFORMATION DISPLAY
t_o	--	Status of assigned vans	Review van status	Vehicle status display
t_1	Receive call for pick up (client location and time of flight)	Availability of vans to pick up client	Enter client location and time of flight Request van assignment	Time of flight and client location entry feedback Assignment request feedback
t_2				Van assignment listing of revised route schedule
t_3		Overview of revised route	Access map display and request route overview	Map showing revtsed route
t_4			Review and verify revised schedule	
t_5			Provide pick up information to client	
t_6		Confirmation of revised route from van	Forward revised route and schedule to van	
t_7	Confirmation from van of revised route			
t_8		Status of assigned vans	Review van status	Vehicle status display

CI4: Preliminary Scenario for Tasks C and E

A central dispatcher for an interstate trucking company has received notification from the highway patrol of the closure of a highway that serves as one of the company's primary routes. Using XVL, the dispatcher identifies the current location of trucks in that vicinity, determines their destinations. uses the routing system to identify alternate routes, and uses the TWC system to notify drivers of the recommended changes in route. Table 34 summarizes scenario C14

Table 34. Timeline of scenario Cl4 events.

TIME	DISPATCHER INPUT	DISPATCHER INFORMATION REQUIREMENTS	DISPATCHER ACTIONS	CVO SYSTEM INFORMATION DISPLAY
t_0		Status of vehicles	Review vehicle status	Large area map Vehicle locations Road congestion
t_1	Receive highway patrol notification of road closure	Identification of any vehicles requiring revised routes	Enter road closure into IRANS Identify vehicle locations with XVL	Road closure entry feedback and display Identification of vehicle requiring route revision
t_2		Exact status of vehicle requiring route revision	Contact driver on TWC system and inform him of road closure	
t_3	Driver Informs dispatcher that he is traveling on planned route		Request driver to pull over and wait for further instructions	
t_4		Shortest revised route to destination	Request revised route	Revised route
t_5		Revised estimated time of arrival at destination	Request revised estimated time of arrival	Revised estimated time of arrival
t_6		Confirmation of route revision	Contact driver and provide revised route and estimated time of arrival	
t_7	Confirmation from truck of revised route			
t_8		Status of vehicles	Review vehicle status	Large area map Vehicle locations Road congestion

APPENDIX A. SUMMARY OF SURVEY RESPONSES

Table 35. Ratings of the importance of ATIS subsystems in supporting overall ATIS objectives.

Ratings:by 43 respondents for private vehicle applications:			
ATIS Subsystem	Mean Rating	Lower 95% C1	upper 95% CI
IRANS	94.3	91.7	98.1
IMSIS	58.5	50.5	66.5
ISIS	50.0	41.4	58.6
IVSAWS	68.3	59.9	76.7
Ratings by 17 respondents with a commercial vehicle operations focus:			
IRANS	97.6	94.4	100.8
IMSIS	51.2	35.9	66.5
ISIS	62.2	48.4	76.0
IVSAWS	70.0	57.3	82.7

Table 36. Ratings of the importance of IVHS objectives in meeting the overall ATIS objectives.

by 43 respondents for private vehicle applications:			
Performance Objective	**Mean Rating**	**Lower 95% CI**	**Upper 95% CI**
Traffic Congestion	81.7	74.7	88.7
Safety	80.3	72.7	87.9
Mobility	80.0	70.5	89.7
Environment & Energy	59.7	50.3	69.1
Economic Productivity	57.8	48.0	67.6
Ratings by 17 respondents with a commercial vehicle operations focus:			
Traffic Congestion	71.4	53.3	89.5
Safety	83.4	70.7	96.1
Mobility	64.9	40.5	89.3
Environment Energy	44.5	23.6	64.4
Economic Productivity	96.4	90.5	102.3

Table 37. Ratings of the importance of ATIS subsystems in meeting the objective of decreased traffic congestion.

Ratings by 43 respondents for ptivate vehicle applications:			
ATIS Subsystem	` Mean Rating	Lower 95% CI	Upper 95% C1
	96.1	92.5	99.7
IMS ES	52.8	43.4	62.2
ISIS	45.3	36.1	54.5
IVSAWS	56.8	47.6	66.0
Ratings by 17 respondents with a commercial vehicle operations focus:			
IRANS	94.9	89.2	100.6
IMSIS	43.8	30.7	56.9
ISIS	39.4	33.0	65.8
IVSAWS	66.4	52.1	80.7

Table 38. Ratings of the importance of ATIS subsystems in meeting the objective of improved safety.

Ratings by 43 respondents for private vehicle applications:			
ATIS Subsystem	**Mean Rating**	**Lower 95% CI**	**Upper 95% CI**
IRANS	66.2	57.2	75.2
IMSIS	34.9	26.9	42.9
ISIS	65.5	55.9	75.1
IVSAWS	89.9	83.3	96.5
Ratings by 17 respondents with a commercial vehicle operations focus:			
IRANS	74.9	63.6	86.2
IMSIS	36.8	24.8	48.8
ISIS	69.4	52.2	86.6
IVSAWS	92.4	84.0	100.8

Table39. Ratings of the importance of ATIS subsystems in meeting the objective of increased and higher quality mobility.

Ratings by 43 respondents for private vehicle applications:			
ATIS Subsystem	**Mean Rating**	**Lower** 95% C1	Upper 95% C1
IRANS	97.0	94.6	99.4
IMS ES	75.5	67.7	83.3
ISIS	52.8	43.2	62.4
IVSAWS	49.3	40.3	58.3
Ratings by 17 respondents with a commercial vehicle operations focus:			
IRANS	92.9	82.5	103.3
IMSIS	48.8	32.0	65.6
ISIS	62.5	46.4	78.6
IVSAWS	58.8	45.2	72.4

Table 40. Ratings of the importance of ATIS subsystems in meeting the objective of improved environmental quality and energy efficiency.

Ratings by 43 respondents for private vehicle applications:			
ATIS Subsystem	**Mean Rating**	**Lower 95% C1**	**Upper 95% C1**
IRANS	97.2	93.6	100.8
IMSIS	52.9	43.3	62.5
ISIS	40.1	31.7	48.5
IVSAWS	40.4	31.2	49.6
Ratings by 17 respondents with a commercial vehicle operations focus:			
	92.3	82.8	101.8
IMSIS	43.8	27.3	60.3
ISIS	49.8	33.0	66.6
IVSAWS	57.9	44.5	71.3

Table 41. Ratings of the importance of ATIS subsystems in meeting the objective of improved economic productivity.

ATIS Subsystem	Mean Rating	Lower 95%C1	Upper 95 % C1
Ratings by 43 respondents for private vehicle applications:			
IRANS	94.4	89.6	99.2
IMSIS	71.9	63.5	80.3
ISIS	41.1	32.1	50.1
IVSAWS	46.2	37.4	55.0
Ratings by 17 respondents with a commercial vehicle operations focus:			
	94.0	85.1	102.9
IMS IS	61.8	45.3	78.3
ISIS	45.7	30.3	61.0
IVSAWS	63.5	48.2	78.8

REFERENCES

Bolczak, R., Salwin, A. E., & McHale, *G.* 'M. *(1992). Evaluation Plan for the ADVANCE Project (Working Paper).* McLean, VA: The MITRE Corporation.

California Department of Transportation. (199 1). *Transportation Technology Development for California: Program and Policy Review.* Sacramento, CA: California Department of Transportation.

Department of Transportation. (December, 1992). *IVHS Strategic Plan: Report to Congress.* Washington, D.C.: DOT.

Dingus, T. A., Hulse, M. C., Alves-Foss, J., Confer, S., Jahns, S., Rice, A., Roberts, I., Hanowski, R. J., & Sorenson, D. (1993). *Development of Human Factors Guidelines for Advanced Traveler Information Systems and Commercial Vehicle Operations: Task A - Literature Review (Working Paper).* Moscow, ID: National Center for Advanced Transportation Technology, University of Idaho.

Fleischman, R. N. (1991). Research and evaluation plans for the TravTek NHS operational field test. *Proceedings of the Vehicle Navigation & Information Systems Conference,* Dearborn MI: Society of Automotive Engineers.

Intelligent Vehicle Highway Society of America. (1992). *Strategic Plan for Intelligent Vehicle-Highway Systems in the United States.* Washington, D.C.: IVHS America.

King, G. F. & Mast, T. M. (1987). Excess travel: Causes, extent and consequences. *Transportation Research Record,* 1111. TRB, National Research Council.

Minnesota Department of Transportation. (1993). *Genesis Report.* St. Paul, MN: Minnesota Department of Transportation.

Mobility *2000.* (1990). *Intelligent Vehicle Highway Systems (IVHS): Operational Benefits.* Dallas, TX: Mobility 2000.

Perez, W. A. & Mast, T. M. (1992). Human factors and Advanced Traveler Information Systems (ATIS). In *Proceedings of the Human Factors Society 36th Annual Meeting,* 1073-1077. Santa Monica, CA: Human Factors Society.

Rillings, J. H. & Betsold, R. J. (1991). Advanced driver information systems. *IEEE Transactions on Vehicular Technology, 40(1)* 3 l-40.

Underwood, S. (1993). *Personal communication of preliminary evaluation criteria for the FAST-TRAC program.* Ann Arbor, MI: University of Michigan.