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**Parking and Routing Information
System Phase I Evaluation—
Individual Evaluation
Test Plans**

Richard J. Carter

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Intelligent Transportation Systems
Johnson City, Tennessee

**PARKING AND ROUTING INFORMATION SYSTEM
PHASE I EVALUATION -
INDIVIDUAL EVALUATION TEST PLANS**

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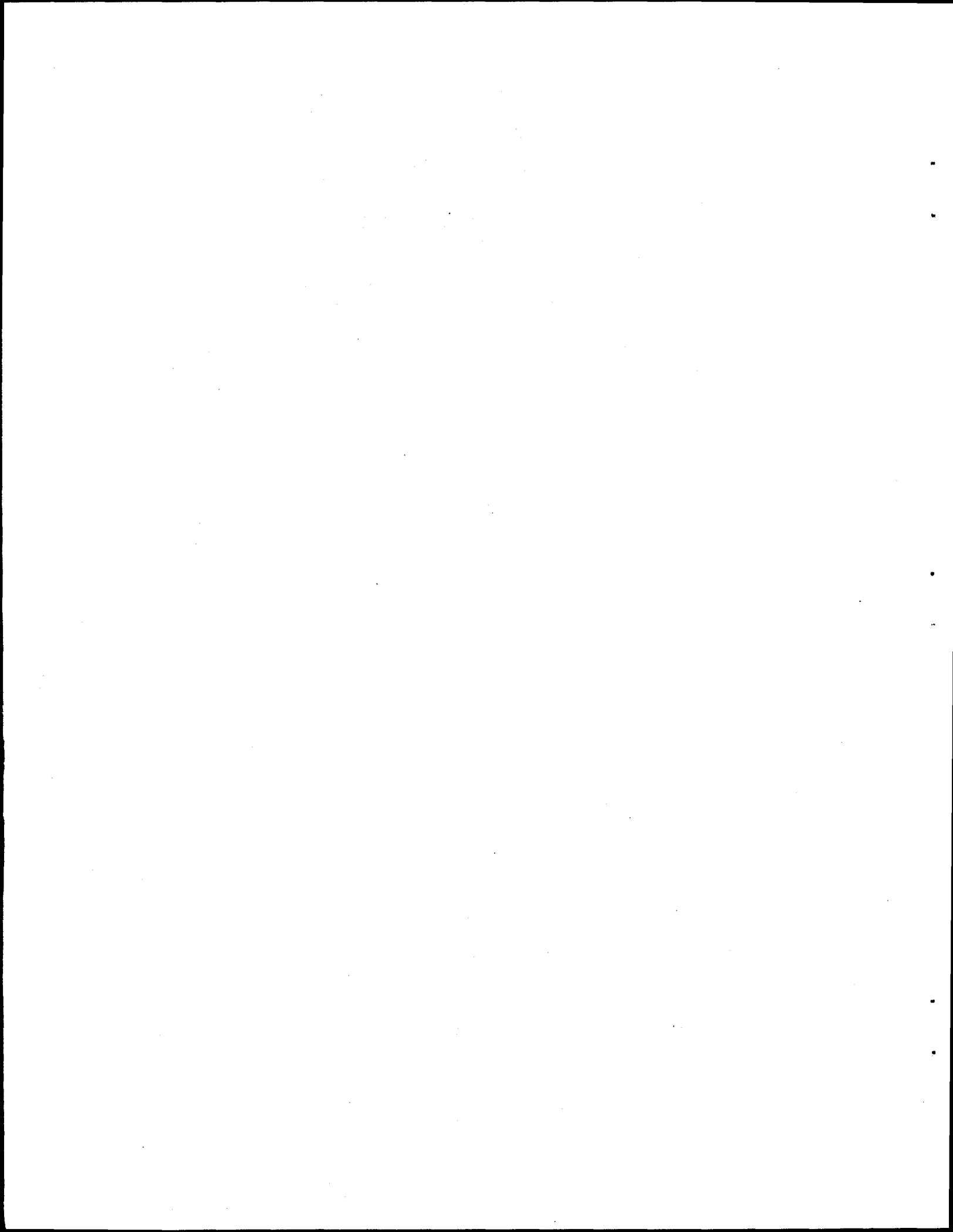


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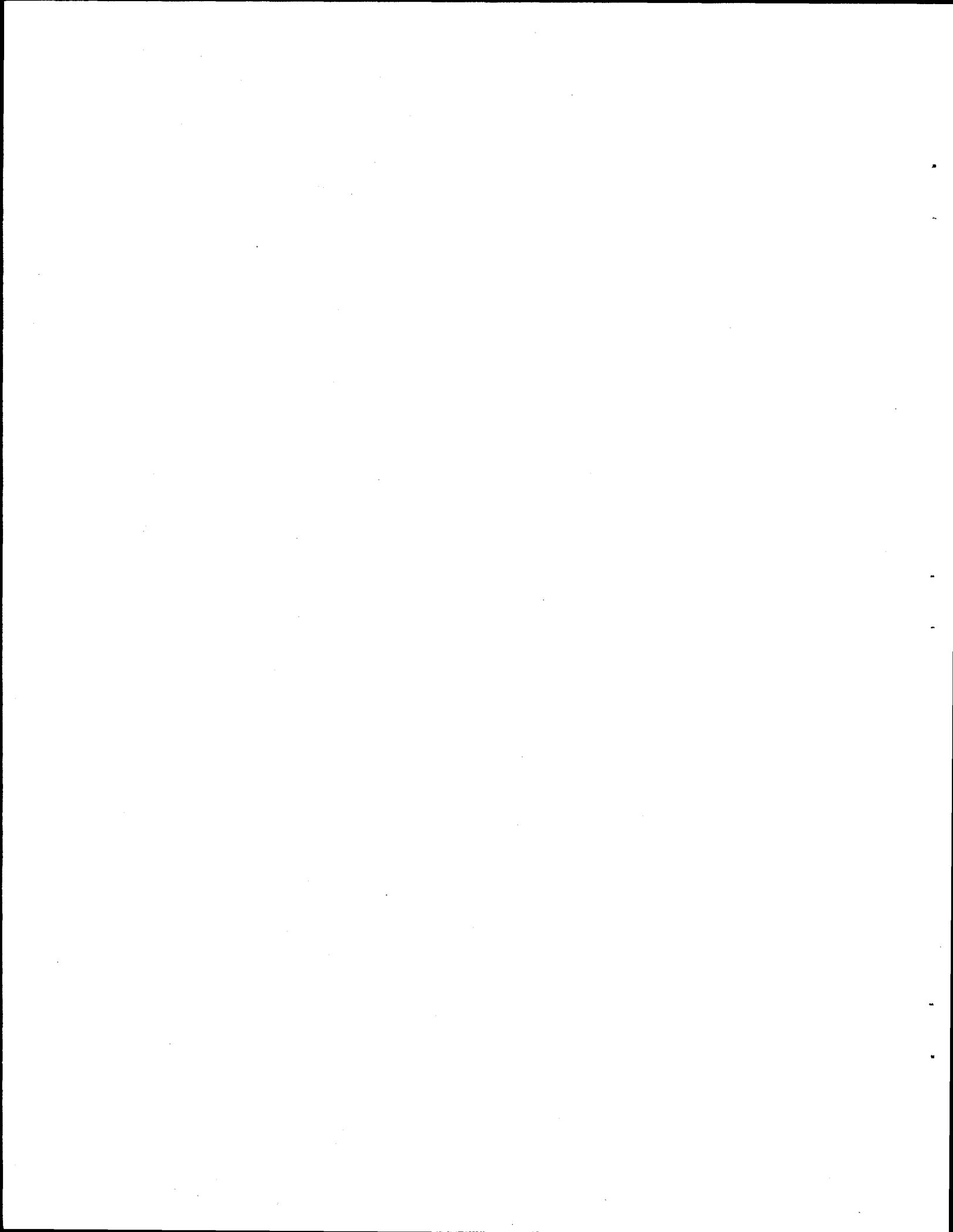
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ABSTRACT

A parking and routing information system (PARIS) is being designed and deployed at a test site on the Mountain Home Veterans Administration campus in Johnson City, Tennessee using three sensor technologies. The purpose of the PARIS project is to demonstrate innovative integration of vehicle sensing technologies with parking management strategies to improve mobility and relieve congestion associated with a growing medical/technology complex. Oak Ridge National Laboratory's (ORNL) role during phase I of the project is to function as the independent evaluator. The evaluation will be performed through the execution of four integrated studies (system performance, user acceptance, institutional and business issues, and transportation systems). The purpose of the system performance study will be to provide the data necessary to evaluate the performance of PARIS and its subsystems. The study will assess: the PARIS architecture and performance as a whole; sensor performance, accuracy, and reliability under expected environmental conditions; processing architecture and performance characteristics; communications architecture and format; and variable message signs (VMS) performance and reliability. The objective of the user acceptance study will be to generate the material required to analyze the vehicle drivers' acceptance and perceptions of PARIS. It will assess: the perception of PARIS usefulness; the perception of reliability; aesthetic acceptance; and VMS signing strategy and content. The institutional and business issues study will be directed at providing the information necessary to investigate the PARIS project organization and management, regulatory and legal, human and facilities resources, financial, jurisdictional, and public/private issues. The study will assess: deployment issues; inter-agency cooperation; and historical considerations. The transportation systems study will be oriented toward producing the data required to examine PARIS' alignment with intelligent transportation systems (ITS) goals, guidelines, and documentation. It will assess: system safety; expandability/extendibility issues; compliance with national ITS objectives; and synchronization with the national system architecture. This technical memorandum presents the four individual evaluation test plans, *System Performance Individual Evaluation Test Plan*, *User Acceptance Individual Evaluation Test Plan*, *Institutional and Business Issues Individual Evaluation Test Plan*, and *Transportation Systems Individual Evaluation Test Plan*, which were developed to support ORNL's responsibilities and functions during the four studies. The plans define the level of effort required to satisfy the data collection, processing, and analysis requirements for the assessment of the system performance, user acceptance, institutional and business issues, and transportation systems components of the PARIS phase I evaluation. Each plan is divided into three subsections: executive summary, detailed study design, and study management.

1. INTRODUCTION

1.1 Purpose of the Evaluation Studies and Plans

The Johnson City, Tennessee (TN) parking and routing information system (PARIS) phase I evaluation will be performed through the execution of four integrated studies (system performance, user acceptance, institutional and business issues, and transportation systems). The purpose of the system performance study will be to provide the data necessary to evaluate the performance of the phase I version of PARIS and its subsystems. Specifically, the study will assess: the PARIS architecture and performance as a whole; sensor performance, accuracy, and reliability under expected environmental conditions; processing architecture and performance characteristics; communications architecture and format; and variable message signs (VMS) performance and reliability.

The objective of the user acceptance study will be to generate the material required to analyze the vehicle drivers' acceptance and perceptions of the phase I version of PARIS. The study will assess: the perception of PARIS usefulness; the perception of reliability; aesthetic acceptance; and VMS signing strategy and content. The institutional and business issues study will be directed at providing the information necessary to investigate the phase I PARIS project organization and management, regulatory and legal, human and facilities resources, financial, jurisdictional, and public/private issues. Specifically, it will assess: deployment issues; inter-agency cooperation; and historical considerations. The study will not compare actual performance to expected performance or infer a 'better' solution since it will be descriptive rather than evaluative in nature. The transportation systems study will be oriented toward producing the data required to examine phase I PARIS' alignment with intelligent transportation systems (ITS) goals, guidelines, and documentation. The study will assess: system safety; expandability/extendibility issues; compliance with national ITS objectives; and synchronization with the national system architecture.

An individual evaluation test plan has been developed for each of the studies and is presented in this report. The plans define the level of effort required to satisfy the data collection, processing, and analysis requirements for the assessment of the system performance, user acceptance, institutional and business issues, and transportation systems components of the PARIS phase I evaluation. The four studies will be conducted in parallel over a six-month period of time. Two months will be dedicated to pre-study activities, three months to study tasks, and one month to post-study requirements.

1.2 Background

The purpose of the PARIS project is to demonstrate innovative integration of vehicle sensing technologies with parking management strategies to improve mobility and relieve congestion associated with a growing medical/technology (med/tech) complex. PARIS is being developed and implemented in a three-phased approach. Phase I which is currently ongoing is oriented

toward the design and deployment of PARIS at a test site on the Mountain Home Veterans Administration (VA) campus using three sensor technologies. In phase II, a parking garage will be constructed, integrating the sensors and PARIS developed in phase I. PARIS will also be extended to cover more parking facilities at the Mountain Home campus and adjacent areas during this phase. Phase III will continue to expand PARIS into the med/tech corridor, incorporate an intermodal transportation aspect, and construct a second intelligent parking facility (if full funding is secured).

1.3 Scope

The topics addressed in the *System Performance, User Acceptance, Institutional and Business Issues, and Transportation Systems Individual Evaluation Test Plans* were selected from the recommended test plan outline developed by Booz-Allen & Hamilton, Inc. for the United States (U.S.) Department of Transportation (DOT), Federal Highway Administration (FHWA, 1995) and the guidelines provided in the *Generic Intelligent Vehicle/Highway Systems (IVHS) Operational Test Evaluation Guidelines* (MITRE, 1993). The objectives, measures of effectiveness (MOE), and hypotheses used in the plans were drawn directly from the *PARIS - Phase I Evaluation Plan* (Raytheon, 1996).

Consistent with the MITRE document, six steps of the evaluation have been identified. These steps are:

1. Evaluation concept development;
2. Evaluation goal definition;
3. Evaluation definition;
4. Evaluation design;
5. Data collection and analysis; and
6. Reporting.

The *Phase I Work Plan* (City of Johnson City, 1994) submitted and approved for this project, along with subsequent meetings and actions, satisfied the contents of steps one and two. The *Evaluation Plan* fulfilled the requirements of step three. The *Data Management and Quality Control/Quality Assurance (QC/QA) Plans* (Carter, 1997), along with the four individual evaluation test plans in this technical memorandum, are the deliverables from step four. The next action is for Oak Ridge National Laboratory (ORNL, the independent evaluator) to begin data collection and analysis.

1.4 Organization of the Report

This technical memorandum is organized into seven sections. They include: Introduction, System Performance Individual Evaluation Test Plan, User Acceptance Individual Evaluation Test Plan, Institutional and Business Issues Individual Evaluation Test Plan, Transportation Systems Individual Evaluation Test Plan, References, and Acronyms and Abbreviations. Each individual

evaluation test plan is divided into three subsections: Executive Summary, Detailed Study Design, and Study Management.

2. SYSTEM PERFORMANCE INDIVIDUAL EVALUATION TEST PLAN

2.1 Executive Summary

2.1.1 Information Needed

The information needed to address each of the system performance study objectives will be generated and/or gathered through a cooperative effort between the independent evaluator and the PARIS evaluation team (i.e., Raytheon Company, Virginia Tech Center for Transportation Research, and Wilbur Smith Associates). A combination of component documentation and specifications, reports, phase I program deliverables, database contents, and field measurements will serve as the mechanism for the collection of the necessary information. Specific procedures and data requirements are provided in section 2.2 of this plan.

2.1.2 Management and Overall Responsibility

Completion of the study activities described herein will be the responsibility of the independent evaluator. ORNL will be accountable for all data collection and analysis, and will prepare the test report. Raytheon will be responsible for supplying needed documentation produced by the project team and providing access to the time-lapsed VCR data and data stored in the distributed database processor.

2.2 Detailed Study Design

2.2.1 Evaluation Scheme

This section describes the overall evaluation scheme. The subsections include: an overview of the evaluation; MOEs and hypotheses to be tested; data sources; and the evaluation technical approach.

2.2.1.1 Evaluation Overview

The goal of the study will be to evaluate system performance. The broad nature of the system performance study, as indicated by the diverse objectives to be addressed, will require the segregation of test activities into five distinct areas, consistent with the five study objectives:

1. System architecture (objective 1);
2. Sensors (objective 2);
3. Processing architecture (objective 3);

4. Communications architecture (objective 4); and
5. VMSs (objective 5).

The purpose of the system architecture portion of the study will be to analyze the PARIS architecture and performance as a whole. The aim will be to take a "systems" view of PARIS. Questions to be answered include:

1. How well has PARIS been designed according to accepted industry design practices and procedures?
2. Does PARIS meet the final system requirements?
3. How well does information actually move through the system from the sensor to final parking information for the user?
4. How well have design considerations to prevent vandalism been integrated into PARIS?

The point of the sensors part of the system performance study will be to investigate sensor performance, accuracy, and reliability under expected environmental conditions. The independent evaluator will evaluate PARIS' sensors using several key technical parameters. Other issues to be covered in this segment of the study are as follows:

1. Sensor applicability for PARIS;
2. Accuracy of the sensors under varying environmental conditions and with known driving patterns;
3. Reliability and expected life span of the sensors given the overall conditions in the med/tech corridor; and
4. System impact of the sensors to PARIS.

The processing architecture piece of the study will be oriented toward assessing the lot and central processing architecture and performance characteristics. Items to be looked at consist of:

1. Computer processing hardware and software to ensure that the design is adequate for maximum throughput and data integrity;
2. Implemented software applicability, functionality, and ease of integration in light of the operating system and hardware configuration;
3. Source code compactness (for efficiency) and thoroughness (for system robustness);
4. Remote access capabilities of PARIS; and
5. Level of security designed into PARIS.

The communications architecture section of the system performance study will be directed at reviewing the communications architecture and format. Problems to be dealt with are the following:

1. How well the communications hardware performs in outdoor conditions and with a variety of lot processors;
2. Whether PARIS can reliably and accurately transmit information over all communication media chosen; and
3. How quickly information is transmitted and processed information is disseminated to the end user.

The VMSs slice of the study will strive to determine VMS performance and reliability. It will also assess:

1. The product's expected life span;
2. Performance and reliability of the VMS electronics; and
3. The performance and reliability of the VMS light sources.

Information regarding the specific data collection methods to be used for each area is provided in subsequent sections of this plan. Collection of data pursuant to each of these areas will be accomplished through a combination of data collection methods:

1. Component documentation and specifications - Compilation of PARIS component documentation and specifications assembled by Raytheon;
2. Reports - Gathering of system failure and maintenance reports produced by Raytheon;
3. Phase I program deliverables - Accumulation of material generated by the PARIS project team (i.e., system integration results, system requirements document, and final hardware description document);
4. Database contents - Use of the time-lapsed VCR data and the distributed database processor; and
5. Field measurements - Collection of system performance data on the Mountain Home VA campus by the independent evaluator's team.

2.2.1.2 Measures of Effectiveness and Hypotheses to Be Tested

To give a focus to the study and to further define the methods necessary to address the study objectives, MOEs and hypotheses were developed for each objective. An MOE is a measurable quantity that is a response, outcome, or dependent variable that is directly related to PARIS system performance. Hypotheses provide a means of proving or disproving some change from the status quo, or the attainment or non-attainment of a prescribed performance objective. The hypotheses presented here may be considered the alternative hypothesis, in a strict statistical sense. The MOEs and hypotheses for each of the five objectives are exhibited in Table 1. MTBF is the abbreviation for mean time between failures which is a measure of system or component reliability.

Table 1. MOEs and Hypotheses for the System Performance Study Objectives

Objectives	MOEs	Hypotheses
1. Assess system architecture and performance as a whole	<ul style="list-style-type: none"> o Design simplicity o Self correction capability o Interface capability o Meets requirements document o Scalableness for full-implementation 	PARIS architecture will enable system performance at nominal levels as specified in the final system requirements document
2. Assess sensor performance, accuracy, and reliability under expected environmental conditions	<ul style="list-style-type: none"> o False alarm rate o Miss rate o Response time o Self diagnostic capability o Meets system requirements document 	Sensor will be sufficiently accurate and reliable under specified environmental conditions and will meet all system requirements guidelines
3. Assess the lot and central processing architecture and performance characteristics	<ul style="list-style-type: none"> o Computer hardware o Software implemented o Interface capabilities o Common communications format for all sensors o Capacity for full-implementation 	Processing architecture will be appropriate and system will provide adequate performance through the completion of phase III
4. Assess the communications architecture and format	<ul style="list-style-type: none"> o Error rate o MTBF rate o Technology merits o Bandwidth for full-implementation 	The communications technology employed will prove reliable and flexible for use throughout the med/tech corridor
5. Assess VMS performance and reliability	<ul style="list-style-type: none"> o Error rate o MTBF rate 	The VMSs will prove both reliable and useful in phase I implementation

2.2.1.3 Data Sources

There will be 10 data sources for the system performance study. They are listed below.

1. PARIS component documentation;
2. PARIS component specifications;
3. System failure reports;
4. Maintenance reports;
5. System integration results;
6. System requirements document;
7. Final hardware description document;
8. Time-lapsed VCR data;
9. Distributed database processor; and
10. Field measurements.

The data sources for each study objective are shown in Table 2. At the intersection (cell) of a data source row with an objective column, an X indicates that the respective objective will use the respective data source.

Table 2. Data Sources for the System Performance Study Objectives

	Objectives				
	System Architecture	Sensors	Processing Architecture	Communications Architecture	VMSs
Data Sources					
Component Documentation	X	X		X	X
Component Specifications		X	X	X	X
System Failure Reports	X	X	X	X	X
Maintenance Reports	X	X	X	X	X
System Integration Results	X		X	X	
System Requirements Document	X	X			X
Final Hardware Description Document			X		
Time-Lapsed VCR Data		X			
Distributed Database Processor	X				
Field Measurements		X		X	X

2.2.1.4 Evaluation Technical Approach

This subsection is divided into: data collection methodology; data reduction methodology; statistical analysis design; key conditions/assumptions; and key constraints/limitations.

2.2.1.4.1 *Data Collection Methodology*

Data needed to analyze the PARIS architecture and performance will be extracted from system failure reports and the system integration results. Information to address how well PARIS has been designed according to accepted industry design practices and procedures will be generated from component documentation and the system requirements document. Material to determine whether PARIS meets the final system requirements will be drawn from the system requirements

document. Data to investigate how well information actually moves through the system will be gathered via system integration results and the distributed database processor. Material to assess how well design considerations to prevent vandalism have been integrated into PARIS will be gleaned from component documentation and system failure and maintenance reports.

Information required to investigate sensor performance, accuracy, and reliability will be garnered from system failure reports, time-lapsed VCR data, and field measurements. Data to evaluate sensors using key technical parameters will be derived from use of time-lapsed VCR data and recorded during field measurements. Material to analyze sensor applicability for PARIS will be pulled from component documentation and specifications, and the system requirements document. Information to assess the accuracy of the sensors under varying environmental conditions and with known driving patterns will be obtained from time-lapsed VCR data and in field measurements. Data to look at reliability and expected life span of the sensors will be derived from system failure and maintenance reports, time-lapsed VCR data, and field measurements. Material to determine the system impact of the sensors to PARIS will be collected via system failure and maintenance reports, and field measurements.

Information to assess the lot and central processing architecture and performance characteristics will be extracted from component specifications and system integration results. Data to evaluate computer processing hardware and software will be compiled via component specifications, maintenance reports, and the final hardware description document. Material to investigate the software for applicability, functionality, and ease of integration will be drawn from maintenance reports and system integration results. Information to analyze source code compactness and thoroughness, the remote access capabilities of PARIS, and the level of security designed into PARIS will be derived from component specifications and system failure reports.

Data needed to review the communications architecture and format will be pulled from component documentation and specifications. Material to analyze how well the communications hardware performs will be obtained via system failure and maintenance reports, and system integration results. Information to evaluate whether PARIS can reliably and accurately transmit information over all communication media chosen will be garnered from system failure reports and collected during field measurements. Data to investigate how quickly information is transmitted and processed information is disseminated will be extracted from system integration results.

Material to determine VMS performance and reliability will be extracted from system failure and maintenance reports, and the system requirements document and recorded during field measurements. Information to assess the product's expected life span will be gleaned via component documentation and specifications. Data to address performance and reliability of the VMS electronics will be derived from system failure and maintenance reports. Material to look at the performance and reliability of the VMS light sources will be drawn from maintenance reports and produced during field measurements.

Collection of the system performance study data will be accomplished in the following manner. Component documentation and specifications and phase I program deliverables will be reviewed and information will be drawn from them on an as-needed basis over the entire study period. System failure and maintenance reports will be gathered from Raytheon once a week. Material will be extracted from the reports as needed to address the system performance objectives. Measurements in the field by the independent evaluator will be performed three times during the evaluation phase: at the beginning, middle, and toward the end. The field measurement activity will primarily be a before-during-after type of effort. All of the above data, information, and/or material will be recorded manually in one of two modes, either by pen/pencil-and-paper or on a personal computer. Time-lapsed VCR data and the distributed database processor digital data will be collected continuously during the entire test period. These data will be compiled by ORNL periodically throughout the duration of the evaluation phase.

2.2.1.4.2 Data Reduction Methodology

The primary data to be reduced by the independent evaluator will be the time-lapsed VCR data, those digitally recorded onto the hard drives of the distributed database processor, and the data garnered during field measurement. All of this information will subsequently be input to a statistical software package(s) for processing. The additional material gathered during data collection will be reviewed and analyzed to answer and address the other questions, issues, items, and problems associated with the study's five objectives.

2.2.1.4.3 Statistical Analysis Design

Most of the study data will be utilized to make qualitative assessments and judgements concerning the system performance objectives, MOEs, and hypotheses. As a result no sophisticated statistics will be used with this information. Simple measures of central tendency and variability (i.e., means and standard deviations) will be derived for the quantitative data collected via time-lapsed VCR, the distributed database processor, and field measurements. Means and standard deviations will also be calculated for the response time MOE under the sensors objective. Bar and/or pie charts will be prepared to graphically represent the data, whichever is most appropriate to present the material. If these quantitative data allow for higher level analyses, then tests of significance for differences between two sample means (commonly referred to as *t*-tests), analyses of variance, and/or non-parametric methods (e.g., Man-Whitney) will be conducted on the means. One-tailed tests will be used in these analyses.

Four different measures (i.e., error rate, false alarm rate, miss rate, and MTBF rate) will be calculated to address specific MOEs. An error is information related. For example in the case of a parking lot space sensor, an error could occur in two situations: the sensor detected the presence of an automobile when no vehicle occupied the space (false alarm), or it did not detect an automobile when there was a vehicle present (miss). A false alarm, in a statistical sense, is a type 1 error; a miss is a type 2 error. A failure is hardware related. It is defined as a condition wherein the hardware does not perform in accordance with the system specification. A critical

failure is a failure which causes the system to be unable to perform its intended function. Some failures can occur which do not impact performance of the intended function. Typically non-critical failures are not included in MTBF calculations, and this will be the case in this study.

Mean time between failures will be defined as the total subsystem operating time divided by the number of critical failures occurring during that operational time. In equation form, MTBF is:

$$MTBF = T_o / F_T$$

where T_o = the total operating time during the study period, and F_T = the total number of critical failures during the study time frame.

False alarm rates and miss rates for the sensors objective will be derived for each type of sensor. Error rates for the communications architecture and VMSs objectives will be calculated for each main component of the communication architecture and for the two VMSs respectively. MTBF rates for the communications architecture will be derived for each primary piece of hardware and in an aggregated form for the whole communications network. MTBF rates for the VMSs will be calculated for each of the two VMSs and as a complete system.

2.2.1.4.4 Key Conditions/Assumptions

The results of the PARIS system performance study will be dependent on a number of factors or conditions involving the expected levels of effort and timing of activities by the project team and the independent evaluator. As a result some assumptions have to be made. They include:

1. The PARIS hardware and software will be installed on the Mountain Home VA campus and be ready to be tested prior to initiation of the study;
2. The component documentation and specifications, reports, and phase I program deliverables will be available when the study begins;
3. The component documentation and specifications, reports, phase I program deliverables, and time-lapsed VCR data will have appropriate information at the right level of detail to address the related objectives, MOEs, hypotheses, questions, issues, items, and problems;
4. The distributed data processor will be accessible from a remote site; and
5. The independent evaluator's field measurements data collection will be thorough and complete.

2.2.1.4.5 Key Constraints/Limitations

There are currently a few test and evaluation limitations that restrict a purely objective and statistically satisfactory evaluation of this study. While these limitations are necessary within the realistic scope of this study, their effects do need to be recognized and understood. The major constraints and limitations are as follows:

1. The system performance evaluation of PARIS will be impacted by the selected sensors, parking lots, and sensor and VMS locations;
2. At the present time, a great majority of the study questions, issues, items, and problems lend themselves to a qualitative rather than a quantitative assessment; and
3. The independent evaluator will need to make a number of decisions based on subjective opinion rather than on objective data because of the early state of development of PARIS.

2.2.2 Study Scheme

This section provides: a physical description of the system performance study; participants; pre-study activities; study activities; and post-study activities.

2.2.2.1 Physical Description

Four data collection efforts will be undertaken during this study:

1. Review and extraction of material from the component documentation and specifications, reports, and phase I program deliverables;
2. Use and recording of information from the time-lapsed VCR data;
3. Collection of data from the distributed database processor; and
4. Gathering of material in the field via data collectors.

2.2.2.2 Participants

A number of organizations will contribute to the implementation of this individual evaluation test plan. The following paragraphs provide a discussion of the participants and their role(s) in the conduct of this study.

ORNL. The independent evaluator will be responsible for: management and direction of the study; data management (as detailed in the *Data Management Plan*); QC/QA (as described in the *QC/QA Plan*); collection of data from the data sources; refinements and revisions to the study design, as needed; cataloging and archiving of the data; data reduction and analysis; and report preparation.

Raytheon. Raytheon will furnish the component documentation and specifications, reports, phase I program deliverables, and time-lapsed VCR data, and make the distributed database processor accessible to ORNL. They will install PARIS on the Mountain Home VA campus prior to the start of the study, advise the independent evaluator of any configuration change, and repair and maintain PARIS throughout the evaluation phase. Raytheon will also coordinate the communication and information exchange between ORNL and the evaluation team.

Evaluation Team. Constituents of the evaluation team will perform any functions required to meet the study objectives and resolve any technical issues.

2.2.2.3 Pre-Study Activities

This subsection is partitioned into: description/participants; data collection forms; distributed database processor; training; configuration; and pilot testing and preliminary analysis.

2.2.2.3.1 *Description/Participants*

Table 3 displays a summary of the tasks to be performed prior to the initiation of the full data collection effort, and the party or parties responsible for the completion of each activity. When more than one agency is listed in the responsibility column, the one listed first has prime responsibility.

Table 3. System Performance Pre-Study Activities and Responsibilities

Activity	Responsibility
Generate the data collection form for component documentation and specifications, system failure and maintenance reports, and program deliverables data collection	ORNL
Furnish the component documentation and specifications and phase I program deliverables to the independent evaluator	Raytheon
Put together the data collection form for time-lapsed VCR data	ORNL
Set up remote access to the distributed database processor	ORNL, Raytheon
Develop the data collection form for field measurements data collection	ORNL
Train the independent evaluator personnel in data collection	ORNL
Establish PARIS configuration	ORNL, Raytheon
Conduct pilot (shakedown) test and preliminary analysis	ORNL

2.2.2.3.2 *Data Collection Forms*

The independent evaluator will design three types of data collection forms for use during the evaluation phase. The first will be utilized with the component documentation and specifications, system failure and maintenance reports, and phase I program deliverables data collection. The second will be used with the time-lapsed VCR data data collection. The third will be employed during the field measurements data collection.

The first data collection form will include, but not be limited to, the following items: design practices and procedures; final system requirements; design considerations to prevent vandalism; expected life span of the sensors; processing architecture software applicability, functionality, and ease of integration; source code compactness and thoroughness; remote access capabilities; level of security; transmission reliability and accuracy over communications media; and expected VMS life span. The time-lapsed VCR data data collection form will have: the date and time at which the parking lot was photographed, the parking lot from which the data were collected, and the number of parking spaces which were occupied and vacant. The field measurements data collection form will contain: the data collector's name, parking lot or VMS name, date and time of the data collection, and the number of occupied and vacant spaces or what the VMS displayed.

2.2.2.3.3 Distributed Database Processor

The distributed database processor is being designed by Raytheon. The independent evaluator's task during pre-study activities in regards to this item will be to set up remote access from Oak Ridge to Johnson City where the distributed database processor will reside.

2.2.2.3.4 Training

Since training is essential for obtaining valid data, the independent evaluator will hold a one-day training session in Oak Ridge for its data collectors. These people will first be given a brief overview of the PARIS project, the evaluation, the system performance study, and their roles during the study. They will then be instructed on use of the three kinds of data collections forms. The data collectors will finally be taught how to access the distributed database processor via the remote hookup at ORNL.

2.2.2.3.5 Configuration

The final step prior to conducting shakedown and beginning to take data for record is to establish the configuration for PARIS which will be evaluated. Hardware and software configurations will be recorded in a configuration table. This table will identify the item, model number, and where in the system the equipment is being used. If the configuration of the hardware and/or software changes during the study period, Raytheon will notify the independent evaluator of the modification. ORNL will record the changes in the configuration table as needed.

2.2.2.3.6 Pilot Testing and Preliminary Analysis

The pilot, or shakedown, test will be conducted primarily to verify that the data collectors are familiar with their roles and responsibilities, to bench-test and fine tune the data collection instruments, and to validate the data collection protocol and data analysis methodology. Once PARIS has been installed and made operational, the independent evaluator will conduct a two-day data collection effort consistent with the procedures to be used during the three-month data collection initiative. One day will be spent at ORNL; the other on the Mountain Home VA

campus. The time in Oak Ridge will be occupied with a search of a selected set of documents and extraction of material related to one or two of the system performance questions, issues, items, and/or problems. The data collectors will complete a few copies of the applicable data collection form during this exercise. The independent evaluator's personnel will also review some of the time-lapsed VCR data and fill in a number of copies of the data collection form. Finally the data collectors will gather data from the distributed database processor via the remote link from the independent evaluator's complex to the PARIS control center.

During the day in Johnson City, the data collectors will observe the parking lots and VMSs, and complete a few copies of the field measurements data collection form. All of the data recorded during these two days will be reduced and analyzed to the extent possible to determine whether any changes or clarifications to the data collection instruments are necessary prior to distribution for full testing. The instruments will be amended as required.

2.2.2.4 Study Activities

This subsection is separated into: description/participants; procedures and data requirements; logbook; environment; and resources/logistics.

2.2.2.4.1 *Description/Participants*

Table 4 presents a listing of the tasks to be completed during the full data collection effort, and the party or parties responsible for the execution of each activity. When more than one agency is listed in the responsibility column, the one listed first has prime responsibility.

Table 4. System Performance Study Activities and Responsibilities

Activity	Responsibility
Review the component documentation and specifications and phase I program deliverables and draw data from them	ORNL
Gather system failure and maintenance reports and extract material from them	ORNL, Raytheon
Collect the time-lapsed VCR data and record information from them	ORNL, Raytheon
Compile digital data from the distributed database processor	ORNL
Conduct measurements in the field	ORNL
Track PARIS configuration	ORNL
Maintain a logbook	ORNL

2.2.2.4.2 *Procedures and Data Requirements*

The data collection procedures which will be used in the review, extraction, and recording of information from the component documentation and specifications, system failure and maintenance reports, phase I program deliverables, and distributed database processor, and the data sources for the system performance study's five objectives were described earlier in this plan. What has not been addressed thus far are the procedures to be employed in time-lapsed VCR data data collection and the field measurements data collection. They are presented below.

The independent evaluator will randomly select ten frames of VCR data from each day's recording and enter information for each frame onto the time-lapsed VCR data data collection form. ORNL during field measurements will perform two items. They will record information from the parking lots and VMSs onto the field measurements data collection form. In addition, the data collectors will install a network analyzer onto the communications network to investigate error rates, lost messages, and MTBF.

2.2.2.4.3 *Logbook*

The independent evaluator will maintain a logbook for the duration of the study period. It will provide a record on the status of the evaluation. The logbook will include recordings of events and observations to be used to interpret and understand the flow of the study, major weather and event occurrences, and other items useful in interpreting the data. The logbook's contents were listed in the *Data Management Plan*.

2.2.2.4.4 *Environment*

Review and extraction of material from the component documentation and specifications, system failure and maintenance reports, phase I program deliverables, and time-lapsed VCR data will be completed at the independent evaluator's complex. Compilation of digital data from the distributed database processor will be accomplished in Oak Ridge via a remote link to the control center in Johnson City. Field measurements will be conducted on the Mountain Home VA campus. The logbook and PARIS configuration table will reside in the independent evaluator's offices; material for these two documents will be transmitted from Raytheon and/or the PARIS installation site.

2.2.2.4.5 *Resources/Logistics*

The independent evaluator will handle all resource and logistics considerations for this study. Conduct of the system performance study will require the availability of at least one computer system and printer meeting the minimum configuration requirements at the independent evaluator's complex. The definition of the hardware system includes all peripheral devices necessary to access the distributed database processor, to review the time-lapsed VCR data, and during the field measurements. The baseline requirements are a Windows 95 compatible

computer, a modem, a VHS player, a VHS monitor, and a network analyzer. Each computer system used for the purposes of this study must be configured to accept the distributed database processor software. Copies of the data collection forms and pens/pencils will be needed for the other portions of the study.

2.2.2.5 Post-Study Activities

This subsection is split into three parts: description/participants; reporting procedures; and data retention/archival procedures.

2.2.2.5.1 *Description/Participants*

Table 5 synthesizes the tasks to be conducted at the conclusion of the data collection effort, and the party responsible for the completion of each activity.

Table 5. System Performance Post-Study Activities and Responsibilities

Activity	Responsibility
Reduction of data	ORNL
Analysis of data	ORNL
Completion of the study report	ORNL
Retain and archive data	ORNL

2.2.2.5.2 *Reporting Procedures*

The independent evaluator will perform all data reduction, processing, and analysis, and will develop the pertinent conclusions based on the results of the data collection effort. At a minimum, the study report will contain the following information: the procedures and tools used in data collection, the sources of all data, the procedures used in the processing and handling of the data, the analytical methods used in data analysis, and the resulting assessments. The report will be prepared in a final draft for review by the evaluation team. ORNL will incorporate comments made by the team and prepare the study report in final form for submission to the City of Johnson City, TNDOT, and FHWA. Specific data files will also be made available to the evaluation team as appropriate, upon request.

The study report will be written to conform to the general outline shown below. The independent evaluator will be responsible for the completion of all sections listed.

- I. Abstract
- II. Executive Summary (summary of study and evaluation findings)

- III. Introduction
 - A. Background
 - B. Purpose of study
 - C. Objectives
- IV. Methods
 - A. Duration of study
 - B. Study configuration
 - C. Study conditions
 - D. Materials and instrumentation
 - E. Detailed study procedures
 - F. Study schedule
 - G. Research design
- V. Results (evaluation findings and technical assessment)
- VI. Discussion
- VII. Conclusions and Recommendations
- VIII. References (if needed)
Appendices (optional)

2.2.2.5.3 *Data Retention/Archival Procedures*

After the completion of the evaluation activities all of the data collections forms, configuration table, logbook, time-lapsed VCR data, and the material gathered via the distributed database processor will be transferred from the independent evaluator to Raytheon. At their discretion, Raytheon will subsequently submit the information to the City of Johnson City, TNDOT, and/or FHWA. If requested to do so, Raytheon will also furnish the data to the national ITS repository.

2.3 Study Management

The schedule provided in Table 6 indicates the specific tasks to be completed under the study. Activities are segregated into pre-study, study, and post-study requirements.

3. USER ACCEPTANCE INDIVIDUAL EVALUATION TEST PLAN

3.1 Executive Summary

3.1.1 Information Needed

The information needed to address each of the user acceptance study objectives will be generated and/or gathered through a cooperative effort between the independent evaluator and the PARIS evaluation team (i.e., Raytheon Company, Virginia Tech Center for Transportation Research, and Wilbur Smith Associates). A combination of phase I program deliverables, assistance from the Mountain Home VA engineering office, historical preservation laws, and questionnaires and

Table 6. Detailed System Performance Study Schedule

Task Name	Months					
	Dec. '96	Jan. '97	Feb. '97	Mar. '97	Apr. '97	May '97
Pre-Study Activities						
Generate the data collection form for documentation and specifications, reports, and program deliverables data collection	■					
Furnish the component documentation and specifications and phase I program deliverables to the independent evaluator		■				
Put together the data collection form for time-lapsed VCR data	■					
Set up remote access to the distributed database processor		■				
Develop the data collection form for field measurements	■					
Train the independent evaluator personnel in data collection			■			
Establish PARIS configuration			■			
Conduct pilot (shakedown) test and preliminary analysis			■			
Study Activities						
Review the component documentation and specifications and phase I program deliverables and draw data from them			■			
Gather reports and extract material from them			■			
Collect the time-lapsed VCR data and record information			■			
Conduct measurements in the field			■			
Compile digital data from the distributed database processor			■			
Track PARIS configuration			■			
Maintain a logbook			■			
Post-Study Activities						
Reduction of data						■
Analysis of data						■
Completion of the study report						■
Retain and archive data						■

interviews will serve as the mechanism for the collection of the necessary information. Specific procedures and data requirements are provided in section 3.2 of this plan.

3.1.2 Management and Overall Responsibility

Completion of the study activities described herein will be the responsibility of the independent evaluator. ORNL will be accountable for all data collection and analysis, and will prepare the test report. Raytheon will be responsible for supplying needed documentation produced by the project team. The Mountain Home VA administration's role will be to provide access to personnel in their engineering office and to the historical preservation laws.

3.2. Detailed Study Design

3.2.1 Evaluation Scheme

This section describes the overall evaluation scheme. The subsections include: an overview of the evaluation; MOEs and hypotheses to be tested; data sources; the evaluation technical approach; and privacy considerations.

3.2.1.1 Evaluation Overview

The goal of the study will be to evaluate vehicle driver acceptance. The broad nature of the user acceptance study, as indicated by the diverse objectives to be addressed, will require the segregation of test activities into four distinct areas, consistent with the four study objectives:

1. System usefulness (objective 1);
2. Reliability (objective 2);
3. Aesthetic acceptance (objective 3); and
4. VMS signing (objective 4).

The purpose of the system usefulness portion of the study will be to analyze the drivers' perception of PARIS usefulness. There are four issues to be covered in this segment of the study. They include:

1. Whether the drivers accept and trust the PARIS technology;
2. The drivers' perceptions of changes in their travel behavior;
3. Whether drivers consider such a system useful for their everyday parking needs; and
4. The drivers' perceptions of the strengths and weaknesses of PARIS.

The point of the reliability part of the user acceptance study will be to investigate the vehicle drivers' perception of reliability. The independent evaluator will assess whether PARIS users believe that the system accurately and reliably senses and displays parking status.

The aesthetic acceptance piece of the study will be oriented toward evaluating PARIS' aesthetic acceptance. Questions to be answered are as follows:

1. Does the installation of PARIS meld into its surroundings (as opposed to being a blight on the landscape)?
2. Is PARIS unobtrusive and aesthetically pleasing?
3. Do the PARIS design and installation meet historical preservation laws?

The VMS signing section of the user acceptance study will be directed at reviewing the VMS signing strategy and content. Items to be dealt with are the following:

1. Driver behavior and changes in driver behavior due to information and parking management strategies;
2. Driver compliance with displayed information;
3. VMS usefulness to the drivers;
4. Visibility/readability of signs in prevailing conditions (e.g., rain, bright sun, and sight-distance); and
5. Spacing between VMSs and parking lots in regards to driver decision time.

Information regarding the specific data collection methods to be used for each area is provided in subsequent sections of this plan. Collection of data pursuant to each of these areas will be accomplished through a combination of data collection methods:

1. Phase I program deliverables - Accumulation of material generated by the PARIS project team (i.e., commuter needs assessment, commuter preference profile, and human factors study);
2. VA engineering office - Consultation with personnel from the Mountain Home VA engineering office;
3. Historical preservation laws - Use of historical preservation laws provided by the VA administration office; and
4. Questionnaires and interviews - Collection of user acceptance data on the Mountain Home VA campus by the independent evaluator's team.

3.2.1.2 Measures of Effectiveness and Hypotheses to Be Tested

To give a focus to the study and to further define the methods necessary to address the study objectives, MOEs and hypotheses were developed for each objective. An MOE is a measurable quantity that is a response, outcome, or dependent variable that is directly related to PARIS user acceptance. Hypotheses provide a means of proving or disproving some change from the status quo, or the attainment or non-attainment of a prescribed acceptance objective. The hypotheses presented here may be considered the alternative hypothesis, in a strict statistical sense. The MOEs and hypotheses for each of the four objectives are exhibited in Table 7.

3.2.1.3 Data Sources

There will be seven data sources for the user acceptance study. They are listed below.

Table 7. MOEs and Hypotheses for the User Acceptance Study Objectives

Objectives	MOEs	Hypotheses
1. Assess perception of system usefulness	o User judgment	Users of PARIS will consider such a system useful for their everyday parking needs
2. Assess perception of reliability	o User judgment	The general public will view PARIS as reliable
3. Assess aesthetic acceptance	o User judgment o Aesthetic considerations o Meets historical guidelines	Users will find PARIS to be unobtrusive and aesthetically pleasing
4. Assess the signing strategy and content	o User judgment o Sign placement o Sign content	The VMSs will prove to be appropriately located and useful to the users

1. Commuter needs assessment;
2. Commuter preference profile;
3. Human factors study;
4. VA engineering office;
5. Historical preservation laws;
6. Questionnaires; and
7. Interviews.

The data sources for each study objective are shown in Table 8. At the intersection (cell) of a data source row with an objective column, an X indicates that the respective objective will use the respective data source.

3.2.1.4 Evaluation Technical Approach

This subsection is divided into: data collection methodology; data reduction methodology; statistical analysis design; key conditions/assumptions; and key constraints/limitations.

3.2.1.4.1 *Data Collection Methodology*

Data needed to analyze the drivers' perception of PARIS usefulness will be extracted from the commuter needs assessment and commuter preference profile, and collected through questionnaires and interviews. Information to address whether the drivers accept and trust the PARIS technology, and material to determine the drivers' perceptions of changes in their travel behavior will be covered in the questionnaires and interviews. Data to investigate whether drivers consider such a system useful for their everyday parking needs will be gathered via the commuter needs assessment, questionnaires, and interviews. Information to identify what the drivers' perceptions of the strengths and weaknesses of PARIS are will be generated through questionnaires and interviews.

Table 8. Data Sources for the User Acceptance Study Objectives

	Objectives			
	System Usefulness	Reliability	Aesthetic Acceptance	VMS Signing
Data Sources				
Commuter Needs Assessment	X			
Commuter Preference Profile	X	X		
Human Factors Study				X
VA Engineering Office			X	
Historical Preservation Laws			X	
Questionnaires	X	X	X	X
Interviews	X	X	X	X

Material to analyze the vehicle drivers' perception of reliability will be gleaned from the commuter preference profile, questionnaires, and interviews. Information required to assess whether PARIS users believe that the system accurately and reliably senses and displays parking status will be recorded via the questionnaires and interviews.

Data to evaluate PARIS' aesthetic acceptance will be pulled from historical preservation laws and will be obtained through discussions with personnel in the VA engineering office, questionnaires, and interviews. Material to answer the question "does the installation of PARIS meld into its surroundings (as opposed to being a blight on the landscape)?" will be derived via consultation with the VA engineering office, questionnaires, and interviews. Information to address whether PARIS is unobtrusive and aesthetically pleasing will be collected via questionnaires and interviews. Data to assess whether the PARIS design and installation meet historical preservation laws will be extracted from information obtained from the VA engineering office and the historical preservation laws.

Material to review the VMS signing strategy and content will be compiled from the human factors study. Data to look at driver behavior and changes in driver behavior due to information and parking management strategies, and information to determine driver compliance with displayed information will be generated through questionnaires and interviews. Material to evaluate VMS usefulness to the drivers will be drawn from the human factors study and gathered via questionnaires and interviews. Information to address the visibility/readability of signs in prevailing conditions will be drawn from the human factors study and garnered via questionnaires and interviews. Data to investigate the spacing between VMSs and parking lots in regards to driver decision time will be derived through questionnaires and interviews.

Collection of the user acceptance study data will be accomplished in the following manner. Phase I program deliverables and the historical preservation laws will be reviewed and information will be pulled from them on an as-needed basis over the entire study period. Personnel from the VA engineering office will be contacted and informal discussions will be held with them as required to cover the associated items in the aesthetic acceptance portion of the study. Information gleaned during the discussions will be recorded by the data collector. Questionnaires will be administered and interviews will be conducted by the independent evaluator three times during the evaluation phase: at the beginning, middle, and toward the end. Questionnaire/interview data will be collected through a post-test design, where the material is gathered after the treatment (PARIS) is implemented. The questionnaire and interview activities will primarily be a before-during-after type of effort. All of the above data, information, and/or material will be recorded manually in one of two modes, either by pen/pencil-and-paper or on a personal computer.

3.2.1.4.2 Data Reduction Methodology

The primary data to be reduced by the independent evaluator will be those generated by the questionnaire and interviews. Only original questionnaires that are 80% "filled-in" will be counted as completed questionnaires. If a questionnaire has either been copied and/or is not 80% filled-in, it will not be used in the evaluation. Anecdotal responses will be reviewed and, where possible, condensed to aid in the analysis of the tabular data. This information will subsequently be input to a statistical software package(s) for processing. The additional material gathered during data collection will be perused and analyzed to address and answer the other issues, questions, and items associated with the study's four objectives.

3.2.1.4.3 Statistical Analysis Design

Most of the study data will be utilized to make qualitative assessments and judgements concerning the user acceptance objectives, MOEs, and hypotheses. As a result no sophisticated statistics will be used with this information. Simple measures of central tendency and variability (i.e., means and standard deviations) will be derived for the quantitative data collected via the closed-ended items of the questionnaire. Percentages will also be calculated to look at the frequency of response to particular items. Bar and/or pie charts will be prepared to graphically represent the data, whichever is most appropriate to present the material. If these quantitative data allow for higher level analyses, then tests of significance for differences between two sample means (commonly referred to as *t*-tests), analyses of variance, and/or non-parametric methods (e.g., Man-Whitney) will be conducted on the means. One-tailed tests will be used in these analyses. Where the format of the data allows, the qualitative responses collected via the open-ended items on the questionnaire and the interview questions will be aggregated and presented in a tabular format.

3.2.1.4.4 Key Conditions/Assumptions

The results of the PARIS user acceptance study will be dependent on a number of factors or

conditions involving the expected levels of effort and timing of activities by the project team and the independent evaluator. As a result some assumptions have to be made. They include:

1. The PARIS hardware and software will be installed on the Mountain Home VA campus and be ready to be tested prior to initiation of the study;
2. The phase I program deliverables and historical preservation laws will be available when the study begins;
3. The phase I program deliverables and historical preservation laws will have appropriate information at the right level of detail to address the related objectives, MOEs, hypotheses, issues, questions, and items;
4. The VA engineering office personnel will be available for consultation and discussions when the study begins;
5. The questionnaire and interview questions will be thorough and complete; and
6. The answers provided by the VA engineering office personnel and to the questionnaire and interview questions will have appropriate material at the correct level of detail to investigate the associated objectives, MOEs, hypotheses, issues, questions, and items.

3.2.1.4.5 *Key Constraints/Limitations*

There are currently a few test and evaluation limitations that restrict a purely objective and statistically satisfactory evaluation of this study. While these limitations are necessary within the realistic scope of this study, their effects do need to be recognized and understood. The major constraints and limitations are as follows:

1. The user acceptance evaluation of PARIS will be impacted by the selected sensors, parking lots, and sensor and VMS locations;
2. The number of vehicle drivers who participate in the questionnaire and interview sessions will be too small to gain insight into the general public as a whole (but should adequately represent a cross-section of users of VA parking lots);
3. A part of the study will be limited to assessing drivers' perceptions of changes in their travel behavior (it will not directly measure changes in driver behavior);
4. The drivers' perceptions gathered via the questionnaire and interview questions will be highly dependent and based solely on the items asked;
5. At the present time, a great majority of the study issues, questions, and items lend themselves to a qualitative rather than a quantitative assessment; and
6. The independent evaluator will need to make a number of decisions based on subjective opinion rather than on objective data because of the early state of development of PARIS.

3.2.1.5 Privacy Consideration

It is understood that some of the information that will be sought by the questionnaire and interview questions for this study may be considered sensitive by the participants. By the same

token, the questionnaire and interview responses from individual drivers will be critical to the success of the data collection and analysis efforts. Consequently, it is important that all of the data will be presented without reference to the people. Results will be published only in aggregate form without naming any participants.

3.2.2 Study Scheme

This section provides: a physical description of the user acceptance study; participants; pre-study activities; study activities; and post-study activities.

3.2.2.1 Physical Description

Three data collection efforts will be undertaken during this study:

1. Review and extraction of material from the phase I program deliverables and the historical preservation laws;
2. Use and recording of information from the VA engineering office personnel; and
3. Gathering of data via questionnaires and interviews.

3.2.2.2 Participants

A number of organizations will contribute to the implementation of this individual evaluation test plan. The following paragraphs provide a discussion of the participants and their role(s) in the conduct of this study.

ORNL. The independent evaluator will be responsible for: management and direction of the study; data management (as detailed in the *Data Management Plan*); QC/QA (as described in the *QC/QA Plan*); collection of the data from the data sources; refinements and revisions to the study design, as needed; cataloging and archiving of the data; data reduction and analysis; and report preparation.

Raytheon. Raytheon will furnish the phase I program deliverables to ORNL. They will install PARIS on the Mountain Home VA campus prior to the start of the study, advise the independent evaluator of any configuration change, and repair and maintain PARIS throughout the evaluation phase. Raytheon will also coordinate the communication and information exchange between ORNL and the evaluation team.

VA Administration. The VA administration will provide access to personnel in their engineering office and to the historical preservation laws.

Project Team. Members of the project team will be accountable for delivery of their respective phase I program deliverables to Raytheon.

Evaluation Team. Constituents of the evaluation team will perform any functions required to meet the study objectives and resolve any technical issues.

3.2.2.3 Pre-Study Activities

This subsection is partitioned into: description/participants; data collection form; questionnaire and interview questions; training; configuration; and pilot testing and preliminary analysis.

3.2.2.3.1 *Description/Participants*

Table 9 displays a summary of the tasks to be performed prior to the initiation of the full data collection effort, and the party or parties responsible for the completion of each activity. When more than one agency is listed in the responsibility column, the one listed first has prime responsibility.

Table 9. User Acceptance Pre-Study Activities and Responsibilities

Activity	Responsibility
Generate the data collection form for phase I program deliverables, VA engineering office discussions, and historical preservation laws data collection	ORNL
Furnish the phase I program deliverables to the independent evaluator	Raytheon
Provide access to VA engineering office personnel and to the historical preservation laws to the independent evaluator	Mountain Home VA administration
Develop the questionnaire and interview questions	ORNL
Train the independent evaluator personnel in data collection, questionnaire administration, and the interview process	ORNL
Establish PARIS configuration	ORNL, Raytheon
Conduct pilot (shakedown) test and preliminary analysis	ORNL

3.2.2.3.2 *Data Collection Form*

The independent evaluator will design a data collection form for use during the evaluation phase. It will be utilized with the phase I program deliverables, VA engineering office discussions, and historical preservation laws data collection. The data collection form will include, but not be limited to, the following items: drivers' perception of PARIS usefulness; usefulness of PARIS for the drivers' everyday use; drivers' perception of reliability; aesthetic acceptance; does PARIS meld into its surroundings; is PARIS unobtrusive and aesthetically pleasing; do the PARIS design and installation meet historical preservation laws; and VMS usefulness to the drivers.

3.2.2.3.3 *Questionnaire and Interview Questions*

A questionnaire consisting of both closed and open-ended items will be created through an iterative process by the independent evaluator. The construction of the questions will be based on guidance provided by Jones (1985) and LoSciuto (1981). A number of the closed-ended items will ask for either a "yes" or "no" response; the others will have rating scales consisting of between four and six alternatives. Room will be provided immediately after each open-ended item for the respondent to write his/her answer. The beginning of the questionnaire will be oriented toward obtaining a user profile of the individual. There will be space for the person to write his name, address, phone number, and basic demographic information (e.g., gender, age, travel routes, time of travel, and parking lot he/she normally uses). The profile material will be used in the analysis of the questionnaire responses and as an aid for selecting people for the interview sessions. There may be different questions generated for each administration period (i.e., beginning, middle, and at the end of the study).

The questionnaire will include, but not be limited to, items covering the following: acceptance and trust of the PARIS technology; drivers' perceptions of changes in their travel behavior; PARIS strengths and weaknesses; do PARIS users believe that the system accurately and reliably senses and displays parking status; driver behavior and changes in driver behavior due to information and parking management strategies; and driver compliance with displayed information.

Based upon the results obtained from the questionnaire, an interview instrument will be constructed. It will consist entirely of open-ended items oriented toward clarifying or gathering further information regarding questionnaire responses.

3.2.2.3.4 *Training*

Since training is essential for obtaining valid data, the independent evaluator will hold a one-day training session in Oak Ridge for its data collectors. These individuals will first be given a brief overview of the PARIS project, the evaluation, the user acceptance study, and their roles during the study. They will then be instructed on use of the data collection form. The data collectors will finally be taught how to administer the questionnaire and how to conduct the interviews.

3.2.2.3.5 *Configuration*

The final step prior to conducting shakedown and beginning to take data for record is to establish the configuration for PARIS which will be evaluated. Hardware and software configurations will be recorded in a configuration table. This table will identify the item, model number, and where in the system the equipment is being used. If the configuration of the hardware and/or software changes during the study period, Raytheon will notify the independent evaluator of the modification. ORNL will record the changes in the configuration table as needed.

3.2.2.3.6 *Pilot Testing and Preliminary Analysis*

The pilot, or shakedown, test will be conducted primarily to verify that the data collectors are familiar with their roles and responsibilities, to bench-test and fine tune the data collection instruments (i.e., data collection form, questionnaire, and interview questions), and to validate the data collection protocol and data analysis methodology. Once PARIS has been installed and made operational, the independent evaluator will conduct a two-day data collection effort consistent with the procedures to be used during the three-month data collection initiative. One day will be spent at ORNL; the other on the Mountain Home VA campus. The time in Oak Ridge will be occupied with a search of a selected set of documents and extraction of material related to one or two of the user acceptance issues, questions, and/or items. The data collectors will complete a few copies of the data collection form during this exercise.

During the day in Johnson City, the data collectors will administer the questionnaire to a number of vehicle drivers; they will also conduct interviews with a couple of individuals at the VA using the interview questions. The data collectors will record the responses of the participant during the practice interview sessions. Upon completion of the questionnaire, each respondent will be questioned in detail about his answers to the questions, to ascertain what the person understood the question to be asking, and the exact meaning of his response. Bench-testing of the questionnaires will enable the independent evaluator to determine whether the items are worded properly (not biased, easily understood) and to detect whether there are any invalid or meaningless patterns to answers occurring.

All of the data gathered during these two days will be reduced and analyzed to the extent possible to determine whether any changes or clarifications to the data collection instruments are necessary prior to distribution for full testing. The instruments will be amended as required.

3.2.2.4 Study Activities

This subsection is separated into: description/participants; procedures and data requirements; logbook; environment; and resources/logistics.

3.2.2.4.1 *Description/Participants*

Table 10 presents a listing of the tasks to be completed during the full data collection effort, and the party responsible for the execution of each activity.

3.2.2.4.2 *Procedures and Data Requirements*

The data collection procedures which will be used in the review, extraction, and recording of information from the phase I program deliverables, historical preservation laws, and informal discussions with the VA engineering office personnel, and the data sources for the user acceptance study's four objectives were described earlier in this plan. What has not been

Table 10. User Acceptance Study Activities and Responsibilities

Activity	Responsibility
Review phase I program deliverables and the historical preservation laws and extract material from them	ORNL
Hold informal discussions with the VA engineering office to address aesthetic acceptance items and record information	ORNL
Administer questionnaires	ORNL
Conduct interviews	ORNL
Track PARIS configuration	ORNL
Maintain a logbook	ORNL

addressed thus far are the procedures to be employed in administering the questionnaire and conducting the interviews. They are presented below.

Each questionnaire will be administered during six sessions. The sessions will be arranged over the course of three days in a room in the VA hospital, one session in the morning and one in the afternoon of each day. People who drive and park on the Mountain Home VA campus will be stopped as they get out of or into their vehicles in one of the VA's parking lots and asked if they would be willing to complete a short questionnaire concerning PARIS either before or after work on a specific set of dates. If they respond affirmatively, they will be informed of the questionnaire sessions and, as a reminder, will be handed a sheet of paper describing the questionnaire session, its location, and the option of times. It is anticipated that between 50 and 75 individuals will participate in each administration period. The participants will be provided incentives (i.e., bagels and cream cheese in the morning, and chips and dip in the afternoon) for their input and time.

During the questionnaire session each person will be handed a questionnaire and a pencil. Before the person begins completing the questionnaire form, he will be told by the independent evaluator that his specific comments will not be associated with him/her and that no published material will identify views expressed by him. Rather, the views of all people will be integrated into a mosaic of views representing a particular group. The individual will also be instructed that if he does not understand any term or question he should ask the administrator for clarification or explanation. When each respondent is finished with the questionnaire, he will be thanked for his participation, and told that his time and responses are very much appreciated.

Follow-up interviews will be held with some of the participants who fill-in the questionnaire after each questionnaire administration period. They will be interviewed individually or in small groups of between two and four people. Before an individual is interviewed, he will be informed of the purpose and background to the interview, and the benefits to the Mountain Home VA through his participation. He will also be told about the anonymity and confidentiality of his specific comments. The interview questions will be used to guide the course of the interviews, but the

discussions themselves will be semi-structured and take form as they proceed. Questions will be asked by the independent evaluator. Comments made by the participants will be recorded by one of ORNL's data collectors. The interview will be scheduled for a mutually agreed upon (by both the participant and data collector) date and time. Each interview will last between one-half and one hour. As with the questionnaire administration, each participant will be provided with an incentive for his input and time, and will be thanked for his time and responses.

3.2.2.4.3 *Logbook*

The independent evaluator will maintain a logbook for the duration of the study period. It will provide a record on the status of the evaluation. The logbook will include recordings of events and observations to be used to interpret and understand the flow of the study, major weather and event occurrences, and other items useful in interpreting the data. The logbook's contents were listed in the *Data Management Plan*.

3.2.2.4.4 *Environment*

Review and extraction of material from the phase I program deliverables and the historical preservation laws will be completed at the independent evaluator's complex. Informal discussions will be held with personnel in the VA engineering office either face-to-face in Johnson City or by telephone call. Questionnaires will be administered and interviews will be conducted on the Mountain Home VA campus. The logbook and PARIS configuration table will reside in the independent evaluator's offices; material for these two documents will be transmitted from Raytheon and/or the PARIS installation site.

3.2.2.4.5 *Resources/Logistics*

The independent evaluator will handle all resource and logistics considerations for this study. Conduct of the user acceptance study will require copies of the data collection form, questionnaire, and interview questions, and pens/pencils to fill-in the data collection instruments.

3.2.2.5 Post-Study Activities

This subsection is split into three parts: description/participants; reporting procedures; and data retention/archival procedures.

3.2.2.5.1 *Description/Participants*

Table 11 synthesizes the tasks to be conducted at the conclusion of the data collection effort, and the party responsible for the completion of each activity.

Table 11. User Acceptance Post-Study Activities and Responsibilities

Activity	Responsibility
Reduction of data	ORNL
Analysis of data	ORNL
Completion of the study report	ORNL
Retain and archive data	ORNL

3.2.2.5.2 Reporting Procedures

The independent evaluator will perform all data reduction, processing, and analysis, and will develop the pertinent conclusions based on the results of the data collection effort. At a minimum, the study report will contain the following information: the procedures and tools used in data collection, the sources of all data, the procedures used in the processing and handling of the data, the analytical methods used in data analysis, and the resulting assessments. The report will be prepared in a final draft for review by the evaluation team. ORNL will incorporate comments made by the team and prepare the study report in final form for submission to the City of Johnson City, TNDOT, and FHWA. Specific data files will also be made available to the evaluation team as appropriate, upon request.

The study report will be written to conform to the general outline shown below. The independent evaluator will be responsible for the completion of all sections listed.

- I. Abstract
- II. Executive Summary (summary of study and evaluation findings)
- III. Introduction
 - A. Background
 - B. Purpose of study
 - C. Objectives
- IV. Methods
 - A. Duration of study
 - B. Study configuration
 - C. Study conditions
 - D. Materials and instrumentation
 - E. Detailed study procedures
 - F. Study schedule
 - G. Research design
- V. Results (evaluation findings and technical assessment)
- VI. Discussion
- VII. Conclusions and Recommendations

VIII. References (if needed)
Appendices (optional)

3.2.2.5.3 *Data Retention/Archival Procedures*

After the completion of the evaluation activities all of the data collections forms, questionnaires, interview notes, configuration table, and logbook will be transferred from the independent evaluator to Raytheon. At their discretion, Raytheon will subsequently submit the information to the City of Johnson City, TNDOT, and/or FHWA. If requested to do so, Raytheon will also furnish the data to the national ITS repository.

3.3 Study Management

The schedule provided in Table 12 indicates the specific tasks to be completed under the study. Activities are segregated into pre-study, study, and post-study requirements.

4. INSTITUTIONAL AND BUSINESS ISSUES INDIVIDUAL EVALUATION TEST PLAN

4.1 Executive Summary

4.1.1 Information Needed

The information needed to address each of the institutional and business issues study objectives will be generated and/or gathered through a cooperative effort between the independent evaluator and the PARIS evaluation team (i.e., Raytheon Company, Virginia Tech Center for Transportation Research, and Wilbur Smith Associates). A combination of a phase I program deliverable, Mountain Home VA regulations, historical preservation laws, and interviews will serve as the mechanism for the collection of the necessary information. Specific procedures and data requirements are provided in section 4.2 of this plan.

4.1.2 Management and Overall Responsibility

Completion of the study activities described herein will be the responsibility of the independent evaluator. ORNL will be accountable for all data collection and analysis, and will prepare the test report. Raytheon will be responsible for supplying the needed documentation produced by Wilbur Smith Associates. The Mountain Home VA administration's role will be to provide access to VA regulations and historical preservation laws.

4.2 Detailed Study Plan

4.2.1 Evaluation Scheme

Table 12. Detailed User Acceptance Study Schedule

Task Name	Months					
	Dec. '96	Jan. '97	Feb. '97	Mar. '97	Apr. '97	May '97
Pre-Study Activities						
Generate the data collection form for program deliverables, VA discussions, and historical preservation laws data collection	■					
Furnish the program deliverables to the independent evaluator		■				
Provide access to VA engineering office personnel and to the historical preservation laws to the independent evaluator		■				
Develop the questionnaire and interview questions	■					
Train the independent evaluator personnel in data collection, questionnaire administration, and the interview process			■			
Establish PARIS configuration		■				
Conduct pilot (shakedown) test and preliminary analysis			■			
Study Activities						
Review phase I program deliverables and the historical preservation laws and extract material from them			■			
Hold information discussions with the VA engineering office to address aesthetic acceptance items and record information			■			
Administer questionnaires			■			
Conduct interviews			■			
Track PARIS configuration			■			
Maintain a logbook			■			
Post-Study Activities						
Reduction of data						■
Analysis of data						■
Completion of the study report						■
Retain and archive data						■

This section describes the overall evaluation scheme. The subsections include: an overview of the evaluation; MOEs and hypotheses to be tested; data sources; the evaluation technical approach; and privacy considerations.

4.2.1.1 Evaluation Overview

The goal of the study will be to evaluate institutional and business issues. The broad nature of the institutional and business issues study, as indicated by the diverse objectives to be addressed, will require the segregation of test activities into three distinct areas, consistent with the three study objectives:

1. Deployment (objective 1);
2. Inter-agency cooperation (objective 2); and
3. Historical (objective 3).

The purpose of the deployment portion of the study will be to analyze the deployment issues. The issues will be identified and subsequently assessed so as to minimize delays in PARIS design, installation, and operation. Questions to be answered are as follows:

1. What institutional and business impediments did the PARIS project team (i.e., Raytheon, Virginia Tech Center for Transportation Research, Wilbur Smith Associates, Virginia Tech Fiber & Electro-Optics Research Center, University of Tennessee Transportation Center, and GEO Decisions, Incorporated) encounter while conducting the project?
2. In what stages of the project did impediments occur?
3. What were the causes of the impediments and how were they overcome?
4. What lessons were learned in dealing with these impediments that can be applied to other projects?

In addition, there are four items to be covered in this segment of the study. They include:

1. Deployment costs associated with the phase I effort and areas for improvement;
2. Deployment costs in the major design areas of sensors, processing, communications, and software;
3. Ways to reduce costs; and
4. Financial issues with the sensors.

The point of the inter-agency cooperation part of the institutional and business issues study will be to investigate and document inter-agency cooperation issues. This slice of the study will not only identify potential bottlenecks, but also develop work-around solutions so as to not jeopardize other aspects of the PARIS effort and its evaluation. There are three questions to be addressed:

1. What institutional and business impediments did the PARIS project team encounter while establishing the partnership?
2. What were the causes of the impediments and how were they overcome?
3. What institutional and jurisdictional issues could impede full implementation?

This section of the study will also evaluate known and unanticipated inter-agency cooperation issues and ways of overcoming them.

The historical piece of the institutional and business issues study will be oriented toward assessing historical considerations. The independent evaluator will determine whether PARIS meets historical enforcement guidelines and is non-intrusive in appearance.

Information regarding the specific data collection methods to be used for each area is provided in subsequent sections of this plan. Collection of data pursuant to each of these areas will be accomplished through a combination of data collection methods:

1. Phase I program deliverables - Accumulation of material generated by the PARIS project team (i.e., parking implementation cost/benefit analysis);
2. VA regulations and historical preservation laws - Use of VA regulations and historical preservation laws provided by the VA administration office; and
3. Interviews - Collection of institutional and business issues data by the independent evaluator's team.

4.2.1.2 Measures of Effectiveness and Hypotheses to Be Tested

To give a focus to the study and to further define the methods necessary to address the study objectives, MOEs and hypotheses were developed for each objective. An MOE is a measurable quantity that is a response, outcome, or dependent variable that is directly related to PARIS institutional and business issues. Hypotheses provide a means of proving or disproving some change from the status quo, or the attainment or non-attainment of a prescribed objective. The hypotheses presented here may be considered the alternative hypothesis, in a strict statistical sense. The MOEs and hypotheses for each of the three objectives are exhibited in Table 13.

Table 13. MOEs and Hypotheses for the Institutional and Business Issues Study Objectives

Objectives	MOEs	Hypotheses
1. Assess deployment issues	<ul style="list-style-type: none"> o Partner perceptions of institutional and business impediments o Cost and/or infrastructure impediments 	Institutional and business issues regarding PARIS deployment will be identified
2. Assess inter-agency cooperation	<ul style="list-style-type: none"> o Documentation of policy, jurisdictional, and other external factors or issues 	Policy, jurisdictional, and other external factors regarding inter-agency cooperation will be identified
3. Assess historical considerations	<ul style="list-style-type: none"> o Aesthetic quality o Architecture guidelines 	PARIS will conform to all historical guidelines

4.2.1.3 Data Sources

There will be four data sources for the institutional and business issues study. They are listed below.

1. Parking implementation cost/benefit analysis;
2. VA regulations;
3. Historical preservation laws; and
4. Interviews.

The data sources for each study objective are shown in Table 14. At the intersection (cell) of a data source row with an objective column, an X indicates that the respective objective will use the respective data source.

Table 14. Data Sources for the Institutional and Business Issues Study Objectives

Data Sources	Objectives		
	Deployment	Inter-Agency Cooperation	Historical
Parking Implementation Cost/Benefit Analysis	X		
VA Regulations			X
Historical Preservation Laws			X
Interviews	X	X	

4.2.1.4 Evaluation Technical Approach

This subsection is divided into: data collection methodology; data reduction methodology; statistical analysis design; key conditions/assumptions; and key constraints/limitations.

4.2.1.4.1 *Data Collection Methodology*

Data needed to analyze PARIS deployment issues will be extracted from the parking implementation cost/benefit analysis and derived from interviews with project partners. Information to address what institutional and business impediments the PARIS project team encountered while conducting the project, material to determine in what stages of the project the impediments occurred, data to investigate what the causes of the impediments were and how they were overcome, and information to assess what lessons were learned in dealing with these impediments that can be applied to other projects will be generated through interviews. Material required to analyze deployment costs associated with the phase I effort and areas for

improvement, and deployment costs in the major design areas of sensors, processing, communications, and software will be drawn from the parking implementation cost/benefit analysis. Data to evaluate ways to reduce costs and financial issues with the sensors will be gathered via the parking implementation cost/benefit analysis and partner interviews.

Information to investigate and document inter-agency cooperation issues, material to develop work-around solutions so as not to jeopardize other aspects of the PARIS effort and its evaluation, data to answer the question "what institutional and business impediments did the PARIS project team encounter while establishing the partnership?", material to address the causes of the impediments and how they were overcome, information to assess what institutional and jurisdictional issues could impede full implementation, and data to evaluate known and unanticipated inter-agency cooperation issues and ways of overcoming them will be gleaned from interviews with the project participants.

Material to assess historical considerations, and information to determine whether PARIS meets historical enforcement guidelines and is non-intrusive in appearance will be garnered from the VA regulations and historical preservation laws.

Collection of the institutional and business issues study data will be accomplished in the following manner. The parking implementation cost/benefit analysis, VA regulations, and the historical preservation laws will be reviewed and information will be drawn from them on an as-needed basis over the entire study period. Personnel from the project team, Mountain Home VA, City of Johnson City, TNDOT, and FHWA will be contacted and informal interviews will be held with them as required to cover the associated items in the deployment and inter-agency cooperation portions of the study. The PARIS participants will be interviewed multiple times during the course of the project. Material discovered during these discussions will be recorded by the independent evaluator. The interview activity will primarily be a during-and-after type of effort. All of the above data, information, and/or material will be recorded manually in one of two modes, either by pen/pencil-and-paper or on a personal computer.

4.2.1.4.2 Data Reduction Methodology

The primary data to be reduced by the independent evaluator will be those generated by the interviews. This information will subsequently be input to a statistical software package(s) for processing. The additional material gathered during data collection will be reviewed and analyzed to answer and address the questions, items, and issues associated with the study's three objectives.

4.2.1.4.3 Statistical Analysis Design

Most of the study data will be utilized to make qualitative assessments and judgements concerning the institutional and business issues objectives, MOEs, and hypotheses. As a result no sophisticated statistics will be used with this information. Simple measures of central tendency

and variability (i.e., means and standard deviations) will be derived for the quantitative data collected via the closed-ended items of the interviews. Percentages will also be calculated to look at the frequency of response to particular items. Bar and/or pie charts will be prepared to graphically represent the data, whichever is most appropriate to present the material. If these quantitative data allow for higher level analyses, then tests of significance for differences between two sample means (commonly referred to as *t*-tests), analyses of variance, and/or non-parametric methods (e.g., Man-Whitney) will be conducted on the means. One-tailed tests will be used in these analyses. Where the format of the data allows, the qualitative responses collected via the open-ended interview questions will be aggregated and presented in a tabular format.

4.2.1.4.4 *Key Conditions/Assumptions*

The results of the PARIS institutional and business issues study will be dependent on a number of factors or conditions involving the expected levels of effort and timing of activities by the project team and the independent evaluator. As a result some assumptions have to be made. They include:

1. The PARIS hardware and software will be installed on the Mountain Home VA campus and be ready to be tested prior to initiation of the study;
2. The parking implementation cost/benefit analysis, VA regulations, and historical preservation laws will be available when the study begins;
3. The parking implementation cost/benefit analysis, VA regulations, and historical preservation laws will have appropriate information at the right level of detail to address the related objectives, MOEs, hypotheses, questions, items, and issues;
4. The PARIS participants will be available for discussions when the study begins;
5. The interview questions will be thorough and complete; and
6. The answers provided by the PARIS participants to the interview questions will have appropriate material at the correct level of detail to investigate the associated objectives, MOEs, hypotheses, questions, items, and issues.

4.2.1.4.5 *Key Constraints/Limitations*

There are currently a few test and evaluation limitations that restrict a purely objective and statistically satisfactory evaluation of this study. While these limitations are necessary within the realistic scope of this study, their effects do need to be recognized and understood. The major constraints and limitations are as follows:

1. The institutional and business issues evaluation of PARIS will be impacted by the selected sensors, parking lots, and sensor and VMS locations;
2. Since the study is intended to be descriptive, rather than evaluative in nature, it will not compare actual performance to expected performance or infer a better solution;
3. The information gathered via the interview questions will be highly dependent and based solely on the items asked;

4. At the present time, a great majority of the study questions, items, and issues lend themselves to a qualitative rather than a quantitative assessment; and
5. The independent evaluator will need to make a number of decisions based on subjective opinion rather than on objective data because of the early state of development of PARIS.

4.2.1.5 Privacy Considerations

It is understood that some of the information that will be sought by the interview questions for this study may be considered sensitive by the participants. By the same token, the interview responses from these individuals will be critical to the success of the data collection and analysis efforts. Consequently, it is important that all of the data will be presented without reference to the people. Results will be published only in aggregate form without naming any participants.

4.2.2 Study Scheme

This section provides: a physical description of the institutional and business issues study; participants; pre-study activities; study activities; and post-study activities.

4.2.2.1 Physical Description

Two data collection efforts will be undertaken during this study:

1. Review and extraction of material from the phase I program deliverable, VA regulations, and historical preservation laws; and
2. Gathering of information via interviews with the project participants.

4.2.2.2 Participants

A number of organizations will contribute to the implementation of this individual evaluation test plan. The following paragraphs provide a discussion of the participants and their role(s) in the conduct of this study.

ORNL. The independent evaluator will be responsible for: management and direction of the study; data management (as detailed in the *Data Management Plan*); QC/QA (as described in the *QC/QA Plan*); collection of the data from the data sources; refinements and revisions to the study design, as needed; cataloging and archiving of the data; data reduction and analysis; and report preparation.

Raytheon. Raytheon will furnish the phase I program deliverable to ORNL. They will install PARIS on the Mountain Home VA campus prior to the start of the study, advise the independent evaluator of any configuration change, and repair and maintain PARIS throughout the evaluation

phase. Raytheon will also coordinate the communication and information exchange between ORNL and the evaluation team.

VA Administration. The VA administration will provide access to VA regulations and to the historical preservation laws.

Project Participants. Personnel from the project team, Mountain Home VA, City of Johnson City, TNDOT, and FHWA will be available for informal interviews. Wilbur Smith Associates will also be accountable for delivery of the parking implementation cost/benefit analysis to Raytheon.

Evaluation Team. Constituents of the evaluation team will perform any functions required to meet the study objectives and resolve any technical issues.

4.2.2.3 Pre-Study Activities

This subsection is partitioned into: description/participants; data collection form; interview questions; training; configuration; and pilot testing and preliminary analysis.

4.2.2.3.1 *Description/Participants*

Table 15 displays a summary of the tasks to be performed prior to the initiation of the full data collection effort, and the party or parties responsible for the completion of each activity. When more than one agency is listed in the responsibility column, the one listed first has prime responsibility.

Table 15. Institutional and Business Issues Pre-Study Activities and Responsibilities

Activity	Responsibility
Generate the data collection form for phase I program deliverable, VA regulations, and historical preservation laws data collection	ORNL
Furnish the phase I program deliverable to the independent evaluator	Raytheon
Provide access to VA regulations and to the historical preservation laws to the independent evaluator	Mountain Home VA administration
Develop the interview questions	ORNL
Make personnel available for the informal interviews	Project team, Mountain Home VA, City of Johnson City, TNDOT, FHWA
Train the independent evaluator personnel in data collection and the interview process	ORNL
Establish PARIS configuration	ORNL, Raytheon
Conduct pilot (shakedown) test and preliminary analysis	ORNL

4.2.2.3.2 *Data Collection Form*

The independent evaluator will design a data collection form for use during the evaluation phase. It will be utilized with the phase I program deliverable, VA regulations, and historical preservation laws data collection. The data collection form will include, but not be limited to, the following items: deployment costs associated with the effort and areas for improvement; deployment costs in the major design areas of sensors, processing, communications, and software; ways to reduce costs and financial issues with the sensors; historical considerations; does PARIS meet historical enforcement guidelines; and is PARIS non-intrusive in appearance.

4.2.2.3.3 *Interview Questions*

Interview questions consisting of both closed and open-ended items will be created through an iterative process by the independent evaluator. The construction of the questions will be based on guidance provided by Jones (1985) and LoSciuto (1981). A number of the closed-ended items will ask for either a "yes" or "no" response; the others will have rating scales consisting of between four and six alternatives. There may be different questions generated for each administration period and each participant type.

The interview questions will include, but not be limited to, items covering the following: deployment issues; institutional and business impediments the PARIS project team encountered while conducting the project; stages of the project in which the impediments occurred; the causes of the impediments and how were they overcome; lessons learned in dealing with the impediments that can be applied to other projects; inter-agency cooperation issues; institutional and business impediments that were encountered while establishing the partnership; institutional and jurisdictional issues that could impede full implementation; and ways of overcoming inter-agency issues.

4.2.2.3.4 *Training*

Since training is essential for obtaining valid data, the independent evaluator will hold a one-day training session in Oak Ridge for its data collectors. These individuals will first be given a brief overview of the PARIS project, the evaluation, the institutional and business issues study, and their roles during the study. They will then be instructed on use of the data collection form. The data collectors will finally be taught how to conduct the interviews.

4.2.2.3.5 *Configuration*

The final step prior to conducting shakedown and beginning to take data for record is to establish the configuration for PARIS which will be evaluated. Hardware and software configurations will be recorded in a configuration table. This table will identify the item, model number, and where in the system the equipment is being used. If the configuration of the hardware and/or software

changes during the study period, Raytheon will notify the independent evaluator of the modification. ORNL will record the changes in the configuration table as needed.

4.2.2.3.6 *Pilot Testing and Preliminary Analysis*

The pilot, or shakedown, test will be conducted primarily to verify that the data collectors are familiar with their roles and responsibilities, to bench-test and fine tune the data collection instruments (i.e., data collection form and interview questions), and to validate the data collection protocol and data analysis methodology. Once PARIS has been installed and made operational, the independent evaluator will conduct a two-day data collection effort consistent with the procedures to be used during the three-month data collection initiative. One day will be spent at ORNL; the other on the Mountain Home VA campus. The time in Oak Ridge will be occupied with a search of a selected set of documents and extraction of material related to one or two of the institutional and business issues questions, items, and/or issues. The data collectors will complete a few copies of the data collection form during this exercise.

During the day in Johnson City, the data collectors will conduct interviews with a couple of individuals from the project team using the interview questions. The data collectors will record the responses of the participant during the practice interview sessions. Upon completion of the interview, each person will be questioned in detail about his/her answers to the questions, to ascertain what the person understood the question to be asking, and the exact meaning of his response. Bench-testing of the interview questions will enable the independent evaluator to determine whether the items are worded properly (not biased, easily understood).

All of the data gathered during these two days will be reduced and analyzed to the extent possible to determine whether any changes or clarifications to the data collection instruments are necessary prior to distribution for full testing. The instruments will be amended as required.

4.2.2.4 Study Activities

This subsection is separated into: description/participants; procedures and data requirements; logbook; environment; and resources/logistics.

4.2.2.4.1 *Description/Participants*

Table 16 presents a listing of the tasks to be completed during the full data collection effort, and the party responsible for the execution of each activity.

4.2.2.4.2 *Procedures and Data Requirements*

The data collection procedures which will be used in the review, extraction, and recording of information from the phase I program deliverable, VA regulations, and the historical preservation laws, and the data sources for the institutional and business issues study's three objectives were

Table 16. Institutional and Business Issues Study Activities and Responsibilities

Activity	Responsibility
Review the phase I program deliverable, VA regulations, and the historical preservation laws and extract material from them	ORNL
Conduct interviews with the PARIS project participants and record information	ORNL
Track PARIS configuration	ORNL
Maintain a logbook	ORNL

described earlier in this plan. What has not been addressed thus far is the procedure to be employed in conducting the interviews. It is presented below.

Project participants will be contacted and convenient dates, times, and locations (for both the participants and data collectors) will be arranged for them to participate in the interviews. Before the individual is interviewed he/she will be told that his specific comments will not be associated with him/her and that no published material will identify views expressed by him. Rather, the views of all persons will be integrated into a mosaic of views representing a particular group. The individual will also be informed that if he does not understand any term or question he should ask the interviewer for clarification or explanation. At the completion of the interview, each person will be thanked for his participation, and told that his time and responses are very much appreciated.

Project participants will be interviewed individually. The interview questions will be used to guide the course of the interviews, but the discussions themselves will be semi-structured and take form as they proceed. Questions will be asked by the independent evaluator. Comments made by the participants will be recorded by one of ORNL's data collectors. Each interview will last between one and one-and-a-half hours.

4.2.2.4.3 *Logbook*

The independent evaluator will maintain a logbook for the duration of the study period. It will provide a record on the status of the evaluation. The logbook will include recordings of events and observations to be used to interpret and understand the flow of the study, major weather and event occurrences, and other items useful in interpreting the data. The logbook's contents were listed in the *Data Management Plan*.

4.2.2.4.4 *Environment*

Review and extraction of material from the phase I program deliverable, VA regulations, and the historical preservation laws will be completed at the independent evaluator's complex. Interviews will be conducted at the respective project participant's location or a mutually agreed upon site.

The logbook and PARIS configuration table will reside in the independent evaluator's offices; material for these two documents will be transmitted from Raytheon and/or the PARIS installation site.

4.2.2.4.5 *Resources/Logistics*

The independent evaluator will handle all resource and logistics considerations for this study. Conduct of the institutional and business issues study will require copies of the data collection form and interview questions, and pens/pencils to fill-in the data collection instruments.

4.2.2.5 Post-Study Activities

This subsection is split into three parts: description/participants; reporting procedures; and data retention/archival procedures.

4.2.2.5.1 *Description/Participants*

Table 17 synthesizes the tasks to be conducted at the conclusion of the data collection effort, and the party responsible for the completion of each activity.

Table 17. Institutional and Business Issues Post-Test Activities and Responsibilities

Activity	Responsibility
Reduction of data	ORNL
Analysis of data	ORNL
Completion of the study report	ORNL
Retain and archive data	ORNL

4.2.2.5.2 *Reporting Procedures*

The independent evaluator will perform all data reduction, processing, and analysis, and will develop the pertinent conclusions based on the results of the data collection effort. At a minimum, the study report will contain the following information: the procedures and tools used in data collection, the sources of all data, the procedures used in the processing and handling of the data, the analytical methods used in data analysis, and the resulting assessments. The report will be prepared in a final draft for review by the evaluation team. ORNL will incorporate comments made by the team and prepare the study report in final form for submission to the City of Johnson City, TNDOT, and FHWA. Specific data files will also be made available to the evaluation team as appropriate, upon request.

The study report will be written to conform to the general outline shown below. The independent evaluator will be responsible for the completion of all sections listed.

- I. Abstract
- II. Executive Summary (summary of study and evaluation findings)
- III. Introduction
 - A. Background
 - B. Purpose of study
 - C. Objectives
- IV. Methods
 - A. Duration of study
 - B. Study configuration
 - C. Study conditions
 - D. Materials and instrumentation
 - E. Detailed study procedures
 - F. Study schedule
 - G. Research design
- V. Results (evaluation findings and technical assessment)
- VI. Discussion
- VII. Conclusions and Recommendations
- VIII. References (if needed)
Appendices (optional)

4.2.2.5.3 *Data Retention/Archival Procedures*

After the completion of the evaluation activities all of the data collections forms, interview notes, configuration table, and logbook will be transferred from the independent evaluator to Raytheon. At their discretion, Raytheon will subsequently submit the information to the City of Johnson City, TNDOT, and/or FHWA. If requested to do so, Raytheon will also furnish the data to the national ITS repository.

4.3 Study Management

The schedule provided in Table 18 indicates the specific tasks to be completed under the study. Activities are segregated into pre-study, study, and post-study requirements.

5. TRANSPORTATION SYSTEMS INDIVIDUAL EVALUATION TEST PLAN

5.1 Executive Summary

5.1.1 Information Needed

Table 18. Detailed Institutional and Business Issues Study Schedule

Task Name	Months					
	Dec. '96	Jan. '97	Feb. '97	Mar. '97	Apr. '97	May '97
Pre-Study Activities						
Generate the data collection form for phase I program deliverable, VA regulations, and historical preservation laws data collection	■					
Furnish the phase I program deliverable to the independent evaluator		■				
Provide access to VA regulations and to the historical preservation laws to the independent evaluator		■				
Develop the interview questions	■					
Make personnel available for the informal interviews		■				
Train the independent evaluator personnel in data collection and the interview process			■			
Establish PARIS configuration			■			
Conduct pilot (shakedown) test and preliminary analysis			■			
Study Activities						
Review the phase I program deliverable, VA regulations, and the historical preservation laws and extract material from them			■			
Conduct interviews with the PARIS project participants and record information			■			
Track PARIS configuration			■			
Maintain a logbook			■			
Post-Study Activities						
Reduction of data						■
Analysis of data						■
Completion of the study report						■
Retain and archive data						■

The information needed to address each of the transportation systems study objectives will be generated and/or gathered through a cooperative effort between the independent evaluator and the PARIS evaluation team (i.e., Raytheon Company, Virginia Tech Center for Transportation Research, and Wilbur Smith Associates). A combination of component specifications, phase I program deliverables, Johnson City med/tech corridor parking plans, Intelligent Transportation

Society of America (ITSA) documentation, U.S. DOT documents, and interviews will serve as the mechanism for the collection of the necessary information. Specific procedures and data requirements are provided in section 5.2 of this plan.

5.1.2 Management and Overall Responsibility

Completion of the study activities described herein will be the responsibility of the independent evaluator. ORNL will be accountable for all data collection and analysis, and will prepare the test report. Raytheon will be responsible for supplying the needed documentation produced by the project team. The City of Johnson City's role will be to provide access to the med/tech corridor parking plans. The functions of ITSA and U.S. DOT will be to furnish the required ITS and system architecture material.

5.2 Detailed Study Design

5.2.1 Evaluation Scheme

This section describes the overall evaluation scheme. The subsections include: an overview of the evaluation; MOEs and hypotheses to be tested; data sources; the evaluation technical approach; and privacy considerations.

5.2.1.1 Evaluation Overview

The goal of the study will be to compare and contrast PARIS with the national ITS goals, objectives, and architecture. The broad nature of the transportation systems study, as indicated by the diverse objectives to be addressed, will require the segregation of test activities into four distinct areas, consistent with the four study objectives:

1. System safety (objective 1);
2. Expandability/extendibility (objective 2);
3. National ITS objectives (objective 3); and
4. National system architecture (objective 4).

The purpose of the system safety portion of the study will be to analyze PARIS safety. PARIS will have been designed to maximize driver safety and to minimize accidents and/or injury. There are three items to be covered in this segment of the study. They include:

1. Whether guidelines concerning the addition of signing, marking of pavement, and installation of a new infrastructure were followed;
2. Whether PARIS was designed in such a way that the driver is not distracted and can take his/her eyes off the road for a minimal time period; and
3. The impact of PARIS on traffic flow, traffic delays, parking queues, decreases in accidents, and other traffic-related issues.

The point of the expandability/extendibility part of the transportation systems study will be to investigate expandability/extendibility issues. The issues will be identified and subsequently assessed so that in future phases of the project PARIS will be able to be used in other facilities with different types of parking logistics. Issues to be dealt with are as follows:

1. The extendibility of PARIS to parking topologies at the Quillen College of Medicine, Johnson City Medical Center, East Tennessee State University, and other med/tech corridor parking facilities;
2. The ability of PARIS to integrate and interface with products to be delivered as outlined in the *Phase 2 Work Plan* (City of Johnson City, 1996);
3. The computer hardware and software to assure that the design will accommodate phases II and III of the project; and
4. The communications used in the phase I effort for applicability and expandability into future phases.

The national ITS objectives piece of the study will be oriented toward evaluating PARIS' compliance with the national ITS objectives. The independent evaluator will determine how closely PARIS complies with the national objectives.

The national system architecture section of the transportation systems study will be directed at reviewing PARIS' synchronization with the national system architecture. ORNL will analyze the synchronization and complimentary nature that PARIS brings to the national ITS system architecture. It is imperative that this and the previous objective are reviewed since they may have a profound impact on future phases of the PARIS project.

Information regarding the specific data collection methods to be used for each area is provided in subsequent sections of this plan. Collection of data pursuant to each of these areas will be accomplished through a combination of data collection methods:

1. Component specifications - Compilation of PARIS component specifications produced by Raytheon;
2. Phase I program deliverables - Accumulation of material generated by the PARIS project team (i.e., user manuals and human factors study);
3. Med/tech corridor parking plans - Use of the med/tech corridor parking plans provided by the City of Johnson City metropolitan planning office;
4. ITS documentation - Gathering of documentation created by ITSA, guidelines propagated by FHWA, and the national system architecture document assembled by U.S. DOT; and
5. Interviews - Collection of transportation systems data by the independent evaluator's team.

5.2.1.2 Measures of Effectiveness and Hypotheses to Be Tested

To give a focus to the study and to further define the methods necessary to address the study objectives, MOEs and hypotheses were developed for each objective. An MOE is a measurable quantity that is a response, outcome, or dependent variable that is directly related to PARIS transportation systems. Hypotheses provide a means of proving or disproving some change from the status quo, or the attainment or non-attainment of a prescribed systems objective. The hypotheses presented here may be considered the alternative hypothesis, in a strict statistical sense. The MOEs and hypotheses for each of the four objectives are exhibited in Table 19. NEMA and MUTCD are the abbreviations for the National Electrical Manufacturer's Association and Manual of Uniform Traffic Control Devices respectively.

Table 19. MOEs and Hypotheses for the Transportation Systems Study Objectives

Objectives	MOEs	Hypotheses
1. Assess system safety	<ul style="list-style-type: none"> o Safety regulations o NEMA specifications o MUTCD document 	PARIS will meet all safety regulations
2. Assess expandability/extendibility issues	<ul style="list-style-type: none"> o Modularity o Ease of hardware and software upgrades o Applicability to other parking scenarios 	PARIS will be modular in nature and able to be used in multiple parking scenarios
3. Assess compliance with national ITS objectives	<ul style="list-style-type: none"> o National objectives 	PARIS will meet national objectives for ITS projects
4. Assess synchronization with national system architecture	<ul style="list-style-type: none"> o National system architecture compliance 	PARIS will be in synchronization with the national system architecture

5.2.1.3 Data Sources

There will be eight data sources for the transportation systems study. They are listed below.

1. PARIS component specifications;
2. PARIS user manuals;
3. Human factors study;
4. Johnson City med/tech corridor parking plans
5. ITSA documentation;
6. FHWA guidelines;
7. National system architecture document; and
8. Interviews.

The data sources for each study objective are shown in Table 20. At the intersection (cell) of a data source row with an objective column, an X indicates that the respective objective will use the respective data source.

Table 20. Data Sources for the Transportation Systems Study Objectives

	Objectives			
	System Safety	Expandability/ Extendibility	National ITS Objectives	National System Architecture
Data Sources				
Component Specifications		X		
User Manuals		X		
Human Factors Study	X			
Med/Tech Corridor Parking Plans		X		
ITSA Documentation			X	X
FHWA Guidelines			X	
National System Architecture Document				X
Interviews	X			

5.2.1.4 Evaluation Technical Approach

This subsection is divided into: data collection methodology; data reduction methodology; statistical analysis design; key conditions/assumptions; and key constraints/limitations.

5.2.1.4.1 *Data Collection Methodology*

Data needed to analyze PARIS safety will be derived from interviews. Information to address whether guidelines concerning the addition of signing, marking of pavement, and installation of a new infrastructure were followed will be extracted from the human factors study. Material to determine whether PARIS was designed in such a way that the driver is not distracted and can take his eyes off the road for a minimal time period will be drawn from the human factors study and generated by interviews. Data to investigate the impact of PARIS on traffic flow, traffic delays, parking queues, decreases in accidents, and other traffic-related issues will be covered in the interviews.

Information to assess expandability/extendibility issues will be gathered via component specifications and the med/tech corridor parking plans. Material required to analyze the extendibility of PARIS to parking topologies at the Quillen College of Medicine, Johnson City Medical Center, East Tennessee State University, and other med/tech corridor parking facilities will be gleaned from the med/tech corridor parking plans. Data to evaluate the ability of PARIS to integrate and interface with products to be delivered as outlined in the *Phase 2 Work Plan* will be garnered from component specifications. Information to investigate the computer hardware and software to assure that the design will accommodate phases II and III of the project will be pulled from component specifications and user manuals. Material to review the communications used in the phase I effort for applicability and expandability into future phases will be obtained via component specifications and the med/tech corridor parking plans.

Data to determine how closely PARIS complies with the national ITS objectives will be derived from ITSA documentation and FHWA guidelines. Information to evaluate the synchronization and complimentary nature that PARIS brings to the national ITS system architecture will be extracted from ITSA documentation and the national system architecture document.

Collection of the transportation systems study data will be accomplished in the following manner. The component specifications, user manuals, human factors study, med/tech corridor parking plans, ITSA documentation, FHWA guidelines, and the national system architecture document will be reviewed and information will be drawn from them on an as-needed basis over the entire study period. Informal interviews will be held with Mountain Home VA personnel as required to cover the associated items in the system safety portion of the study. These individuals will be interviewed multiple times during the course of the study. Formal interviews will be conducted with people who park in VA parking lots C, D, and E twice during the evaluation phase (at the middle and toward the end). Material discovered during all of the discussions will be recorded by the independent evaluator. Interview data will be collected through a post-test design, where the information is gathered after the treatment (PARIS) is implemented. The interview activities will primarily be during-and-after types of effort. All of the above data, information, and/or material will be recorded manually in one of two modes, either by pen/pencil-and-paper or on a personal computer.

5.2.1.4.2 *Data Reduction Methodology*

The primary data to be reduced by the independent evaluator will be those generated by the interviews. This information will subsequently be input to a statistical software package(s) for processing. The additional material gathered during data collection will be reviewed and analyzed to answer and address the items and issues associated with the study's four objectives.

5.2.1.4.3 *Statistical Analysis Design*

Most of the study data will be utilized to make qualitative assessments and judgements concerning the transportation systems objectives, MOEs, and hypotheses. As a result no sophisticated

statistics will be used with this information. Simple measures of central tendency and variability (i.e., means and standard deviations) will be derived for the quantitative data collected via the closed-ended items of the interviews. Percentages will also be calculated to look at the frequency of response to particular items. Bar and/or pie charts will be prepared to graphically represent the data, whichever is most appropriate to present the material. If these quantitative data allow for higher level analyses, then tests of significance for differences between two sample means (commonly referred to as *t*-tests), analyses of variance, and/or non-parametric methods (e.g., Man-Whitney) will be conducted on the means. One-tailed tests will be used in these analyses. Where the format of the data allows, the qualitative responses collected via the open-ended interview questions will be aggregated and presented in a tabular format.

5.2.1.4.4 Key Conditions/Assumptions

The results of the PARIS transportation systems study will be dependent on a number of factors or conditions involving the expected levels of effort and timing of activities by the project team and the independent evaluator. As a result some assumptions have to be made. They include:

1. The PARIS hardware and software will be installed on the Mountain Home VA campus and be ready to be tested prior to initiation of the study;
2. The component specifications, user manuals, human factors study, med/tech corridor parking plans, ITSA documentation, FHWA guidelines, and national system architecture document will be available when the study begins;
3. The component specifications, user manuals, human factors study, med/tech corridor parking plans, ITSA documentation, FHWA guidelines, and national system architecture document will have appropriate information at the right level of detail to address the related objectives, MOEs, hypotheses, items, and issues;
4. The VA personnel will be available for discussions when the study begins;
5. The interview questions will be thorough and complete; and
6. The answers provided by the VA personnel and PARIS participants to the interview questions will have appropriate material at the correct level of detail to investigate the associated objectives, MOEs, hypotheses, items, and issues.

5.2.1.4.5 Key Constraints/Limitations

There are currently a few test and evaluation limitations that restrict a purely objective and statistically satisfactory evaluation of this study. While these limitations are necessary within the realistic scope of this study, their effects do need to be recognized and understood. The major constraints and limitations are as follows:

1. The transportation systems evaluation of PARIS will be impacted by the selected sensors, parking lots, and sensor and VMS locations;

2. The number of vehicle drivers who participate in the interview sessions will be too small to gain insight into the general public as a whole (but should adequately represent a cross-section of users of VA parking lots);
3. It will be difficult to assess compliance with the national ITS objectives and synchronization with the national system architecture with such a small deployment site and relatively few users;
4. Since the study is intended to be descriptive, rather than evaluative in nature, it will not compare actual performance to expected performance or infer a better solution;
5. The information gathered via the interview questions will be highly dependent and based solely on the items asked;
6. At the present time, a great majority of the study items and issues lend themselves to a qualitative rather than a quantitative assessment; and
7. The independent evaluator will need to make a number of decisions based on subjective opinion rather than on objective data because of the early state of development of PARIS.

5.2.1.5 Privacy Considerations

It is understood that some of the information that will be sought by the interview questions for this study may be considered sensitive by the participants. By the same token, the interview responses from these individuals will be critical to the success of the data collection and analysis efforts. Consequently, it is important that all of the data will be presented without reference to the people. Results will be published only in aggregate form without naming any participants.

5.2.2 Study Scheme

This section provides: a physical description of the transportation systems study; participants; pre-study activities; study activities; and post-study activities.

5.2.2.1 Physical Description

Two data collection efforts will be undertaken during this study:

1. Review and extraction of material from the component specifications, phase I program deliverables, med/tech corridor parking plans, and ITSA and U.S. DOT documentation and guidelines; and
2. Gathering of information via interviews with VA personnel and PARIS participants.

5.2.2.2 Participants

A number of organizations will contribute to the implementation of this individual evaluation test plan. The following paragraphs provide a discussion of the participants and their role(s) in the conduct of this study.

ORNL. The independent evaluator will be responsible for: management and direction of the study; data management (as detailed in the *Data Management Plan*); QC/QA (as described in the *QC/QA Plan*); collection of the data from the data sources; refinements and revisions to the study design, as needed; cataloging and archiving of the data; data reduction and analysis; and report preparation.

Raytheon. Raytheon will furnish the component specifications and the phase I program deliverables to ORNL. They will install PARIS on the Mountain Home VA campus prior to the start of the study, advise the independent evaluator of any configuration change, and repair and maintain PARIS throughout the evaluation phase. Raytheon will also coordinate the communication and information exchange between ORNL and the evaluation team.

City of Johnson City. The City of Johnson City will provide access to the med/tech corridor parking plans.

ITSA and U.S. DOT. ITSA will furnish the needed ITS-related documentation. U.S. DOT will supply the FHWA guidelines and national system architecture document.

Project Team. Personnel from the Mountain Home VA will be available for informal interviews. The University of Tennessee Transportation Center will be accountable for delivery of the human factors study to Raytheon.

Evaluation Team. Constituents of the evaluation team will perform any functions required to meet the study objectives and resolve any technical issues.

5.2.2.3 Pre-Study Activities

This subsection is partitioned into: description/participants; data collection form; interview questions; training; configuration; and pilot testing and preliminary analysis.

5.2.2.3.1 *Description/Participants*

Table 21 displays a summary of the tasks to be performed prior to the initiation of the full data collection effort, and the party or parties responsible for the completion of each activity. When more than one agency is listed in the responsibility column, the one listed first has prime responsibility.

5.2.2.3.2 *Data Collection Form*

The independent evaluator will design a data collection form for use during the evaluation phase. It will be utilized with the component specifications, phase I program deliverables, med/tech corridor parking plans, ITSA documentation, FHWA guidelines, and national system architecture document data collection.

Table 21. Transportations Systems Pre-Study Activities and Responsibilities

Activity	Responsibility
Generate the data collection form for component specifications, phase I program deliverables, med/tech corridor parking plans, ITSA documentation, FHWA guidelines, and national system architecture document data collection	ORNL
Furnish the component specifications and phase I program deliverables to the independent evaluator	Raytheon
Provide access to the med/tech corridor parking plans, ITSA documentation, FHWA guidelines, and national system architecture document to the independent evaluator	City of Johnson City, ITSA, U.S. DOT
Develop the interview questions	ORNL
Make personnel available for the informal interviews	Mountain Home VA
Train the independent evaluator personnel in data collection and the interview process	ORNL
Establish PARIS configuration	ORNL, Raytheon
Conduct pilot (shakedown) test and preliminary analysis	ORNL

The data collection form will include, but not be limited to, the following items: were guidelines concerning the addition of signing, marking of pavement, and installation of a new infrastructure followed; expandability/extendibility issues; extendibility of PARIS to parking topologies at the Quillen College of Medicine, Johnson City Medical Center, East Tennessee State University, and other med/tech corridor parking facilities; the ability of PARIS to integrate and interface with products to be delivered as outlined in the *Phase 2 Work Plan*; will the computer hardware and software design accommodate phases II and III of the project; applicability and expandability of communications used in the phase I effort into future phases; how closely does PARIS comply with the national ITS objectives; and synchronization and the complimentary nature that PARIS brings to the national ITS system architecture.

5.2.2.3.3 Interview Questions

Interview questions consisting of both closed and open-ended items will be created through an iterative process by the independent evaluator. The construction of the questions will be based on guidance provided by Jones (1985) and LoSciuto (1981). A number of the closed-ended items will ask for either a "yes" or "no" response; the others will have rating scales consisting of between four and six alternatives. There will be different questions generated for each administration period (middle and at the end of the study) and each participant type (VA personnel and PARIS participants).

The interview questions will include, but not be limited to, items covering the following: PARIS safety; was PARIS designed in such a way that the driver is not distracted and can take his eyes off the road for a minimal time period; and the impact of PARIS on traffic flow, traffic delays, parking queues, decreases in accidents, and other traffic-related issues.

5.2.2.3.4 Training

Since training is essential for obtaining valid data, the independent evaluator will hold a one-day training session in Oak Ridge for its data collectors. These individuals will first be given a brief overview of the PARIS project, the evaluation, the transportation systems study, and their roles during the study. They will then be instructed on use of the data collection form. The data collectors will finally be taught how to conduct the interviews.

5.2.2.3.5 Configuration

The final step prior to conducting shakedown and beginning to take data for record is to establish the configuration for PARIS which will be evaluated. Hardware and software configurations will be recorded in a configuration table. This table will identify the item, model number, and where in the system the equipment is being used. If the configuration of the hardware and/or software changes during the study period, Raytheon will notify the independent evaluator of the modification. ORNL will record the changes in the configuration table as needed.

5.2.2.3.6 Pilot Testing and Preliminary Analysis

The pilot, or shakedown, test will be conducted primarily to verify that the data collectors are familiar with their roles and responsibilities, to bench-test and fine tune the data collection instruments (i.e., data collection form and interview questions), and to validate the data collection protocol and data analysis methodology. Once PARIS has been installed and made operational, the independent evaluator will conduct a two-day data collection effort consistent with the procedures to be used during the three-month data collection initiative. One day will be spent at ORNL; the other on the Mountain Home VA campus. The time in Oak Ridge will be occupied with a search of a selected set of documents and extraction of material related to one or two of the transportation systems items and/or issues. The data collectors will complete a few copies of the data collection form during this exercise.

During the day in Johnson City, the data collectors will conduct interviews with a couple of vehicle drivers and individuals from the VA using the interview questions. The data collectors will record the responses of the participant during the practice interview sessions. Upon completion of the interview, each person will be questioned in detail about his answers to the questions, to ascertain what the person understood the question to be asking, and the exact meaning of his response. Bench-testing of the interview questions will enable the independent evaluator to determine whether the items are worded properly (not biased, easily understood).

All of the data gathered during these two days will be reduced and analyzed to the extent possible to determine whether any changes or clarifications to the data collection instruments are necessary prior to distribution for full testing. The instruments will be amended as required.

5.2.2.4 Study Activities

This subsection is separated into: description/participants; procedures and data requirements; logbook; environment; and resources/logistics.

5.2.2.4.1 *Description/Participants*

Table 22 presents a listing of the tasks to be completed during the full data collection effort, and the party responsible for the execution of each activity.

Table 22. Transportation Systems Study Activities and Responsibilities

Activity	Responsibility
Review the component specifications, phase I program deliverables, med/tech corridor parking plans, ITSA documentation, FHWA guidelines, and national system architecture document and extract material from them	ORNL
Conduct interviews with the VA personnel and PARIS participants and record information	ORNL
Track PARIS configuration	ORNL
Maintain a logbook	ORNL

5.2.2.4.2 *Procedures and Data Requirements*

The data collection procedures which will be used in the review, extraction, and recording of information from the component specifications, phase I program deliverables, med/tech corridor parking plans, ITSA documentation, FHWA guidelines, and national system architecture document, and the data sources for the transportation systems study's four objectives were described earlier in this plan. What has not been addressed thus far are the procedures to be employed in conducting the interviews. They are presented below.

VA personnel and PARIS participants will be contacted and convenient dates and times (for both the participants and data collectors) will be arranged for them to participate in the interviews. Before the individual is interviewed he/she will be told that his specific comments will not be associated with him/her and that no published material will identify views expressed by him. Rather, the views of all persons will be integrated into a mosaic of views representing a particular

group. The individual will also be informed that if he does not understand any term or question he should ask the interviewer for clarification or explanation. At the completion of the interview, each person will be thanked for his participation, and told that his time and responses are very much appreciated.

The VA personnel and PARIS participants will be interviewed individually or in small groups of between two and four people. The interview questions will be used to guide the course of the interviews, but the discussions themselves will be semi-structured and take form as they proceed. Questions will be asked by the independent evaluator. Comments made by the individuals will be recorded by one of ORNL's data collectors. Each interview will last between one-half and one hour.

5.2.2.4.3 *Logbook*

The independent evaluator will maintain a logbook for the duration of the study period. It will provide a record on the status of the evaluation. The logbook will include recordings of events and observations to be used to interpret and understand the flow of the study, major weather and event occurrences, and other items useful in interpreting the data. The logbook's contents were listed in the *Data Management Plan*.

5.2.2.4.4 *Environment*

Review and extraction of material from the component specifications, phase I program deliverables, med/tech corridor parking plans, ITSA documentation, FHWA guidelines, and national system architecture document will be completed at the independent evaluator's complex. Informal interviews will be held with VA personnel either face-to-face in Johnson City or by telephone call. Formal interviews with people who park in VA parking lots C, D, and E will be conducted on the Mountain Home VA campus. The logbook and PARIS configuration table will reside in the independent evaluator's offices; material for these two documents will be transmitted from Raytheon and/or the PARIS installation site.

5.2.2.4.5 *Resources/Logistics*

The independent evaluator will handle all resource and logistics considerations for this study. Conduct of the transportation systems study will require copies of the data collection form and interview questions, and pens/pencils to fill-in the data collection instruments.

5.2.2.5 Post-Study Activities

This subsection is split into three parts: description/participants; reporting procedures; and data retention/archival procedures.

5.2.2.5.1 *Description/Participants*

Table 23 synthesizes the tasks to be conducted at the conclusion of the data collection effort, and the party responsible for the completion of each activity.

Table 23. Transportation Systems Post-Study Activities and Responsibilities

Activity	Responsibility
Reduction of data	ORNL
Analysis of data	ORNL
Completion of the study report	ORNL
Retain and archive data	ORNL

5.2.2.5.2 *Reporting Procedures*

The independent evaluator will perform all data reduction, processing, and analysis, and will develop the pertinent conclusions based on the results of the data collection effort. At a minimum, the study report will contain the following information: the procedures and tools used in data collection, the sources of all data, the procedures used in the processing and handling of the data, the analytical methods used in data analysis, and the resulting assessments. The report will be prepared in a final draft for review by the evaluation team. ORNL will incorporate comments made by the team and prepare the study report in final form for submission to the City of Johnson City, TNDOT, and FHWA. Specific data files will also be made available to the evaluation team as appropriate, upon request.

The study report will be written to conform to the general outline shown below. The independent evaluator will be responsible for the completion of all sections listed.

- I. Abstract
- II. Executive Summary (summary of study and evaluation findings)
- III. Introduction
 - A. Background
 - B. Purpose of study
 - C. Objectives
- IV. Methods
 - A. Duration of study
 - B. Study configuration
 - C. Study conditions
 - D. Materials and instrumentation
 - E. Detailed study procedures

- F. Study schedule
- G. Research design
- V. Results (evaluation findings and technical assessment)
- VI. Discussion
- VII. Conclusions and Recommendations
- VIII. References (if needed)
- Appendices (optional)

5.2.2.5.3 *Data Retention/Archival Procedures*

After the completion of the evaluation activities all of the data collections forms, interview notes, configuration table, and logbook will be transferred from the independent evaluator to Raytheon. At their discretion, Raytheon will subsequently submit the information to the City of Johnson City, TNDOT, and/or FHWA. If requested to do so, Raytheon will also furnish the data to the national ITS repository.

5.3 Study Management

The schedule provided in Table 24 indicates the specific tasks to be completed under the study. Activities are segregated into pre-study, study, and post-study requirements.

6. REFERENCES

The following documents were consulted during the preparation of the individual evaluation test plans:

Booz-Allen & Hamilton (1996). Guidelines for evaluation of FHWA ITS field tests, Draft.

Booz-Allen & Hamilton (1995). Southwest electronic one-stop shopping field operational test, Motor carrier individual test plan.

Carter, R. J. (1997). PARIS phase I evaluation - Data management and QC/QA plans, ORNL/TM-13361. ORNL: Oak Ridge, TN.

City of Johnson City (1996). ITS work plan, The Johnson City med/tech corridor, Phase II.

City of Johnson City (1994). ITS work plan, The Johnson City med/tech corridor, Phase I.

Clark Atlanta University (1996). Detailed test plan for evaluating institutional and business issues of the Atlanta driver advisory system (ADAS).

Concord Associates, Inc. (1996). Detailed test plan for evaluating user acceptance of the ADAS.

Table 24. Detailed Transportation Systems Study Schedule

Task Name	Months					
	Dec. '96	Jan. '97	Feb. '97	Mar. '97	Apr. '97	May '97
Pre-Study Activities						
Generate the data collection form for component specifications, program deliverables, parking plans, ITSA documentation, FHWA guidelines, and architecture document data collection	■					
Furnish the component specifications and phase I program deliverables to the independent evaluator		■				
Provide access to the med/tech corridor parking plans, ITSA documentation, FHWA guidelines, and national system architecture document to the independent evaluator		■				
Develop the interview questions	■					
Make personnel available for the informal interviews		■				
Train the independent evaluator personnel			■			
Establish PARIS configuration			■			
Conduct pilot (shakedown) test and preliminary analysis			■			
Study Activities						
Review the component specifications, program deliverables, parking plans, ITSA documentation, FHWA guidelines, and system architecture document and extract material from them			■			
Conduct interviews and record information			■			
Track PARIS configuration			■			
Maintain a logbook			■			
Post-Study Activities						
Reduction of data						■
Analysis of data						■
Completion of the study report						■
Retain and archive data						■

Georgia Tech Research Institute (1996). Detailed test plan for evaluating system performance of the ADAS.

Jones, R. A. (1985). Research methods in social and behavioral sciences. Sinauer Associates, Incorporated: Sunderland, Massachusetts.

LoSciuto, L. (1981). Questionnaires and interviews. In L. H. Kidder (ed.), Sellitz, Wrightsman, and Cook's research methods in social relations (4th ed., pp. 144-197). Holt, Rinehart, and Winston, Incorporated: Chicago, Illinois.

MITRE (1993). Generic IVHS operational test evaluation guidelines.

Northwestern University Transportation Center and Booz-Allen & Hamilton (1995). Advanced driver and vehicle advisory navigation concept (ADVANCE), Dynamic route guidance - yoked driver study evaluation test plan.

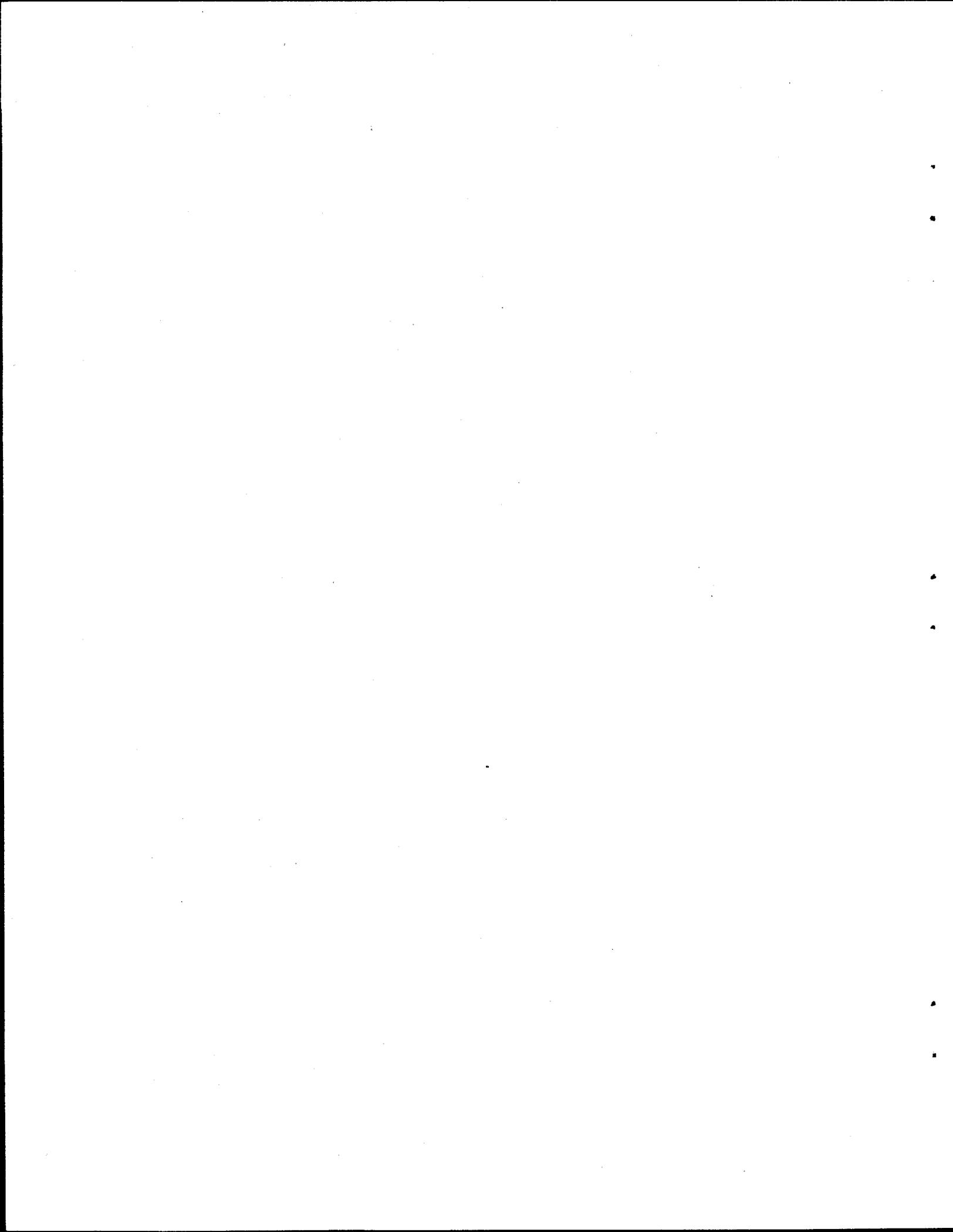
Northwestern University Transportation Center and Booz-Allen & Hamilton (1995). ADVANCE, Familiar driver evaluation test plan.

Raytheon (1996). ITS, Johnson City, TN, PARIS - phase I, Evaluation plan, Revision C.

7. ACRONYMS AND ABBREVIATIONS

ADAS	Atlanta driver advisory system
ADVANCE	advanced driver and vehicle advisory navigation concept
DOT	Department of Transportation
FHWA	Federal Highway Administration
F_T	total number of critical failures during the study time frame
ITS	intelligent transportation systems
ITSA	Intelligent Transportation Society of America
IVHS	intelligent vehicle/highway systems
med/tech	medical/technology
MOE	measure of effectiveness
MTBF	mean time between failures
MUTCD	Manual of Uniform Traffic Control Devices
NEMA	National Electrical Manufacturer's Association

ORNL Oak Ridge National Laboratory
PARIS parking and routing information system
QA quality assurance
QC quality control
TN Tennessee
T_o total operating time during the study period
U.S. United States
VA Veterans Administration
VMS variable message sign



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