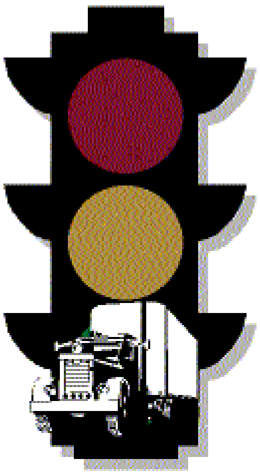

Oregon Green Light

CVO Evaluation

FINAL REPORT

Executive Summary

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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.

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1 INTRODUCTION

1.1 BACKGROUND

This Report is the Executive Summary for 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 has installed twenty-one mainline systems featuring weigh-in-motion (WIM) devices and automatic vehicle identification (AVI) at the major weigh stations and ports-of-entry in 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 other locations.

The purpose of this report is to present a summary of the findings of all the Detailed Test Plans conducted for the evaluation. The Detailed Test Plans were published in 1997, "The 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 [2]. 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 Oregon "Green Light" CVO Project - *Individual Test Plans* (ITP) [3]. The detailed test plan documents [1] expand on the information provided in the ITP and provide in detail the activities planned for each *evaluation measure.*

1.2 PURPOSE AND SCOPE

The purpose of this Executive summary is to summarize the principal findings from each Detailed Test Plan (DTP). Each of the DTP's is summarized in Exhibit 1-1.

As the evaluation progressed, some simplifications were made as it became clear that some elements of Green Light would be modified or eliminated. For example, objective 2.6 was eliminated because vision technology was eliminated from ODOT's plans. Also, a major change was implemented for DTP #7 where a simulation tool was developed to enable benefits of electronic screening to be evaluated. Simulation was necessary because the evaluation was proceeding concurrently with deployment, and, it was not possible to collect data that would enable measurement of impacts. Because the impact of pre-screening on fuel consumption was also determined using the simulation, that study (DTP #9) is reported with DTP #7. Exhibit 1-2 shows a summary of the DTP's that were completed.

The findings will be presented in Chapter 2, in the order of the detailed test plans. A general discussion regarding the success of the Green Light project is given in Chapter 4. Conclusions and Recommendations are given in Chapter 4.

EXHIBIT 1-1 Summary of Detailed Test Plans as Planned

Detailed Test Plan	Objective	Measure	Hypothesis / Assumption
DTP #1	1.1 Determine change in safety compliance with the Federal Motor Carrier Safety Regulations	1.1.1 Proportion of compliant (with FMCSR) trucks / carriers of total inspected and total processed per month.	The proportion of compliant trucks will eventually increase.
		1.1.2 Proportion of non-compliant (with FMCSR) trucks-carriers of total inspected and total processed per month.	The proportion of non-compliant trucks will eventually decrease.
DTP #2	1.2 Determine change in truck behavior due to the Road Weather Information System	1.2.1 Ratio of mean speed in inclement weather to that in good weather, before & after installation.	Truck speeds will decrease in inclement weather.
DTP #3		1.2.2 Ratio of accidents before & after installation if sufficient data exists.	Accident risk will decrease with better information available on weather conditions.
DTP #4	1.3 Determine change in truck behavior due to the Downhill Speed Information System	1.3.1 Ratio of mean speed on downhill sections, before & after installation.	Mean speeds will decrease.
DTP #5		1.3.2 Ratio of accidents before & after installation if sufficient data exists.	Accidents will decrease.
DTP #4		1.3.3 Comparison of mean speeds with advisory speeds	Mean speeds will converge towards advisory speeds.
DTP #6	2.1 Determine changes in tax administration costs	2.1.1 Determine the change in the resources required in the collection process, i.e., *hardware, software, staff etc.*	Tax collection will become more automatic and costs reduced (refer to the 1994 Green Light Document).
DTP #6		2.1.2 Determine the change in the resources required in the auditing process (government and carrier).	Audit process will become more automatic.
DTP #6	2.2 Determine changes in tax evasion	2.2.1 Determine changes in highway use tax revenues collected & why.	Oregon Green Light will support changes.
DTP #7	2.3 Determine changes in vehicles processed at each site	2.3.1 Compare total vehicles processed (cleared & not-cleared).	Number processed will increase.
DTP #7		2.3.2 Compare no. of interruptions per shift & total time.	Interruptions will decrease.
DTP #8		2.3.3 Observe system availability.	Availability will be approximately 95%.
DTP #8		2.3.4 Observe system availability for long combination vehicles at Farewell Bend	The system availability for LCVs at Farewell Bend will be approximately 95%.

DTP #7	2.4 Determine productivity to motor carriers	2.4.1 Compare truck flow on the mainline before & after installation.	Truck flow will increase.
DTP #9	2.5 Determine impacts on energy	2.5.1 Estimate changes in fuel use before and after using I-75 experience.	Fuel consumption will decrease.
DTP #10	2.6 Determine the ability of vision technology to support 100 percent electronic screening service	2.6.1 Evaluate the accuracy of the vision system by comparison of vision readout with actual plate numbers.	Vision system will be accurate at least 90% of the time.
DTP #11	3.1 Assess motor carrier acceptance	3.1.1 Determine attitude towards electronic screening, including perceived impacts.	The majority of carriers will have a positive attitude.
DTP #11		3.1.2 Determine attitude towards new services, e.g., select carriers-vehicles for inspection based on inspection and compliance status.	The majority of carriers will have a positive attitude.
DTP #11		3.1.3 Evaluate motor carrier acceptance of mainline electronic screening.	Carriers will demonstrate acceptace by installing transponders.
DTP #12	3.2 Assess agency acceptance	3.2.1 Determine agency attitude towards electronic screening, including perceived impacts.	The majority of agency personnel will have a positive attitude.
DTP #12		3.2.2 Determine agency attitude towards new services, e.g., select carriers-vehicles for inspection based on inspection and compliance status.	The majority of agency personnel will have a positive attitude.
DTP #13	4.1 Document regional and national mainstreaming issues	4.1.1 Identify, assess and document pertinent regional and national issues (e.g. IOU, HELP, CVISN, ITS Systems Architecture, DSRC) and assess the impacts to Green Light for customers and providers.	Knowledge of pertinent regional and national issues will increases the effectiveness of the Green Light program.
DTP #13	4.2 Document approaches attempted to solve mainstreaming issues and final resolutions	4.2.1 Document approaches attempted to solve regional and national mainstreaming issues as they arise, and final resolutions.	Participation in pertinent regional and national issues will contribute to the effectiveness of the Green Light program.
DTP #14	5.1 Document non-technical interoperability issues	5.1.1 Identify, assess and document pertinent non-technical interoperability issues as they arise for customers and providers.	Knowledge of pertinent non-technical issues will increases the effectiveness of the Green Light program.
DTP #14	5.2 Document approaches attempted to solve interoperability issues and final resolutions	5.2.1 Document approaches attempted to solve non-technical interoperability issues as they arise, and final resolutions.	Documentation of participation in, and approaches used to resolve pertinent non-technical issues will contribute to the effectiveness of the Green Light program.

EXHIBIT 1-2 Summary of DTP's as Completed

DTP	Test Measure	Description	Outcome
	All	Executive Summary	
DTP #1	1.1.1 and 1.1.2	Inspection Compliance	Completed as Planned
DTP #2	1.2.1	RWIS – Speed Study	Combined and Reduced in Scope
DTP #3	1.2.2	RWIS - Accidents	
DTP #4	1.3.1	DSIS - Speed Study	Combined and Reduced in Scope
DTP #5	1.3.2	DSIS – Accidents	
DTP #6	2.1.1, 2.1.2 and 2.2.1	Tax Collection and Auditing	Completed as Planned
DTP #7	2.3.1, 2.3.2, and 2.4.1	Simulating the Impact of Electronic Screening	Completed as Planned Combined with DTP #9
DTP #8	2.3.3 and 2.3.4	System Availability	Completed with Reduced Scope
DTP #9	2.5.1	Fuel Consumption	Completed as Planned Combined with DTP #9
DTP #10	2.6.1	Assess Vision Technology	No Evaluation Conducted
DTP #11	3.1.1 and 3.1.2	Assess Motor Carrier Acceptance	Completed as Planned
DTP #12	3.2.1 and 3.2.2	Assess Agency Acceptance	Completed as Planned
DTP #13	4.1.1 and 4.2.1	Mainstreaming Issues	Combined and Completed as Planned
DTP #14	5.1.1 and 5.2.1	Non-technical Interoperability Issues	

2 SUMMARY OF FINDINGS

This chapter summarizes the findings from each of the detailed test plans.

2.1 DTP #1 – Inspection Compliance

Out-of-service violations found during a series of random inspections (in 1998 and 1999) were used as an indicator of change in vehicle safety. The study found no significant changes in compliance rates at sites where Green Light technology was deployed. However, there was a significant increase in the total number of violations per inspection at non-GL, fixed sites. The most consistent pattern observed was a decrease in violation rates at non-fixed (or mobile) sites. The number of violations, the number of OOS violations, and the number of vehicle OOS violations per inspection decreased. Combining data across site types, the only significant difference was an increase in violations per inspection between 1998 and 1999.

It is important to note that over the course of the evaluation period, from January 1998 to July 1999, there was a low transponder penetration in relation to the total traffic bypassing the Green Light facility at Woodburn POE. At the end of the data collection period for this study in July 1999 there were approximately 3000 transponders in the field, less than the amount needed to actually show a change in compliance as a result of Green Light. This number increased substantially to over 10, 000 transponders in the field in July 2000. Green Light bypasses also increased dramatically from about 28,000 in July 1999 to approximately 60,000 by July 2000.

This study established a baseline for future studies that should show that safety compliance increases as Green Light is fully deployed and a significant truck population carry transponders. It is strongly recommended that ODOT conduct random inspections annually so that it can be clearly demonstrated that safety of the truck fleet is Improving.

2.2 DTP #2 – Road Weather Information System – Speed Study

ODOT's travel advisory web page has underwent several upgrades in during the last 12 months of the evaluation. 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 providing real-time 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 not accomplished before the evaluation was completed, due to the incompatibility of the existing hardware interfacing with the signs in Ladd Canyon. Combined with the prohibitive costs of retrofitting signs with compatible hardware and/or purchasing new signs, this 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, trucks could be equipped with palmtop computers that can query road conditions via the Internet. Until such technology is mainstream, information kiosks at rest areas, truck stops, and weigh stations, could be incorporated into ODOT's existing infrastructure without a great deal of capital expense, and would reach all carriers, regardless of their technological advancements.

2.3 DTP #3 – Road Weather Information System – Accident Study

Available accident data has given a good baseline approach to continued monitoring of accidents in the Ladd Canyon area. It is strongly recommended that ODOT continue to collect data so that the impact of the RWIS can be measured.

2.4 DTP #4 – Downhill Speed Information System – Speed Study

Although the Emigrant Hill DSIS was not been deployed, the evaluation indicates that DSIS is a valuable tool that will be 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.

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

2.5 DTP #5 - Downhill Speed Information System – Accident Study

Available accident data has given a good baseline approach to continued monitoring of accidents at Emigrant Hill. It is strongly recommended that ODOT continue to collect data so that the impact of the DSIS can be measured.

2.6 DTP #6 – Tax Collection and Auditing

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 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 increase in the number of observations enabled by Green Light 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. This will also serve as a deterrent to weight-mile tax evasion.

Green Light will lead to an increase in the number of observations, improved accuracy, and, allow for a better selection of files to be audited. However, it will have little effect on the process of auditing. The auditing process 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

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

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.

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.

2.7 DTP #7 – Simulating the Impact of Electronic Screening

The simulation findings indicate that electronic screening will reduce travel time and fuel consumption for trucks participating in the electronic screening programs, or transponder equipped trucks. Findings also indicate that electronic screening will decrease the occurrence of unobserved bypasses resulting from full queues and increase the percentage of trucks being screened for safety and compliance. The effectiveness of electronic screening will be situational. Several variables, including truck traffic volumes at the weigh station, the percentage of motor carriers participating in the electronic screening program, and Oregon's commercial vehicle enforcement policies and procedures will determine the degree to which the electronic screening program meets its objectives.

An advantage of the simulation model is that the ODOT is not limited to the analysis of the scenarios selected for this report. ODOT staff can run the model on any personal computer with the Windows 95 or higher operating systems. With the Arena Viewer, users are able to alter input parameters such as traffic level, transponder rate, and number and length of inspections, to perform "what if" scenarios. ODOT can also analyze the impact that changes in operational procedure and/or staffing levels would have on the functionality of the weigh station. For example, ODOT could examine the impact of changing the threshold weight for the bypass lane or closing the ramp bypass lane entirely. Also, it can be shown that if the ramp bypass lane were closed, electronically screened vehicles would realize greater time savings than vehicles not participating in the program.

In the scenario described above, closing the ramp bypass lane would also serve the objectives of ODOT's motor vehicle enforcement objectives. At the time of data collection, the ramp bypass lane allowed vehicles weighing less than 75 percent of the legal limit to bypass the static scale and return to the mainline. By bringing all vehicles to a stop at the static scale, the Woodburn staff would have the opportunity to visually check all vehicles not participating in the electronic screening. The ramp bypass lane serves the purpose of reducing congestion within the weigh station and thus minimizing unobserved bypasses, while maintaining weight screening on all vehicles that enter the weigh station. With enough vehicles participating in the program, electronic screening will give ODOT more flexibility in setting operational procedures. The simulation model will assist ODOT in assessing the impact of proposed changes in procedures.

Although closing the ramp bypass lane would result in the most dramatic changes in travel time savings for participating vehicles and would allow for a visual check of all vehicles, it is more likely that operational procedures would change incrementally. The simulation package gives the end user the ability to vary the percentage of vehicles and determine the threshold weight that would bring the greatest number of vehicles to the static scale without resulting in unobserved bypasses.

For this evaluation of weigh station efficiency, the Arena Viewer software "packed" with the Woodburn model is considered a deliverable equal in and of itself. Not only does the simulation provide a robust medium for evaluation but the powerful animation capability makes it possible to demonstrate the functionality of the weigh station and the impact of electronic screening to a broader audience.

2.8 DTP #8 – System Availability

The evaluation was designed to take place over a two-year period after the roadside systems were deployed. However, at the time the evaluation contract was completed, only seven of the twenty-one sites had been deployed, and had not been functioning for two years. The data collected were analyzed and indicated that the system was available at least 95% of the time to Weighmasters and Motor Carriers at the seven sites, when considered in aggregate. The data collected at Farewell Bend indicate that the system availability for long combination vehicles was nearly 100%.

It is strongly recommended that ODOT continue to evaluate data available in the Trouble Report Master Log and publish the results on an annual basis.

2.9 DTP #11 – Assess Motor Carrier Acceptance

A questionnaire survey was designed to monitor and assess motor carrier acceptance of Green Light technologies. Two surveys ("before" and "after") were sent to carriers who operate in Oregon. The first survey was conducted in 1998, and the second in 2000.

The main goal of the questionnaire surveys was to obtain the following:

- User attitudes to electronic screening and its perceived impacts on the motor carrier.
- User attitudes to new services such as Road Weather Information System (RWIS) and Downhill Speed Information System (DSIS).

The survey design was based on the method described in the "Mail and Telephone Surveys – Total Design Method" by Don A. Dilliman. Mailing included an initial cover letter, the survey, and a brief description of Green Light components, a follow-up postcard, and finally a second survey identical to the first, but with a slightly different cover letter.

Surveys were mailed to a random sample of carriers registered to operate in Oregon. The population of motor carriers was divided into three strata based on the location of the carriers listed in ODOT's database. Twelve hundred Oregon carriers made up the first stratum (Oregon carriers). One thousand carriers based in Washington, California, Idaho, and Nevada comprised a second stratum (Pacific Norwest carriers) while 1,000 of carriers of the remaining states and Canadian provinces made up to the third stratum (Other carriers).

The percentage of respondents to the survey was about 10 percent less in the "after" survey than in the "before" survey. The experience level of the participants is evenly distributed across strata with no significant variations in both "before" and "after" surveys. Nearly half (50%) of the respondants had been working in the industry for more than 20 years. Overall, smaller carriers dominated the sample with about three-quarters (75%) having fleet sizes of one to ten trucks. However, the medium fleet size (11 – 99 tractors) showed significant changes in the "after" or second survey.

A summary of findings is listed below:

- 41% of carriers agree (19% disagree) that Mainline Preclearance will benefit their company in the "before" survey while about 32% of carriers agree (25% disagree) with this statement in the "after" survey.
- 60% of carriers agree (that Road Weather Information System (RWIS will benefit their company in the "before" survey and 52% of carriers agree with this statement in the "after" survey. Approximate 15% disagree with the statement in both surveys.
- Over 50% of carriers agree with the policy of screening trucking for possible inspection based on recent compliance with federal safety regulations (nearly 16 % disagree) in both "before" and "after" surveys.
- Over 60% of carriers rate the overall performance of ODOT's Motor Carrier Services as "Good" (nearly 26% rate it "Fair" and about 4% rate it "poor") in both "before" and "after" surveys. 9% rate it "Excellent" in the "before" survey and 6% in the "after" survey.

The evaluation of motor carrier acceptance by tracking transponder penetration since they were introduced in 1997 showed that, after a slow start, the industry embraced the technology. At the time the evaluation was completed, nearly 12,500 transponders were in use.

2.10 DTP #12 – Agency Acceptance

The purpose of this study was to gain insight about how Green Light met its initial objectives in the eyes of the personnel that work with the system as well as those that developed and deployed it. The interviews provided an opportunity to document the lessons learned during Green Light's deployment. The study used an interview process tailored to focus on both Green Light's benefits, and the obstacles that may have hindered the development of the system's integration into the ODOT's business and operations. It was intended that the results of this part of the evaluation would provide a valuable resource to those deploying similar projects.

The interviews consisted of asking up to nine questions of a targeted group of ODOT's leadership and personnel involved closely with the Green Light deployment. The summary of responses shows a high level of agency acceptance as well as an understanding of the benefits gained and recognition of lessons learned. The last question dealt with lessons learned and is repeated below, followed by a summary of the responses:

> ***"What have been some lessons learned in the inception of Green Light, and what have been deterrents to its complete and successful operation?"***

Interoperability was commented on as a problem, specifically regarding the differing business models between different systems and the competitive politics surrounding the issue. It was stated that only the federal government has the power to enforce cooperation, but they have not. The technology is not a real problem, but the political resistance is. The program also has had installation and assimilation problems because of the lack of a central coherent training or marketing plan. Training was done piecemeal all over the state, so the same battles were fought over and over again. A comprehensive and organized introduction and training program would have increased early acceptance and eased the transition. The trucking industry as a whole is not an early adopter of technology, and a solid, timely marketing program should have been implemented. Some of the marketing that was done was done prematurely, which let carrier interest fade before the system was up and running. An important lesson is that by giving out free transponders to new members, the startup risk of new technology was shifted away from the truckers, so they became much more agreeable to the program. While this method may not be appropriate everywhere, it is important to note that carriers want to save time and money, but an untried system that fails will cost them more than it saves, so they are wary about investing in it. Reducing transponder costs as much as possible will diminish this reluctance. Ultimately, the system should be nationwide. This will reduce the costs to truckers the most, and so will be the most accepted, used, and useful. The Oregon system is up and running, but at present multiple transponders must be purchased to use systems in multiple states. Overcoming the barriers between systems is necessary for the system in any state to fully mature and achieve its potential.

2.11 DTP #13 & #14 - Mainstreaming and Non-technical Interoperability Issues

This part of the evaluation was weighted heavily towards interoperability issues, because those issues proved to be significant in delaying market penetration of mainline technologies. Mainstreaming proceeded in a steady and non-controversial way. The literature supports this conclusion; there are many articles that report on the widespread adoption of the technologies.

It is clear that achieving interoperability between different programs is very difficult. Even the MAPS and Advantage CVO states (with very similar business models) took four years from the start of Green Light to form an agreement.

Although a one-way interoperability agreement was reached between NORPASS and PrePass, it was unsatisfactory to Oregon, and, caused them to withdraw from NORPASS. Green Light carriers are still interoperable with NORPASS (they must pay the $45 enrollment fee) and, NORPASS carriers operate in the Green Light system free of charge. As yet, no satisfactory agreement has been reached between Green Light and Prepass for one-way interoperability.

A positive outcome of Oregon’s withdrawal from NORPASS is that it transferred ownership of transponders to the carriers, and, distributed an additional 7,500 transponders in three months. There are now 12,500 trucks equipped with Green Light transponders. This is half their original target, but, considering the current progress, they could reach their target before 12/31/2000.

A satisfactory compromise needs to be reached between Oregon and PrePass before interoperability can be achieved. Oregon should hold to its principles, which are endorsed by other states and by many in the trucking industry. However, they will likely need to compromise, but, only to the degree to which their customers agree. The major principle is regarding HELP's limitation of the use of PrePass transponders.

An issue for many Green Light carriers is the fee structure used by PrePass. However, the market will determine if carriers are prepared to pay PrePass's fees. PrePass may need to introduce alternative fee schedules to attract a diverse range of customers.

A longer term issue is reaching an interoperability agreement that will enable PrePass carriers to operate in Green Light. At this time there is an impasse with regard to PrePass obtaining some cost recovery as well as protecting there carrier's data privacy. However, there are several examples of PrePass carriers that have requested enrollment in Green Light (and NORPASS) and have been refused by PrePass. Carriers can enroll in each system separately and obtain a transponder for each, but, there are problems when a truck has two transponders in the cab. Since the Green Light and PrePass transponders are the same, this situation is unnecessary!

Oregon was very successful in the distribution of transponders after opting to withdraw from NORPASS and deciding to act as their own transponder administrator. The two significant changes that Oregon introduced (as the administrator) were: a) transferring ownership of transponders to the carrier, and, b) providing new transponders at no cost. At the time the evaluation was concluded 12,500 transponders had been distributed. Another 12,500 will be distributed free of charge, before a carrier must purchase their own transponder. It is strongly recommended that ODOT continue the successful practice of targeting those carriers that would benefit the most from mainline , i.e. those that operate most in the Green Light corridors.

It is likely that ODOT will reach its goal of issuing a total of 25,000 transponders during 2001. The state should consider continuing free distribution of transponders. A market survey may be appropriate to guide this decision. It is certainly likely that those enrolled in the program would be willing to pay (if they had to do over) but enrolling new carriers will become difficult at some point. Removing the best incentive (free transponders) may halt the rapid progress that has been made in market penetration.

3 DISCUSSION

This chapter provides a general discussion of issues relating to the evaluation but not specifically addressed in any of the detailed test plans.

The Green Light Project was initiated in 1995 to fulfill Oregon's vision of creating an automated and intelligent truck transportation system. As the project nears completion, it has proved successful, by improving the safety and efficiency of the commercial trucking industry while at the same time increasing the performance of roadside facilities without physically expanding them, and protecting the public investment in the infrastructure.

Through the Green Light weigh station modernization program, Oregon has installed Mainline Systems at 21 weigh stations to electronically screen trucks as they approach at highway speeds. The deployment at all 21 sites was completed and fully operational by March 2001. Weigh-in-motion (WIM) systems check the vehicle's weight and height, and, automatic vehicle identification (AVI) systems check records for registration, tax status, and safety inspection status. The driver is signaled with an in cab device to either Report to the station or to Bypass.

During 1999 nearly 280,000 mainline bypasses occurred at completed sites, and, in 2000 this number rose to more than 640,000. All 21 sites were fully deployed by March 2001, and, the number of bypasses will continue to increase as more carriers enroll, freeing weigh site personnel and facilities to process only those trucks that need their attention, and, saving considerable time (and money) for trucks that bypass. Calculable savings occurred in several ways:

(1) The cost of physically expanding 11 of the 21 weigh stations was avoided,

(2) The cost of building five replacement weigh stations for facilities that would otherwise be rendered obsolete was avoided,

(3) The cost of early repair to the infrastructure as a result of increased overweight truck traffic was avoided, and

(4) The trucking industry operates more efficiently and avoids costs it would have incurred in a strictly conventional, time-consuming stop-and-weigh process.

Each of these cost saving mechanisms is addressed in more detail below.

Truck traffic increased almost 40 percent in the I-5 corridor between Portland and Salem from 1990-1998. The two weigh sites in this area were designed in the mid-1980's to weigh about 2,500 trucks a day, but today the traffic load has increased to more than 5,000 trucks a day. Truck traffic along the I-84 corridor has increased by similar amounts. To accommodate these increases in truck traffic 11 weigh stations would require expansion including extension of the off-ramps and added static scales. The total estimated cost for extending the ramps and adding a static scale at each site was $2,262,700. Through the Green Light mainline system, Oregon avoided spending millions on facility expansion at major weigh stations.

An additional five weigh stations would soon be rendered obsolete, and, there is no room to physically expand them at their current location. If replacement stations could be built, within appropriate proximity to each station, the cost of construction would be a minimum of $14.5 million. However the biggest cost consideration would be in land acquisition. If electronic screening were not available at these locations Oregon would be forced to close the stations, thus removing any visible enforcement, and, forced to accept compromises to its size and weight enforcement effort.

By implementing Green Light systems, Oregon identified and stopped more overweight trucks than previously. Without Green Light these trucks would proceed with the potential to cause millions in highway pavement damage. In a model developed by researchers in Idaho, the benefit in prevented damage can be estimated for a weigh station in a typical highway application. The study indicated that a single weigh station, covering an area of 160 miles, would prevent approximately $46 million in pavement damage during an average life span of 10 years. An earlier Federally Funded study indicated that overloaded truck axles cost up to $670 million per year (nationally) in pavement damage. Thus with 21 improved weigh stations enhancing the ability to minimize overloaded vehicles, Oregon could save well in excess of $200 million during the next 10 years. Although there is no generally accepted way to calculate the actual amount, the savings realized are related to costs associated with: (1) the effect of deteriorating pavement conditions on fuel economy, tire wear, and other related maintenance costs, (2) time delays suffered during pavement resurfacing, reconstruction, rehabilitation, and maintenance, and, (3) time delays suffered due to traffic control related to remodeling, upgrading, and/or reconstruction of weigh stations.

Finally, by utilizing Green Light the trucking industry enjoys efficiencies and avoids costs that are built into the conventional weigh station operation. What’s it worth to a truck driver to pre-clear a weigh station at highway speeds? Operating a heavy truck has been estimated by the American Trucking Association to cost $1.92 per mile. Assuming an average hourly speed of 39 miles-per-hour (from departure to destination), a cost of $1.24 per minute is realized. Truck drivers save at least three minutes per weigh station bypass. Therefore it is conservatively projected, based on the current rate of about 60,000 bypasses a month in Oregon, that in the next 10 years the Green Light mainline system is expected to pre-clear 7.2 million trucks. This will save the industry more than $25 million in operating costs as it saves 360,000 hours of travel time. However, it is anticipated that the number of bypasses will increase substantially as more carriers enroll, resulting in much larger savings.

In summary, the Oregon Green Light project has been immediately beneficial, yet designed for the future; the system will continue to provide financial benefits in the form of cost avoidance to the taxpayer and to the trucking industry. The model deployment has clearly demonstrated the benefits of mainline . It has also demonstrated that achieving interoperability (see sections 2.10 and 2.11) is a difficult process that may prove more difficult to achieve than providing technically excellent systems.

4 CONCLUSIONS AND RECOMMENDATION

The independent evaluation was initiated in August 1995 and concluded in June 2000. Oregon State University was prime contractor, with Iowa State University as a sub-contractor, and, WHM Transportation Engineering as a consultant. Fourteen test plans were developed to evaluate: safety, productivity, user acceptance, mainstreaming issues and interoperability issues. At the time the evaluation was concluded, the Green Light sites were not fully deployed; the Conclusions and Recommendations are therefore based on tests conducted on an incomplete system. Nevertheless, they are a strong indicator of future performance.

4.1 Conclusions

Safety: Out-of-service violations found during a series of random inspections (in 1998 and 1999) were used as an indicator of change in vehicle safety. At the time of these inspections there were few transponders distributed and, therefore, no significant changes were observed. However, the study established a baseline for future studies that should show that safety compliance increases as Green Light is fully deployed and a significant number of trucks carry transponders. Evaluation of the Road Weather Information System (RWIS) and the Downhill Speed Information System (DSIS) could not be completed as planned because the systems were not fully deployed. However, the methodology for the evaluation should be applied once deployment is completed

Productivity: A study of the auditing and collection processes for the weight–mile tax indicated that Green Light technology significantly increases the level of auditing possible. Ability to do this will improve productivity but not result in any changes to the processes. A simulation model was also developed for sites. The model clearly demonstrated that system capacity increased as transponder penetration increased, and, provides a powerful tool (because of the animation capability) to demonstrate impacts of electronic screening to a broad audience. A third productivity study of seven functional sites indicated that the system will be available at least 95% of the time. This suggests a very high productivity when all 21 sites are deployed.

User Acceptance: Before and after surveys were conducted in 1998 and 2000 to assess motor carrier acceptance of Green Light technologies (electronic screening). There was little difference in the results of the 2 surveys. However, in both surveys, the majority of motor carriers were supportive of electronic screening and were satisfied with ODOT's Motor Carrier Services. The steady increase in transponders issued is the strongest indicator of user support; 10,000 were issued in 2000 after a slow penetration in 1998 and 1999. The indication is that ODOT will reach its goal of issuing 25,000 transponders in 2001, largely due to growth in user acceptance.

Agency Acceptance: Interviews were conducted with ODOT leaders as well as with personnel involved closely with the Green Light deployment. The responses showed a high level of agency acceptance as well as an understanding of the benefits gained and recognition of lessons learned. Interoperability was commented on as a problem, specifically regarding the differing business models between different systems and the competitive politics surrounding the issue. It was stated that only the federal government has the power to enforce co-operation. However, this was not done and a solution has not yet been found.

Mainstreaming and Interoperability Issues: Mainstreaming proceeded in a steady and non-controversial way. However, there have been many interoperability issues. It is clear that ODOT and PrePass must reach a satisfactory compromise before interoperability can be achieved. ODOT should hold to its principles, which are endorsed by other states and by many in the trucking industry.

In summary, the Oregon Green Light project has been immediately beneficial, yet designed for the future; the system will continue to provide financial benefits in the form of cost avoidance to the taxpayer and to the trucking industry. The model deployment has clearly demonstrated the benefits of mainline . It has also demonstrated that achieving interoperability (see sections 2.10 and 2.11) is a difficult process that may prove more difficult to achieve than providing technically excellent systems.

4.2 Recommendation

Because the evaluation contract was concluded before all elements of the Green Light project were fully deployed, the evaluation was incomplete. Nevertheless, the evaluation conducted demonstrated that the project was successful as indicated in the foregoing sections of this Executive Summary. However, it is strongly recommended that ODOT continue evaluation of Green Light using the framework established in the evaluation contract.

5 REFERENCES

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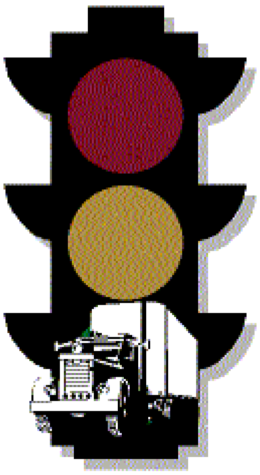
2. Bell, C.A., B. McCall, and, C.M. Walton, "The Oregon 'Green Light' CVO Project, Evaluation Plan", GLEV9601, Oregon State University, Transportation Research Institute, September 1996.

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.



Oregon Green Light

CVO Evaluation

FINAL REPORT

DETAILED TEST PLAN 1

Safety Compliance Test

Paul E. Montagne

Chris A. Bell

Transportation Research Report No. 00-12

Transportation Research Institute

Oregon State University

Corvallis, OR 97331

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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.

Lastly, a special thanks to John Kinateder and John Orban of Battelle for their contributions to this Detailed Test Plan.

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1 INTRODUCTION

1.1 BACKGROUND

This Detailed Test Report is the first 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 presents the results of Detailed Test Plan (DTP) #1. 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 measure what effects Green Light has had on safety compliance of commercial motor vehicle operating in the state of Oregon.

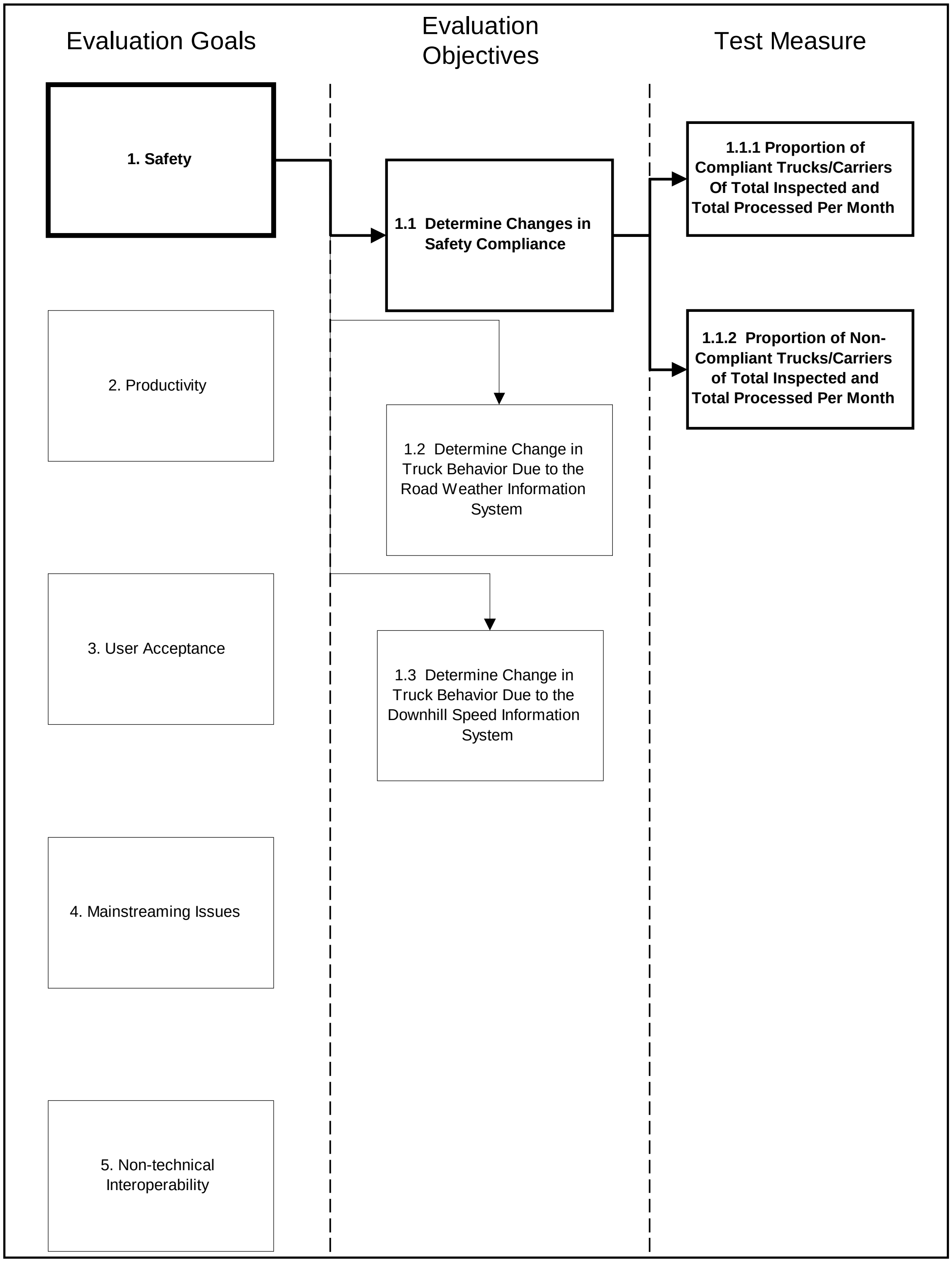
The evaluation measures used to determine change in safety compliance for the Oregon Green Light are stated below:

1.1.1 Examine changes in proportion of trucks compliant with Federal Motor Carrier Safety Regulations (FMCSR) within Oregon.

1.1.2 Assessment of targeting procedures at sites incorporating electronic screening.

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 Exhibit 1-1. The test measures outlined in this document are highlighted for reference.

Exhibit 1-1 Evaluation Goals, Objectives, and Measures

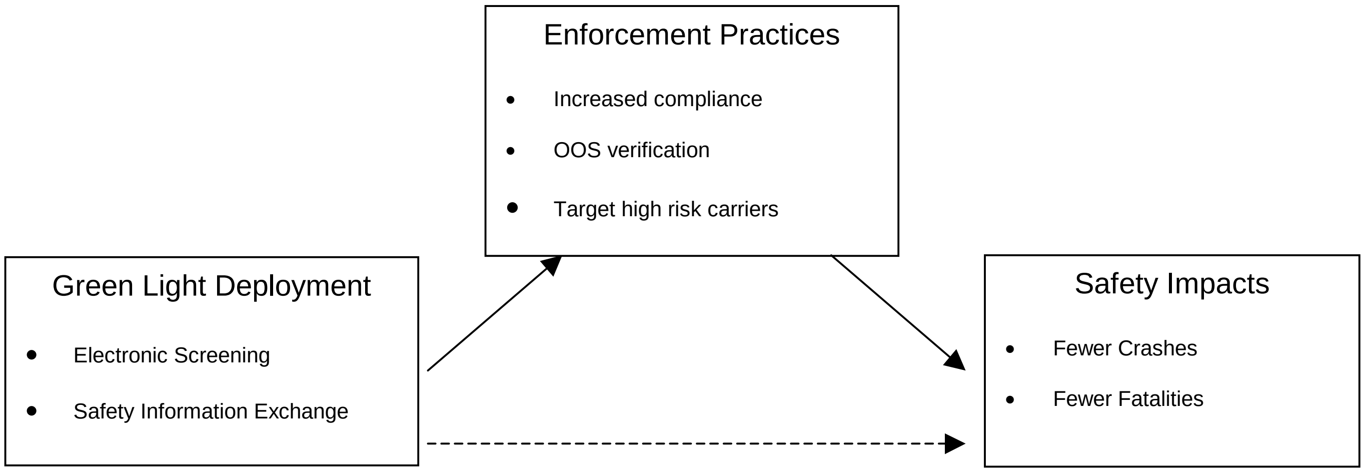


1.3 DISCUSSION

According to the Federal Highway Administration's (FHWA's) Office of Motor Carriers (OMC), over 150,000 trucks (including commercial and private vehicles) were involved in highway accidents in 1994 Truck and Bus Accident Fact Book, October 1996 [4]. These accidents caused injuries to 110,000 persons and resulted in 5,500 deaths. To combat this problem, state and federal agencies employ various strategies such as stricter enforcement of traffic laws, improving vehicle and highway designs, and developing and using on-board safety systems (e.g., driver warning systems). For commercial vehicles, the strategy also includes improved enforcement of Federal Motor Carrier Safety Regulations (FMCSR) and Hazardous Materials Regulations (HMR). In 1996, OMC estimated that 32 percent of the vehicles traveling the nation's highways are out of compliance with applicable commercial vehicle regulations [*OMC National Fleet Safety Survey*, 1996]. Green Lights' use of roadside screening is expected to have significant impacts on roadside safety enforcement practices. In particular, Green Light will result in more efficient enforcement operations, increased compliance with safety regulations, and, ultimately, safer highways.

The main focus of this study will be on the relationship between Green Light deployment and its impact on enforcement practices. The relationship between enforcement practices and safety impacts (i.e., reduced crashes and fatalities) also needs to be established to link safety benefits to the deployment of Green Light. Results from literature, as well as new analyses, can help determine this relationship. This two-step approach is illustrated in Exhibit 1-2. The third relationship (indicated by the dashed line between Green Light deployment and safety impacts) can also be studied using empirical methods. However, this approach has significant challenges because the Green Light -related reduction in crashes and fatalities is expected to be small compared to the impacts of other factors (e.g., weather, road construction, traffic changes).

Exhibit 1-2 Relationships Between Green Light Deployment, Enforcement Practices, and Safety Impacts.



Green Light technologies are expected to help improve compliance with safety regulations in two ways both resulting from increased effectiveness of roadside inspection operations. The direct, but smaller, impact is the removal of unsafe drivers and vehicles from the highways. It is anticipated that the screening and safety information exchange technologies will allow inspectors to rapidly select commercial vehicles for inspection based on the carrier's safety record. Also, on-line access to driver violation records and results of recent truck inspections will help target unsafe drivers and trucks.

The indirect effect, which is expected to be much larger, is that drivers and carriers will modify their behavior to avoid inspections. Specifically, it is assumed that carriers will expend more resources to ensure that their vehicles stay in compliance. Carriers with good safety records (low risk) will have a small probability of being inspected. High-risk carriers will try to improve their safety rating to avoid increased inspections. Of course, if Green Light does not help inspectors target the high-risk carriers, there will not be any *added* incentive for a carrier to maintain a good safety rating.

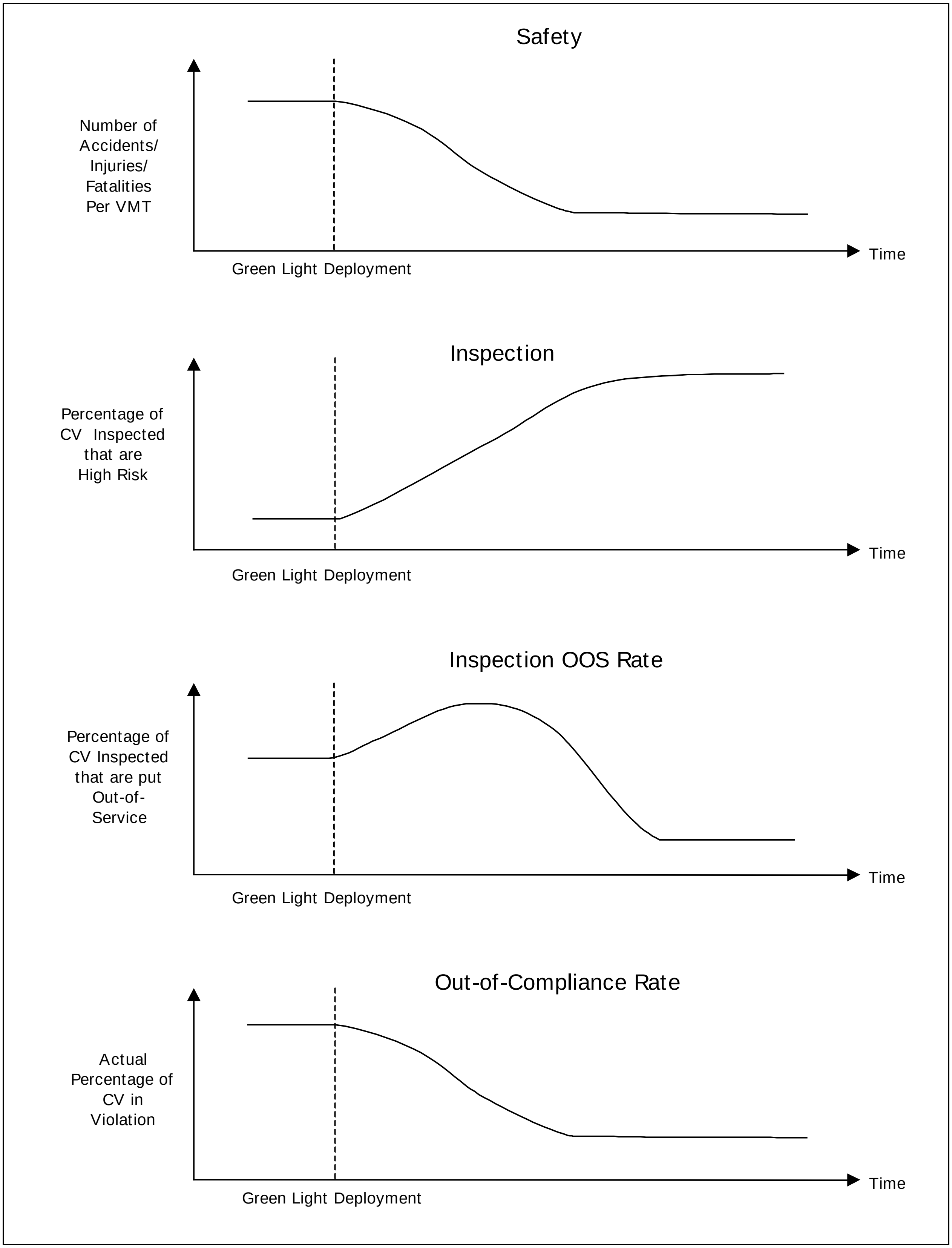
The impacts of Green Light on safety will be difficult to quantify. In fact, these impacts will probably take effect over a long period of time. Initially, the high-risk carriers must perceive an increase in the cost of doing business resulting from increased fines and more frequent delays at roadside inspection sites. The hypothesis is that these operators will then adjust their safety program in order to improve compliance rates. Of course it is possible that they will, instead, choose to employ avoidance tactics. This impact also needs to be investigated. Assuming that a high-risk carrier chooses to improve its safety program, the improvement in compliance rates will eventually result in improved safety performance.

Estimating the impact of Green Light in terms of safety simply by analyzing accident data is not feasible for a number of reasons. First, because accidents are rare events, their associated consequences (property damage, etc.) are highly variable, and therefore may provide limited evidence of a change from a short period of deployment and evaluation. Second, even if an effect is measured, it may be difficult to attribute the effect to the introduction of the technology.

Using compliance rates as a surrogate for accident rates will help to address both of these issues. Estimating compliance rates is much more feasible than estimating rates of accidents that are attributable to safety violations. Also, the hypothesis that Green Light affects safety by improving motor carrier compliance can be tested separately.

Exhibit 1-3 qualitatively illustrates the relationships among key data elements in this approach. The first panel shows a decrease in the number of accidents, injuries, and fatalities that is anticipated following the deployment of Green Light. However, in order to infer that an observed decrease in accidents was caused by the deployment of Green Light, a more detailed analysis of the process is required. *It is anticipated that the deployment of the electronic clearance components of Green Light will improve compliance enforcement through better targeting of high-risk carriers and more efficient use of inspection resources.* Thus, as illustrated in the second panel, it is expected that there will be an increase in the percentage of vehicles inspected that belong to high-risk carriers. High-risk in this context refers to carriers that are more likely than others to be put out of service (OOS) for failing to comply with the FMCSR. Alternative definitions of high-risk carriers based on accident and fatality rates will also be investigated. The third panel reflects how the percentage of vehicles that are put OOS is expected to rise initially because of the improved targeting of high-risk carriers. Eventually, the carriers will modify their behavior to improve compliance. Thus, assuming that enforcement procedures do not change, the OOS rate is expected to decrease. The fourth panel shows how the out-of-compliance rate (percent of violators on the road) is expected to change. This decrease is then expected to result in the safety improvement.

Exhibit 1-3 Relationships Between Key Elements in the Green Light Safety Analysis



2 TEST METHODOLOGY

2.1 PHYSICAL DESCRIPTION

The random inspection study was developed in conjunction with Battelle as part of their evaluation of CVISN. The purpose of this test is to measure the rate of compliance with safety regulations by motor carriers traveling in the northern I-5 corridor in Oregon. This study will incorporate random selection of vehicles to ensure that the screening practices usually followed by the inspectors do not bias the compliance rate estimates. The random sampling conducted under this study is not intended to improve enforcement efficiency. Rather, the results will be used to infer whether the advances introduced under Green Light result in reduced rates of violation by average carriers, thereby addressing the evaluation objective to determine whether Green Light has a positive impact on safety.

This test is designed to measure whether the new technologies introduced under Green Light help to deter violations of safety regulations. To measure this, we plan to test whether if there is a change in commercial vehicle safety violation rates. Towards this end, we would like to estimate the compliance rate of the commercial vehicle population at large – not only those that are targeted for inspection. This requires some degree of random inspection. The compliance rate study was conducted along the northern I-5 corridor Oregon.

2.1.1 Survey Design

A survey design was used to select sites along the northern I-5 corridor, including dates and times to conduct inspections, and to select vehicles at those sites for inspection. Four, month-long random inspection campaigns were conducted six months apart. The data collected was analyzed by standard survey methods, based on a random sample. Trends were estimated, and comparisons will be made across sites and over time based on linear models. Battelle's statistics group conducted data analysis, with findings being presented to OSU for inclusion in this report.

2.1.2 Assumptions and Constraints

Several assumptions and constraints are necessary in the design of the random sampling plan.

- The selected sites cover a network representing same truck compliance rate as the entire area.
- The volume counts made during the course of the inspections are representative of the traffic that passes that site.
- An assumption is made that the compliance rate during the night shift is the same as that during the "swing shift."

Some of the key constraints in Oregon are:

- Due to safety, inspections can only be conducted at night at the ports of entry. It will be necessary to assume that these locations have similar compliance properties with the other types of sites.
- Participants in Green Light are subject to scrutiny with regard to their safety status. Those meeting high safety standards may be enrolled as premium carriers or "Trusted Carrier Partners". Upon meeting these qualifications the carriers are not subject to random selection – *at the Green Light (transponder reader) sites*. At the sites where all vehicles are recorded manually, basic enrollees can be included in the random selection process.

The test will be conducted in one-month intervals. The first test was conducted during January of 1998, with subsequent tests following in July 1998, January 1999, and July 1999.

ODOT MCEO managers followed the same schedule in each if the four campaigns according to the day of week and time of day an inspection occurred. This schedule of random inspections planned for the first month is provided in Exhibit 2-1. The schedule was generated based on past inspections conducted in Oregon. For instance, if the vast majority of inspections were conducted at the ports-of-entry, this schedule was generated so that the same proportion of randoms were completed at the ports-of-entry as well. Many of the selected sites had conflicts, especially those sites that were randomly chosen for night inspections, but are not equipped. These sites were subsequently changed to daytime inspections.

Those inspections that were selected at non-fixed sites, i.e. Multnomah Co. and Yamhill Co., were conducted at sites routinely chosen by the inspectors who work that area.

Exhibit 2-1 Site Selections For January 1998

Date of Shift	Site ID (Scale No)	Location	Day of Shift	Time of Shift
02JAN98	1404	Cascade Locks POE	Friday	Day
	3602	Dayton.	Friday	Day
06JAN98	2677	Multnomah Co.	Tuesday	Day
07JAN98	1404	Cascade Locks POE	Wednesday	Day
	2409	Woodburn POE	Wednesday	Day
	2677	Multnomah Co.	Wednesday	Day
08JAN98	0261	Blodgett, WB	Thursday	Day
	1404	Cascade Locks POE	Thursday	Day
			Thursday	Day
09JAN98	2408	Woodburn POE	Friday	Day
			Friday	Day
			Friday	Day
	1404	Cascade Locks	Friday	Day
	2677	Multnomah Co.	Friday	Day
10JAN98	2004	Lombard and N. Simmons	Saturday	Day
11JAN98	2409	Woodburn POE	Sunday	Day
12JAN98	1404	Cascade Locks POE	Monday	Day
13JAN98	2601	Rocky Point	Tuesday	Day
	2408	Woodburn NB	Tuesday	Night
	2409	Woodburn POE	Tuesday	Day
			Tuesday	Night
	3677	Yamhill Co.	Tuesday	Day
	2677	Multnomah Co.	Tuesday	Day
14JAN98	0261	Blodgett, WB	Wednesday	Day
	2409	Woodburn POE	Wednesday	Day
			Wednesday	Night
15JAN98	2409	Woodburn POE	Thursday	Day
			Thursday	Day
	0307	Brightwood, WB	Thursday	Day
	2601	Rocky Point	Thursday	Day
	2677	Multnomah Co.	Thursday	Night
16JAN98	304	Rock Creek	Friday	Night
	2677	Multnomah Co.	Friday	Day
	2409	Woodburn POE	Friday	Day
18JAN98	1404	Cascade Locks POE	Sunday	Day
19JAN98	2601	Rocky Point	Monday	Day
	2409	Woodburn POE	Monday	Day
			Monday	Day
20JAN98	2002	Walterville	Tuesday	Day
21JAN98	2002	Walterville	Wednesday	Day
	2205	Foster	Wednesday	Day
	2409	Woodburn POE	Wednesday	Day
22JAN98	2407	Hubbard	Thursday	Night
	1404	Cascade Locks POE	Thursday	Night
	2409	Woodburn POE	Thursday	Day
			Thursday	Day
			Thursday	Night
23JAN98	2677	Multnomah Co.	Friday	Day
	2701	Eola	Friday	Day

Date of Shift	Site ID (Scale No)	Location	Day of Shift	Time of Shift
25JAN98	2409	Woodburn POE	Sunday	Day
26JAN98	2409	Woodburn NB	Monday	Day
	2601	Rocky Point	Monday	Day
	3677	Yamhill Co.	Monday	Day
27JAN98	2601	Rocky Point	Tuesday	Night
28JAN98	2409	Woodburn POE	Wednesday	Day
29JAN98	0304	Rock Creek	Thursday	Day
	2409	Woodburn POE	Thursday	Day
			Thursday	Day
			Thursday	Day
			Thursday	Day

Exhibit 2-2 provides a list of random non-fixed locations inspected within Multnomah County and were randomly selected from a list of six locations provided by the Multnomah Co. inspectors. The two days assigned to non-fixed random inspections in Yamhill Co. were chosen by the inspectors to reflect characteristics of vehicles using I-5 in the northwest corridor.

Exhibit 2-2 Specific Locations to Sample in Multnomah County

Date	Day	Time	Location
January 6	Tuesday	Day	Lombard and N. Simmons
January 7	Wednesday	Day	NE 223rd and NE Glisan
January 9	Friday	Day	NE Marine Drive and NE 223rd
January 10	Saturday	Day	Lombard and N. Simmons
January 13	Tuesday	Day	NE 223rd and NE Glisan
January 15	Thursday	Night	NE 223rd and NE Glisan
January 16	Friday	Day	NE 122nd and NE Inverness
January 23	Friday	Day	NE 122nd and NE Inverness

The primary supporting data used to design the study include:

- Oregon's past inspection data, as downloaded from SafetyNet for the period October 1996 through September 1997. This was used to characterize their existing inspection program.

- A list of non-fixed inspection sites for Multnomah Co. that are indicative of truck travel in that county. Ideally, these inspection sites would be mutually exclusive and selectively exhaustive of trucks travelling in the county.
- Estimates of truck volume at the inspection locations in the northern I-5 corridor

2.1.3 Scope of Survey

Although about 30,000 inspections are conducted on trucks throughout Oregon each year, it was decided that the desired information could probably be obtained from a corridor study, provided that enough data could be collected there.

Using the information obtained about where most of the inspections were done and by whom, and using judgement to identify sites that could be used to characterize compliance characteristics of vehicles traveling in the I-5 corridor, a geographic scope was decided upon.

Determining the number of random inspections to conduct involved a tradeoff of desired precision with the impact that a random campaign would, itself, have on compliance characteristics. Specifically, Green Light's mainline preclearance deployment introduces technologies that are, among several enhancements, intended to improve the state's vehicle selection protocols – and supposedly, this will have a deterrence effect on violators. Conducting too many random inspections might have its own effect on compliance rates which may obscure the effect of Green Light on compliance rates. Therefore, it was decided that no more than 10 percent of the inspections conducted in the region of interest during the course of a year should be devoted to the evaluation because of the potential impact on operations. In the targeted corridor, this means that about 600 to 700 random inspections should be performed per year as part of the evaluation. With two campaigns per year, this reduces to 300 to 350 per campaign.

2.1.4 *Sampling Design*

To enable an inference that is representative of all the sites within the geographic scope illustrated in Exhibit 2-2, a random sample of sites must be identified for conduct of inspections. In addition, it is necessary that all sites within that region have a positive, known probability of being selected. However, it is neither necessary nor practical to give each location the same probability of selection. Sites where several inspections are conducted can be emphasized, and sites where inspections are conducted only rarely can be included with only very low probability and still achieve an unbiased estimate of the true compliance rate.

The 48 sites in the northern I-5 corridor were divided into four strata: Ports of Entry (POEs), Green Light sites, fixed non-GL sites, and non-fixed sites. Based on the historical allocation of inspections to these strata, Exhibit 2-3 illustrates the allocation of random inspections to these strata for the inspection campaigns.

Exhibit 2-3 Allocation of Inspections to Strata

Stratum	Inspections conducted 10/1/96 through 9/30/97	Planned Random Inspections
Ports of Entry	3381	32
Green Light Sites	793	8
Fixed Sites (non-GL)	932	10
Non-Fixed Sites	954	10

For each inspection campaign, a schedule was issued to the MCEO managers and the Multnomah Sheriff's Department for deployment of their staff conduct the inspections. There were slight departures resulting from weather and illness, but it was mostly adhered to. When dates were not met, inspections were conducted at a similar day and time.

3 RESULTS

The compliance rate study in Oregon provided data to test the two hypotheses associated with safety impacts. These are:

> Hypothesis 1: The number of violations per inspection did not change after Green Light technologies were introduced in the corridor.
>
> Hypothesis 2: Changes in compliance rates between 1998 and 1999 were the same for sites with GL technologies as for sites without GL technologies.

It was assumed that carriers and truck drivers would tend to improve compliance with safety regulations to reap the benefits, or avoid the enforcement ramifications, of electronic screening.

About Deployment

The study was conducted with the assumption that as more carriers became equipped with transponders and are actively participating in Green Light, that the general trucking population would move towards compliance. In order for this to actually take place, the truck stream entering sites equipped with mainline preclearance would have to change significantly. The key component of Green Light that makes this assumption work is that carriers are actively screened based on their safety records. Those trucks with "clean" bills of health remain out of the traffic stream reporting to the scale. As more "safe" trucks are screened on the mainline and taken out of the stream to the static scale, the truck stream changes to one that is more likely to have an OOS violation.

As was described in the previous chapter, data was collected and examined on compliance rates in the general trucking populations. This required conduct of random Level I inspections, in contrast to targeted inspections conducted under standard procedures, when standard practices are designed to inspect the vehicles with the greatest problems. Random inspections were conducted to allow characterization of the general trucking population, these inspections were conducted at three different types of sites during four campaigns, over a period of two years. Most of the inspections were conducted at weigh stations, but a good number were also conducted at roadside or mobile locations (which in Oregon are often referred to as "non-fixed").

Random inspections were conducted at two sites with electronic screening systems deployed. These were the Woodburn Southbound port of entry (POE), which was the first site established with the "Green Light" system in Oregon, and the Woodburn Northbound (NB) weigh station. Both of these sites are on I-5 in Northern Oregon. The Woodburn POE was equipped and running before the start of this random inspection campaign, and Woodburn NB was equipped halfway through. Roughly the same sampling design and inspection schedule was used for each of the four campaigns, so the number of inspections conducted at Green Light sites increased for the second half of the test (due to the inspections conducted at Woodburn NB during the second half of the test).

Exhibit 3-1 displays the division of the various sites (where inspections were performed) into three categories for presentation: Green Light sites, non-Green Light fixed sites, and non-Green Light non-fixed sites. At the top of each column is the number of inspections conducted. A total of 1,223 random inspections were conducted for this evaluation.

Exhibit 3-1 Site Categories

Type of Site		
Green Light (408 Inspections)	Non-Green Light Fixed (591 Inspections)	Non-Fixed (224 Inspections)
Woodburn POE Woodburn NB	Blodgett EB Blodgett WB Brightwood Cascade Locks Dayton Eola Foster Rocky Point Rock Creek Walterville	Hwy 18 McKibbon Rd, Unspecified location (Yamhill Co.) --- Lombard and N Simmons, Lombard and Pier Park, McMinnville, Yamhill Co. N. Lombard and Bruce Ave., NE 122nd and NE Inverness, NE 223rd and NE Glisan, NE Marine Dr and NE 223rd (Multnomah Co.)

Exhibit 3-2 provides estimates of the violation rates for each of the three categories, estimated from each of the sampling campaigns. The table displays the number of shifts during which random inspections were conducted and the total number of random inspections performed. Three different violation rates are displayed:

- Average number of violations per vehicle (any FMCSR)
- Average number of OOS violations per vehicle
- Proportion of vehicles with at least one OOS violation
- Average number of Driver OOS violations
- Average number of Vehicle OOS violations

Each of these violation rates should be interpreted as “violations per vehicle,” and not “violations per inspection.” The statistical design and random nature of this study allows us to make inferences to the general truck population.

Exhibit 3-2 Violation Rates

Type of Site	Sampling Campaign	Number of Shifts	Total # Inspections	Average # Violations Per Vehicle (∀ 2 SD)	Average # OOS Violations Per Vehicle (∀ 2 SD)	Proportion of Vehicles with OOS Violations (∀ 2 SD)	Average # Driver OOS Violations Per Vehicle (∀ 2 SD)	Average # Vehicle OOS Violations Per Vehicle (∀ 2 SD)
GL	**Jan 98**	15	93	1.74 ∀ 0.44	0.52 ∀ 0.18	0.34 ∀ 0.12	0.04 ∀ 0.06	0.43 ∀ 0.18
	July 98	15	90	1.17 ∀ 0.40	0.22 ∀ 0.12	0.16 ∀ 0.08	0.02 ∀ 0.04	0.19 ∀ 0.10
	Jan 99	17	107	2.28 ∀ 0.76	0.38 ∀ 0.18	0.24 ∀ 0.12	0.05 ∀ 0.04	0.34 ∀ 0.16
	July 99	17	118	1.65 ∀ 0.66	0.46 ∀ 0.18	0.31 ∀ 0.12	0.04 ∀ 0.04	0.41 ∀ 0.18
NGL-Fixed	**Jan 98**	25	154	**1.81 ∀ 0.46**	0.40 ∀ 0.14	0.24 ∀ 0.08	0.00	0.39 ∀ 0.14
	July 98	25	170	**1.61 ∀ 0.32**	0.31 ∀ 0.12	0.22 ∀ 0.06	0.00	0.83 ∀ 0.86
	Jan 99	21	131	2.52 ∀ 0.82 ↑	0.48 ∀ 0.18	0.26 ∀ 0.10	0.00	0.47 ∀ 0.18
	July 99	21	148	2.25 ∀ 0.38 ↑	0.40 ∀ 0.14	0.23 ∀ 0.08	0.05 ∀ 0.06	0.35 ∀ 0.12
Non-Fixed	**Jan 98**	10	57	3.08 ∀ 0.68	0.95 ∀ 0.34	0.47 ∀ 0.16	0.01 ∀ 0.02	0.87 ∀ 0.32
	July 98	10	60	3.01 ∀ 0.72	0.92 ∀ 0.36	0.51 ∀ 0.16	0.09 ∀ 0.12	3.09 ∀ 1.28
	Jan 99	10	59	**2.09 ∀ 0.62 ↓**	**0.55 ∀ 0.28 ↓**	0.24 ∀ 0.08	0.05 ∀ 0.06	**0.50 ∀ 0.24 ↓**
	July 99	9	54	**1.91 ∀ 0.54 ↓**	**0.55 ∀ 0.16 ↓**	0.54 ∀ 0.16	0.01 ∀ 0.02	**0.53 ∀ 0.16 ↓**
Combined Across Site Types	**Jan 98**	50	304	**1.93 ∀ 0.34**	0.48 ∀ 0.10	0.28 ∀ 0.06	0.01 ∀ 0.02	0.44 ∀ 0.10
	July 98	50	320	**1.69 ∀ 0.26**	0.36 ∀ 0.10	0.24 ∀ 0.06	0.01 ∀ 0.02	0.98 ∀ 0.64
	Jan 99	48	297	2.43 ∀ 0.60 ↑	0.46 ∀ 0.14	0.25 ∀ 0.06	0.02 ∀ 0.02	0.45 ∀ 0.14
	July 99	47	320	2.08 ∀ 0.30 ↑	0.43 ∀ 0.10	0.28 ∀ 0.08	0.05 ∀ 0.04	0.38 ∀ 0.10

The following figures show confidence intervals for each of the five responses measured, over time, by site. Each violation rate estimate is listed with a +/- number, which can be used to calculate an approximate 95 percent confidence interval. The intervals were constructed with

95 percent confidence of containing the true violation rate.

Statistical tests were performed to determine if the rates observed in 1999 were significantly different from those observed in 1998 (addressing Hypothesis 1). The results are presented in the boxes showing the 1999 results. In Exhibit 3-2, if '↑' appears in the boxes showing the 1999 results, that implies that (on average) violation rates were found to be higher in 1999 than in 1998, and the increase was statistically significant. Similarly, '↓' means that violation rates decreased. Simple year-to-year comparisons were performed, in which aggregate rates from 1999 were compared with aggregate rates from 1998. So either no arrows appear (if the difference was insignificant), or two up arrows appear (if violation rates increased), or two down arrows appear (if violation rates decreased).

Exhibits 3-3 through 3-5 display the violation rate estimates presented in Exhibit 3-2, with 95 percent confidence bounds, by sampling campaign, separately for each stratum. Notice that no changes in compliance rates were significant at sites where GL technology was deployed. However, there was a significant increase in the total number of violations per inspection at non-GL, fixed sites. The most consistent pattern observed was a decrease in violation rates at non-fixed (or mobile) sites. The number of violations, the number of OOS violations, and the number of vehicle OOS violations per inspection decreased. Combining data across site types, the only significant difference was an increase in violations per inspection between 1998 and 1999.

Exhibit 3-3 Average Number of Violations per Vehicle Over Time

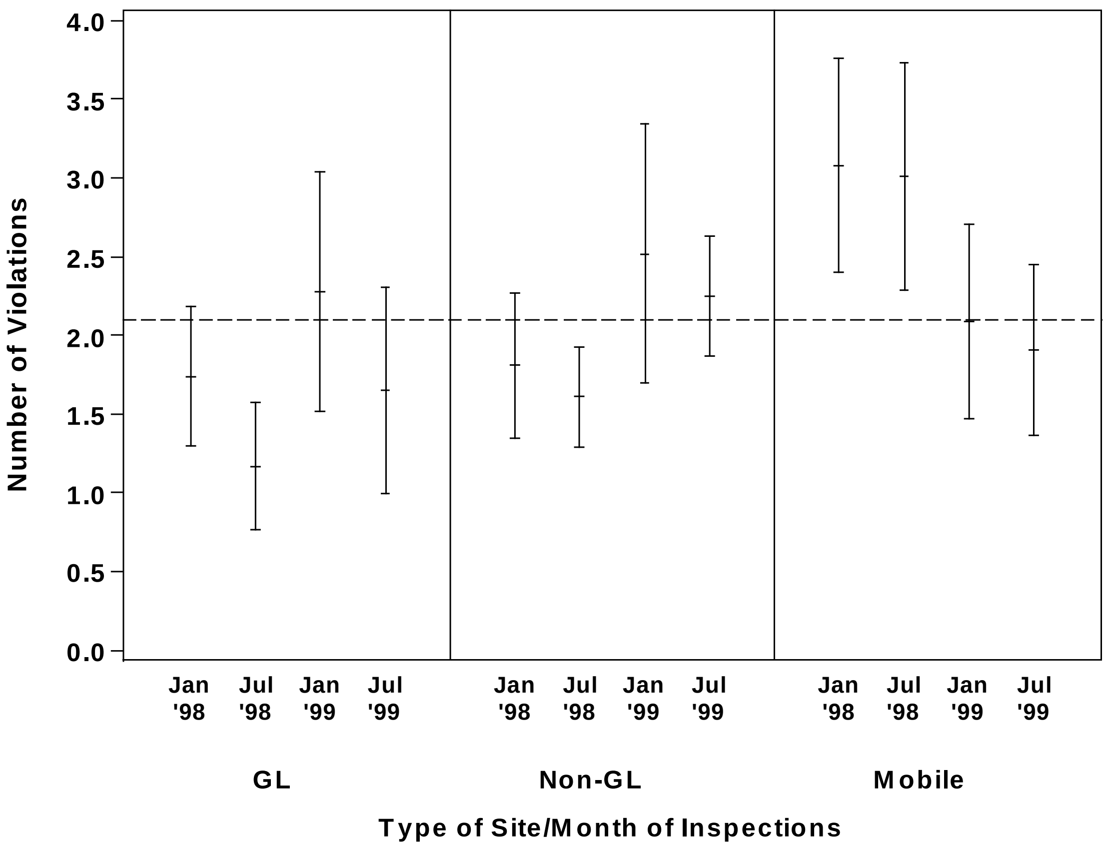


Exhibit 3-4 Average Number of OOS Violations per Vehicle

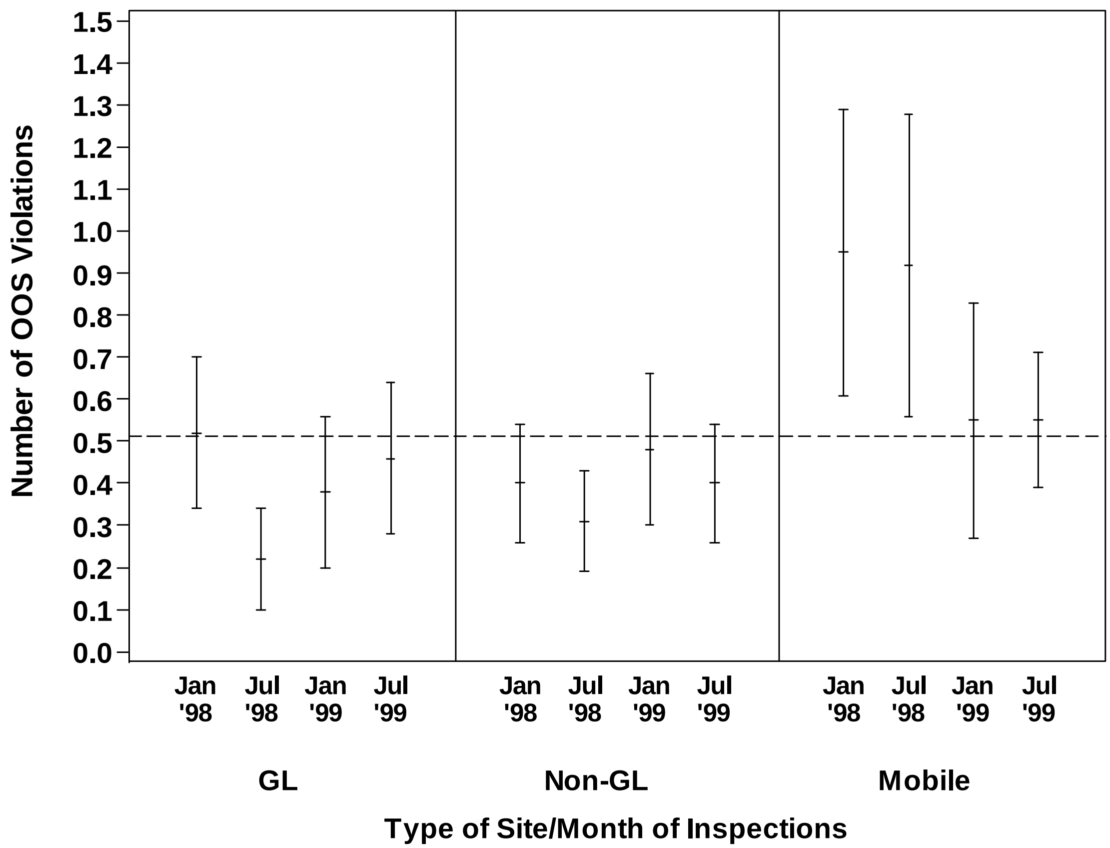


Exhibit 3-5 Percentage of Vehicles With an OOS Violation

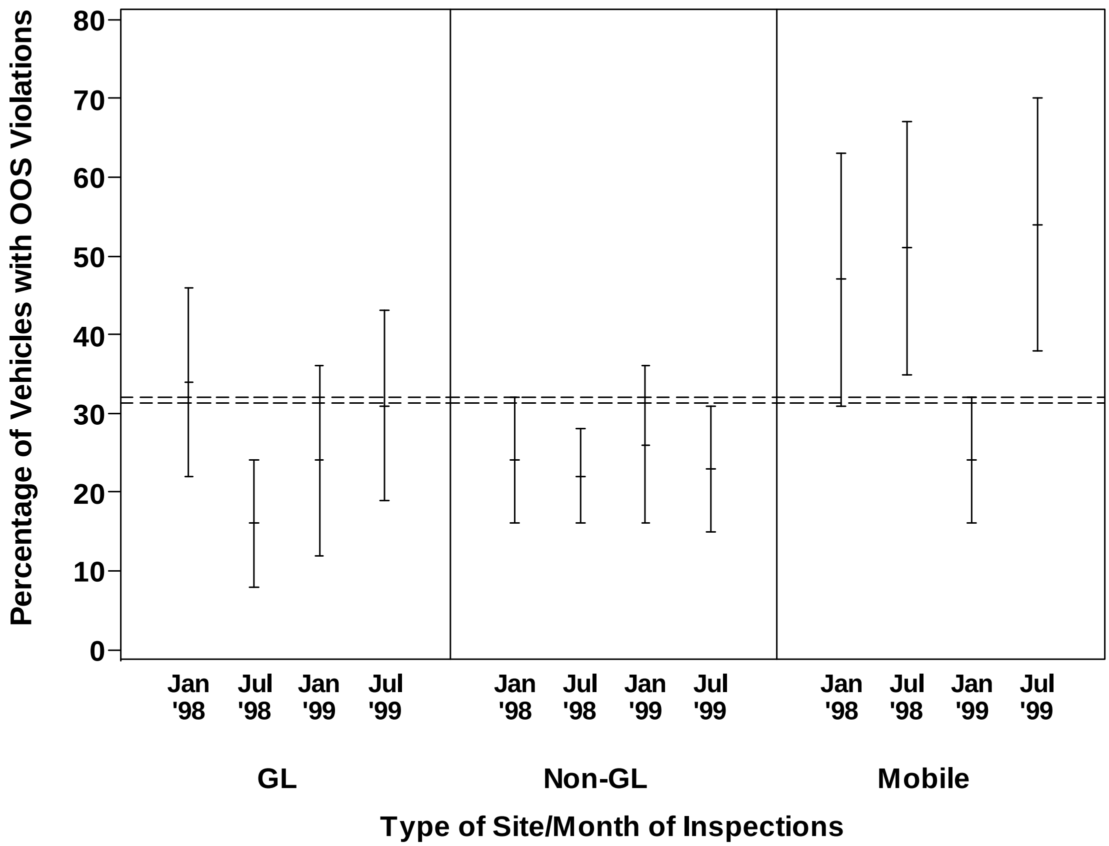


Exhibit 3-6 Average Number of Vehicle OOS Violations per Vehicle

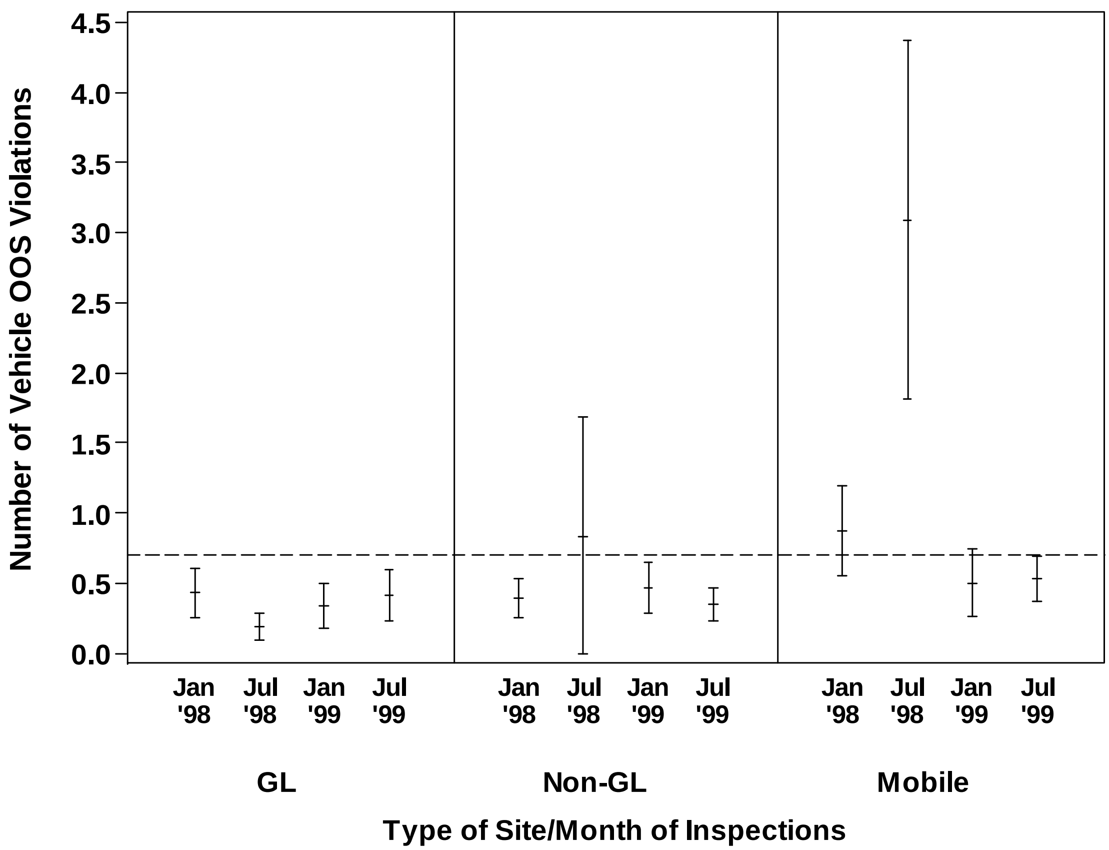
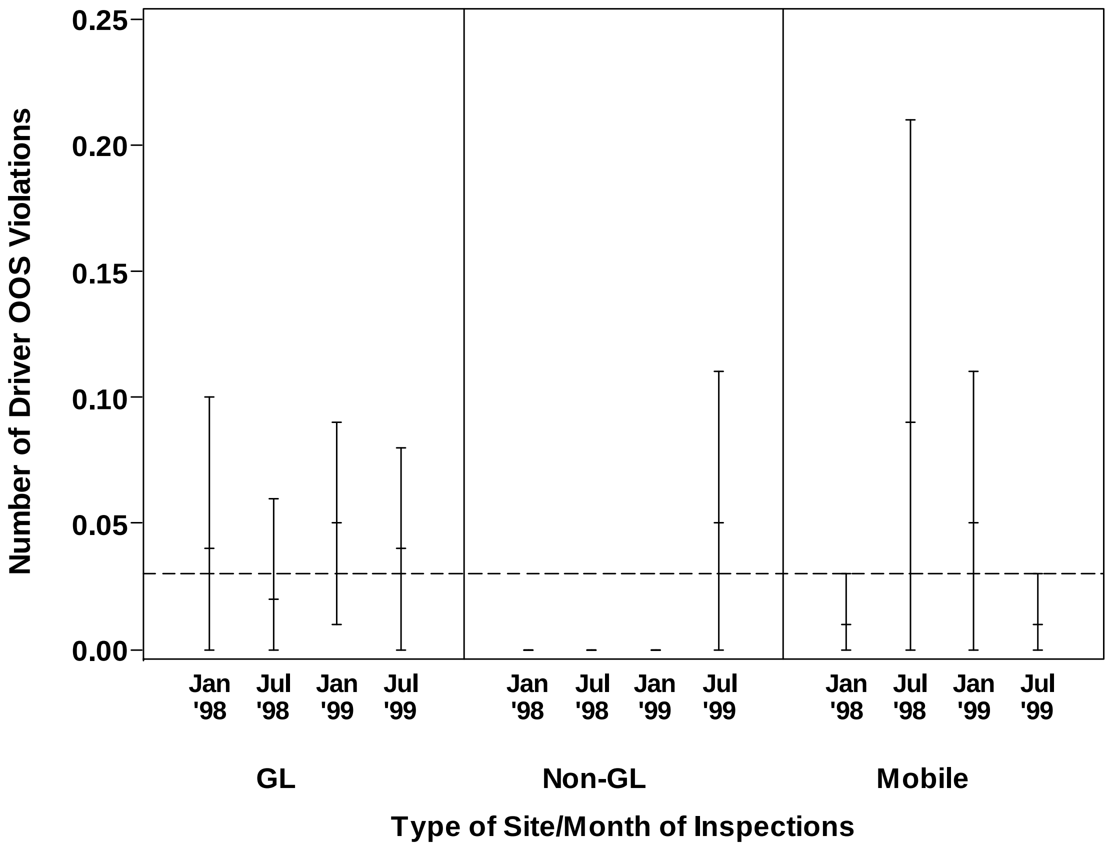


Exhibit 3-7 Average Number of Driver OOS Orders per Vehicle



Exhibits 3-8 through 3-12 present subsets of the information in Exhibit 3-2 with an emphasis on the contrasts between 1998 and 1999.

Exhibit 3-8 Number of Violations per Vehicle, by Stratum

Type of Site	1998	1999	% Increase[1]	GL	Non-GL Fixed	Non-Fixed
GL	1.46	1.97	+35%			
Non-GL Fixed	1.71	2.39	+39%			
Non-Fixed	3.05	2.00	-34%	*	*	

* denotes statistical significance across strata

Exhibit 3-8 provides for each stratum the estimated compliance rate averaged across January and July campaigns for 1998 and 1999, and the difference, measured as a percentage of the 1998 rate. These months were averaged to account for seasonal variations. **The difference is printed in bold italics if it was statistically significant**. In addition, Exhibit 3-8 shows which of the increases (or decreases) over time were statistically different from each other, when compared across strata as identified with an asterisk. This identifies site categories for which compliance behavior has changed to a degree different from other site categories (addressing Hypothesis 2).

An explanation is best understood with an example. When examining Exhibit 3-8, the drop of 34 percent in violations per vehicle observed at the non-fixed sites is not statistically significant in terms of the change in violations between the two years. The drop was significantly different from the changes observed in both of the “fixed” types of sites. The other sites exhibited increases in this measure, though only for non-GL sites was the increase (in its own right)

[1] A negative number indicates that the rate in Jan 99 was lower than the rate in Jan 98

significant. Exhibit 3-9 presents similar test results, simplified by combining all non-Green Light sites into one class, called Non-Green Light.

Exhibit 3-9 Number of Violations per Vehicle, Green Light versus Non-Green Light

Type of Site	1998	1999	% Increase	Green Light	Non Green Light
Green Light	1.46	1.97	+35%		
Non Green Light	1.88	2.34	+24%		

* denotes statistical significance across strata

Exhibits 3-10 and 3-11 present similar information and test results, focusing on OOS violations instead of all violations. Exhibit 3-10 indicates that there was a significant drop in OOS rates at the non-fixed sites, and this drop was significantly different from the changes observed at the two types of fixed sites (Green Light and non-Green Light). Averaged with the fixed non-Green Light sites, there were no significant changes between 1998 and 1999.

Exhibit 3-10 Number of OOS Violations per Vehicle, by Stratum

Type of Site	1998	1999	% Increase	GL	Non-GL Fixed	Non-Fixed
GL-Other	0.37	0.42	+14%			
Non-GL Fixed	0.36	0.44	+24%			
Non-Fixed	0.94	0.55	**-41%**	*	*	

* denotes statistical significance across strata

Exhibit 3-11 Number of OoS Violations per Vehicle, Green Light versus Non-Green Light

Type of Site	1998	1999	% Increase	Green Light	Non Green Light
Green Light	0.37	0.42	+14%		
Non-Green Light	0.43	0.45	+5%		

Exhibits 3-12 and 3-13 focus on the percentage of vehicles with at least one OOS violation. There were no significant drops in the percentage of vehicle with an OoS violation between the categories.

Exhibit 3-12 Percentage of Vehicles with OOS Violations, By Stratum

Type of Site	1998	1999	% Increase	GL	Non-GL Fixed	Non-Fixed
GL-Other	25%	28%	+10%			
Non-GL Fixed	23%	25%	+7%			
Non-Fixed	49%	39%	-20%			

Exhibit 3-13 Percentage of Vehicles with OOS Violations, GL versus Non-GL

Type of Site	1998	1999	% Increase	Green Light	Non Green Light
Green Light	25%	28%	+10%		
Non-Green Light	27%	26%	-2%		

Exhibit 3-14 and 3-15 display similar test results for the proportion of vehicles with at least one OOS violation and Exhibits 11a and 11b display test results for driver OOS violations. No changes or differences were statistically significant by either stratification for either of these measures.

Exhibit 3-14 Number of Driver OOS Orders per Vehicle, By Stratum

Type of Site	1998	1999	% Increase	GL	Non-GL Fixed	Non-Fixed
GL-Other	0.03	0.05	+50%			
Non-GL Fixed	0.00	0.03	NA			
Non-Fixed	0.05	0.03	-40%			

Exhibit 3-15 Number of Driver OOS Orders per Vehicle, Green Light versus Non-Green Light

Type of Site	1998	1999	% Increase	Green Light	Non Green Light
Green Light	0.03	0.05	+50%		
Non Green Light	0.01	0.03	+200%		

Exhibits 3-16 and 3-17 show the number of vehicle OOS violations per vehicle. Exhibit 3-17 shows a significant drop of 74 percent in vehicle OOS orders at non-fixed sites. This drop was not observed at the fixed sites. No changes were significant when comparing Green Light to non-Green Light sites.

Exhibit 3-16 Number of Vehicle OOS Orders per Vehicle, By Stratum

Type of Site	1998	1999	% Increase	GL	Non-GL Fixed	Non-Fixed
GL-Other	0.31	0.38	+21%			
Non-GL Fixed	0.61	0.41	-33%			
Non-Fixed	1.98	0.52	**-74%**	*	*	

* denotes statistical significance across strata

Exhibit 3-17 Number of Vehicle OOS Orders per Vehicle, Green Light versus Non-Green Light

Type of Site	1998	1999	% Increase	Green Light	Non Green Light
Green Light	0.31	0.38	+21%		
Non Green Light	0.79	0.43	-45%		

As described in the study design, vehicles were selected independently at sites divided into four different strata during three different sampling campaigns. In our analysis, we assume that inspections conducted in different campaigns are independent (i.e., the choice of a vehicle in any of the campaigns has no effect on the choice of vehicles in any of the other campaigns).

Thus, we can treat the results obtained from separate campaigns as if they were from different strata.

4 CONCLUSIONS AND RECOMENDATIONS

Overall, the study found no significant changes in compliance rates at sites where GL technology was deployed. However, there was a significant increase in the total number of violations per inspection at non-GL, fixed sites. The most consistent pattern observed was a decrease in violation rates at non-fixed (or mobile) sites. At these sites, the number of violations, OOS violations, and vehicle OOS violations per inspection decreased. Combining data across site types, the only significant difference was an increase in violations per vehicle between 1998 and 1999 in non-GL fixed sites vs GL sites.

It is important to note that over the course of the evaluation period, from January 98 to July 1999, there was a low transponder penetration in relation to the total traffic bypassing the Green Light facility at Woodburn POE. At the end of the data collection period for this study in July of 1999, there were approximately 3000 transponders in the field, less than the amount needed to actually show a change in compliance as a result of Green Light. This number has since increased substantially to over 10,000 transponders in the field in July 2000. Green Light bypasses have also increased substantially from 28,000 bypasses in July 1999 to approximately 60,000 by July 2000. With these changes, one can expect considerable changes in compliance at GL vs. non-GL sites.

While the results of this study were largely inconclusive in establishing the relationship between Green Light deployment and its impact on enforcement practices, it did lay the groundwork for establishing such a relationship in the future. With increased transponder penetration and the continuing deployment of Green Light technology at Oregon weigh stations, random inspection studies can establish documented change in truck safety as a result of mainline preclearence. It is a recommendation that ODOT MCTD consider continuing random inspections as outlined in this study to document how this new technology is effecting truck safety. The results of this study provide a controlled baseline from which such future studies can be contrasted.

5 REFERENCES

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

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3. 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.

4. Bell, C.A., S.U. Randhawa, P. Ryus, and, Z. Xu, "Development of an Integrated System For Evaluation of Oregon's Truck Data - Phase I: Database Development and Preliminary Evaluation of Data" TNW93-05 Transportation Northwest Final Report, August 1993.