Oregon Green Light

CVO Evaluation

FINAL REPORT

DETAILED TEST PLANS 2 and 3

Evaluation of the Road Weather Information System (RWIS)

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This project was funded by the Oregon Department of Transportation (ODOT) as a requirement for an Independent Evaluation through their ITS Partnership Agreement with the Federal Highway Administration to deploy a mainline preclearance system in the state of Oregon. The project was of five years duration, and, was administered by ODOT's Motor Carrier Transportation Division. Oregon State University (OSU) Transportation Research Institute was the prime contractor for the independent evaluation, with Chris Bell as the principal investigator. The Center for Transportation Research and Education (CTRE) at Iowa State University was a sub-contractor to OSU, with Bill McCall as the principal investigator. Michael C. Walton of WHM Transportation Engineering served as a consultant for several aspects of the evaluation.

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TABLE OF CONTENTS

TABLE OF FIGURES

1 DETAILED TEST INTRODUCTION

1.1 BACKGROUND

This Detailed Test Report is the second of 8 reports submitted as part of the independent technical evaluation of the Oregon Green Light CVO project. The Oregon Department of Transportation (ODOT) is near completion of the implementation of their Intelligent Vehicle Highway System Strategic Plan for Commercial Vehicle Operations (now referred to as ITS/CVO). Through Green Light, Oregon is installing twenty-one mainline preclearance systems featuring weigh-in-motion (WIM) devices and automatic vehicle identification (AVI) at the major weigh stations and ports-of-entry throughout the state. In addition, certain sites have been equipped with safety enhancements that regulate road conditions and speed. Examples are the Downhill Speed Information System at Emigrant Hill, and the installation of weather stations at three location across the state.

This report is to present the results of Detailed Test Plan (DTP) #2. There will be similar reports for all other Detailed Test Plans developed for the Green Light Evaluation. The Detailed Test Plans were published in 1997, Oregon "Green Light" CVO Evaluation-Detailed Test Plans [1]. Earlier documents providing essential background to the Evaluation are the Evaluation Plan [2], and , Individual Test Plans (ITP) [3].

Each of the tests conducted by the research team for the evaluation of Green Light addressed one of five goals of the evaluation as documented in the Evaluation Plan. These are:

- Assessment of Safety
- Assessment of Productivity
- Assessment of User Acceptance

- Assessment of Mainstreaming Issues
- Assessment of Non-Technical Interoperability Issues

The objectives associated with each goal are given in detail in the Individual Test Plans [3]. In addition, condensed one-page tables are contained in the appendices of the ITP, outlining the measures to be conducted for each of the stated objectives. The detailed test plan documents expand on the information provided in the ITP and provide in detail the activities planned for each *evaluation measure* during the course of the evaluation in regards to the stated objectives.

1.2 PURPOSE AND SCOPE

This report presents the results of two test measures employed to determine what effects Green Light has had on commercial motor vehicle safety due to the installation of the Road Weather Information System (RWIS).

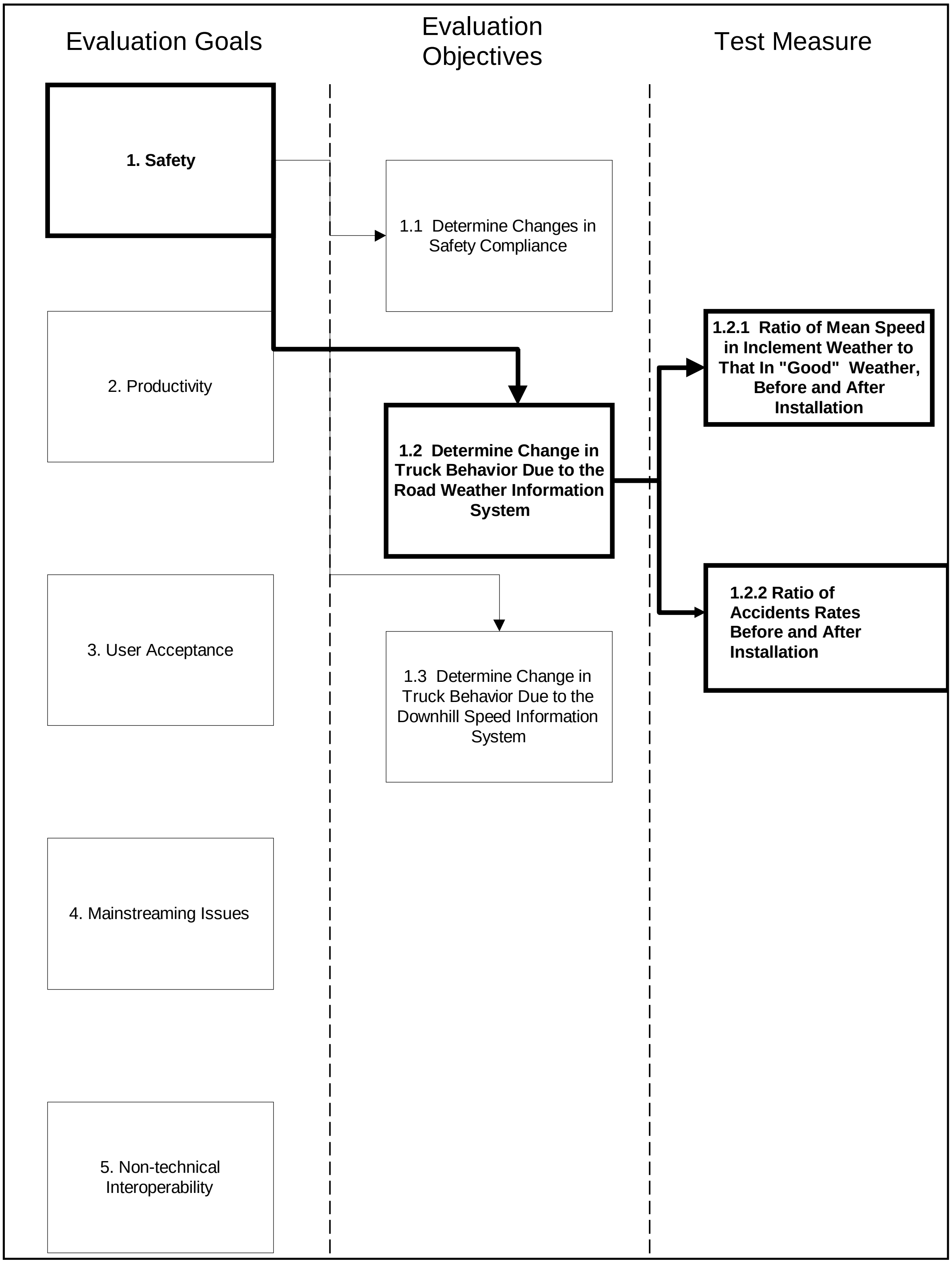
The evaluation measures used to determine change in safety compliance due to RWIS are stated below:

Measure 1.2.1 Ratio of mean speeds in inclement weather to that in “good” weather, before and after installation of Road Weather Information System

Measure 1.2.2 Ratio of accidents before and after installation of the Road Weather Information System

A detailed description of the hypothesis to be tested as well as the test methodology and deliverables is described in detail in Chapter 2. Chapter 3 provides results of the test, while conclusions and recommendations can be found in Chapter 4. The scope of this detailed test plan within the context of the overall Green Light Evaluation is shown in Figure 1-1. The test measures outlined in this document are highlighted for reference.

Figure 1-1 Evaluation Goals, Objectives, and Measures



1.3

1.3 DISCUSSION

Currently, most highway agencies rely on regional forecasts supplied by the National Weather Service for operation planning with regards to snow and ice control and travel advisories. In an effort to collect more timely data with accurate shot-term predictions of snowfall or icing on a small stretch of highway or county road, Road Weather Information Systems are currently being used primarily by maintenance crews as an aid in reducing costs for snow and ice control. The information has been shown to reduce the costs of winter maintenance by as much as 10% [4]. Recently, these systems have been incorporated into intelligent transportation systems (ITS) as a means of aiding vehicle operators.

In general, the technologies incorporated into an RWIS include a combination of pavement sensors, subgrade sensors, meteorological sensors, roadway thermography, pavement and weather forecasts, and communication hardware such as variable message signs (VMS) or computer monitors for the dissemination of information. The system configuration is typically one or more remote weather stations and/or pavement sensors each with its own on-site computer or remote processing unit (RPU). A central processing unit (CPU) polls each of the RPUs and creates a database for output. A description of the weather systems slated for construction under Green Light is given in the report “The Green Light CVO Project-Phase 1, Road Weather Information Services Scope of Work [5]. A progress report from January 1997 appends the “Scope of Work” document and provides recent changes including the proposal for an additional RWIS at Siskiyou Summit [6].

Remote processing units will be installed in three locations under the auspices of Green Light. These locations are identified in Figure 1-2. Several other RPU locations are being upgraded to create a statewide weather information database that can provide information to motorists via the Traffic Management Operations Center (TMOC) in Portland, through message signs located around the state. Future expansion called for disseminating the information to motorists through information kiosks, and on the Internet.

Initially, the research team focused evaluation efforts on the Ladd Canyon installation on I-84 east of LaGrande. The Ladd Canyon RWIS is located near the center of the canyon adjacent to the existing rest areas at approximately milepost (MP) 270. A single remote processing unit was installed at this location for integration with existing variable message signs at either side of the canyon. Currently, the signs are manually activated via computer and modem to deliver weather warnings to passing traffic. Existing signs are located at MP 263 westbound (WB) at the North Powder exit and at MP 286 eastbound (EB) just south of LaGrande. Each of these signs were installed because of the dangerous conditions that develop in the microclimates of Ladd Canyon, namely high winds, drifting snow and poor visibility. The canyon is frequently closed to mobile home use during winter months.

Figure 1-2 Green Light RWIS Locations

- Green Light RWIS Locations

2 TEST METHODOLOGY

Two separate tests were developed for the evaluation of the Ladd Canyon RWIS System. One, the RWIS Speed Study, was to examine the change in truck vehicle speeds as various messages were transmitted to oncoming drivers through a variable message sign installed at either end of the canyon. The second test, the RWIS Accident Study, was a cursory examination of accident data before and after the RWIS installation in the area of Ladd Canyon.

2.1 RWIS SPEED STUDY

This section discusses in detail the work conducted in the evaluation of the Ladd Canyon RWIS system on I-84 east of La Grande. Because of changes in the configuration of the RWIS and how it was incorporated into ODOT's existing weather information system, the evaluation did not take place as outlined in the DTP. In lieu of the original plan of networking the RPU's and servers with variable message signs that can give real time feedback to passing trucks, the Green Light installations were incorporated into the development of a state-wide weather database. The database was intended to provide the latest weather observations to all motorists via the INTERNET as part of ODOT's Tripcheck, a web-based travel information site (www.tripcheck.com).

This test was initially designed to focus on the collection and analysis of message sign logs and vehicle speed data under a variety of climatic conditions in order to determine the effectiveness of the RWIS system in controlling driver behavior. Of primary concern are what effects the existing variable message signs in Ladd Canyon have on vehicle speeds, and how that impact will change once the RWIS has been deployed. The test is a before/after study in which comparisons will be made between similar data sets collected before and after the system is installed.

The following hypothesis is given in support of the test measure and will be tested according to accepted statistical techniques:

1.2.1 Vehicle speeds will decrease after the installation of RWIS message boards in inclement weather.

2.1.1 Pre-test Activities

Pre-test activities for this measure focused on the sources, quality and availability of data, developing a time frame for establishing benchmarks, and determining site locations. Accomplishments of the activity undertaken by OSU as part of the pre-test activities is summarized in Figure 2-1.

Figure 2-1 Pre-Test Activities RWISA Speed Study

Work Planned	Work Accomplished
Identification of Data Sources and Availability	• Samples of speed records were collected by existing weigh-in-motion (WIM) loops in Ladd Canyon • WIM data samples were output using the REPORTER software package for input into EXCEL spreadsheets to develop data collection procedures. • Records of displayed messages appearing on the VMSs in Ladd Canyon were collected from ODOT district offices in La Grande. • Samples of activity logs of construction activities were collected from ODOT district offices in La Grande. • Sources for daily records of pavement conditions in Ladd Canyon were reviewed. These are provided via the existing Ladd Canyon weather station, and are available for download via the Internet. • OSU collected a base set of data in January 1997 by radar gun in Ladd Canyon. The data was to be used to supplement speed data collected by the WIM.
Determination of Benchmark Timeframe	• WIM speed data is available from 1991 and was collected over the course of the study period by ODOT. • VMS logs are available from 1992 and will continue to be collected by ODOT over the course of the study. Records for calendar year 1994 up until the RWIS installation in 1997 is deemed sufficient for benchmark data.

2.1.2 Test Conduct Activities

Test conduct activities and accomplishments are summarized below in Figure 2-2.

Figure 2-2 Test Conduct Activities RWIS Speed Study

Work Planned	Work Accomplished
1. Collection and Analysis of WIM Data	
1a) Collect all available WIM data for the years 1994 up to the time of installation	• Baseline data was collected from May 1994 through 1996. • A second piezo sensor was installed on the east bound passing lane over the summer of 1997.
1b) Process the daily binary files using REPORTER	• Data collected through 1996 was processed.
1c) Import the data into Excel Spreadsheets	• not completed
2. Collection and Analysis of VMS Message Logs	
2a) Collect VMS message logs	• Message Logs were collected from 1994 through 1996.
2b) Correlate VMS logs with WIM data in EXCEL	• not completed
3. Collection and Analysis of Construction Activity Logs	
3a) Collect construction logs	• not completed
3b) Correlate construction logs with WIM data in EXCEL	• not completed
4. Collection of ODOT Road Reports	
4a) Collect ODOT Road Reports	• not completed
4b) Correlate road conditions with WIM data in EXCEL	• not completed
5. Collection of new speed data (spot speed surveys)	
5a) Acquire vehicle and radar gun	• A speed gun was acquired for ODOT regional office in LaGrande to be used throughout the evaluation
5b) Determine when to collect data	• A schedule was developed, collecting data three times per year beginning in January 1997.
5c) Conduct the spot speed survey	• The first spot survey was completed in January of 1997.
5d) Compile data using SPEEDZONE	• January 97 speed survey was compiled
5e) Import the data into EXCEL spreadsheets	• not completed
6. Collection of Data after Installation	
	• not completed

2.2 RWIS ACCIDENT STUDY

This test was initially designed to present truck crash data occurring in the vicinity of Ladd Canyon. The test was intended to measure what effects weather patterns and road conditions have had on truck crashes, and how that impact will change once the RWIS had been deployed with messages to passing truck drivers about road conditions in Ladd Canyon. The test was designed as a before/after study in which comparisons will be made between similar data sets before and after the RWIS is installed.

The following hypothesis is given in support of the measure and will be tested according to accepted statistical techniques:

> **1.2.1 Accidents in the vicinity of the RWIS system will decrease as timely information on road conditions is provided to motorists.**

2.2.1 Pre-test Activities

Pre-test activities for this measure will focus on the sources, quality and availability of accident data, developing a time frame for establishing benchmarks, and determining site locations. Accomplishments of the activity undertaken by OSU as part of the pre-test activities is summarized in Figure 2-3.

Figure 2-3 Pre-Test Activities RWIS Accident Study

Work Planned	Work Accomplished
1) Data Sources and Availability	Potential data sources were identified as: • Oregon DOT's accident records database • Records of displayed messages appearing on the VMSs in Ladd Canyon • Activity logs of construction activities during the study period • Daily records of pavement conditions Samples of the data sources were collected
2) Determination of Benchmark Timeframe	• Completed • Available accident data for 1994 through deployment will be compared with data collected after deployment of RWIS.

2.2.2 Test Conduct Activities

Below is a summary of the work planned and accomplishments achieved according to the original DTP.

Figure 2-4 Test Conduct Activities RWIS Accident Study

1) Collection and Analysis of Accident Data	
1a) Collect all recorded accidents between milepost 263 and 286 up to RWIS installation	• Completed
1b) Tabulate accident data into EXCEL spreadsheets	• Not completed, results in next draft
1c) Calculate the accident rate for the section of highway in question	• Not completed, results in next draft
2) Collection and Analysis of VMS Message Logs	
2a) Collect VMS Logs	• Not completed, no results presented
2b) Correlate VMS logs with WIM data in EXCEL	• Not completed, no results presented
3) Collection and Analysis of Construction Activity Logs	
3a) Collect construction logs	• Not completed, no results presented
3b) Correlate construction logs w/ accident data	• Not completed, no results presented
4) Collection of ODOT Road Reports	
4a) Collect ODOT Road Reports	• Not completed, no results presented
4b) Correlate road conditions with accident data in EXCEL	• Not completed, no results presented

3 RESULTS OF EVALUATION

3.1 RWIS Speed Study

The installation of the RWIS equipment provided through Green Light was completed in August of 1997 at Ladd Canyon, Siskiyou Summit and at Celio on the Columbia Gorge. This included RPUs, inroad sensors, and servers to collect and disseminate the data. At this time OSU had been collecting speed and VMS data for nearly a year for the evaluation of the Ladd Canyon installation. There was still a degree of uncertainty as to whether the new equipment would be compatible with the software used to deliver messages to the existing VMS in Ladd Canyon, and other technologies were being considered.

ODOT continued to test the interface of the existing signs in Ladd Canyon. The interface to the VMS was developed by Vultron, and was the same system that provided output of the signs display for the evaluation. The software was written using 16-bit code, and was in effect, incompatible with the 32-bit architecture of the NT systems used to collect data fro the RPU's. This made it impossible for the signs to be automatically interfaced with the sensor data coming from the RWIS. The prices of variable message signs were prohibitive in cost ($250,000+) for the scope of the project.

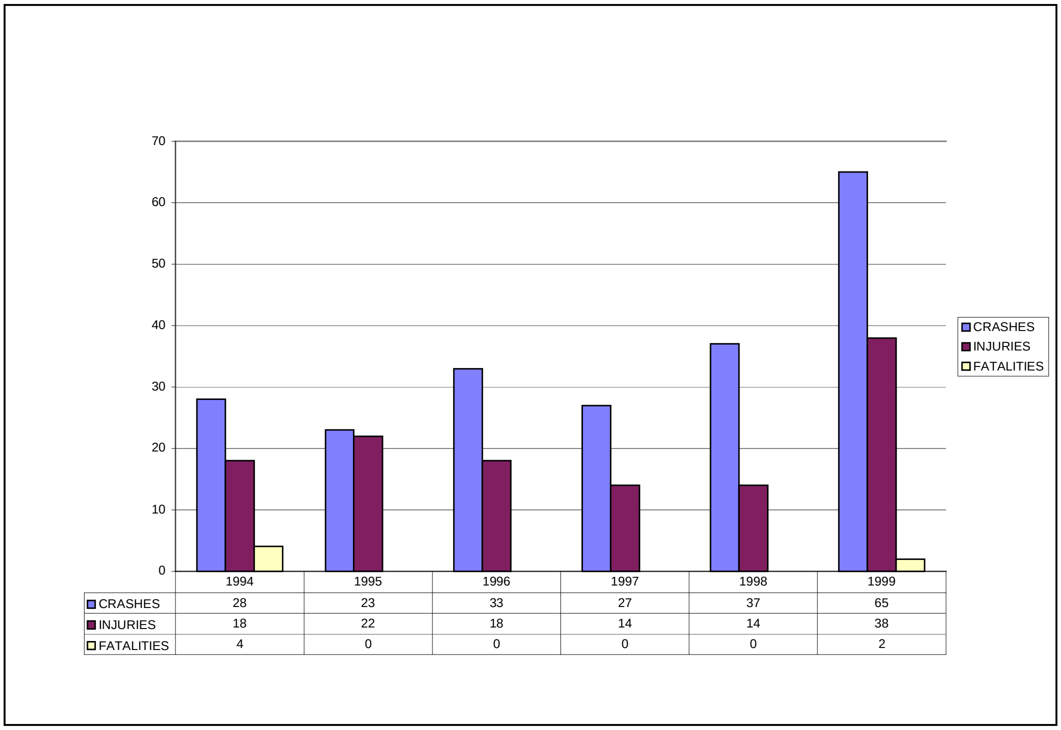
By 1998, after much testing the idea of interfacing with the existing VMS in North Powder and La Grande, a decision was made by ODOT to move towards the idea of integrating the Green Light RWIS technology with ODOTs plan for a travel advisory network via the Internet. Included in this was consideration of kiosks at truck stops and/or rest areas for dissemination of real time information to truck drivers about road conditions. Subsequently, efforts to interface the RWIS with the VMS were not pursued. At that point the process of "pre-data" collection was postponed.

3.2 RWIS Accident Study

The original intent of this evaluation was to examine changes in driver behavior as a result of the installation of the RWIS in Ladd Canyon focusing on its ability to relay real-time road conditions to motorists approaching the canyon. ODOT had existing VMS signs on either side of the canyon to relay the road conditions reported by the system. The intended result was to show decreases in accident rates over time. With the decision to incorporate the RWIS into a statewide database, the ability to pinpoint the effects of the RWIS system on crash events was difficult to do with any real precision. Accidents are very rare events, and with the loss of control over the messages being relayed to passing motorists, the evaluation was altered to a presentation of cursory accident statistics in the study area.

Figure 3-1 illustrates the results of available crash data in the Ladd Canyon corridor on Interstate 84.

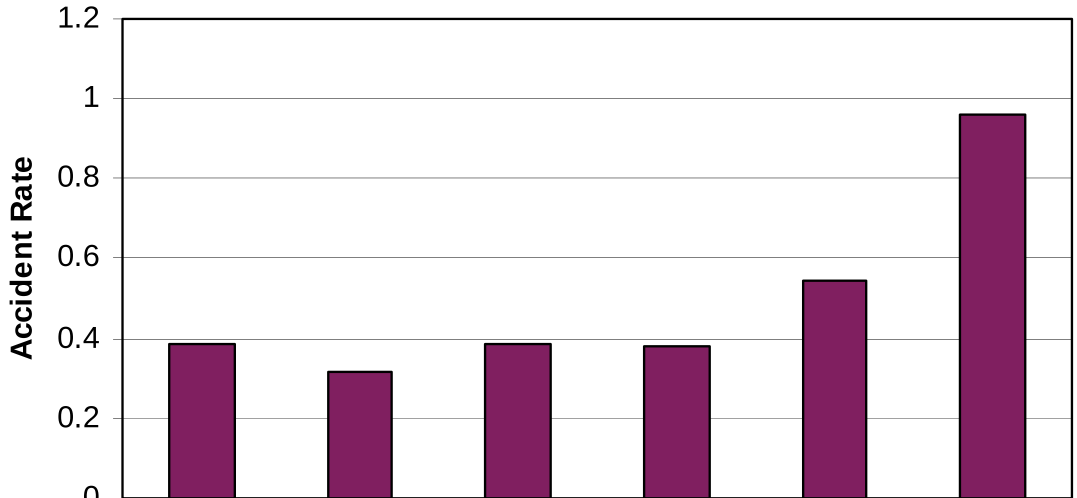
Figure 3-1 Vehicular Crashes in Ladd Canyon 1994-1999



This data represents *all crashes* in the corridor, including both automobiles and commercial motor vehicle traffic. There has been a steady upward trend in the number of crashes over the course of the study period, with the exception of 1997. The reasons for changes in the numbers of crashes reported in Ladd Canyon vary for a number of reasons. One reason is that significant changes have been made in the accident reporting procedure over the course of the study period. Accidents are more likely to be reported now that more stringent guidelines have been adopted by the state of Oregon. In addition, traffic has increased significantly on Oregon's interstates.

Figure 3-2 shows accident rate figures over the course of the study period.

Figure 3-2 Ladd Canyon Accident Rates 1994-1999



1994	1995	1996	1997	1998	1999
0.386	0.319	0.384	0.378	0.547	0.96

Accident rates adjust crash figures to take into account the increases in average daily traffic in the study area. Accidents rose sharply during the course of 1999 as compared to previous years. The majority of these accidents took place under adverse conditions as shown in Figure 3-3.

Figure 3-3 Accidents By Road Condition Ladd Canyon 1994-1999

ROAD CONDITIONS	1994	1995	1996	1997	1998	1999
DRY	5	8	15	11	13	19
ICY	19	10	14	10	14	43
SNOW	2	3	1	1	1	1
OTHER/UNKNOWN	0	0	0	2	1	0
WET	2	2	3	3	8	2
TOTAL	28	23	33	27	37	65

4 CONCLUSIONS AND RECOMMENDATIONS

ODOT's travel advisory web page has undergone several upgrades in recent months. In January of 2000, a test version of TripCheck was launched, a high powered web interface that brings together several mediums of information for travelers. Information from the Green Light RWIS sensors are combined with 13 other weather stations across the state to provide timely weather and road conditions to motorists. In addition, TripCheck offers general information such as a listing of construction projects that could pose delays, public transportation services and schedules, rest area locations, and scenic byways.

The RWIS installations were successful in meeting the goal of adding additional realtime weather data for public use through the Traffic Management Operations Center in Portland. The server installations in La Grande, The Dalles and Ashland relay the information quickly and efficiently, enhancing the existing infrastructure used to provide weather conditions in these three areas known for their high occurrence of truck crashes.

The interface with truck traffic through the use of variable message signs was never accomplished due to the incompatibility of the existing hardware interfacing with the signs in Ladd Canyon. That, combined with the prohibitive costs of retrofitting signs with compatible hardware and/or purchasing new signs led to an incomplete evaluation of the motor carriers adjusting speed to adverse weather conditions.

Detailed test plan #11, the Motor Carrier Survey, provides additional insight into how motor carriers feel about the RWIS system as intended by ODOT. The survey found that 60% of carriers agree that RWIS would benefit their company (14% disagree and 26% have no opinion).

Recommendations for future work would be to pursue the dissemination of real time data to the roadside, rather than solely through the Internet. With the advent of wireless data communications, the idea of trucks equipped with palmtop computers that can query road conditions via the Internet, is available. On the other hand, it is technology that is far from mainstream. Providing information kiosks at rest areas truck stops, and weigh stations, is technology that can be incorporated into ODOT's existing infrastructure without a great deal of capital expense, and would reach all carriers, regardless of their technological advancements.

Accident and speed data collected in the Ladd Canyon area over the course of this study is useful in providing a baseline for determining the effects of RWIS technology as it relates to truck safety. It is strongly recommended that ODOT continue to collect and analyze truck crashes and their causes in relation to weather to help determine the effects RWIS is having on truck safety. Speed data, where available , can also be useful in providing relationships in those areas where RWIS is deployed with a feedback mechanism, such as a variable message sign. If ever ODOT integrates real time feedback to truck drivers about road conditions, the collection and analysis of speed data can provide insight into how the technology is altering truck behavior.

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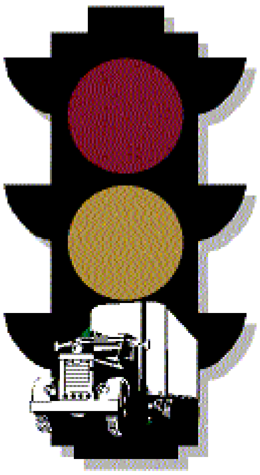

Oregon Green Light

CVO Evaluation

DRAFT FINAL REPORT

DETAILED TEST PLANS 4 and 5

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DISCLAIMER

TABLE OF CONTENTS

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The purpose of this report is to present the results of Detailed Test Plan (DTP) #4. There will be similar reports for all other Detailed Test Plans developed for the Green Light Evaluation. The Detailed Test Plans were published in 1997, Oregon "Green Light" CVO Evaluation-Detailed Test Plans [1]. Earlier documents providing essential background to the Evaluation are the Evaluation Plan [2], and , Individual Test Plans (ITP) [3].

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1.2 PURPOSE AND SCOPE

This report presents the results of three test measures employed to determine what effects Green Light has had on commercial motor vehicle *safety* due to the installation of the Downhill Information System (DSIS). The analysis concerns changes in speed of truck traffic descending Emigrant Hill westbound under a variety of scenarios. An analysis of accident data before and after the installation of the DSIS system (Measure 1.3.2) completes the evaluation of the Emigrant Hill DSIS.

The evaluation measures for this particular test plan are stated below:

1.3.1 Comparison of the mean speed of ODOT-transponder-equipped vehicles when the DSIS is operating with when it is not.

1.3.2 Ratio of accidents before and after installation of Downhill Speed Information System

1.3.3 Comparison of the mean speed of ODOT-transponder-equipped vehicles with that of trucks with no transponders when the DSIS is operating.

A detailed description of the hypothesis to be tested as well as the test methodology and deliverables is described in detail in Chapter 2 for the Speed Study, and in Chapter Three for the Accident Analysis. Chapter 4 provides results of the tests, while conclusions and recommendations can be found in Chapter 4. The scope of this detailed test within the context of the overall Green Light Evaluation is shown in Figure 1-1. The test measures outlined in this document are highlighted for reference.

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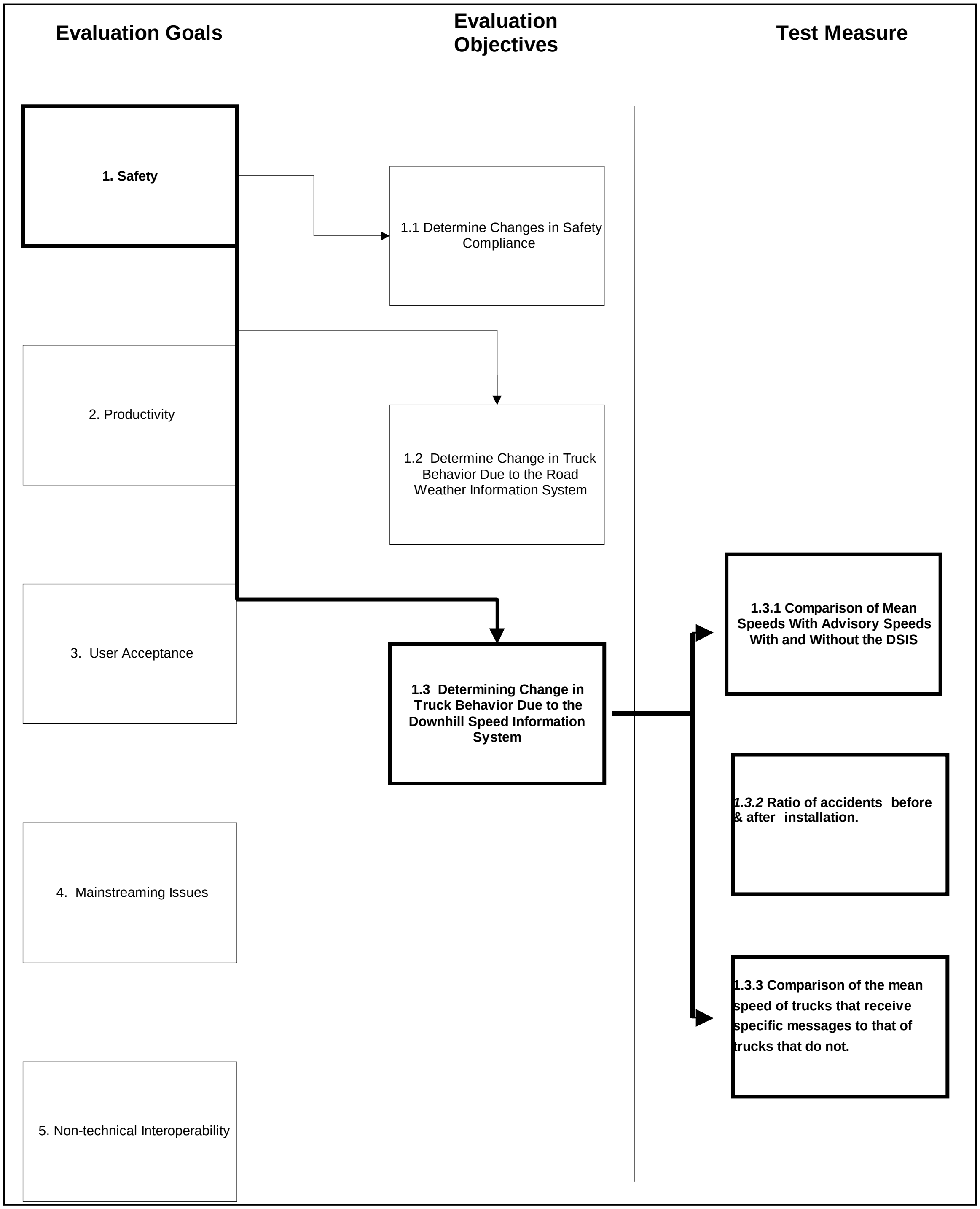


1.3 DISCUSSION

Downhill Speed Information Systems seek to affect commercial vehicle driver behavior by providing a safe downhill speed message for their specific vehicle via a variable message sign. The purpose is to reduce the frequency and severity of downgrade truck accidents. Two of the systems are being installed in Oregon, one at Emigrant Hill on I-84 and a second atop Siskiyou Summit on I-5 (see Figure 1-2). The Emigrant Hill system is currently operational, while the Siskiyou Summit location is not yet under construction.

Figure 1-2 DSIS Locations in Oregon

In the case of Oregon's downhill system, a weigh-in-motion device, electronic transponder, and an overhead variable message sign all combine to effectively weigh a vehicle, retrieve its OPUC information, and relay a message to the driver. [4]

The DSIS will calculate and display a safe descent speed for each truck passing through the system at greater than 40,000 lb. gross vehicle weight, based on three factors:

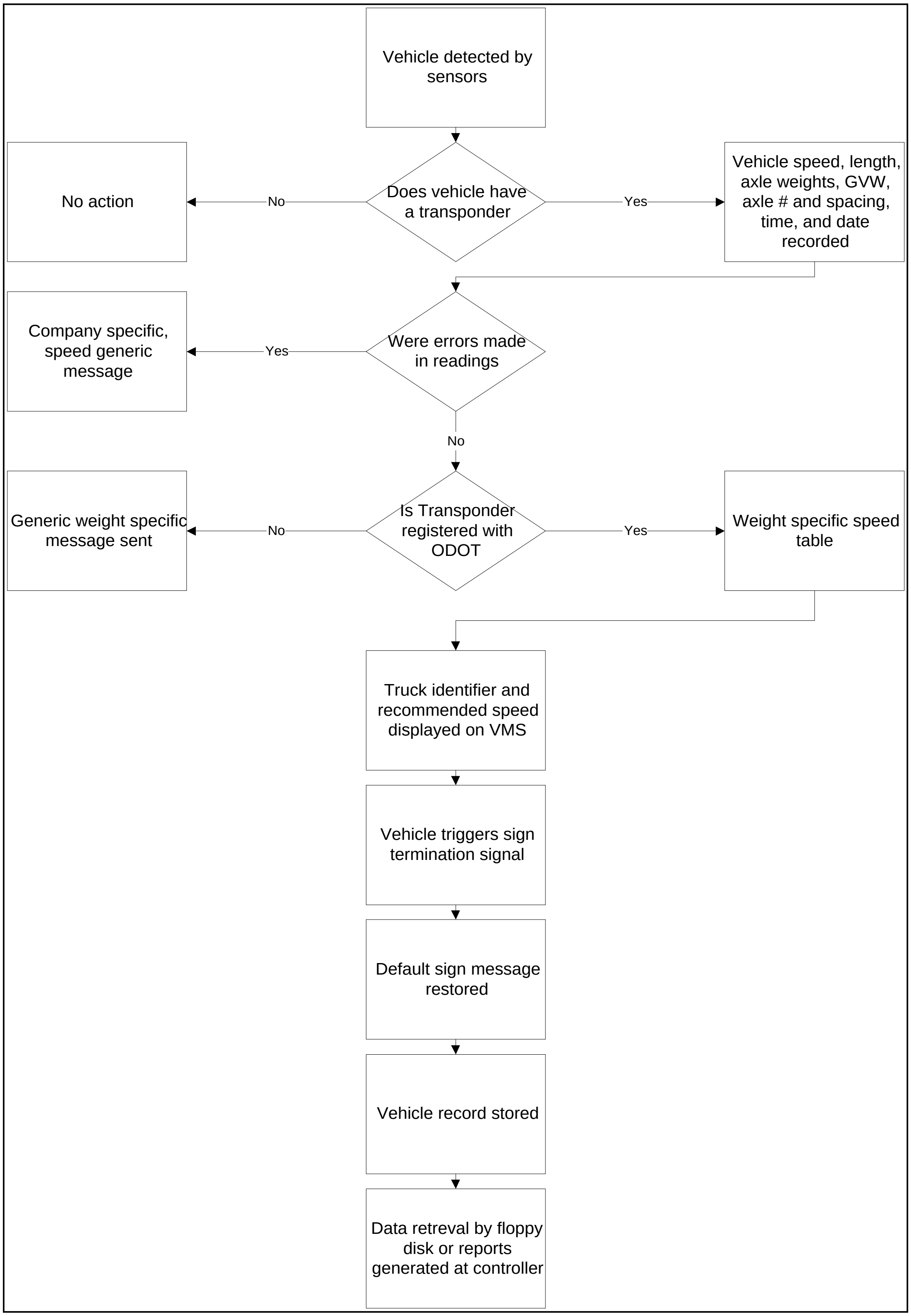
truck configuration

gross vehicle weight

steepness of grade

A flow chart of the system operation for the DSIS is shown in Figure 1-3.

Figure 1-3 DSIS Operation Flowchart



An overhead variable message sign down stream of the loop detectors and weight-in-motions strips will display the advised speed. In the case of Emigrant Hill, as shown in Figure 1-4, a weigh station is conveniently located at the top of the pass and a variable message sign is in place after it.

Figure 1-4 VMS From Emigrant Hill Weigh Station

WIM strips and transponder scanners have been installed one mile upstream of the weigh station directly on the freeway as part of Green Light's integration of mainline preclearence. Based on the weight measured by the WIM and the information gathered from the transponder signal, a decision whether to pull the truck into the weigh station is made. Trucks that are within the legal limit and have the proper registration and safety credentials bypass the weigh station and continue on the freeway. Once past the weigh station, the bypassed trucks receive an advisory message from the VMS such as "Mayflower truck #XXX, based on your weight of 70,000lbs, your recommended speed is 20 mph." (See Figure 1-3). Trucks that are not bypassed receive a similar message when they exit the weigh station.

2 TEST METHODOLOGY (Speed Study)

2.1 PHYSICAL DESCRIPTION

This section discusses in detail the activities to be carried out in the evaluation of the DSIS system at Emigrant Hill on I-84 east of Pendleton. Because of increased delays in the construction and deployment of the Emigrant Hill DSIS, the evaluation was postponed until the site became operational. To date, the Emigrant Hill DSIS has not been deployed and as a result this portion of the Detailed test plan was not completed.

The test is scheduled to take place of the course of two days in the month of June 2000. Oregon State University has agreed to conduct the evaluation as part of a no-cost extension using graduate students to conduct the research study. The actual schedule will be set according to ODOT's approval of the site.

2.1.1 Purpose

These tests will focus on the collection and analysis of commercial motor vehicle (CMV) speed data on the descent WB from Emigrant Hill on Interstate 84. For the purposes of this study, a commercial motor vehicle is any vehicle with a gross vehicle weight greater than 60,000 lb. Specifically, the tests will measure:

1. How truck speeds change when the DSIS is operating compared with when it is not
2. How the truck speeds differ from the recommended speed.

The descent from the summit is approximately nine miles, with a 6% grade and some sharp curves. It is an area that has seen a number of truck accidents due to excessive speed and brake failure. The DSIS system is being installed at this site to encourage drivers to descend at a recommended speed based on weight.

2.1.2 Hypothesis

The following hypotheses were given in support of the two measures and will be tested according to accepted statistical techniques.

1.3.1 Mean speeds in the vicinity of the operating DSIS system will converge towards advisory speeds.

1.3.2 Mean speeds of trucks that receive a specific message will converge toward advisory speeds more quickly than those that do not receive a specific message.

2.2 PRETEST ACTIVITIES

Pretest activities for this measure will focus on the sources, quality, and availability of data, and determining the appropriate sample size. These steps are discussed in detail below.

2.2.1 Data Sources and Availability

The primary data source for this test measure is speed data collected by radar gun at Emigrant Hill (spot speed surveys). As the DSIS system is operational but many CMV carriers have not yet installed transponders, the following four "focus groups" of trucks will be simultaneously sampled for comparison.

1. Trucks that have transponders that are registered in the ODOT database
2. Trucks with transponders that are not registered with ODOT
3. Trucks with transponders, but received some error in reading them or in measuring the truck's weight. This group includes trucks outside the weight range of 60 to 80klb.
4. Trucks that have no transponders

As shown in the DSIS flow chart, Figure 1-2, these four groups will be treated differently by the DSIS. Trucks with ODOT transponders will receive a message specific to their truck, e.g. "Bi-Mart Truck #XXX, your speed…." Trucks with non-ODOT transponders will also receive a message, but it will not be specific to them, e.g. "Truck Advisory – Recommended Downhill Speed for your weight…." Trucks that were erroneously read will receive a generic caution or a truck specific message depending on the error that occurred. Trucks with no transponders will not trigger the system and so will not receive a variable message. There is still the painted sign at the top of Emigrant Hill giving suggested speeds for weight ranges, and these trucks will read their advised speed from that sign.

The collection of new speed data will measure changes in driver behavior and how much those changes can be attributed to the recommended speed displayed to them. The speed data will be collected using a calibrated radar gun at several points of the descent. Speeds will be logged by hand into data collection sheets that ODOT will provide. Data can then be keyed directly into EXCEL. The data will be analyzed using accepted statistical techniques.

2.2.2 Calculation of Sample Size

A basic premise of statistical analysis is that any "natural phenomenon" occurring a large number of times will approximate the normal distribution or "bell curve." Depending on the degree of accuracy desired from the normal approximation, "a large number" could be anywhere from thirty to several hundred. The composition and volume of traffic is measured by ODOT each year at various points around the state and is reported in the transportation volume tables [5]. From those measurements, an estimate of the population size, or the number of trucks descending Emigrant Hill each day, can be calculated. In both 1997 and 1998 At ODOT recorder 30-004, which is on I-84 near Pendleton, approximately 27% of traffic volume would be considered truck traffic. This included single-unit, 3-axle vehicles and larger. The volume of traffic, per day, at milepost 233.45 near Emigrant Park was 8,700 vehicles in 1997 and 8,300 vehicles in 1998. Projecting these measurements, we can expect somewhere in the vicinity of 2300 trucks to descend Emigrant Hill on any particular day in 1999, which is a sufficiently large number to assume a normal distribution of truck behavior.

When estimating the mean of a normal population, such as the mean speed of trucks descending Emigrant Hill, it is possible to calculate the sample size necessary to ensure a certain degree of confidence. Standard estimation theory states that the sample size *n* necessary to ensure that the error in estimating the population mean μ will be less than a specified amount e according to the following theorem [4]:

$$n = \left(\frac{z_{\frac{\alpha}{2}} / \sigma}{e}\right)^2$$

Where n is the sample size
Z is the value of the standard normal distribution
σ is the variance, α the uncertainty, and e the acceptable error

Therefore, if the sample mean *x* is to be used as an estimate of $\underline{\mu}$, one can be (1-σ)100% confident that the error will be less than a specified amount *e*.

Strictly speaking, the formula above is applicable only if the population variance for the sample is known. Lacking this information, a preliminary sample size of n>30 can be used to calculate a standard deviation which will suffice as an estimate of σ, and then an estimate of the necessary number of additional measurements can be made. However, previous studies have given the approximate variance of traffic speeds, and so with a 95% confidence interval (z=1.96) and a degree of uncertainty of α at .05, approximately 150 trucks for each group will be surveyed. A revised estimate will be made on site after 30 or more samples.

2.3 TEST CONDUCT ACTIVITIES

2.3.1 Participants

Transportation Research Institute (Paul Montagne, staff) - will conduct the research, including collection and analysis of data.

ODOT Motor Carrier Enforcement Officer - will operate the weigh scale during the test.

2.3.2 Equipment

- Calibrated speed gun provided by ODOT
- WIM Mainframe computer and variable message sign provided by ODOT
- Two sets of two-way radios provided by TRI
- Clipboards, data collection sheets, paper provided by ODOT
- Van provided by OSU

2.3.3 Procedure

1) Predetermine collection period

The data will be collected during daylight hours and on days when weather is not a factor. High visibility days are preferred to eliminate any unnecessary bias. Two different locations will be selected on the descent for data collection. The spot surveys will be recorded for each focus group simultaneously, so there will be a minimum of complicating factors such as weather, road construction, etc. The weigh station must also be closed.

2) Acquire equipment

The vehicle used for the speed study will be an inconspicuous, white mini-van, provided by the state motor pool at Oregon State University. There are no distinct markings on the van other than a “state motor pool” bumper sticker and state issued license plates. The radar gun will be provided by ODOT. The same gun will be used throughout the study. It is regularly serviced and calibrated and is reasonably accurate. The research team will keep a calibration history of the gun. Oregon State University will provide the two-way radios, clipboards, and any other minor equipment.

3) Conduct the spot speed survey

Each spot survey will require two researchers, one at the top of Emigrant hill to record vehicle types, weights, and recommended speeds, and a second researcher downstream manning the radar gun. Data will be collected when the weigh station is not officially operating, but the system will be on so the researcher at the top of the hill can record weights, truck id’s and recommended speeds. Two-way radios will be used to communicate between the researchers.

The data will be collected from inside the vehicle. The van will be parked on the right hand shoulder in a conspicuous location away from any overpasses or exits. The gun will be mounted on the dashboard and covered with a newspaper or other inconspicuous camouflage. This will hopefully prevent drivers from knowing that their speeds are being measured and encourage them to drive normally.

1d) Analysis of data

Speeds will be keyed into an EXCEL spreadsheet for analysis. The data, time, location, recommended speed and weather and road conditions will be recorded. Mean speeds will be calculated from the data and then compared to the advisory speeds. Data sets for each focus group will be compared to the others so as to reveal changes in mean speeds.

2.4 POST-TEST ACTIVITIES

2.4.1 Reporting Procedures for Individual Test

A test report will be prepared for each of the test measures outlined in the evaluation plan and will proceed as follows.

1. Preparation of a draft report for the test (this document) to be submitted to the steering committee (SC) for their approval.
2. Approval of the SC at a scheduled meeting.
3. Preparation of a final report for each test, incorporating SC recommendations.
4. Submittal of 1 hardcopy original, 1 electronic original, and ten bound copies of the report to ODOT's project management team.
5. Transmittal of the report by ODOT to FHWA.

2.4.2 Reporting Schedule

A test summary report will be prepared highlighting findings from all of the test measures. The document will be produced as follows:

1. Preparation of a draft report summarizing the results of all the individual test reports for submittal to the SC.
2. Approval of the SC at a scheduled meeting.
3. Preparation of a final test summary report, incorporating SC recommendations.
4. Submittal of 1 hardcopy original, 1 electronic original, and ten bound copies of the summary report to ODOT's project management team.
5. Transmittal of the test reports by ODOT to FHWA.
6. Reporting Schedule for Test Summary

A reporting schedule is shown below for the test summary report:

Figure 2-4 Reporting Schedule - Test Summary Reports

Deliverables	Schedule	Scheduled Due Date*
Drafts of Test Summary Report	July 1 - July 15, 2000	July 15, 2000
Review of Test Summary Report by Steering Committee	July15, 2000-July 31, 2000	July 31 , 2000
Test Summary Report (Final)	Aug 1 – Aug 30, 2000	Aug 30, 2000

3 TEST METHODOLOGY (ACCIDENT STUDY)

3.1 PHYSICAL DESCRIPTION

This section discusses in detail the work conducted in the evaluation of the Emigrant Hill DSIS system on I-84 east of La Grande. OSU has altered the original DTP to that of a cursory analysis of available crash data for a number of reasons:

- Interstate 84 was under construction for most of the evaluation period, with traffic on the westbound lanes rerouted to the eastbound lanes, or vice versa for approximately 16 months.
- The DSIS is still in the process of being deployed, all “post- deployment” accident analysis was not conducted

Accident studies require a great deal of control to eliminate noise presented by other factors such as road construction and varying delays. With changes to the study area, and an inability to collect any post DSIS accident data, it was determined that the a cursory examination of accident rates be compiled lieu of the original plan. A continuation of this analysis once the DSIS becomes operational will be recommended in this report.

3.1.1 Purpose

This test was initially designed to present truck crash data occurring in the westbound lanes of I-84 descending from Emigrant Hill. The test was intended to measure what effects DSIS would have on truck crash rates, and how that impact would change with the installation of the DSIS at the summit. The test was designed as a before/after study in which comparisons will be made between similar data sets before and after the DSIS is installed. As was mentioned above, this approach has been altered, with the presentation of accident results only through 1999.

The descent from the summit is approximately nine miles, with a 6% grade and some sharp curves. It is an area that has seen a number of truck accidents due to excessive speed and brake failure. The DSIS system is being installed at this site to encourage drivers to descend at a recommended speed based on weight. This area is identified by ODOT as one of ten "high truck crash corridors" due to it steep grades and frequency of crashes.

3.1.2 Hypothesis

The following hypothesis was given in support of the test measure and will be tested according to accepted statistical techniques.

1.3.2 Accidents in the vicinity of the DSIS system will decrease as messages are relayed to passing trucks prior to descent of Emigrant Hill

3.2 PRETEST ACTIVITIES

Work Planned	Work Accomplished
1) Data Sources and Availability	Potential data sources were identified as: • Oregon DOT's accident records database • Records of displayed messages appearing on the VMSs in Ladd Canyon • Activity logs of construction activities during the study period • Daily records of pavement conditions • Escape Ramp Data, if available • Samples of the data sources were collected
2) Determination of Benchmark Timeframe	• Completed • Available accident data for 1997 through deployment will be compared with data collected after deployment of DSIS.

3.3 TEST CONDUCT ACTIVITIES

Below is a summary of the work planned and accomplishments achieved according to the original DTP.

1) Collection and Analysis of Accident Data	
1a) Collect all recorded accidents between milepost 263 and 286 up to DSIS installation (1997-1999)	• Completed
1b) Tabulate accident data into EXCEL spreadsheets	• Completed
1c) Calculate the accident rate for the section of highway in question	• Completed
2) Collection and Analysis of VMS Message Logs	
2a) Collect VMS Logs	• Not completed, no results presented
2b) Correlate VMS logs with WIM data in EXCEL	• Not completed, no results presented
3) Collection and Analysis of Construction Activity Logs	
3a) Collect construction logs	• Not completed, no results presented
3b) Correlate construction logs w/ accident data	• Not completed, no results presented
4) Collection of ODOT Road Reports	
4a) Collect ODOT Road Reports	• Not completed, no results presented
4b) Correlate road conditions with accident data in EXCEL	• Not completed, no results presented

4 RESULTS

4.1 RESULTS - DSIS SPEED STUDY

To date, the Emigrant Hill DSIS has not been deployed and as a result this portion of the detailed test plan was not completed.

4.2 RESULTS - DSIS ACCIDENT STUDY

Three years of accident data was collected for the pre-deployment phase accident analyses of Emigrant Hill. Figure 4-1 below shows the total number of reported accidents (both cars and trucks) occurring between mileposts 216 and 218 of I-84 for the years 1997-1999. This includes both eastbound and westbound lanes.

Figure 4-1 Emigrant Hill Accidents 1997-1999

	INJURY	FATAL	TOTAL
1997	17	0	21
1998	8	0	24
1999	38	2	65

Causes of all reported accidents occurring at Emigrant Hill for the years 1997-1999 are shown below in Figure 4-2.

Figure 4-2 Accident Causes, Emigrant Hill 1997-1999

	1997	1998	1999
SPEED	8	6	59
IMPROPER OVERTAKING	6	10	3
FOLLOW TOO CLOSE	1	1	1
DUII	1	2	1
OTHER	5	5	1
TOTAL	21	24	64

Accidents due to speed and improper overtaking, continue to dominate the crashes that occur on the hill.

Figure 4-3 Accident Conditions Emigrant Hill 1997-1999

	1997	1998	1999
DRY	8	16	19
ICY	11	3	43
SNOW	1	1	1
OTHER	1	4	2
TOTAL	21	24	65

As accidents are rare events, it is useful to express the frequency of accidents in terms if the rate in which they occur. This is based on changes in average daily traffic from year to year. Figure 4-4 below shows the accident rates for Emigrant Hill from 1997-1999.

Figure 4-4 Accident Rates, Emigrant Hill 1997-1999

1997	0.535
1998	0.626
1999	0.652

5 CONCLUSIONS AND RECOMMENDATIONS

Although the Emigrant Hill DSIS has not been deployed, OSU feels that the system is a valuable tool that will truly prove beneficial to the trucking community. Emigrant Hill continues to be listed as a high truck crash corridor in the state of Oregon, with 62 crashes occurring in 1999 due to speed and improper overtaking. The DSIS could aid in reducing these numbers through a warning system of advised speeds and personalized signing as proposed in the Green Light Project.

In conclusion, OSU recommends that ODOT continue to pursue deployment of this technology, and if possible, conduct an evaluation of its effectiveness.

6 REFERENCES

1. Bell, C.A., B. McCall, and, C.M. Walton, "Oregon Green Light CVO Evaluation-Detailed Test Plans, Detailed Test Plans 1-14", GLEV9603-GLEV9711, March 1997.

2. Bell, C.A., B. McCall, and, C.M. Walton, "The Oregon 'Green Light' CVO Project, Evaluation Plan" GLEV9601, Oregon State University, Transportation Research Institute, September 1996.

3. Bell, C.A., B. McCall, and, C.M. Walton, The Oregon Green Light CVO Project, Individual Test Plan GLEV9602, Oregon State University, Transportation Research Institute, October 1996.

4. ODOT Research and New Technology, Transportation Development Branch, "Oregon Green Light CVO Project - Overview and Phase III Workplan" Oregon Department of Transportation, Salem OR, January 1997.

7 APPENDICES

APPENDIX A

TEST PLAN FOR THE TRACKING FUNCTIONALITY OF THE GREEN LIGHT PROJECT EMIGRANT HILL DOWNHILL SPEED INFORMATION SYSTEM (DSIS)

APPENDIX A
TEST PLAN FOR THE TRACKING FUNCTIONALITY OF THE GREEN LIGHT PROJECT EMIGRANT HILL DOWNHILL SPEED INFORMATION SYSTEM (DSIS)

1.0 Introduction

The purpose of this document is to outline the tests to be performed for the Emigrant Hill DSIS tracking functionality.

2.0 Required Equipment

The configuration of the vehicles to be used for the DSIS functionality test include:

a) A vehicle with five or more axles with a weight that is > 60(kips) and < 80(kips), and is equipped with a transponder that is registered in the ODOT database;

b) A vehicle with five or more axles with a weight that is > 60(kips) and < 80(kips), and is equipped with a transponder that is not matched in the ODOT database;

c) A vehicle with a weight that is > 80(kips) or < 60(kips), and/or a vehicle that has less than five axles, and is equipped with a transponder that is registered in the ODOT database.

3.0 Procedure

The test is broken down into 4 areas to test the operation of the DSIS system. For each of the tests the test vehicle will proceed over the mainline Weigh-In-Motion (WIM) Location in order to:

a) Verify that the VMS is able to display all types of messages required for the operation of the DSIS System,

b) Verify that the VMS will not display a downhill message when ODOT is displaying a message such as “CONSTRUCTION ZONE,” and,

Verify that an ODOT message will immediately override any downhill message that is being displayed (the downhill message will immediately cease to appear).

Verify that the DSIS System will continue to function when the Weigh Station is closed and the

Pre-Clearance System is off.

The test vehicles may either be trucks from the mainstream traffic, or a dedicated test vehicle such as the scale truck.

The Downhill Warning System (DWS) needs to query the Variable Message Sign (VMS) because ODOT has the higher priority of using the VMS. When the VMS is not being used by ODOT, the DWS can send a Downhill Warning message to the VMS and the VMS will display the message.

The VMS will display three lines of information when providing a Downhill Warning message. All three lines of the Downhill Warning message should be centered in capital letters on the VMS. The company name in the second line of the Downhill Warning message will have 18 characters or less (including spaces) and will display only whole words. For example, the company name WINDSOR ROCK PRODUCTS would be shortened to WINDSOR ROCK rather than WINDSOR ROCK PRODU.

In accordance with the Emigrant Hill Downhill System Design, Section 2.4, Downhill Warning System (DWS), the Downhill Message will be displayed as soon as it is received by the VMS, and will be displayed during the user definable time. At the end of the user definable time, the DWS software will send a command to blank the displayed message on the VMS.

If there is no Downhill Warning message displayed for the vehicle, the vehicle is expected to follow the recommended safe speed for the respective type of vehicle as specified on the fixed road message sign.

3.1 DSIS Systems Messages

Verify that the VMS is able to display all types of messages required for the operation of the DSIS System. Four functional tests, using four different conditions, are required to create the four different DWS message options.

3.1.1 Downhill Message Displayed (Carrier/Warning Specific)

The Company name for this test will exceed 18 characters. The transponder will identify the vehicle as it passes over the mainline WIM. The WIM scale system and the State Supervisory Computer (SSC) display will make a sort decision and send this sort decision to the Automatic Vehicle Identification (AVI) writer. The AVI unit will write the sort decision to the vehicle's transponder and direct the driver to either bypass or enter the Weigh Station. The WIM system will then communicate with the SSC to retrieve a company name and unit number from the vehicle database. After the vehicle bypasses or exits the Weigh Station, it will pass the post Weigh Station AVI Reader and approach the DWS. The SSC will communicate to the Automatic Vehicle Classification (AVC) system which will in turn communicate a message to the VMS, if available (not being used by ODOT), using a speed based on vehicle weight, and that is consistent with the law. The Downhill Warning Message will not truncate the Company name and will only display whole words for the vehicle, and will be displayed as follows:

TRUCK ADVISORY

COMPANY NAME

XX MPH DOWNHILL

TRUCK-SPECIFIC MESSAGE DISPLAYED ON THE VMS	YES	NO
WHOLE-WORDS ONLY MESSAGE DISPLAYED ON THE VMS	YES	NO
WARNING-SPECIFIC MESSAGE DISPLAYED ON THE VMS	YES	NO

Downhill Message Displayed (Carrier/Warning-Generic)

The transponder will be configured in such a way so that it is not matched with the vehicle, or is not in the ODOT database. The WIM scale system and the SSC display will make a sort decision and send this sort decision to the AVI writer. The AVI unit will write the sort decision to the vehicle's transponder and direct the driver to either bypass or enter the Weigh Station. The WIM system will then communicate with the SSC in an attempt to retrieve a company name and unit number from the vehicle database. However, because the vehicle is unmatched, a company name will not be available. After the vehicle bypasses or exits the Weigh Station, it will pass the post Weigh Station AVI Reader and approach the DWS. The SSC will then communicate to the AVC system, which will in turn communicate to display a Company- and Warning-generic message to the VMS if available (not being used by ODOT). The Downhill Warning Message for the vehicle will be displayed as follows:

TRUCK ADVISORY

CAUTION

STEEP DOWNGRADE

REPORT REASON CODE ONOTDB APPEARS	YES	NO
VEHICLE MATCHED (TRANSPONDER # APPEARS ON SSC)	YES	NO
GENERIC DWM DISPLAYED ON THE VMS	YES	NO

Downhill Message Displayed (Carrier Specific - Warning Generic)

The test vehicle will have less than five axles and a vehicle weight of < 60(kips). The transponder will identify the vehicle as it passes over the mainline WIM. The WIM scale system and the SSC display will make a sort decision and send this sort decision to the AVI writer. The AVI unit will write the sort decision to the vehicle's transponder and direct the driver to either bypass or enter the Weigh Station. The WIM system will then communicate with the SSC to retrieve a company name and unit number from the vehicle database. After the vehicle bypasses or exits the Weigh Station, it will pass the post Weigh Station AVI Reader and approach the DWS. The SSC will communicate to the AVC system, which will in turn communicate to display a Company-specific, Warning-generic message to the VMS if available (not being used by ODOT). The Downhill Warning Message for the vehicle will be displayed as follows:

TRUCK ADVISORY

COMPANY NAME

STEEP DOWNGRADE

VEHICLE MATCHED (COMPANY NAME APPEARS ON SSC)	YES	NO
COMPANY NAME DISPLAYED ON THE VMS	YES	NO
GENERIC WARNING DISPLAYED ON THE VMS	YES	NO

Message Not Created

The test vehicle, which will not be equipped with a transponder, will pass over the mainline WIM. As a result, the DWS software will not be able to initiate the process for creating a Downhill Warning message and the VMS will not display a message for the test vehicle.

MESSAGE DISPLAYED ON THE VMS YES NO

3.2 AVC Generated Message Unable to Override ODOT Display

ODOT will display the message “Test Message” on the VMS. The test vehicle will pass over the mainline WIM. The transponder will identify the vehicle as it passes over the mainline WIM. The WIM scale system and the SSC display will make a sort decision and send this sort decision to the AVI writer. The AVI unit will write the sort decision to the AVI transponder and direct the driver to either bypass or enter into the Weigh Station. After the vehicle bypasses or exits the Weigh Station, it will pass the post Weigh Station AVI Reader and approach the DWS. The WIM system will then communicate with the SSC to retrieve a company name and unit number from the vehicle database. The SSC will communicate to the AVC which will in turn attempt to communicate a truck-specific message to the VMS, however it will be unable to override the ODOT message.

VEHICLE MATCHED (COMPANY NAME APPEARS ON VMS) YES NO

ODOT MESSAGE DISPLAYED ON VMS (TEST MESSAGE) YES NO

WIM SYSTEM OVERRIDE OF ODOT MESSAGE YES NO

3.3 ODOT Overrides AVC Generated Message

The test vehicle will pass over the mainline WIM. The transponder will identify the vehicle via the AVI Reader as it passes over the mainline WIM. The WIM scale system and the SSC display will make a sort decision and send this sort decision to the AVI writer. The AVI unit will write the sort decision to the transponder and direct the driver to either bypass or enter the Weigh Station. After the vehicle bypasses or exits the Weigh Station, it will pass the post Weigh Station AVI Reader and approach the DWS. The WIM system will then communicate with the SSC to retrieve a company name and unit number from the vehicle database. The SSC will communicate to the AVC, which will in turn communicate a truck-specific message to the VMS. ODOT will then override the AVC with the message "Test Message" which will display on the VMS. The AVC-generated message will cease to appear.

VEHICLE MATCHED (COMPANY NAME APPEARS ON VMS)	YES	NO
DWS MESSAGE DISPLAYED ON THE VMS	YES	NO
ODOT MESSAGE OVERRIDE DWS MESSAGE	YES	NO

Message Displayed for AVI-Equipped Carriers When Weigh Station is Closed

The test vehicle will pass over the mainline WIM. After the vehicle bypasses the Weigh Station, it will pass the post Weigh Station AVI Reader and approach the DWS. The WIM system will then communicate with the SSC to retrieve a company name and unit number from the vehicle database. The SSC will communicate to the AVC system which will in turn communicate a message to the VMS, if available (not being used by ODOT), using a speed, based on vehicle weight and that is consistent with the law. The Downhill Warning Message for the vehicle will be displayed as follows:

TRUCK ADVISORY

COMPANY NAME

XX MPH DOWNHILL

VEHICLE MATCHED (COMPANY NAME APPEARS ON SSC)	YES	NO
TRUCK-SPECIFIC MESSAGE DISPLAYED ON THE VMS	YES	NO
WARNING-SPECIFIC MESSAGE DISPLAYED ON THE VMS	YES	NO

4.0 Repeat Test Scenarios, as Necessary

If the system fails any of the tests in 3.1 to 3.3, the failed test must be repeated three (3) additional times. If the system does not pass the test in 3 out of 4 cases, the configuration of the software should be checked before re-testing that portion of the functionality.

Oregon Green Light

CVO Evaluation

FINAL REPORT

DETAILED TEST PLAN 6

Evaluation of the Changes in the Auditing Process and Collection of Highway Use Tax Revenues

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Conducted by sub-contract for Oregon State University
Transportation Research Institute
Transportation Research Report No. 00-015

June 2000

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The authors are indebted to the personnel of ODOT's Motor Carrier Transportation Division, who have provided information and data to the evaluation team throughout the project. We are particularly indebted to Ken Evert, Gregg Dal Ponte, Randal Thomas and David Fifer. Ken's untimely death in 1998 meant that he did not see his vision completed. The evaluation team is forever indebted to him for his support and for the opportunity to participate in the deployment.

Table of Contents

Table of Exhibits

1. INTRODUCTION

This Detailed Test Report is Number 6 submitted as part of the independent technical evaluation of the Oregon Green Light CVO project. The Oregon Department of Transportation (ODOT) is in the process of implementing their Intelligent Transportation System Strategic Plan for Commercial Vehicle Operations (referred to ITS/CVO). Through Green Light, Oregon is installing twenty-two mainline preclearance systems featuring weigh-in-motion (WIM) devices and automatic vehicle identification (AVI) at the major weigh stations and ports-of-entry (P.O.E.) throughout the state. In addition, certain sites are being equipped with further safety enhancements that regulate road conditions and speed.

Each of the tests conducted by the research team for the evaluation of Green Light addresses one of the five goals of the evaluation as documented in the Evaluation Plan. These goals are:

- Assessment of Safety
- Assessment of Productivity
- Assessment of User Acceptance
- Assessment of Mainstreaming Issues
- Assessment of Non-Technical Interoperability Issues

The objectives associated with each goal are given in the Oregon Green Light CVO Project- Individual Test Plans (ITP). In addition, condensed one-page tables are contained in the appendices of the ITP, outlining the measures to be conducted for each of the stated objectives. The detailed test plan documents expand on the information provided in the ITP and provide in detail the activities carried out for each evaluation measure during the course of the evaluation in regards to the stated objectives.

1.2 PURPOSE AND SCOPE

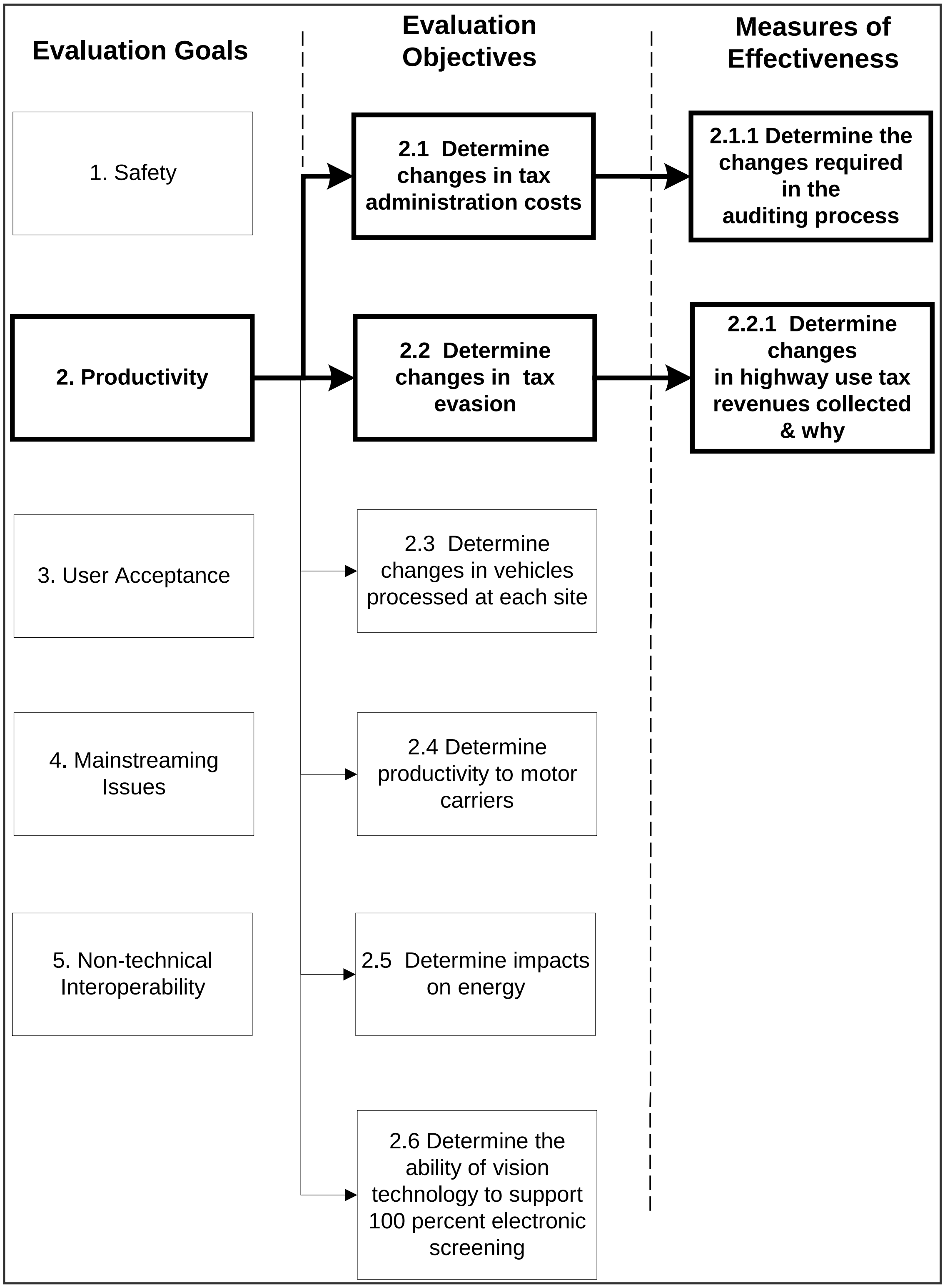
This report represents the findings employed to determine the following evaluation objectives: Determine changes in tax administration costs, and Determine changes in tax evasion; two of the six objectives in support of the goals of assessing productivity . The accompanying Detailed Test Plan for this report is DTP #6.

The evaluation measures used to determine the changes in productivity are stated below:

- Determine changes in the auditing process.
- Determine changes in the highway use tax revenues collected and why.

Exhibit 1-1 describes the relationship among the overall evaluation goals to the evaluation objectives and the measures of effectiveness (MOE) for this evaluation report.

EXHIBIT 1-1 EVALUATION GOALS, OBJECTIVES, AND MEASURES



1.3 DISCUSSION

For the 1993 – 1995 biennium, the cost of administering (including all costs of collection, auditing, and enforcement activities) Oregon's highway use tax collections was estimated to be $21.1 million, or 4.8 percent of revenues collected. The evasion rate was estimated to be five percent of total receipts, equating roughly to $22 million in lost revenue for the same biennium.

In 1993, the Oregon Department of Transportation and the then Oregon Public Utilities Commission drafted a strategic plan for ITS/CVO in Oregon. Included in this plan were a list of specific goals, the second of which was to benefit government through increased efficiency and effectiveness. The resulting Green Light initiative was designed to improve the efficiency of the tax auditing process, as well as the effectiveness of the process in terms of the collection rate. The evaluation report describes the impact that Green Light has had to date on both the efficiency and effectiveness of Oregon's highway use tax collection.

2. TEST METHODOLOGY

2.1 PHYSICAL DESCRIPTION

This section describes the activities that were carried out to meet the evaluation objectives. The purpose of test was to measure any changes in the weight-mile tax auditing process and the impact of Green Light on the process.

The test was designed to measure whether the technologies introduced under Green Light increased the efficiency and effectiveness of the auditing process. To measure this, we examined the auditing process prior to the deployment of Green Light, and re-examined the processes after Green Light deployment.

2.1.1 Purpose and Scope

The first step in determining the changes in the auditing process was to establish a baseline. That is, identify the individual transactions and activities that make up the processes and determine the resources required to execute these activities. A process map was developed to clearly identify these activities for tax auditing. The auditing process was identified through interviews with the Oregon Department of Transportation staff and reviews of budget reports and records.

The second step was to develop a process map of planned modifications to the tax collection and auditing processes that were the result of the introduction of Green Light. The resources required to support each planned activity were identified through interviews with the Oregon Department of Transportation staff and review of budget reports and estimates of future activity costs.

Finally, since it was not entirely clear how Green Light would change the auditing process the research team revisited the process approximately one year after the beginning of Green Light deployment. The process map reflects any changes following the deployment of Green Light.

Any changes in the weight-mile tax collection rate were to be determined by comparing the estimated rate for three fiscal years following implementation of Green Light with baseline estimates. The tax evasion rates stated in the 1996 *Oregon Weight-Mile Tax Study* (Cambridge Systematics, Inc. and SYDEC, Inc. February 1996) served as a baseline measurement.

2.1.2 Hypotheses

The following hypotheses were tested:

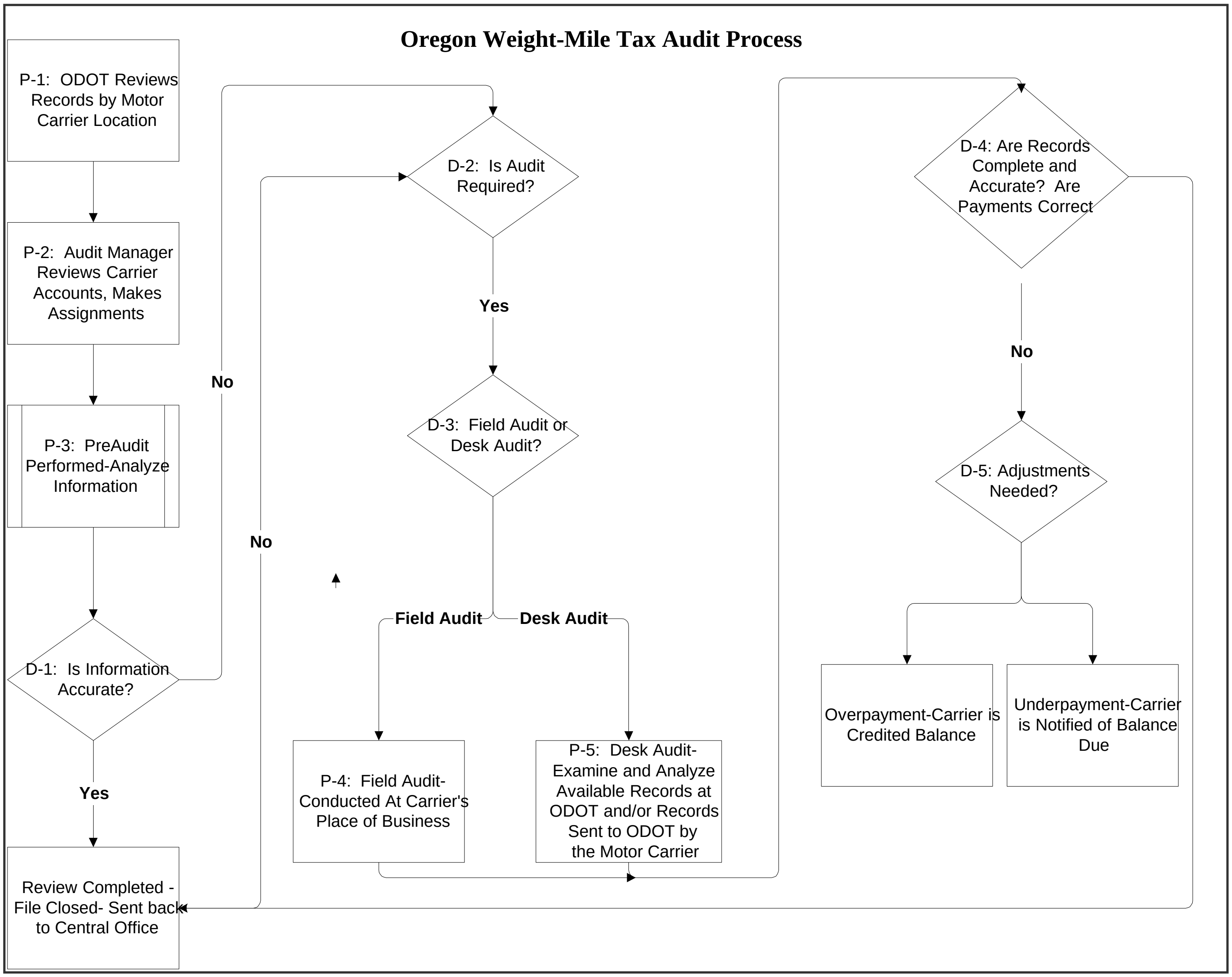
2.1.2.1 The audit process will become more automatic.

2.1.2.2 Oregon Green Light will support changes.

The following report is based on interviews with the staff of the Oregon Motor Carrier Audit Division and a review of ODOT documents. It begins with a review of the motor carrier weight-mile tax audit process, and is followed by a discussion of the effect of Green Light on the auditing process. The report concludes with options for further inquiry.

Exhibit 2-1 describes the weight-mile tax audit process.

EXHIBIT 2-1 OREGON WEIGHT-MILE TAX AUDIT PROCESS



2.1.3 Tax Audit Procedures

The audit procedures, as shown in the above diagram, are as follows:

Process One: The Oregon Department of Transportation's Motor Carrier Audit Manager, annually reviews the records of the motor carrier accounts by general geographic location.

Process Two: The motor carrier records are then arranged by zip codes, and assignments are made by on location. Auditors are assigned to given geographic area. As most carriers are based outside of Oregon (approximately 8,647 of the 23,859 registered carriers are Oregon-based), auditors will travel to other areas of the country, if needed, to conduct the audit.

Process Three: The Pre-Audit Procedure is an initial analysis of the carrier's account information. The accounts are reviewed for errors and discrepancies in their transactions. The pre-audit procedure is described in the Oregon Audit Manual. The pre-audit is conducted using a weighted formula to predict the probability of a substantial recovery. The weighted formula includes five variables; a.) The number of trucks in the fleet; b.) Collection activity; c.) Extended weight, (i.e., operations in excess of 80,000 pounds); d.) Non-reported operations; and e.) Previous audit activities. The formula allows the pre-audit staff to identify those accounts that require greater scrutiny due to either the size or complexity of the account, the history of weight-mile tax discrepancies or obvious discrepancies in the current tax report. Discrepancies such as simple mathematical errors, or some other minor mistakes, may be addressed and corrected via telephone conversation with the carrier officials. The pre-audit consists of comparing the number of miles traveled by the carrier to the amount of weight-mile tax paid by the carrier. The pre-audit also examines any additional permit requests made by the carrier, such as an over-dimensional permit. The pre-audit also obtains records from the weigh stations that indicate which units were weighed at a given weigh station. These weigh station records are then compared to the mileage reports filed by the motor carrier.

Decision One: The pre-audit determines whether the information that is submitted by the motor carrier is complete and accurate. If the account is found to be in order, then the file is sent back to the central office with no further action required. If the account is found not to be in order; if discrepancies and errors are discovered, then further action is required. Examples of some discrepancies are failure by the motor carrier to submit monthly mileage reports, failure to submit quarterly mileage reports, the carrier's mileage reports and Oregon DOT Scale Reports fail to reconcile, mileage rate errors, or overweight operations.

Process Four: If the information in the carrier's file is accurate and complete, the review is complete and the file is sent back to the central office for re-filing. No further action is required on this account.

Decision Two: If the discrepancies in the carrier's mileage reports cannot be readily reconciled, then an audit of the carrier's records is required. The can be one of two types, a Field Audit or a Desk Audit.

Decision Three: A field audit is an audit in which the auditor goes to the carrier's place of business and conducts the audit. A desk audit is one in which the auditor conducts the audit in his or her office. The carrier is requested to submit the necessary records to the auditor.

Process Five: If a desk audit is conducted, the records are reviewed at the auditor's office. The audit is performed by mail, fax, and telephone. This type of audit is usually conducted when it is determined that simple procedural errors occurred in the carrier's report. The audit may determine that the carrier requires some education and technical assistance to reconcile the account. Generally, the carrier is asked to submit a number of records to the auditor. These records may be a sample of the carrier's operations, or it may be a full audit of all operations. Records that can be requested are: drivers' records of duty status (logs), carrier trip reports showing origin and destination, bills of lading, load tickets for shippers, freight bills, and dispatch records, along with the mileage reports.

Process Six: A field audit is required when the carrier's report is found to be complex and requires a more in-depth investigation. The field audit is conducted at the carrier's place of business. The same types of records are examined, but a larger sample of the carrier's operations is reviewed to conduct the audit. Discrepancies that could require a field audit are a large carrier with complex operations, or trips being omitted from the carrier's weight-mile tax filings.

Decision Four: If, during the audit, the records are found to be complete, the review is completed and the file is returned to the central office. If the records are not found to be complete, then adjustments are required to the carrier's tax filings. The carrier may also require assistance and education to complete the tax filing accurately in future.

Decision Five: The adjustments to carrier's tax filing may be in the form of a refund due or the carrier may have to pay the full amount of tax due, based on the auditor's findings.

Process Seven: If it is found that the carrier has overpaid the tax, the carrier is credited the balance. The balance may be credited to the next month's filing, or the Motor Carrier Transportation Division could issue a refund check.

Process Eight: If the carrier has underpaid the tax, the carrier is notified of the balance due, and the carrier must reconcile the amount due. If the carrier disputes the auditor's findings, there are appeals procedures available.

After the auditor completes the audit and writes the report, the audit is sent for billing and the file is returned to the central office.

2.1.4 Preliminary Analysis of the Tax Audit Process

The procedural objective of the Oregon Department of Transportation is to review all motor carriers' weight-mile tax accounts within a three-year cycle. In recent years, other commitments such as meeting the auditing requirements for membership to the International Fuel Tax Administration (IFTA) and the International Registration Plan (IRP) have prevented ODOT's Audit Division from fully meeting this objective. Nevertheless, between 25 percent and 30 percent of accounts are reviewed.

The pre-audit staff consists of eight analysts. For the first six months of Fiscal Year 96-97, the pre-audit staff analyzed 3.5 files per direct labor hour. The average cost per review was $13.01. The goal of the staff is to complete a review of fifty accounts every three days. Between 80 percent and 90 percent of all files reviewed by the pre-audit staff require no further action. These files are returned to records upon completion of the review. Including supervisors, there are 31 field auditors. For the first six months of the '96-'97 biennium, an audit took an average of 32 direct labor hours.

The auditing process was re-examined in 1999 and it has remained essentially unchanged since 1996. Files are arranged and assigned according to location. The auditors must manually and carefully review, analyze, and reconcile the accounts. The average time to audit remains 31.5 hours. It must be stated, however, that Green Light has not been fully deployed at the time of this report.

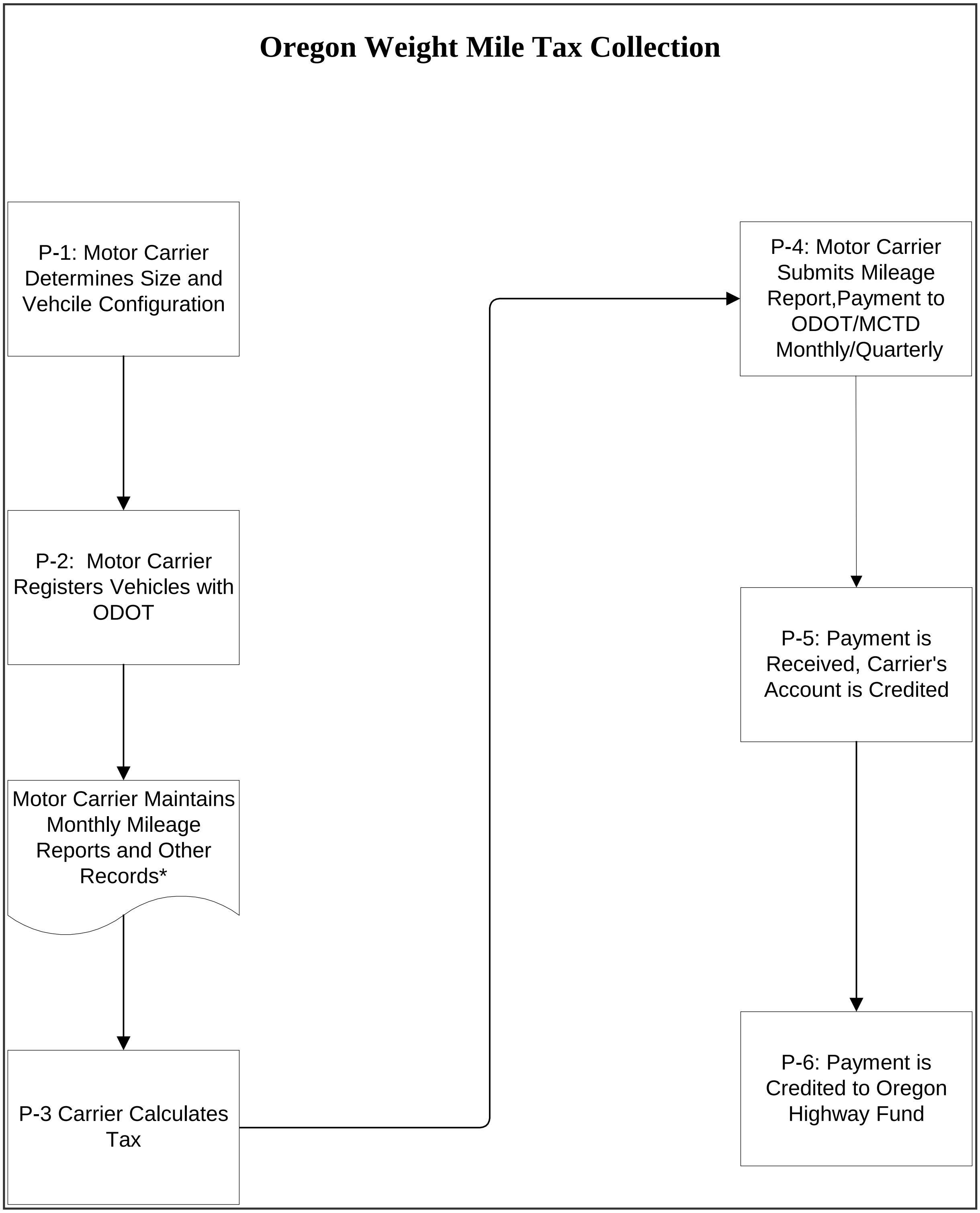
2.2.1 Weight-Mile Tax Collection Procedures

Following the determination of the audit process, the second part of the test was to determine any changes in tax collection. The following measure was examined, as listed in Detailed Test Plan #6:

Determine changes in highway use tax collected and why

The weight-mile tax collection process was first examined in 1996. The following process map describes the weight-mile tax collection process, as it was determined in 1996. The process was re-examined in 1999, and to this point there have been no measurable changes in the collection process

EXHIBIT 2-2 WEIGHT-MILE TAX COLLECTION PROCESS



2.2.1.1 Brief Explanation of Weight-Mile Tax Collection

The Weight-Mile Tax (WMT) in Oregon is a self-reporting tax, which means that the motor carrier determines the amount of tax to be paid to Oregon, based on the miles operated by that carrier, and the declared weight of the vehicles operated by the carrier. The WMT is applicable to vehicles with a declared weight over 26,000 pounds; either solo power units only, or in combination (e.g., tractor-trailer units). Vehicles with declared weights of under 26,000 pounds pay fuel tax at the pump.

2.2.1.2 Collection Procedures

As depicted in the process map on the previous page, the WMT process is as follows:

Process One: The motor carrier determines the size of its fleet, and the configuration of each vehicle that is being operated in the State of Oregon. The motor carrier then makes a declaration to the state of the vehicles' combined weight to be operated in the state. The combined weight is the maximum weight of the vehicle, including its load. Weights are declared in 2,000-pound increments. The tax is then based on the declared weight, plus the amount of miles operated by that vehicle. The carrier must maintain records of each trip operated by that vehicle within the State of Oregon.

Process Two: The motor carrier, whether based in Oregon or outside of Oregon, must register its vehicles that it intends to operate in Oregon with the State of Oregon's Department of Transportation (ODOT). This registration may be done in person, or by mail. ODOT then issues a registration plate for each vehicle registered by the motor carrier.

Records that are to be maintained: The motor carrier must maintain records showing the total miles operated by the vehicle for each month. The records are maintained for each power unit, as well as, any trailer configuration, if the carrier has declared weights for that configuration.

Process Three: The carrier must pay the tax rate applicable to the miles associated with each operation and its declared weight. The tax is compiled based on the amount of Oregon miles operated by the carrier, and each vehicle's declared weight.

Process Four: Depending on the size and extent of the carrier's operations in Oregon, the carrier can submit its reports and payments either monthly or quarterly. The reports are sent to the Motor Carrier Transportation Division of ODOT. These reports show the miles operated by the motor carrier within the State of Oregon. Along with the Highway Use Tax Report, the motor carrier must send the tax payment.

Process Five: Once payment is received, the motor carrier's account is credited with the amount paid.

Process Six: The Weight-Mile Tax is a dedicated tax. All payments made by motor carriers are dedicated to the state's highway fund, less the agency's operating expenses, for improvements, safety enhancements, construction, and maintenance of the highway system.

2.3.1 Test Activities

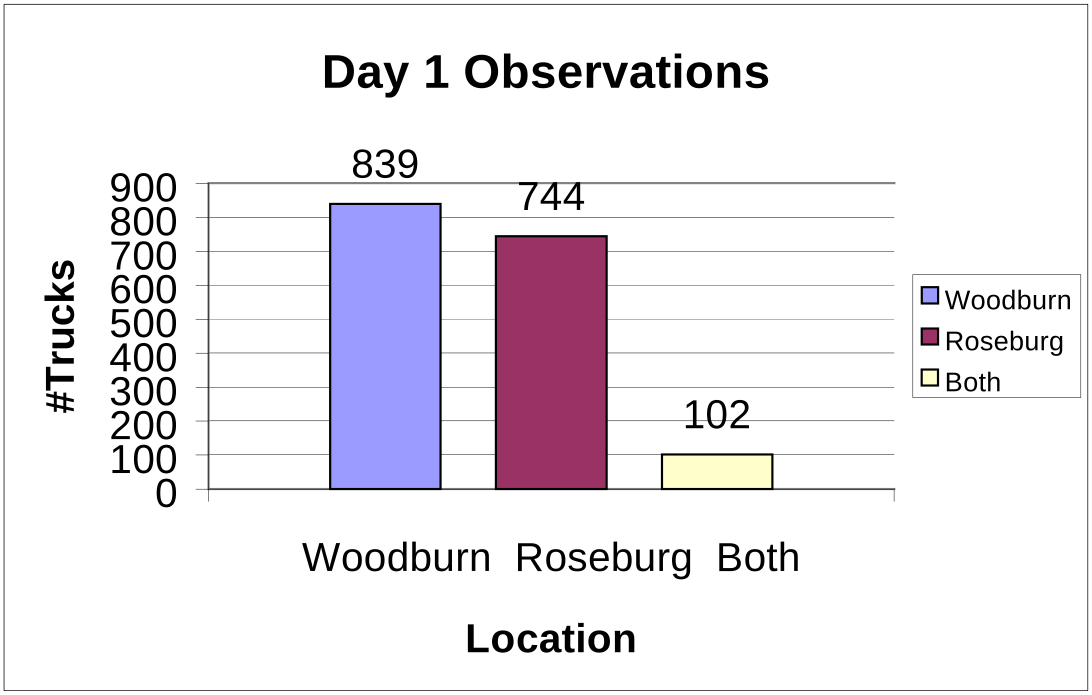
To test the hypotheses that the auditing process would become more automated and the Green Light technology would support those changes, the research team collected field data in 1999 to compare to the baseline data collected earlier.

The field data collection process consisted of recording the plate numbers of the trucks as they passed the Woodburn Port of Entry (P.O.E.), either at the weigh station or on the mainline. A second group of observers recorded the trucks as they entered the Roseburg weigh station located approximately 144 miles to the south of the Woodburn Port of Entry. The recorded plate numbers were then compared and contrasted to determine which trucks passed both stations within the given time frame.

The plate numbers of the trucks that were observed at both weigh stations were then compared to the quarterly tax reports filed with ODOT. This comparison was conducted to determine which of the observed trucks reported at least 144 miles, the distance between the two observation points.

The cursory examination of the tax reports indicated that the trucks had reported at least 144 miles.

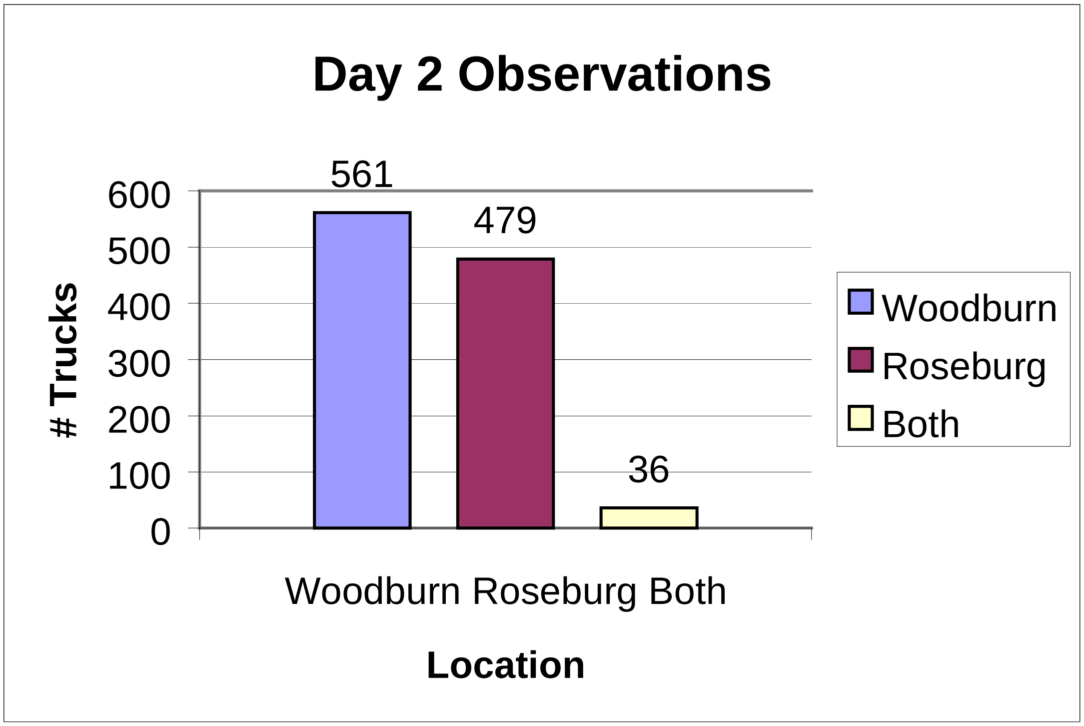
EXHIBIT 2-3 DAY 1 OBSERVATIONS AT WEIGH STATIONS



The graph illustrates the observations made on Day 1 in the fall of 1999. As one can see the graph shows that 839 trucks were observed and recorded at the Woodburn P.O.E. during the data collection period. The next bar shows 744 trucks were observed and recorded at the Roseburg Weigh Station. Finally, after comparing the records of observations, it was determined that 102 trucks passed both weigh stations during the observation period, roughly six percent of the total observations made.

The tax records of the trucks that passed both weigh stations were later examined to determine if at least 144 miles were reported to ODOT. The examination determined that the trucks that were observed at both data collection points had reported at least 144 miles traveled in Oregon for that time period.

EXHIBIT 2-4 DAY 2 OBSERVATIONS AT WEIGH STATIONS



The graph illustrates the observations made on Day 2 in the fall of 1999. As one can see the graph shows that 561 trucks were observed and recorded at the Woodburn P.O.E. during the data collection period. The next bar shows 479 trucks were observed and recorded at the Roseburg Weigh Station. Finally, after comparing the records of observations, it was determined that 36 trucks passed both weigh stations during the observation period, roughly three percent of the total observations made.

The tax records of the trucks that passed both weigh stations were later examined to determine if at least 144 miles were reported. Following an examination of the quarterly tax reports, it was determined that these trucks that were observed at both data collection points had reported at least 144 miles traveled in Oregon for that time period.

EXHIBIT 2-5 MILES REPORTED TABLE

Tax Records of Trucks Observed at Both Scales	At Least 144 Miles Reported in Quarter
Day 1	Yes
Day 2	Yes

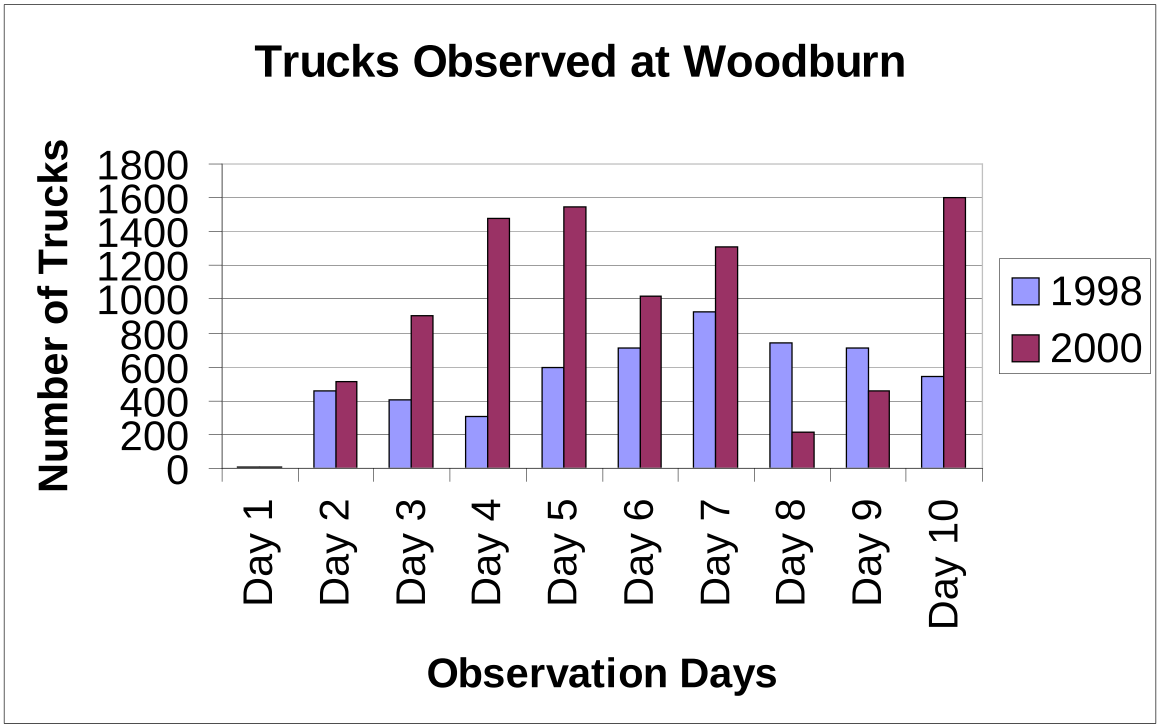
Exhibit 2-6 indicates that the 138 trucks that were observed at both of the Woodburn and Roseburg weigh stations had reported at least 144 miles traveled in Oregon during the observation period.

2.3.2 Study Constraints

Granted, this is a very small sample. Generally, 138 observations are not statistically significant within an infinite population. Time constraints prevented the research team from more completely expanding the sample. It must be emphasized, however, that at the time of this report, Green Light has not been fully deployed. At the time of the data collection, in October of 1999 only approximately 3,000 transponders had been issued. Since that time, however, Oregon DOT has issued approximately 6,500 additional transponders. Therefore, it is recommended that the effects Green Light be analyzed again a year from now when more transponder-equipped vehicles are in service and a larger sample can be examined.

Based on this small sample, however, the data indicate that the observed trucks, observed electronically or otherwise, are likely to report their miles operated in Oregon to ODOT.

EXHIBIT 2-6 VEHICLE INCREASES AT WOODBURN



2.3.3 Truck Volume Increases

The above graph illustrates the increases in the number of trucks passing through the Woodburn P.O.E. during a ten-day observation period. The number of trucks that were observed during the ten days in January of 2000 were then compared to the same ten-day period in 1998. The trend shows a general increase in the number of trucks passing through the Woodburn P.O.E. The most recent traffic data available to the Oregon Department of Transportation's planning office indicate that truck traffic in the vicinity of Woodburn on the south bound lane of Interstate 5 is currently growing at an annual rate of 2.6 percent. If the trend continues, the need for electronic screening will also increase in order to screen more trucks more efficiently. As we indicated in the weigh station simulation report, an average of 270 vehicles (trucks) per hour were observed passing through the southbound Woodburn P.O.E. Assuming that the traffic growth rate remains constant, 340 vph would be realized in the year 2003, 375 vph in 2010, and 410 vph in 2013.

3. FINDINGS

The impact of Green Light increases the capacity of a weigh station to observe motor carriers' operations. For each truck that uses a transponder, a space is created in the weigh station queue. Assuming that the Oregon Department of Transportation (ODOT) maintains the volume of traffic currently processed through the static scales, the total number of observations will increase equal to the rate of growth in transponder-equipped trucks. For trucks that have transponders, observations will be recorded at every pass by the weigh station. For trucks without transponders, the likelihood of having to stop at the static scale, thus being observed will increase.

Observations or third party data are an integral part of the weight-mile tax auditing process. Weight-mile tax reports are generated by the motor carrier on a monthly or quarterly basis. Reported trips are compared to observations within the state. Observations are currently made at the weigh station through vehicle weighing, safety inspections, and traffic citations. Weigh station observations are by far the most prevalent observations.

The use of Green Light technology will increase the number of weigh station observations. The increase in the number of observations will allow the audit unit to more effectively select motor carriers for audit. By having more observations, there is a greater chance of detecting unreported trips. Additional observations will also improve the accuracy of motor carrier audits. The additional information will allow the field auditors to more precisely and assuredly estimate a vehicle's pattern of operation with the boundaries of Oregon.

Observations will also serve as a deterrent to weight-mile tax evasion. Motor carriers that have been audited in the past, or have learned from other's experiences, are quite conscious of the fact that weigh station observations are used by ODOT to verify weight-mile tax reports. In reviewing drivers' records of duty status against tax reports and weigh station observations, it has been observed that drivers will note those trips in which their vehicles have been weighed and report those trips.

Although Oregon Green Light will lead to an increase in the number of observations that will, in turn, result in improved accuracy, and, allows for a better selection of files to be audited, however, it will have little effect on the process of auditing.

The auditing process nonetheless calls for manual review of all files by the Pre-audit staff. A few lines of additional data might add a few seconds to the pre-audit staff review. Conversely, the additional data might allow the pre-audit staff to more quickly identify unreported operations, flag the files for audit, and move along to the next file. If either or both scenarios prove to be correct, the effect on the efficiency of the pre-audit process, measured in the amount of resources that it takes to review a file, will be negligible.

Field auditors use weigh station observations to piece together a vehicle's pattern of operation within Oregon. Because weigh station observations are more easily accessed than motor carrier records, the time that it takes to conduct an audit might be shortened. However, unless a truck is observed in several locations on all trips, review of data from a variety of sources will continue to be the norm. The effect that electronic clearance will have on the efficiency of the desk and field audit processes, measured in the amount of resources that it takes to conduct a desk or field audit, will be negligible.

With regard to tax collection, the “Oregon Weight-Mile Tax Study” of 1996 concluded that the “evasion rate of the weight miles tax is approximately five percent of the total tax liability, or ten million dollars per year." Although the amount of revenue lost to evasion each year is quite significant, it is only a small portion of motor carriers are actually submitting incomplete or inaccurate tax reports. [1] To meet the objectives set forth in Measure 2.2.1 “Determine the changes in highway use tax and why”, the study team focused on the effect that Oregon Green Light technology has on the behavior of these motor carriers and the ability of the audit branch to detect and adjust inaccurate and/or incomplete tax reports. For example, the Woodburn Port of Entry currently allows all vehicles that weigh less than 62,000 lbs. on the ramp weigh in motion scale to take the ramp bypass lane and thus avoid direct observation. Consistently, 60 percent of trucks that pass through Port of Entry are not directly observed. Assuming that the number of transponder-equipped vehicles increases as is expected, a substantial percentage of trucks will be checked electronically on the mainline and the static scales will no longer be operating at or near capacity. The weigh station will then be able to lower the threshold weight of the ramp bypass and pull in a higher percentage of non-transponder equipped trucks for static scale weighing and observation.

According to Motor Carrier Auditors, motor carriers are quite cognizant of the fact that the audit branch uses weigh station observations. For those motor carriers that are tempted to report only those trips in which they are observed, the additional observations will serve as a direct deterrent resulting in greater tax receipts per registered motor carrier.

[1] Oregon Weight Mile Tax Study (Cambridge Systematics, Inc., Sydec Inc., and Pacific Rim Resources, Inc. February 20th, 1996.)

Deterrence alone will not eliminate tax evasion. As one auditor stated during the group interviews, “Tax evasion is more often an act of omission than an act of commission.” Poor record keeping and/or a lack of understanding of reporting procedure results in inaccurate or inadequate tax filings. The increase in the number of observations resulting from the introduction of electronic clearance will allow the pre-audit team to detect and adjust inaccurate and/or incomplete tax reports. By having more observations, there is a greater chance of catching unreported trips in both in pre-audit and field audit. While Green Light will provide more observations to assist auditors, this analysis did not determine significant changes in the processes.