IDAHO OUT-OF-SERVICE VERIFICATION FIELD OPERATIONAL TEST

FINAL REPORT

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For over two years, one of the major project team members, Hughes Missile Systems, struggled to implement the video technology that was the key component of the out-of-service verification system. After a number of field test failures, missed deadlines, warnings, and changes in company personnel, the contract with Hughes was terminated in July 1998.

Coming four years after the project start, the elimination of the video component was a major loss for the project. Already two years behind schedule when Hughes was dismissed from the project team, and with much of the project budget already spent, the Idaho National Engineering and Environmental Laboratory undertook a major redesign in the verification system. Fortunately, the original system design was flexible enough that it could readily be changed to operate under new conditions with new sensor inputs. A modified system based on AVI tag reader technology was designed in fall 1998. The system was installed at the I-84 East Boise Port of Entry test site in October 1998.

This change in the system design forced a significant change in the project evaluation. In addition to scaling back the scope of the system, the time available for field testing was greatly reduced. A simulated field test was conducted in December 1998, and a full system test was conducted in March and April 1999.

Despite these problems and delays, the partnership prevailed and the field test provided the project team with the opportunity to learn a number of valuable lessons, some of which may be of interest to both the federal government and to transportation operating agencies across the U.S.

1.2 Lessons Learned and Conclusions Drawn

- The project planning process must include a more thorough assessment of the key technologies included in the system design, particularly when these technologies are new and unproven in the application being considered. As a result of this experience, the project team recommends a change in the way in which project management plans are developed.
- The failure of the key technology component did not happen suddenly, but over time, with warning signs that should have been seen more clearly by the project partners. The video identification system was delivered late and was never functional. Repeated attempts to fix the system failed. Further, the video team underwent a number of personnel changes, indicating the lack of seriousness with which Hughes took this project. Hughes’ perception of itself as a vendor and not a full team member resulted in the lack of commitment so clearly needed for this project to be a success.
- Technical difficulties with the original video system precluded a high level of end user involvement in this project, but it is clear that end users of a verification system should be involved from the very beginning of the project, through the planning, system design, and development of the system.
- It is critical to understand how a new project will affect legacy systems already in operation. More coordination between an OOS project team and the team developing ASPEN and other software tools would reduce the problems encountered by inspectors using a merged set of software packages.
- This limited test system showed great promise, but it performed more like a beta-version than a completed system. Additional development may resolve the technical problems so that some of the components can be used in other out-of-service verification systems. The system as a whole was moderately effective at monitoring out-of-service vehicles, and it did provide direct fax and email notification to trucking companies and agencies responsible for monitoring out-of-service vehicles.

- The failure of the original video vehicle identification system showed the benefits of having a flexible, network-based open architecture. System designs should be capable of using alternative sensors and approaches.

2.0 INTRODUCTION

The Out-of-Service Verification Field Operational Test Project was initiated in 1994. The purpose of the project was to test the feasibility of using sensors and a computerized tracking system to augment the ability of inspectors to monitor and control the status of vehicles that had been placed out of service until the violations were cleared. As such, the system not only required development of new technology for vehicle sensing, but it also required interfacing into an existing inspection computer record system (ASPEN) and a well-developed methodology of inspection that was comfortable for both drivers and inspectors.

The project was conducted in Boise, Idaho by a partnership that included the Idaho State Police (ISP), the Idaho National Engineering and Environmental Laboratory (INEEL), the Idaho Transportation Department (ITD), and the U.S. Department of Transportation (U.S. DOT). The University of Idaho’s National Institute for Advanced Transportation Technology (NIATT) is the independent evaluator for the project. This report describes the out-of-service verification system that was put in place at the East Boise Port of Entry on Interstate 84 and results of the tests that were conducted on the system.

2.1 Project Overview

The U.S. Congress is concerned that highway safety has been reduced by commercial vehicles returning to operation, after being placed out-of-service, without mitigating safety problems. Congress has instructed the Motor Carrier Safety Assistance Program (MCSAP) to develop procedures to ensure compliance with out-of-service orders. These procedures are to ensure that vehicles not meeting minimum safety standards are taken out-of-service, and kept out-of-service until the violation has been resolved.

Violations are of two basic types, vehicle violations and driver violations. Many vehicle violations are minor and can be repaired by the driver at the inspection site. Some vehicle violations are major and necessitate either on-site or off-site repairs. Driver violations are

logbook violations (exceeding driving time limits, for example) or driving condition violations (drug or alcohol use, disqualification or suspended licenses, and so on).
To be corrected, these conditions require either the passage of an allotted amount of time or the replacement of the driver. The U.S. DOT is interested in improving monitoring capabilities for commercial vehicles and drivers that have been placed out-of-service. Generally, the out-of-service order results from serious safety violations detected during inspection or a driver condition that disqualifies the driver from operating the vehicle.

In addition, all states in the U.S., as well as the Canadian provinces and Mexico, are members of the Commercial Vehicle Safety Alliance (CVSA). As a member of this organization, the State of Idaho is conducting inspections according to an adopted standard, and using the standard for placing vehicles and drivers out-of-service. The common interest of the CVSA is in determining at what point violations become imminent safety hazards, warranting the removal of vehicles or drivers from service.

Since current human resources and technologies do not easily allow for continuous vehicle and driver monitoring or impoundment, there is a need for a cost effective method of tracking out-of-service vehicles and drivers. It is the intent of this Intelligent Transportation System (ITS) operational test to address this need.

2.2 Intelligent Transportation Systems Program

The Intelligent Transportation Systems (ITS) program was initiated by the federal government in 1991. ITS is the application of advanced technologies such as computers, electronics, communications, and safety systems to solve the problems of the nation’s transportation network. Four key principles guide the ITS program:

- To promote the implementation of a technically integrated and jurisdictionally coordinated transportation system across the country.
- To support on-going applied research and technology transfer.
- To ensure that newly developed ITS technologies and service are safe and

cost-effective.

- To create a new industry by involving and emphasizing the private sector in all aspects of the program.

ITS field operational tests are conducted on advanced technology or new applications of existing technology systems to determine the overall effectiveness and potential for future broad-based deployment.

2.3 Problem Statement

Considerable state and federal resources are dedicated to identifying vehicles and drivers that fail to maintain safe operation on the roadways. If a cost effective system is not available to monitor these vehicles and drivers until the resolution of the safety violation(s), there is a potential for these vehicles to enter the traffic stream before correction of the problem. If this occurs without notification, the resources (human resources, time, training, etc.) spent to identify the safety deficiency have been lost, and additional risk has been incurred.

Out-of-service orders are the result of safety violations for commercial vehicles or the drivers of these vehicles. Vehicles that enter the traffic stream without properly resolving the out-of-service condition can pose a serious safety risk to the public. To ensure they do not re-enter the transportation system before violations are cleared, an advanced and continuous monitoring and notification system should be used. This system should also include the ability to monitor out-of-service conditions at ports of entry while inspectors are off-duty. Current facilities and technologies do not allow for continuous monitoring or impoundment. It is a complex problem that involves limited inspection and impoundment resources, many possible violations and potential resolutions, and a need not to interfere with interstate commerce and basic personal liberties.

Improving the process of monitoring out-of-service drivers and/or vehicles requires that four criteria be met:

- The system must be useful in both high and low-density traffic flows, so that it can be applicable to many situations, and therefore useful to agencies and inspection locations nationwide.
- The system must integrate "off the shelf" technology. Both hardware and software must be readily available and proven technology.
- The system must provide enforceability. There must be a mechanism for notification of enforcement officers, enabling follow-up on drivers or vehicles that violate the out-of-service order.
- There must be a degree of intelligence in the system, so it can distinguish information pertinent to different scenarios.

2.4 Project Description

This project installed and tested advanced communications, specially-modified automated vehicle identification tags and readers, and computer integration technology at the East Boise Port of Entry along I-84 just east of Boise, Idaho. The purpose of this project is to assess the effectiveness of the system in logging and controlling commercial vehicles and drivers that have been put out-of-service because of a safety related violation. The goal is to better enforce the out-of-service orders and encourage the drivers and commercial vehicle carriers to make the necessary repairs or resolve driver issues before taking the truck back onto the highway.

2.5 Evaluation: Outputs and Outcomes

A vital part of the field operational test program is the independent evaluation. The independent evaluation measures the effectiveness of the advanced technology equipment and operation of the new system.[1]

[1] *Idaho Out-of-Service Verification Field Operational Test, Evaluation Test Plan, April 1998* (revised October 1998), University of Idaho.

The evaluation measures consist of two types, outputs and outcomes. The output measures consist of evaluating the performance of the individual sensors and the integrated system, including the institutional issues. The outcome measures consist of evaluating the benefits of the operational improvements achieved through deployment of the integrated system.

Output evaluation measures focus on the accuracy of the individual systems including the inspection report laptop, communications, AVI tags and readers, local intelligence computer, and the messaging computer. The overall system integration/operation are included. In addition, the institutional issues which arose during the project design, installation, and testing are documented. Outcome evaluation measures focus on the potential operational improvements and user acceptance.

2.6 Project Partnership

A team of contributors was assembled to meet the objectives of the out-of-service verification project. The original team consisted of ISP, INEEL, ITD, the Hughes Missile Systems Company (HMSC), and U.S. DOT. ISP served as the overall project manager of the project, while the INEEL had the major responsibility for system and component design and integration. NIATT served as the project independent evaluator.

2.7 Project History

Originally scheduled to run from October 1994 to July 1997, the problems with the video identification system forced an extension of the project through June 1999. A list of the key project events is given in Table 1.

Table 1. Project Chronology

Date	Key Event
1/94	Proposal submitted to U.S. DOT
10/94	Detailed system design and partner contract development initiated
11/94	Test and evaluation plan (scheduled to be completed by 4/95)
7/95 – 3/96	Project management plan (scheduled to be completed by 8/95)
9/96	INEEL field trials (delayed two months because of late arrival of video identification equipment and installation team)
1/97	Hughes video team modifies equipment; results are not positive
5/97	Hughes video team modifies equipment; results are not positive
9/97	Hughes video team modifies equipment; results are not positive
10/97	Initial installation of OOS system components at East Boise POE
2/98	Hughes video team modifies equipment; results are not positive
4/98	Hughes video team modifies equipment; results are not positive
5/98	Discussions on eliminating Hughes from the project are begun
7/98	Hughes contract closed out, eliminated as project partner
7/98	AVI components retrieved from East Boise POE and returned to INEEL for system redesign
10/98	New OOS system reinstalled at East Boise POE
11/98	First inspection report is captured by OOS system and RF OOS tag is successfully monitored
12/98	Simulation test
3/99 – 4/99	System field test

Project Planning and System Design

The first phase of the project consisted of two major parts, project planning and system design.

The project proposal was submitted to U.S. DOT in January 1994. The proposal was favorably reviewed and funding for the project was committed. Initial project partnership meetings were held in Fall 1994. During the next two years, the project team discussed and debated the nature of the system, the components that were required, and how the system could be implemented. The project team completed the project management plan in 1996. The initial test and evaluation plan was completed the same year.

Video Identification System Problems

The video identification was considered to be an essential system component from the very start of the project. Video was to be used to identify and record the license plates when a vehicle was first taken out-of-service, monitor the location of the vehicle based on its video image, and note when the vehicle left the port of entry again based on identifying its image.

Unfortunately Hughes Missile Systems experienced problems with its video system from the very beginning. Repeated site visits in 1996 and 1997 failed to fix problems with the operation of the system. This was a significant problem, since the video system was an essential part of the system operation. Finally, after a number of ultimatums from the project partners, the Hughes video system was eliminated from the out-of-service verification system.

Final Project Design, Installation, and Test

With the termination of the Hughes contract, INEEL conducted a complete system redesign. The scope of the system operation was reduced while the role of the AVI tags was increased. INEEL completed this redesign in October 1998 and the system was redeployed in November 1998.

The field test was initiated in November 1998, with the first inspection report captured by the out-of-service system at 4:05 pm on November 19, 1998. The RF tag was successfully monitored for eight hours. The simulation testing of the out-of-service system was started on November 30, 1998 and continued through December 4, 1998.

2.8 Guide to this Report

This report describes the results of the out-of-service verification field operational test. Section 3 of the report describes the system configuration, both the original system design as well as the design that was finally implemented and tested in the field. Section 4 describes the deployment of the system and the testing that was conducted. Section 5 summarizes the assessment of the technical performance of the system. Section 6 presents an estimate of the cost of deploying the system. Section 7 summarizes the recommendation from the project partners and the lessons learned from this project. Section 8 presents the conclusions.

3.0 SYSTEM CONFIGURATION

The basic premise of the out-of-service system is to provide the technology to monitor vehicles that have been taken of-out-service, whether the inspection area is staffed or not. Two configurations of the out-of-service system were developed. The first of these (the original configuration) included the Hughes Missile Systems Video Vehicle Identification System (VVIS). A fully operable VVIS was never demonstrated, and therefore this configuration was not used as part of the test. A discussion of how this configuration was designed to operate is included here for completeness.

The second configuration (the modified configuration) consisted of using reengineered Automatic Vehicle Identification (AVI) tags for monitoring out-of-service vehicles and drivers. This configuration calls for the modified AVI tag to be temporarily attached to the vehicle. The following provides a description of the two configurations.

3.1 Original Configuration

The original system consisted of eight different elements:

- two VVIS units
- two AVI systems
- a kiosk
- laptop computers running U.S. DOT Aspen software
- local intelligence computer
- mailer computer
- radio frequency (RF) Ethernet
- RF modems

The system components were controlled by a total of ten independent software processes developed under a distributed architecture. This distributed architecture used TCP/IP and

Windows Sockets to allow the processes to reside on several different computers or on a single computer, depending upon the overall system needs.

Figure 1 shows the locations of the system components for the original system configuration. The inspections of drivers and vehicles are performed at position 1. Inspection information is entered on the MCSAP inspector's laptop computer at this location. When the inspection report is complete, it is automatically transmitted over the RF Ethernet to the local intelligence computer at position 3. An auxiliary software process called Aspen Monitor, written specifically for this project, handles the transmission of the Aspen inspection report. If the vehicle/driver is out-of-service, the inspector enters the unique identifier of an AVI tag into a special field in the Aspen inspection report, and the driver is issued the tag with that identifier. The tag is carried by the driver (e.g. in a shirt pocket), used during the out-of-service stay at the POE, and returned prior to departing.

When the Local Intelligence software process receives the inspection report, Local Intelligence parses the inspection report information. If the vehicle and/or driver are placed out-of-service, the inspection report information is transmitted to the Mail Server process on the mailer computer, also located at position 3. The Mail Server process sends out a "new inspection report received" message to predetermined recipients. Mail Server also sends a fax of the inspection report information to the carrier, if a carrier fax number is provided in the inspection report.

Data are captured at position 2 that allows the out-of-service system to detect when an inspected vehicle is departing the POE. At position 2, the first VVIS unit captures an image of the license plate of the vehicle. Simultaneous with the VVIS image capture, the AVI tag previously issued to the driver is also read. Since the AVI tag identifier is in the inspection report, reading the tag at the same time that the VVIS image is captured allows Local Intelligence to correlate the image with an inspection report that was received earlier.

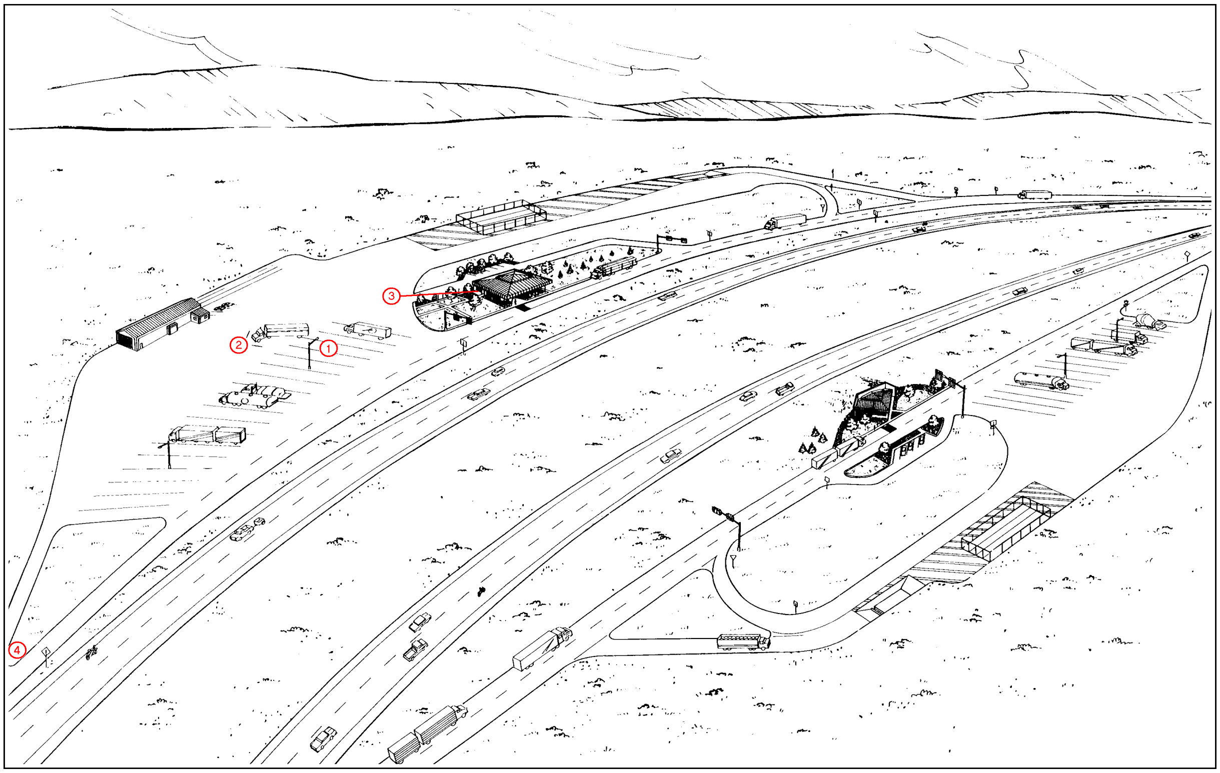

Figure 1. East Boise port of entry, original configuration

Position 1-location where inspections are performed.

Position 2-vehicle is checked into the OOS CV Monitoring System using one VVIS unit and one AVI unit.

Position 3-location of local intelligence, kiosk, and mail server computers.

Position 4-exit location where the second VVIS unit is located.

Once the vehicle has passed position 2 the driver may park in any appropriate location at the POE. When the out-of-service condition(s) has been corrected the driver approaches the kiosk at position 3. As the driver approaches the kiosk, a tag reader at the kiosk automatically reads the AVI tag and the kiosk notifies Local Intelligence that a tag has been read. Local Intelligence compares the tag identifier with those in inspection reports active in the system. Within a fraction of a second, Local Intelligence locates the correct report and sends the information to the kiosk. At the kiosk, the inspection information is automatically displayed on the computer screen and the driver is allowed to indicate on a touchscreen if the out-of-service conditions have been corrected.

After the driver has completed the transaction, he or she is instructed by a message, displayed on the kiosk screen, to deposit the AVI tag in a receptacle located at the kiosk. The receptacle reads the tag identifier and Local Intelligence is notified of this tag read. At this point the driver may leave the POE.

As the vehicle exits the POE it passes by position 4, where the second VVIS unit is located. This VVIS unit captures an image of the license plate and compares it with license plate images of vehicles that have been placed out-of-service. If a match between the two license plate images is found, the VVIS at position 4 notifies Local Intelligence. Once this notification is received, Local Intelligence determines the correct action to take, based upon data collected from the driver's interactions (or lack of interactions) with the out-of-service System.

When Local Intelligence has determined the correct notification(s) to send out, the information is transmitted to the Mail Server process on the messaging computer and faxes and E-mail notifications are automatically formulated and distributed. Notifications can indicate potential runners (drivers who leave the POE without correcting violations), that the driver exited without clearing violations at the kiosk, that the driver departed with the AVI tag, or that the inspector wanted to be notified when the vehicle departed.

3.2 Modified Configuration

The above configuration was never used because the VVIS units were never in an acceptably operable state. When faced with this situation, the project partners worked to achieve an alternate design that would accomplish three goals: provide equivalent benefits to the original configuration, use existing system components and software, and be achievable with the remaining project resources. The modified configuration met each of these goals.

This configuration consisted of six different elements:

- two AVI systems
- laptop computers running U.S. DOT Aspen software
- local intelligence computer
- messaging computer
- radio frequency (RF) Ethernet
- RF modems

Figure 2 shows the key locations in the modified configuration. In this configuration, the presence of out-of-service vehicles and drivers is monitored using radio frequency (RF) tags attached to the vehicle. As shown in Figure 3, the RF tags have a power loop that can be broken to allow the tag to be attached to the vehicle. These tags were produced by modifying the Hughes AVI tags that were part of the original system. The modification to the tags is shown in Figure 4. This modification produced a tag that is fully operational when the power loop is connected, but when the power loop is disconnected, even momentarily, the tag is “disarmed” for a period of ten minutes.

In this way, the presence of the tag can be electronically observed, and if it is not read in some time slightly less than the rearming time of ten minutes, Local Intelligence is notified that the tag is no longer present or has been tampered with. This notification to Local Intelligence will cause appropriate notification events to be generated.

Inspections are performed at position 1. As in the original configuration, inspection reports are completed on the inspector’s laptop using Aspen and then transmitted automatically to the Local Intelligence process by Aspen Monitor. Local Intelligence transmits the inspection report to the Mail Server process at position 4. There, “new inspection report received” messages are sent out to predetermined recipients (ISP, the trucking company), and a fax to the carrier is formulated and automatically delivered, if the report contained a carrier fax number. The local intelligence computer is located at position 3 for this configuration.

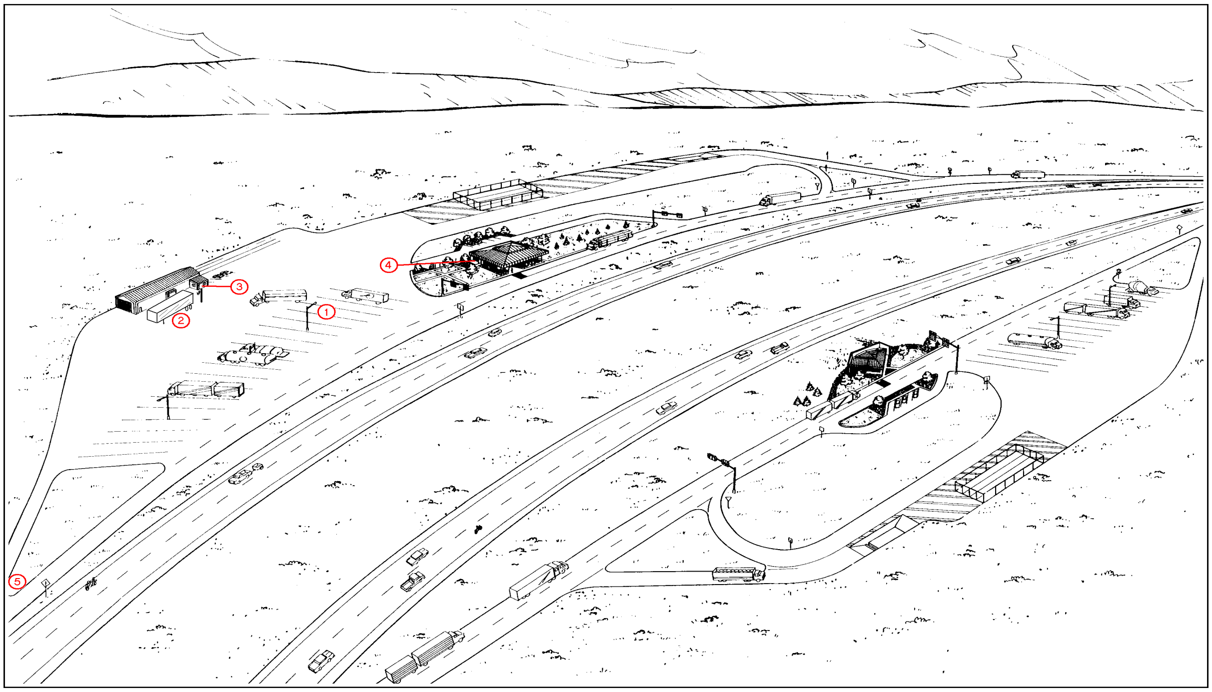

Figure 2. East Boise port of entry, modified configuration

Position 1-Location where inspections are performed.
Position 2-Location where OOS vehicles are parked while OOS.
Position 3-Local intelligence computer, first AVI unit for monitoring OOS vehicles.
Position 4-Mail server computer location.
Position 5-Second AVI unit for detecting vehicles departing without returning the OOS AVI tag.

Vehicles that have been placed out-of-service are parked at position 2, where a RF out-of-service tag reader antenna is located.

Once the vehicle is parked, the inspector attaches a RF out-of-service tag to the vehicle and a software process developed for the modified configuration begins to monitor the tag. This new process is known as OOS Tracker. OOS Tracker reads the tag, notes that the tag is present, and then instructs the tag to sleep for 30 seconds. Having the tag sleep and awaken in this manner greatly extends battery life. In fact, calculations and limited testing indicate that a single tag could be monitored for over one year.

When the tag awakens the read/sleep/awaken sequence is repeated. Each time OOS Tracker reads a tag for which there is an associated inspection report, a timer specific to that tag/inspection report is reset. Should the time between the last read of the tag and current time exceed ten minutes, OOS Tracker sends a message to Local Intelligence indicating that the tag is no longer readable. When this message is received, Local Intelligence parses the inspection report to determine what action should be taken.

For example, if the out-of-service order pertains to a time-related violation and the appropriate amount of time has not elapsed, Local Intelligence will send a message to the Mail Server process, on the messaging computer, indicating that a potential runner condition has been detected. The Mail Server would then formulate the correct E-mail and fax notifications and deliver the notifications to designated parties, such as law enforcement, POE, carrier, downline inspection sites, etc.

A second tag reader is located at position 5. If a vehicle departs the Port of Entry with the tag still attached to the vehicle, the exit reader detects the tag and Local Intelligence is notified. Local Intelligence then sends a message to the Mail Server, where the appropriate notification is formulated and delivered.

Figure 3 illustrates a Radio Frequency (RF) out-of-service tag. The power supply loop is broken at the connector, the wire is fed through an opening on the power unit or a trailer unit of the vehicle, and then reattached. Actual dimensions of the RF out-of-service tag are 4 ¾” x 3 ¾ “ x 1 ¼” with a power supply loop approximately 24” long.

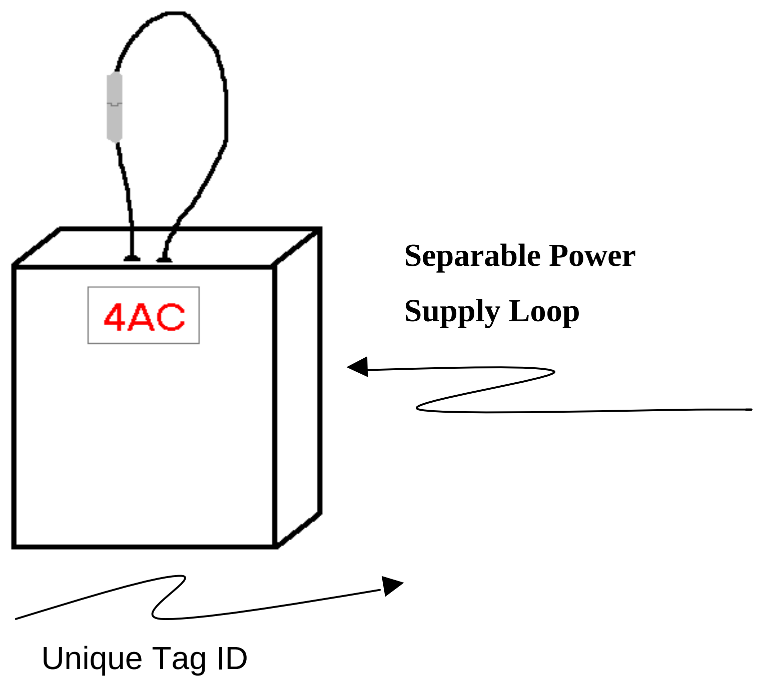

Figure 3. Radio frequency (RF) out-of-service tag

Figure 4 is a schematic of the circuit added to the Hughes AVI tag to produce the radio frequency (RF) out-of-service tag.

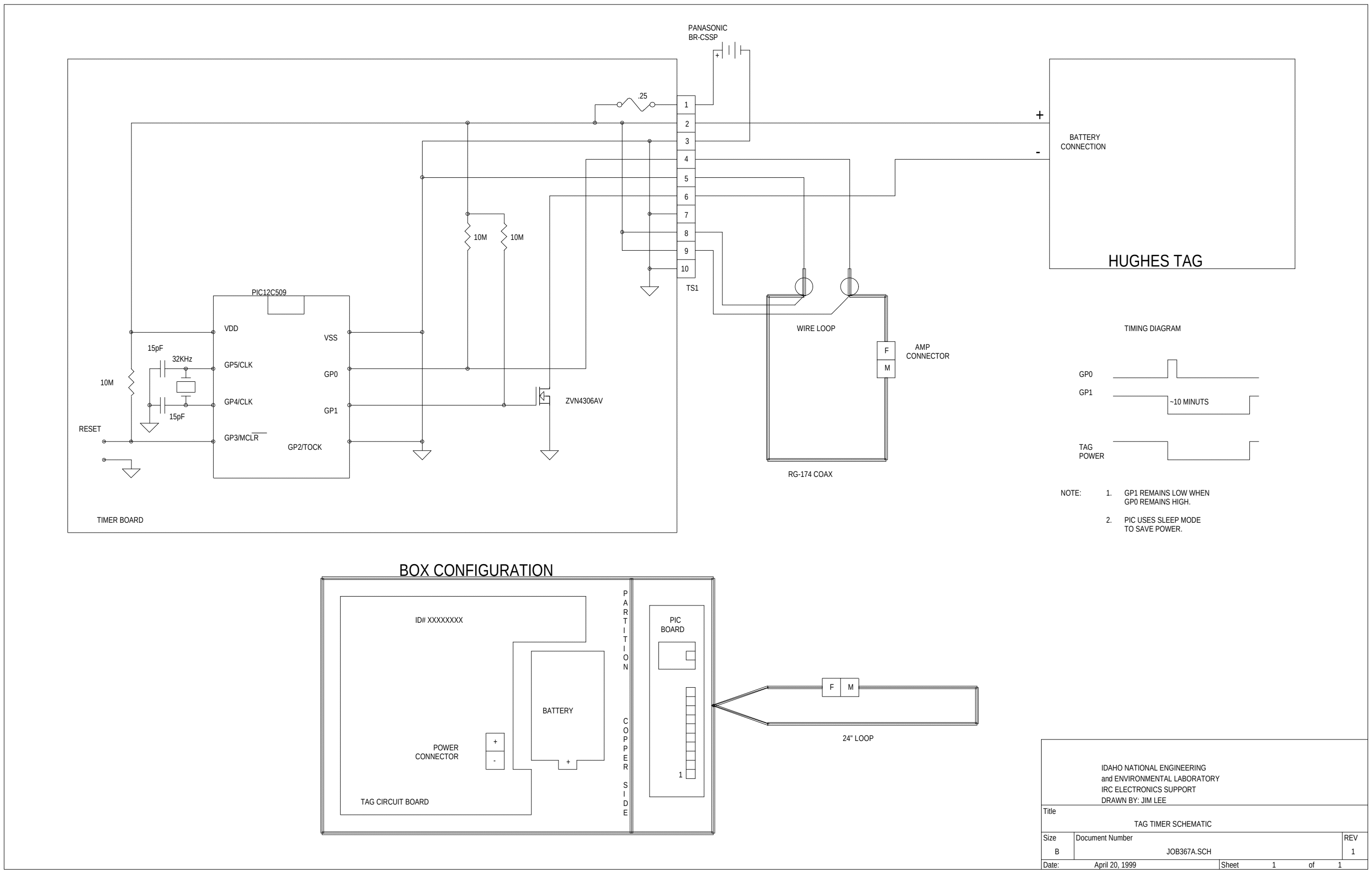

Figure 4. Schematic of circuit added to Hughes AVI tag

4.0 DEPLOYMENT AND TESTING

This section of the report describes the testing approach used to determine the system's effectiveness in monitoring commercial vehicles placed out-of-service, and to describe the results of that testing. The intent is to help determine the feasibility of deploying similar systems in other areas.

4.1 Field Evaluation Methodology

Data collection was conducted in two phases. The first phase was a series of simulated out-of-service orders designed to test all of the possible events that the system might normally expect to experience. The second phase was a field test of the system, using actual out-of-service inspection situations.

Simulation

This phase consisted of simulating out-of-service orders and the resulting monitoring activities that were envisioned if the system were actually deployed. The purpose of the simulation was to assess the system's ability to properly document the entire range of possible inputs and to understand the system's actual response to these inputs. The simulation was conducted on December 3 and 4, 1998.

Ten simulation cases were developed which encompassed all of the system events that could occur. A list of these cases is given in Table 2. While these cases did not attempt to account for anomalies, they did capture all of the normal sequences of events that the system was designed to monitor.

Table 2. Simulation test cases

Scenario Type	Case	Description
Time violations	I-1	the AVI tag is no longer readable during the time that the vehicle should remain parked in the port of entry lot
	I-2	the AVI tag is no longer readable after the out-of-service duration has elapsed and the system, through the inspector's report, has been asked to notify the inspector of any action
	I-3	the AVI tag is no longer readable after the out-of-service duration has elapsed and the system, through the inspector's report, has not been asked to notify the inspector of any action
	I-4	the AVI tag is read on the ramp leaving the Port of entry before the out-of-service duration has elapsed
	I-5	the AVI tag is read on the ramp leaving the Port of entry after the out-of-service duration has elapsed and the system, through the inspector's report, has been asked to notify the inspector of any action
	I-6	the AVI tag is read on the ramp leaving the Port of entry after the out-of-service duration has elapsed and the system, through the inspector's report, has not been asked to notify the inspector of any action
Non-time related violations	II-1	the AVI tag is no longer readable and the system, through the inspector's report, has been asked to notify the inspector of any action
	II-2	the AVI tag is no longer readable and the system, through the inspector's report, has not been asked to notify the inspector of any action
	II-3	the AVI tag is read on the ramp leaving the Port of entry and the system, through the inspector's report, has been asked to notify the inspector of any action
	II-4	the AVI tag is read on the ramp leaving the Port of entry and the system, through the inspector's report, has not been asked to notify the inspector of any action

Ten simulations were then conducted for eight of the cases and five simulations were conducted for the remaining two cases. During the simulations, the team generated fictitious inspection reports with a variety of violation types, submitted these reports to the system, activated AVI tags where the reader could detect them, and moved or deactivated the tags in accordance with the case being simulated. Once a simulated inspection report was entered into the system and an AVI tag was activated in the parking area, there were a limited number of events that the system could experience based on information in the inspection report.

When the system no longer detected a tag, it continued to attempt to read it for just less than ten minutes. After that time period the system logged an event that the tag was no longer present. This event was termed a tag “time out.” When the simulated violation required that the truck remain out-of-service for a specified duration (called a time-related violation), that information was included in the inspection report. From this, the system could determine whether the “time out” event was premature or not, and hence whether the driver was a runner or not.

A second antenna, or reader, for detecting the AVI tags was located at the ramp where trucks re-enter Interstate 84 eastbound. Another event that the system could detect and document was that of a tag being carried past this exit reader. This would happen if the driver neglected to remove the tag when leaving the out-of-service parking area and the POE.

The inspection report also contained a field for inspector notification. If the inspector marked “yes,” the system was supposed to send an e-mail message to the inspector when the tag timed out or was read at the exit reader. If the system sent this message it would also log that event in the same electronic file that the “early tag time out” and “tag detected at exit” events were logged.

The system sent e-mail messages to evaluation staff for each inspection report written, for each inspector notification sent and for each runner event. Monitoring the system during the simulation involved observation of the OOS Tracker program on the desktop computer in the inspection building, noting the status of faxed reports and reviewing e-mails sent by the system. The system also logged the results of the tag monitoring in several computer files. The inspection reports, the log files and the e-mails sent by the system were then analyzed to determine if the system responded properly.

The simulation was conducted with a high level of control over the inputs that the system received. These ranged from the details of inspection report submission to activation, movement, and deactivation of the AVI tags. By controlling these factors the evaluation team was able to anticipate all of the data that the system should store for each simulated out-of-service order. After the simulation was completed, the actual data collected was compared with the expected system response.

System Field Test

The system was then tested under actual commercial vehicle inspection circumstances between March 30 and April 10, 1999. Several ISP officers conducted and documented the inspections. The data from the inspection reports was entered into ASPEN by Corporal Jim Eavenson and submitted to the Local Intelligence computer. Some of the reports were submitted using the desktop computer that executed the Local Intelligence process as well as the OOS Tracker process, while others were submitted using a laptop computer provided by INEEL.

The laptop computer provided by IDLE was not used, as originally planned, because it was not a dedicated computer and interface difficulties arose. In addition to using the laptop for the out-of-service testing, ISP was also using it to connect to their network and conduct their online operations. ISP used the Windows 95 operating system, and the out-of-service project used Windows NT (which proved to be a more robust operating system for running the RF Ethernet components.) However, it is assumed that the evaluation of the INEEL dedicated laptop running Windows NT reflects a general assessment of a laptop computer configured and dedicated to the out-of-service system.

After the inspection report was submitted, the system allowed about ten minutes for the AVI tag to be activated before the tag would be identified as missing. In order to avoid premature tag time out due to a delay in activating the tag, tags were often placed on the vehicle prior to submission of the report to Local Intelligence. This modification to the process also allowed the inspector time to discuss the purpose and use of the tag with the driver.

After the tag was placed and the report submitted, the system was observed to verify that the tag was being read by the system. If monitoring did not begin, attempts to initiate monitoring usually included resubmitting the inspection report alone, or selecting an alternate AVI tag and resubmitting the inspection report.

The system was then allowed to run the course of monitoring and sending out messages, during which time data was stored by the Local Intelligence computer. These data were then analyzed to evaluate the effectiveness of the system. This analysis was done with a general assumption that the data logged by the Local Intelligence computer was correct. This assumption was substantiated by the results of the simulation.

During the test, the AVI tag reader that had been located at the ramp leading back onto eastbound I-84 was not active, due to issues discovered during the simulation regarding synchronization of the tag reader. There were no AVI tags unaccounted for at the end of the test period, indicating that the risk of tag loss is low.

During much of the test period, evaluation staff was on site to observe and collect data regarding system performance, actual events associated with the inspections, and driver reactions. In addition, during several out-of-service orders near the end of the test period, a video camera was used to record after-hours events at the out-of-service parking area.

4.2 Data Collection and Analysis

The simulation, which took place over the course of two days in December 1998, generated 90 out-of-service events. Some minor modifications to the system were made as a result of knowledge gained during the simulation. Field testing then took place over a two-week period in late March and early April. During this test, 38 out-of-service events were generated and monitored.

During both the simulation and the field test, data was collected by the system and by evaluation staff. This data consisted of the following:

- The evaluator's log file stored by the LI computer
- The ASPEN log file stored by ASPEN
- The OOS Tracker log file stored by OOS Tracker
- All of the original inspection reports
- Faxes sent by the system
- E-mails sent by the system
- Video tapes of the inspection area for the last four nights of the test
- Questionnaires and notes kept by Corporal Eavenson
- Documentation kept by evaluation personnel

The log files generated by the various software components of the system consisted of lines of data in text format that indicated any actions taken by the software. For instance, a line of data stored by Local Intelligence might document that tag monitoring had begun in association with a specific inspection report and AVI tag, and indicating the time and date that the action had been taken. The faxes and e-mails contained system action data, including the time and date of the action and a reformatted version of the inspection report.
The videotapes were time stamped and showed actual activities that occurred in the out-of-service parking area for the last four nights of the test period.

Questionnaires were developed after the simulation for use during the test to facilitate capturing the events during the test. These were then filled out during the test, primarily by Corporal Eavenson, who also kept detailed notes. Evaluation personnel, although not present during all of the test period, also kept notes that were useful during the analysis.

5.0 TECHNICAL PERFORMANCE ASSESSMENT

Assessment of the system consisted of applying the analysis to the data to answer several questions regarding the individual components and the overall system. These evaluation questions, or measures, and the results of the analysis are presented in Table 3.

Table 3. Technical performance assessment results

Laptop and Desktop Computers		
Measure 1	Percent of time laptop successfully transmitted report	81.3
Measure 2	Percent of time desktop successfully transmitted report	100.0
Measure 3	Percent of time laptop successfully received confirmation	12.5
Measure 4	Percent of time desktop successfully received confirmation	81.8
AVI Tags and Reader		
Measure 5	Percent of time AVI tag monitoring successfully started	86.3
Measure 6	Percent of monitoring starts that were successfully completed	77.1
Local Intelligence Computer		
Measure 7	Percentage of events logged correctly	98.5
Measure 8	Percent of instructions correctly sent from LI to messaging computer	98.7
Messaging Computer		
Measure 9	Percentage of OOS notification faxes successfully sent and received	100.0
Measure 10	Percentage of e-mail notifications correctly sent	99.0
Measure 11	Percent of carrier faxes correctly initiated	100.0
Out-of-Service Violation Runners		
Measure 12	Percent of OOS vehicles identified by the system as runners	50.0
Measure 13	Percent of total OOS vehicles identified as runners due to system limitations	13.2
Measure 14	Percent of total OOS vehicles identified as runners due to system deficiencies	31.6
Measure 15	Percent of identified runners verified as runners	5.3
Measure 16	Percent of runners apprehended	0.0
Overall System		
Measure 17	Percent of OOS orders monitored properly through entire process	13.5
Measure 18	Adjusted percent of OOS orders monitored properly (adjustment for laptop network settings and daylight savings time issues)	43.2

5.1 Evaluation of Technical Performance Results

The results of this analysis reflect the fact that the system was essentially a "beta" test version, and should not be expected to perform as fully developed, commercial-grade technology. The analysis shows that some components of the system worked well in their current form, while others need additional development. Assessment of the performance of the system overall is a measure of how frequently all of the components worked properly for an entire out-of-service order. Since an error by just one of the components during the process results in a failure for that record, the overall performance appears low. The variety of errors that can occur highlights the complexity of the analysis, which, in turn, challenged efforts to simplify the presentation of results.

Each of the components and several overall system measures are discussed below to provide an understanding of the numerical values representing system performance.

Measures 1-4: Laptop and Desktop

Initially, the concept for entering inspection data and submitting reports to the system identified laptop computers that could be used within individual ISP vehicles during the inspection. However, as stated earlier, these laptops were not working properly, due to interface difficulties between the network that ISP was using (Windows 95) and the network the OOS test used (Windows NT). Consequently, one dedicated laptop computer, running Windows NT, was substituted. This was provided by INEEL.

During the test, the task of entering data was shifted to the desktop computer in the inspection building. This was done primarily to avoid the difficulties being experienced with communication between the laptop and the Local Intelligence computer via the RF Ethernet. The results indicate that the reliability of communications was much higher with the desktop than the laptop (100 percent successful transmissions vs. 81.3 percent).

This communication consisted of both the transmission of the inspection report from either the laptop or the desktop to the Local Intelligence computer, and a confirmation message being transmitted back from this computer that the report had been received. In the case of the laptop, this was accomplished by a RF signal. For the desktop, this communication was addressed by the local area network at the POE facility. This was true even though the same desktop machine was used to send the report and to run the Local Intelligence process. Measures for these components therefore encompass both transmission and confirmation functions.

It is evident from these results that additional communication system design and development are necessary for this set of components. We believe these issues could be resolved through focused efforts to improve the RF Ethernet by which the laptop communicates with the Local Intelligence computer. This is fundamental to the original concept of submitting inspection reports from an inspection vehicle in the out-of-service parking area.

Measures 5-6: AVI Tags and Reader

The AVI tags are key components in that they form the direct link to the out-of-service vehicle. Potential factors in system failure include exposure to the elements and potential tampering. These factors apply to both the tags and reader. The entire range of these factors is difficult to anticipate.

Communication between the AVI tag and reader seemed to be the weak link in the overall system. The AVI tag monitoring was successfully started more than 85 percent of the time. Of these monitoring starts, 77 percent were successfully completed. Often, it was difficult to initiate monitoring of the AVI tag due to the system's inability to detect the tag. On other occasions the system began monitoring the tag as it was intended to do, but later lost the tag signal for no apparent reason. Many occasions of communication failure required re-sending the report or replacing the AVI tag.

The project did not have the time or resources to pursue the cause of this problem, but the failures could be due to one or more possible reasons: changes in the tag orientation (wind blowing the tag), low battery levels in the tag, signal blockage, or perhaps static electricity in the redesigned tag caused the power to turn on and arm the tag. Since the tag was not reconnected, it subsequently would have timed out. If static electricity were the cause, adjustment of the circuit would not be a significant issue. However, it is suggested that future projects investigate other RF tagging technologies designed specifically for this purpose.

While a second reader located adjacent to the port of entry exit ramp was used during the simulation, the test utilized only the main reader in the out-of-service parking area. None of the tags used for the test, however, were lost or stolen.

Measures 7-8 : Local Intelligence Computer (LI)

The desktop computer in the inspection building was used for a variety of tasks, including inspection report data entry, documenting system events, sending event information to the Messaging Computer, and running OOS Tracker. The evaluation of the effectiveness of the computer at all of these processes was done through analysis of the system events documented in the evaluator's log file. A high level of confidence in this log file information was established through the analysis of the simulation, as measures 7 and 8 show over 98 percent correctly logged events and correctly transmitted instructions. The data stored by the Local Intelligence process, in the form of the evaluator's log file, was used in conjunction with field notes to establish the basis for evaluating the remaining system components.

Measures 9-11: Messaging Computer

The messaging computer received instructions from the Local Intelligence computer, which it then sent on as a fax, an e-mail or both. This process was also very reliable, with nearly 100 percent successes. The system, of course, could not send faxes when no fax number was provided or if the number provided was erroneous. When the latter occurred, the system documented an attempt to send the fax. In either case, system performance was not penalized in the analysis.

Measures 12-16: Runner Notifications

The evaluation considered how the system handled out-of-service order runners overall. Measures 12 through 16 show the system's difficulties in identifying runners. The system is designed to compare the time that an AVI tag is lost with the time that the driver or truck was to remain parked. If the tag is lost early, the system should identify the truck associated with that tag as a runner. There are two types of events that account for the difference between vehicles that the system identifies as runners and those that actually are runners. These are system limitations and system deficiencies.

System Limitations

Five of the nineteen runner notices were the result of system limitations. These cases include three instances of tag removal due to the arrival of a second driver who could legally drive a vehicle for which the initial driver had been placed out-of-service. On one occasion a report was entered into the system, and subsequently the determination was made that the vehicle should not be out-of-service. This was the result of human error for which the correction procedure—removing the tag and releasing the driver—did not delete the lines of data already stored in the Local Intelligence computer file. The final case occurred when the inspector removed one vehicle from monitoring in order to accommodate a vehicle for which the out-of-service time period was much greater.

System Deficiencies

Another twelve of the nineteen identified runners were due to system deficiencies, or 31.6 percent of the total out-of-service vehicles. Five of these deficiencies are attributable to the fact that the computer did not adjust for daylight savings time. This is a simple problem that, once corrected, reduces Measure 14 from 31.6 percent to 18.4 percent. The remaining seven system deficiencies are cases where the system inappropriately identified a vehicle as a runner.

The remaining two runner notifications consist of cases where the system identified runners during the night. In the first case, the driver stated during a follow-up telephone conversation that he did not depart until after the out-of-service time had expired. The analysis assumes that the system is correct in this discrepancy. In the second case, the driver did, in fact, leave the monitoring area and the POE before the out-of-service time had expired, as verified by the videotape recording. This data constitutes the result for Measure 15. In neither of these cases was a runner apprehended, which accounts for the results for Measure 16.

Measures 17-18: Overall System Measures

The low rate of overall successful monitoring is due in part to two simple system issues that could have easily been corrected for the entire test. The first of these, as mentioned above, was the fact that the computer did not reset the internal clock with the change to daylight savings time. This created five additional false “runner” notifications. The second was a network setting in the laptop computer. This erroneous network setting is believed to account for twelve instances where the laptop did not receive a confirmation message from the Local Intelligence computer. Had these two issues been avoided the overall system performance, shown as Measure 17, would have been improved from 13.5 to 43.2 percent, shown as Measure 18.

5.2 Technical Performance Assessment Conclusions

Analysis of the data shows that the system as a whole was only moderately effective at monitoring out-of-service vehicles. A number of the errors contributing to this lack of effectiveness are not explainable, in that they occur within the internal system functions. The most significant problems encountered, however, were generally attributable to specific system components. For example, one of the AVI tags consistently presented problems in communicating with the reader and is therefore believed to be faulty. This problem, in addition to those already discussed, tends to reflect the immaturity of the system. It is important to note that the system is essentially a new application of a technology that was modified specifically for this test.

Evaluation of this system was complex, due to the number of opportunities for system failure. Minor complications at any phase in the inspection, communication or monitoring processes can result in system failure. The variety among these issues made classification of failures difficult. Furthermore, it is probable that the entire range of potential complications was not experienced during the evaluation.

Limitations of The Out-of-Service System Technology

The field evaluations point out several limitations of the system technology. These limitations are summarized below:

- The distance between RF tag and antenna is limited to a 150' maximum distance.
- The RF tags are moderately intolerant of improper orientation.
- Objects that obstruct the line-of-sight between the tag and antenna can and do block the signal, which can result in false notifications.
- The system cannot determine that a mechanical violation has been fixed.
- The system cannot determine whether a new driver is being used to replace an out-of-service driver.
- The system cannot determine that a vehicle is exiting the POE under "personal use" clause.
- The RF link between the Local Intelligence computer and laptops requires a line-of-sight between laptops and the POE scale house antenna for reliable communication.
- The Aspen system must be exited for the out-of-service system Aspen Monitor process to detect the new inspection report and transmit it.

Problem With This Out-of-Service System

In addition to system design flaws, there are several problems that were identified in the operation of the system:

- The inspector laptops require reconfiguration each time they are used for the out-of-service project at the POE.
- The Aspen/Aspen Monitor interaction results in unpredictable behavior of the inspector laptops.
- The Aspen/Aspen Monitor does not handle large numbers of inspections correctly, as evidenced by the invalid information placed in the state-defined out-of-service tag number field.

What this Out-of-Service System Can Do

The system does provide several important features for the out-of-service process:

- It can automatically send a fax copy of the inspection report to carriers when a vehicle or driver is placed out-of-service.
- It can notify anyone via e-mail or fax if any one of six events occurs.
- It can successfully monitor out-of-service vehicles with real violations.

Situations This System Cannot Monitor

During the course of the evaluation, several circumstances arose that could not be monitored by the system in its current configuration. These circumstances generally represent situations relating to time: when an out-of-service vehicle on which a tag has been placed can legally depart the monitoring area before the out-of-service time period has expired, or where no time period has been specified. These situations are described below.

- Second Driver Scenario: If a driver is placed out-of-service for a violation such as a false logbook, the truck can be legally driven away by some other qualified driver. This can happen if the carrier is local or has another truck coming by the port with a team of drivers. This situation did occur in three instances during the test. The system will detect this scenario as a runner event.

- Trailer Disconnect: The out-of-service order prohibits the driver from driving the truck for business, but does not dictate what he/she must do during the out-of-service duration. Legally, the driver can disconnect the trailer and drive the tractor for personal use and then come back later to continue with the load. If the AVI tag is placed on the tractor portion of the vehicle, the system will detect this scenario as a runner event.
- Mechanical Violation: If a truck is placed out-of-service for a mechanical violation, the order is in effect only until the defect on the truck has been repaired. In this situation, the inspection report does not indicate an out-of-service duration. The system cannot monitor this situation to determine if the violation has been satisfactorily resolved.

Situations That Can Generate False Runner Notifications

In addition, several issues can complicate the monitoring process in such a fashion as to generate false runner notifications. We believe these issues could be resolved through additional system development. They are listed below.

- Unintentional Disconnect: If the AVI tag is disconnected accidentally for any reason before the duration of the out-of-service order has expired, the system will likely detect a runner and send the associated notifications.
- AVI Tag Signal Blocked: A vehicle parked between the AVI tag and the reader can potentially block the signal. This can happen if, for instance, a repair vehicle is on site to fix a truck that has been placed out-of-service and parks next to the vehicle in such a fashion to block the signal. The system would likely detect this scenario as a runner event.
- Tag Orientation: The orientation of the AVI tag is critical in order for the reader to be able to read it. This can be a problem if the wind blows the tag into an undesirable orientation. If this happens and the reader quits reading the tag, the system will likely detect this scenario as a runner event.

6.0 SYSTEM COST

Since the original system configuration was not deployed, the following guidelines on system cost pertain only to the modified system. This system is more compact in many ways than the original system configuration, and therefore the cost of this system is greatly reduced.

Certain costs will be dependent on the installation location. These costs relate to the physical infrastructure of the installation and will be determined by factors such as electrical supply availability, the need to install mounting poles, availability of analog telephone lines, the availability of Ethernet connectivity, and whether physical barricades need to be placed to protect equipment. Electrical power requirements are not great, but the installation may require adding as many as two 120 volt 15 amp circuits. Mounting infrastructure may require the installation of two poles that allow antennas to be affixed at a height approximately 15 feet above ground level. The antennas represent only a small weight load, and therefore the poles may be of a light-duty type or antennas may be mounted on existing buildings if the locations are appropriate.

The system design allows for a certain amount of flexibility in the components that are required for installation. A minimal installation can be achieved with very few components. These components are a single personal computer, one vehicle to roadside communicator, RF Ethernet, and perhaps 50 out-of-service tags. The out-of-service tags may be used multiple times and therefore the cost of tags should be distributed over the number of expected uses. Summarized costs for the minimal system are provided in Table 4.

Table 4. Minimal system costs

Item	Cost
Personal Computer	$5,000
Vehicle to Roadside Communicator	$10,000
50 OOS tags	$6,000
RF Ethernet	$5,000
TOTAL	**$26,000**

A more full-featured system will contain a slightly larger number of system components, including additional computers, roadside communicators and modems. These components and their estimated cost are given in Table 5.

Table 5. Full-featured system costs

Item	Cost
Two Personal Computers	10,000
Two Vehicle to Roadside Communicators	20,000
50 OOS tags	6,000
RF Ethernet	5,000
RF Modems	7,000
TOTAL	**48,000**

The values given in Table 4 and Table 5 should be taken as general estimates, since they do not include installation and infrastructure costs. These costs will be highly variable, depending upon the specifics of the installation location. Lastly, it should be noted that the current state of the system is not a commercial-grade, turnkey system. In order for the system to be developed to that level, additional resources will be required. It is estimated that the amount of funding needed to bring the system to commercial grade is in the range of $100K - $200K, depending on operational requirements of the end product.

7.0 RECOMMENDATIONS AND LESSONS LEARNED

Most large and technologically challenging projects are a rich source of lessons learned. The Idaho Out-of-Service Operational Test is no exception. It is the intent of this section to discuss lessons learned from the Idaho Out-of-Service Operational Test with the objective of helping future projects.

While there is overlap among the lessons learned, it is possible to break them into three categories. These three categories are planning, component failure, and system design and development.

7.1 Planning

Significant amounts of planning effort went into the project, and this planning produced a logical flow of planned events leading to project conclusion. Problems arose in spite of this planning. These problems were the result of not deferring to the plan when unexpected events occurred and from the scope of the planning not being broad enough.

Initial planning should be conducted during the proposal stage, so that once the proposal is submitted, project participants believe with reasonable certainty that the project being proposed is achievable. This level of planning is often made very difficult by short turnaround times required for proposal submissions, and it can be especially difficult where partners have no previous working relationship. Some of the questions that should be addressed during the proposal development process are:

- What are the technological and institutional requirements that are being addressed by the project?
- What are the risk factors associated with each technological component?
- What is the probability of successful implementation of each technological component and of the integrated system?

- Are there institutional issues that may impact the use of specific technologies, either positively or negatively?
- If a "risky" technology is being proposed as part of the system, is there a contingency plan for addressing a possible failure of that component?

Candid answers to the above questions during the proposal process will help to establish a solid foundation for project execution. At this stage of the planning each partner must also realize that a long-term sustained effort may be required. Commitment to this effort should be affirmed through an Memorandum of Understanding or similar mechanism.

Once funding is received, the first step of the project should be the development of a Project Management Plan. This document should be a natural progression of the proposal and the thinking that went into the proposal development. A very detailed Project Management Plan was developed for the Idaho Out-of-Service Operational Test, and this document was used for developing contracts with project partners. The weakness of the plan was that it was essentially developed by a single project partner rather than a focused team of individuals representing each project partner. As a result of this approach, each partner did not assume the level of ownership necessary for executing the plan. This experience has led us to advocate a different strategy for development of the Project Management Plan. The steps provided below define the strategy.

Step One: One project partner outlines a plan for project execution that takes the level of detail developed for the proposal to the next level.

Step Two: Representatives of each partner convene for facilitated sessions to establish more and more detail until the resolution of the tasks for the project are of a maximum duration of a week.

Step Three: This detailed set of tasks and milestones is developed into the full Project Management Plan that further describes each task and milestone and the consequences of failing to accomplish the tasks and meet milestones.

Step Four: Each partner's tasks and milestones are used to develop contracts for project execution.

Step four above is critical to the success of the project. This step will provide the project partners with the necessary tool to maintain project momentum. For example, economic disincentives may be used for missed milestones or deliverables, while incentives can be used for exceeding expectations.

7.2 Component Failure

The observations and suggestions given above are the outgrowth of a significant challenge faced by the project. This challenge was the failure of the video identification technology that was the responsibility of a single project partner. Failure of the component ultimately led to the withdrawal of the partner from the project. This withdrawal was made possible by the fact that tasks taken from the Project Management Plan were included in the contract agreement. It is unfortunate, however, that the withdrawal did not occur sooner in the project. A more detailed set of tasks and milestones would have made this withdrawal more timely and allowed for the possibility of including a different partner capable of supplying video technology.

There were a number of warning signs early in the project that indicated that the partner was not as committed to the project as required for successful completion. These warning signs were:

- Multiple personnel changes
- Lack of commitment to the Project Management Plan
- Inability to make a shift in thinking from that of a vendor to that of a project partner
- Missing the first significant milestone, by delivery of a nonfunctional system six weeks behind schedule

Future ITS partnerships should take specific note of items one and four, since the last item is essentially a natural consequence of multiple personnel changes. The project partner should have been removed from the project at that point. Making the change at this early juncture would have preserved significant levels of funding in the budgets of the remaining partners. This condition would have allowed for the inclusion of a new partner. However, allowing the partner to remain in the project after this time created significant spending inefficiencies in the budgets of the other partners.

The partner responsible for the video technology was the only project partner that represented the private sector, while the remaining partners represented either the state or the federal government. Since the private partner was accustomed to thinking in terms of being a vendor, and the remaining partners were more accustomed to thinking of themselves as part of a larger system, a difference in perspectives developed. Not addressing this issue can create an operating environment where private partners operate as if they are outside the partnership; manifesting itself as a lack of commitment to the project.

The lesson here is that public entities in public/private partnerships need to understand this difference in viewpoint and develop strategies to overcome it, in order to realize the full benefit of the partnership. An important issue for public sector participants to understand about private sector participants is how projects are prioritized. Typically, in the private sector, projects are prioritized based upon how large an impact the project will have on the company's revenue stream. What may seem like a significant amount of funding to the public sector may be viewed by a private sector company as a low priority, behind projects with much higher dollar values.

7.3 System Design and Development

Many of the lessons learned from system design and development overlap with lessons learned for planning. These lessons, however, are important enough to command special attention.

Involve End Users

It is clear that the group that will ultimately use the system should be part of the planning, system design, and development of the system. This group should be part of a feedback loop throughout the life of the project. Although this seems obvious, technical difficulties with the original video system precluded this degree of involvement. Much of the project's time and resources were spent developing the modified system configuration, so that by the time the system was up and running and the end users were brought in to test and operate the system, the project was nearing completion. Participation was also made more difficult by geography, in that partners were not collocated. This problem can be overcome, but it needs to be recognized at project inception and mechanisms must be put in place to overcome it.

Identify Legacy Systems

Another lesson learned is the importance of understanding legacy systems and the impacts they will have on system design, development, and use. While legacy systems such as Aspen, SafetyNet, and the MCSAP inspection laptops were not directly part of the system development, their impacts were significant. It is suggested that, during the proposal stage of a project, all legacy systems be identified, so that costs of working with these systems can be accurately identified and incorporated in the proposal. During the planning stage, representatives for these legacy systems should become part of the project as much as possible, so that newly developed systems can interface seamlessly with existing systems. Once the project is underway, it is important that owners of legacy systems continue to cooperate with the project team, so that the end product meets a broader set of needs and that project development efforts are not negatively impacted by changes in legacy systems.

The above considerations are even more important with projects of long duration or where schedules become protracted. Because of the difficulties encountered during this project, the schedule lengthened considerably. The lengthened schedule allowed legacy systems to change, which created the need for system redevelopment. This redevelopment could have had a lesser impact if greater coordination between the owners of legacy systems and the project had been incorporated in the project from the beginning.

8.0 CONCLUSIONS

The Idaho Out-of-Service Verification Field Operational Test was initiated to test the feasibility of a video-based identification system to keep out-of-service vehicles and drivers off the highway until the violations causing the out-of-service order were resolved. Problems with the key technology component, the video identification system, delayed the deployment of the system for over two years and forced a significant scaling back of the capabilities of the system.

Despite, or maybe because of, these problems, there are several important lessons learned and conclusions that can be drawn from this experience:

- The project planning process must include a more thorough assessment of the key technologies that are included in the system design, particularly when these technologies are new and unproven in the application being considered. As a result of this experience, the project team recommends a change in the way in which project management plans are developed.
- The failure of the key technology component did not happen suddenly, but over time, with warning signs that should have been seen more clearly by the project partners. The video identification system was delivered late and was never functional. Repeated attempts to fix the system failed. Further, the video team underwent a number of personnel changes, indicating the lack of seriousness with which Hughes took this project. Hughes' perception of itself as a vendor and not a full team member resulted in the lack of commitment so clearly needed for this project to be a success.
- Though technical difficulties with the original video system precluded a high level of end user involvement in this project, it is clear that end users of a verification system should be involved from the very beginning of the project, through the planning, system design, and development of the system. They should be a part of a feedback loop throughout the life of the project.

- It is critical to understand how a new project will affect legacy systems already in operation. While systems such as Aspen, SafetyNet, and the MCSAP inspection laptops were not directly part of the system development, the impact of these systems was significant. More coordination between an OOS project team and the team developing ASPEN and other software tools would reduce the problems encountered by inspectors using a merged set of software packages.
- This limited test system showed great promise, but it performed more like a beta-version than a completed system. Additional development may resolve the technical problems so that some of the components can be used in other out-of-service verification systems.
- The failure of the original video vehicle identification system showed the benefits of having a flexible, network-based open architecture. System designs should be capable of using alternative sensors and approaches.
- There is considerable interest in the capability of automated notifications of OOS violations and status. This system as a whole was moderately effective at monitoring out-of-service vehicles, and it did provide direct fax and email notification to trucking companies and agencies responsible for monitoring out-of-service vehicles. Further development of this capability should be included in future projects.