Onboard Safety Systems/Trucking Industry Demographics

U.S. Department of Transportation
Federal Motor Carrier Safety Administration

November 2016

FOREWORD

This study focused on documenting and analyzing the unique factors that may increase onboard safety system (OSS) deployment across various sectors of the trucking industry, with some emphasis on small- to medium-sized carriers. The research methodology included case studies that examined carrier and driver issues, costs, and perceptions regarding the use and acceptance of OSS technologies.

The major activities that were undertaken as part of this initiative included:

- Literature review of previous OSS studies.
- OSS carrier and driver survey.
- Case study and data validation.
- Expert panel review and advisory process.
- Final report.

Note: This document is the final report for the contract under which the study was performed. During the course of the study, separate task reports for each of the major tasks completed were also developed with related appendixes. These are available under separate cover.

NOTICE

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16. Abstract

Research sponsored by the Federal Motor Carrier Safety Administration (FMCSA) in 2008 documented discrete safety technology investment differences that exist across motor carrier fleet sizes. In response, this research analyzed the use of onboard safety systems (OSSs) by small carriers (fewer than 50 power units), drivers/owner-operators, and the requisite OSS investment motivators and barriers. This research identified and measured OSS investment and deployment patterns within the trucking industry by mapping carrier-level OSS use with financial and operational differences by fleet size.

The research findings provide guidance on the challenges and unique perspectives that various industry sectors have toward adopting OSS technologies. These technologies were limited to Stability Control Systems (SCSs), Lane Departure Warning Systems (LDWSs), and Collision Warning Systems (CWSs). This information can provide industry stakeholders and Government representatives with investment thresholds and requirements, potential adoption strategies, and public-private collaboration opportunities.

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Unclassified	**Unclassified**	**112**	

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SI* (MODERN METRIC) CONVERSION FACTORS

TABLE OF APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
In	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME	1,000 L shall be shown in m^3	
fl oz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2,000 lb)	0.907	megagrams (or “metric ton”)	mg (or “t”)
		TEMPERATURE	Temperature is in exact degrees	
°F	Fahrenheit	5 × (F-32) ÷ 9 or (F-32) ÷ 1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		Force and Pressure or Stress		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

TABLE OF APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
ml	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
mg (or “t”)	megagrams (or “metric ton”)	1.103	short tons (2,000 lb)	T
		TEMPERATURE	Temperature is in exact degrees	
°C	Celsius	1.8C + 32	Fahrenheit	°F
		ILLUMINATION		
Lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		Force & Pressure Or Stress		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003, Section 508-accessible version September 2009.)

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LIST OF ACRONYMS

ACC	adaptive cruise control
ATA	American Trucking Associations
ATRI	American Transportation Research Institute
CMV	commercial motor vehicle
CWS	collision warning system
EPA	Environmental Protection Agency
ESC	electronic stability control
FARS	Fatality Analysis Reporting System
FCWS	forward collision warning system
FMCSA	Federal Motor Carrier Safety Administration
FOT	field operational test
LDWS	lane departure warning system
MATS	Mid-American Truck Show
NHTSA	National Highway Traffic Safety Administration
OEM	original equipment manufacturer
OOIDA	Owner-Operator Independent Drivers' Association
OSS	onboard safety system
OSS/ID	Onboard Safety Systems/Trucking Industry Demographics
ROI	return on investment
RSA	roll stability advisor
RSC	roll stability control
RSS	roll stability system
SCS	stability control system
SVRD	single vehicle roadway departure
TMC	Technology and Maintenance Council

UMTRI	University of Michigan Transportation Research Institute
USDOT	U.S. Department of Transportation

EXECUTIVE SUMMARY

RATIONALE AND BACKGROUND

While truck-involved crash rates decline, raw crash statistics are somewhat stagnant. However, several onboard safety systems (OSSs) have been proven to provide a "responsibility-neutral" solution to safety events. Consequently, a leading goal of the Federal Motor Carrier Safety Administration (FMCSA) is to accelerate the deployment of OSS across the entire trucking industry. In recognizing that acceptance of OSS technologies is critical to improving safety, FMCSA has sponsored numerous studies on the efficacy and industry adoption of OSSs, including a cost-benefit analysis.

An important finding of FMCSA's OSS cost-benefit analysis was that the economic, safety, and technical outputs did not cohesively apply to smaller trucking companies and owner-operators. Operating characteristics, investment approaches, financial viability, staff resources, and insurance plans all created unique considerations for small carriers. For the sake of clarity and simplicity, owner-operators and small carriers are generally viewed as analogous in this research. Recognizing that the OSS cost-benefit analysis was not necessarily applicable to small carriers, FMCSA sponsored and partnered in this research to understand and document small carrier issues and opportunities associated with OSS technologies.

RESEARCH OBJECTIVES

OSS technologies (e.g., collision warning systems [CWSs], lane departure warning systems [LDWSs], and stability control systems [SCSs]), are showing significant promise for improving highway safety. For more than a decade, OSS technologies have been an emerging and evolving tool for improving vehicle safety, particularly within the trucking industry. Many motor carriers and drivers are anecdotally aware of the potential benefits associated with OSS deployment and use in their day-to-day operations. Empirical research documents the safety benefits and investment returns that can be expected from OSS adoption. However, there are considerable impediments to expanded OSS adoption by motor carriers, particularly in the area of OSS knowledge gaps. The objective of this research is to improve understanding and insights related to expanding OSS utilization.

For this study, key research components include:

- Data collection and analysis of OSS use and deployment through user and non-user surveys and case studies.
- Expert panel support providing preliminary guidance and document reviews.
- A final report synthesizing the multiple task reports on OSS deployment issues, as well as strategies to increase adoption of these systems by carriers, stratified by fleet sizes and sectors.

Although OSS use in the trucking industry is growing, recently completed research shows that certain sectors of the trucking industry, such as owner-operators and small carriers, have a lower rate of OSS deployment than larger carriers. To address this issue, the researchers examined the specific factors that contribute to carrier deployment challenges. Several objectives were developed for this study, including:

- Analysis of OSS investment and deployment patterns within the trucking industry.
- Identification of operational differences and related OSS investment issues across fleet sizes and sectors, particularly small carriers.
- Development of strategies that address unique ways to accelerate OSS deployment.

The resulting research details the challenges and unique perspectives that various industry sectors have toward the adoption of OSS technologies. Attention is paid to differences in perspectives and familiarity among carriers and drivers related to SCSs, LDWSs, and CWSs. This information can provide industry stakeholders and Government representatives with potential adoption strategies and collaboration opportunities.

TECHNICAL APPROACH

For the Onboard Safety Systems/Trucking Industry Demographics (OSS/ID) study, multiple tasks were initiated to gather critical data and information relating to OSS deployment opportunities and challenges. The following activities were completed:

- Developed a project work plan.
- Updated the literature review.
- Convened a panel of experts on safety technology.
- Conducted a multifaceted industry data collection program.
- Examined multiple fleet and driver case studies.
- Produced a final report.

Prior to commencing the OSS/ID research, a project work plan was developed. The role of the work plan was to ensure that all aspects of the project were managed according to the requirements of the original proposal and task order. Upon acceptance of the work plan, a literature review and analysis were conducted to understand how historical research on the topic of OSSs impacted the OSS/ID project. Particular attention was paid to studies assessing differences in technology acceptance by various carrier sizes. Economic, operational, and safety factors were identified and documented. Each topic was researched to determine possible explanations for minimal small carrier OSS deployment. In addition, research gaps were identified and a synthesis of the findings was created. Finally, relevant information was incorporated into the development of the survey guides.

To ensure that the literature review findings were appropriately synthesized with carrier and driver survey data to portray an accurate depiction of deployment patterns, a panel of subject matter experts was convened. This group included members who represented relevant industry stakeholder segments, including the American Trucking Associations' (ATA) Small Carrier Advisory Committee and Owner-Operator Independent Drivers' Association (OOIDA). The panel reviewed and commented on various deliverables through webinars and "report response forms."

A survey and interview guide was developed and pretested with the panel, with the findings disseminated to targeted drivers and carriers. The researchers applied multiple statistical formulas to the data received.

A final research task involving case study assessments was commenced to further understand and document the factors that influence a carrier's decision to purchase OSS technologies at various fleet sizes. Representative fleet-size participants were included for both users and non-users. The case studies also included two carriers that were at the early stages of deploying OSS technologies (emerging users). The predetermined carrier sizes included are shown in Table 1.

Table 1. Industry case study matrix.

Fleet Size	Users	Non-users	Emerging Users
Small Fleet Carriers (1–49 Trucks)	2	1	0
Medium Fleet Carriers (50–249 Trucks)	2	1	0
Larger Fleet Carriers (250–999 Trucks)	2	1	0
Very Large Fleet (1,000+ Trucks)	2	1	0
User Evolution	0	0	2

A follow-up data collection exercise was also used as a validation tool to verify the unique findings of the individual case studies. The key case study findings were reviewed, calibrated and/or validated at a large, national trucking industry event primarily geared toward small carriers and owner-operators.

After compiling the information and results gathered from the literature review, surveys, case study, and expert panel input, a final report was drafted and presented to FMCSA.

SUMMARY OF STUDY FINDINGS

The carrier data collection surveys were disseminated to target samples through several participating organizations, including the ATA, the 50 State trucking associations, and the OOIDA, all of which participated in a review of the survey prior to distribution. The survey length was relatively short to increase the response rate. A broad sampling of carriers was surveyed in order to ensure a representative sample of respondents and their requisite perspectives.

Through the compilation of demographic information and Likert scale questions, several key carrier findings were determined, including:

- More than 88 percent of all carriers surveyed did not have any experience with the OSS technologies.
- The majority (60 percent) of the leading factors that influence a carrier's decision to invest in an OSS were cost-related.
- Similarly, 60 percent of carrier concerns that would decrease the likelihood of purchasing an OSS were cost issues.
- Carriers suggested several means of alleviating specific deployment barriers, such as purchase assistance programs, OSS training support, and additional OSS research.
- Various communication networks and media were the primary mode through which carriers were introduced to the OSS technologies.

Truck driver acceptance is also a key component of OSS use, which led the team to collect large datasets from this sample. The driver survey was disseminated through State and national driver and fleet owner associations. Because drivers are widely disbursed, several methods of survey distribution were used, including broadcast fax and online survey tools.

Information was gathered through open-ended questions and Likert scale assessments. Key driver findings include:

- More than 72 percent of all drivers who participated in the survey had no experience with OSS technologies.
- Drivers requested additional research showing the benefits of OSS technologies, such as crash reductions and driver distraction concerns.
- Drivers are most concerned about affordability and indicated this was the top issue that would decrease their acceptance and use of OSS technologies.
- On average, drivers were more familiar with each of the individual systems included in this study than were carriers.

Throughout the case study analyses, carriers indicated that cost- and accident-related issues drive most aspects of OSS deployment. For instance, as shown in Table 2, all four fleet size segments identified cost and accident reduction as primary motivators for purchasing a system. However, carriers did not typically make decisions to purchase a system until all relevant data were collected and evaluated.

Table 2. Top carrier motivators for purchase, by fleet size.

Fleet Size	Rank	Frequency
Small Fleet Cost	1	3
Small Fleet OSS Capabilities	2	2
Small Fleet Accident Reduction	3	1
Small Fleet Improved Safety	3	1
Small Fleet Insurance Savings	3	1
Small Fleet Maintenance	3	1
Medium Fleet Accident Reduction	1	6
Medium Fleet Cost	2	4
Medium Fleet OSS Capabilities	3	3
Medium Fleet Improved Safety	3	3
Large Fleet Accident Reduction	1	5
Large Fleet Cost	2	4
Large Fleet Data on OSS Benefits	3	2
Large Fleet Fuel Economy	3	2
Very Large Fleet Accident Reduction	1	6
Very Large Data on OSS Benefits	2	4
Very Large Cost	3	3

Interestingly, all non-users indicated that they would conduct internal testing and trials of the products before considering a purchase, yet only two-thirds of the users actually completed some form of internal testing. The OSS testing resulted in a variety of positive and negative findings, including a lack of uniformity and corroboration with external OSS data sources (e.g., vendor-provided data).

Although most case study carriers had formal procedures for "locking up" funds, the majority did not initially have funding available in the budget. OSS training provided to drivers and maintenance staff varied considerably among carriers in the amount of time needed to train employees and the manner of providing information.

During the case study validation process, it was made clear to the research team that cost was a principal concern, as it appeared in four out of the five most frequently sought out types of OSS information. Expanded safety statistics and analyses and detailed cost information were again identified as top motivators for OSS purchase. A list of paraphrased responses and desired information follows:

Safety Statistics

- Provide assistance to ensure safety on the road.
- Document data on crash mitigation and lives saved.
- Serve as a backup product to determine crash liability.

Purchase Price

- Needs to be lower than the current purchase price.
- There are many other competing expenses, and relative OSS prices are currently too high.
- Purchase price is too high without a guarantee that it will work properly.
- If the cost is higher than the benefit, there is no need for the system.

Overall Cost/Expense

- Needs to be low.
- Operating margins are so small that costs need to be monitored.
- Money still needs to be made, and competition remains high.
- Money is hard to come by in any economy, particularly a bad one.

Insurance Cost

- Insurance premium discounts are needed to justify system cost.
- Insurance should be more costly for non-users.
- Immediate reductions for using the systems rather than *ex post facto* delay (e.g., waiting for rates to decrease as a result of lower crashes encountered).

Product Features

- Should have the ability to easily control volume (e.g., construction zones).
- Should be integrated with other OSS technologies as well as real-time communications.
- Truck warnings to determine what the object is (e.g., car).
- Notification of unsafe passenger vehicles during passing.

CONCLUSIONS

Three primary focus areas were identified to assist in the acceleration of OSS adoption, including:

- Increasing industry awareness.
- Overcoming deployment barriers.
- Creating an industry-wide safety culture.

Increased awareness could be attained through a variety of strategies, such as:

- OSS research promotion and publication in trade magazines.

- Informational materials/promotional brochures at truck dealerships.
- Local seminars or meetings with carrier safety groups and associations.
- Onsite fleet visits from vendors, Government officials, or researchers to discuss findings from OSS studies.

Overcoming multiple deployment barriers may be difficult if a carrier is inherently risk-averse to implementing a safety technology. Methods to reduce this uncertainty may include providing Government assistance in facilitating investment and adoption of OSS products, creating a grant program, and providing objective information in easy-to-understand formats.

Supporting the development of a carrier-wide safety culture would help trucking industry stakeholders focus on safety objectives in general and on OSS technologies as a mechanism for obtaining the objectives. However, several steps would be needed to achieve this goal, including:

- Defining and promoting carrier safety cultures.
- Addressing the carrier and driver barriers to accomplishing safety goals.
- Utilizing the proposed awareness opportunities.
- Developing safety knowledge through additional training.
- Increasing communication between carriers and drivers.

NEXT STEPS

Although considerable research has been conducted on OSS technologies, there appears to be a lack of information available to carriers. A more technical mapping of information, information sources, and program opportunities should be developed as an initial step to resolve carrier and driver requirements and concerns.

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1. INTRODUCTION

1.1 BACKGROUND

The Onboard Safety System/Industry Demographics (OSS/ID) initiative was initially commenced to expand on discoveries generated from the Federal Motor Carrier Safety Administration's (FMCSA's) Onboard Safety System (OSS) Cost-Benefit Analysis reports. It was determined that unique requirements, business models, and operational processes relating to owner-operators and small carriers differentiate them from the major populations targeted by the cost-benefit assessments. Research was needed to understand how the small carrier sample is different from the rest of the trucking population in terms of OSS adoption.

To support FMCSA's goal of accelerating OSS investment across all carrier demographics, this study examined the barriers that small carriers face when considering deployment opportunities.

Over the past 20 years, the number of large truck crashes has remained relatively stable.(1) Though the fatality rate per 100 million vehicle miles traveled has decreased considerably, the overall fatality rate has stabilized near 5,000 fatalities per year. Several solutions have been proposed to improve this recurring issue, including the use of OSS. Despite the fact that these technologies are available to motor carriers, only a small fraction of the industry uses the systems.

Acceptance and deployment of OSSs are critical to reducing fatalities and injuries involving commercial motor vehicles (CMVs). Through previous studies, it is documented that OSS technology usage varies widely based on motor carrier demographics, including size, sector, and operations. Especially among small carriers (defined as fewer than 50 power units for the purpose of this study) system use is relatively low compared to medium, large, and very large carriers. Manufacturers have attempted to cater to smaller trucking companies through various adoption strategies, but research indicates that small carriers typically wait to invest until larger companies have implemented the systems on a larger scale.(2) Therefore, this study was designed to further understand the underlying factors for a lack of investment by small carriers and to suggest strategies to accelerate OSS deployment across all sectors. Most OSS analyses focus on three primary OSS technologies, each with a specific accident-prevention objective.

1.1.1 Lane Departure Warning Systems

A lane departure warning system (LDWS) is an electronic system that primarily uses automated video feeds to assess lane position with respect to lane markings, although additional sensors and systems (some using metalicized lane-striping materials) have been tested.(3) Some systems issue directional warnings, while others use visual indicators on a user interface to display whether or not the vehicle is centered in the lane on a time-averaged basis. In addition, a LDWS will notify the driver if the system malfunctions or if the lane markings are insufficient for detecting problems. However, LDWSs do not take active vehicle control to avoid a lane departure; the systems simply alert the driver if a potentially unsafe situation is detected.

A LDWS can be installed as an aftermarket device or it can be installed by the original equipment manufacturer (OEM) when the vehicle is being manufactured.(4) Costs for a LDWS vary and typically decrease as the number of products ordered increases. Typically, unit costs range from $800 to $2,000.

1.1.2 Stability Control Systems

There are two primary types of stability control systems (SCSs). A roll stability control (RSC) system is designed to monitor rollover thresholds through the use of wheel speed sensors and a lateral accelerometer.(5) The RSC system can provide anti-lock braking, traction control, and roll control to prevent rollovers if the rollover thresholds are exceeded.

An electronic stability control (ESC) system is similar to an RSC, but includes an assessment of:

- Wheel speed.
- Yaw.
- Steering angle.
- Control pressure sensors.
- Longitudinal and lateral accelerometers.(6)

In many instances, ESC can prevent rollovers, jack-knifing, oversteering, and understeering by detecting lateral instability. Additionally, the system provides anti-lock braking along with roll, yaw, and traction control. If an ESC system detects yaw instability or a low roadway coefficient of friction, the system engages to prevent rollovers.

The cost per unit varies greatly depending upon the features of the SCS unit, the number of units purchased, and whether it is RSC or ESC. According to one manufacturer, ESC systems are slightly more expensive than RSC, and range from $1,600 to $1,900.(7) RSC prices range from $800 to $1,000. Most are installed by the OEM when the truck is manufactured; however, aftermarket products are available.(8)

1.1.3 Collision Warning Systems

The primary function of forward and side collision warning systems (CWSs) is to reduce rear-end and side-impact crashes.(9) If there is an unsafe interval between the truck and a vehicle in front of or beside it, the CWS's radar sensors provide visual and auditory alarms. Also, if a dangerous situation presents itself in which a truck approaches a slower moving vehicle, progressive warnings alert the driver. Similar to CWS, the Forward Collision Warning System (FCWS) can integrate an adaptive cruise control (ACC) system. This automatically maintains a pre-established following interval between the truck and a vehicle in front, and adjusts some combination of the truck's transmission, throttle, cruise control, and/or foundation brakes to regulate truck speed. FCWSs have been found to be most useful for avoiding rear-end crashes when vehicles are traveling at moderate to higher speeds.(10)

Depending upon the features included in the product, the installed cost per unit ranges from $1,000 to $3,000.(11) When integrated with CWS, ACC systems can add between $350 and $400 to the cost.

1.2 RESEARCH OBJECTIVES

To better understand and address the challenges of deploying and using OSS technologies across all relevant sectors of the trucking industry, FMCSA and the American Transportation Research Institute (ATRI) collaborated to develop a study with the stated objectives to:

- Analyze OSS technology investment and deployment patterns within the trucking industry.
- Identify operational differences and related OSS technology investment issues across fleet sizes and sectors, particularly among small carriers.
- Develop strategies that address unique opportunities for accelerating OSS technology deployment.

The results can provide both government and industry stakeholders with more detailed information regarding the specific challenges and unique perspectives of various carrier sizes relating to OSS deployment. In addition, this initiative can provide the basis for FMCSA and the trucking industry to assess the adoption strategies developed by researchers and practitioners for possible collaboration opportunities in the future.

OSS technologies have been available as a resource for improving safety for more than a decade, and many carriers and drivers have basic awareness of the potential benefits associated with OSS technologies. However, improved understanding and acceptance by motor carriers and drivers are critical to successful widespread OSS deployment if a reduction of fatalities and injuries in crashes involving CMVs is to be realized. Specific challenges still exist, especially among small carriers. The objective of this research is to identify those small carrier issues and impediments and develop a strategy for increasing OSS adoption.

For this study, key research components included:

- Data collection and analysis of OSS technology utilization and deployment through survey and case study analyses.
- Support from a panel of subject experts for research guidance and review.
- A final report documenting OSS technology deployment issues as well as strategies to increase adoption of these systems by carriers of various fleet sizes and operating sectors.

1.3 TECHNICAL APPROACH

The study process was predicated on the following primary tasks and deliverables:

- Project work plan.
- Literature review and research synthesis.
- Expert panel on safety technology.
- Wide-ranging industry data collection and analysis.
- Case studies
- Framework and methodology.
- Preparation and presentation of findings.

1.3.1 Project Work Plan

A work plan was created prior to the launch of the OSS/ID study. The purpose of the plan was to manage all aspects of the project in an organized and effective manner. It contained a description of all activities associated with the project as well as a timeline indicating deadlines for deliverables. In order to keep FMCSA informed on the progress of the study, weekly updates were distributed. In each update, key project activities and findings were described.

1.3.2 Literature Review and Synthesis

An updated literature review was developed to ensure a current understanding of the variations and differences in technology acceptance and deployment across fleet sizes. Small carriers were the primary focus of the review. In addition, the purpose of the literature review was to identify research information gaps and compile a record of current research and knowledge related to carrier/technology differences. The literature review gathered and examined various literature resources, including public sector, industry, and academic publications. The resulting information was initially compiled into an extended bibliography. However, in order to further expand upon the information provided by each resource, a synthesis was created.

Economic, operational, and safety factors were documented in the literature review compendium. To understand small carrier issues in particular, small company business practices were examined. The findings were used to determine potential explanations for the current delay in small carrier adoption of onboard safety technologies. Literature findings were used to provide preliminary direction for constructing the carrier and driver surveys.

1.3.3 Expert Panel on Safety Technology

An expert panel was used to guide relevant and appropriate data collection and to provide technical assistance to the research methodology. This group consisted of industry stakeholders with different OSS relationships and perspectives. In this manner, the researchers gained a comprehensive understanding of OSS issues. Beyond survey and case study design review, expert panelists provided comment on most final deliverables to ensure accuracy. Members also participated in the American Trucking Associations' (ATA) Small Carrier Advisory Committee meeting in October 2008 and in a project webinar in January 2009 to provide feedback on preliminary findings and next steps.

The recommendations of the expert panel analysis were compiled and submitted to FMCSA. If clarification was needed, the expert panel members were contacted for further discussion. In addition, a webinar "meeting minutes" document was created and organized to reflect the expert panel comments and questions received.

1.3.4 Wide-ranging Industry Data Collection and Analysis

A survey was designed to assess the current perceptions of OSS technologies for carriers and drivers. Through the survey methodology, proactive measures were identified to increase the likelihood of investment in OSS technologies. The results were examined and described through a survey report. Equivalent carrier and driver survey forms were developed and beta tested. Modifications were made to the draft surveys based on the beta-testing feedback. The finalized versions were disseminated online through media contacts, and through the Owner-Operator Independent Drivers' Association (OOIDA), State truck driving championships, and ATA. Survey tabulations were calculated, and a draft report was produced. In the draft report, survey tabulations were incorporated along with a corresponding analysis, followed by descriptive charts and graphs.

1.3.5 Case Studies Framework and Methodology

The case study process was used to further document the factors that motor carriers of different fleet sizes consider when making the decision to deploy an OSS technology. In particular, the researchers sought to understand possible deployment differences between small carriers and larger fleets. A case study outline and interview guide were constructed for the task and approved by FMCSA. Case study participants were selected based on fleet size, operating sector, and OSS exposure. A total of 20 participants were involved in the process, consisting of at least two OSS users and one non-user for each of the following fleet size categories: small (1–49), medium (50–249), large (250–999), and very large (1,000+). The design also included two OSS users that were in the preliminary phase of deploying the systems (see Table 1 on page xiii).

Preliminary case study findings were discussed with expert panelists during the January 2009 webinar. Because case study samples were small relative to the general population of interest, further clarifications were recommended by the expert panel to explain case study findings. More small carriers were interviewed at a large truck show that was primarily comprised of small carriers and owner-operators.

1.3.6 Preparation and Presentation of Findings

The final report was completed by consolidating the information gathered during the literature review, carrier and driver surveys, case study, and expert panel processes. The documents that were components in each task were synthesized into the final report. An onsite presentation was made to FMCSA describing the findings detailed in the report.

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2. ONBOARD SAFETY SYSTEMS/INDUSTRY DEMOGRAPHICS LITERATURE REVIEW

2.1 ONBOARD SAFETY SYSTEMS SAFETY RESEARCH ASSESSMENT

A literature scan was conducted, including online academic journals and reports by the U.S. Department of Transportation (USDOT), ATA, OOIDA, ATRI, and the Small Business Administration. Published literature addressing the technology deployment differences between small and large carriers was limited. Therefore, interviews were conducted with OOIDA and ATA representatives to gain additional insight from those who work directly with small carriers and owner-operators.

2.1.1 Battelle, "Evaluation of the Freightliner Intelligent Vehicle Initiative Field Operational Test: Final Report" (2003)

Battelle, in conjunction with Freightliner, the University of Michigan Transportation Research Institute (UMTRI), and OSS suppliers, conducted a field operational test (FOT) of the roll stability advisor and RSC. The goal of the study was to assess the benefits (e.g., safety, financial, and other) of the systems to understand deployment and commercialization issues. To do so, several factors—such as efficacy and productivity—were analyzed through various methods of examination involved in the FOT. Comparing previous crash data from the Fatality Analysis Reporting System (FARS) to the potential number of crashes prevented through the use of the systems, potential roll stability advisor (RSA) efficacy rates were 20 percent for rollovers and 33 percent for single vehicle roadway departure (SVRD). Additionally, during the FOT, driver awareness increased, there were no distraction issues, and managerial concerns were minimal.

2.1.2 Society of Automotive Engineers International, "A Comparison of Crash Patterns in Heavy Trucks With and Without Collision Warning System Technology" (2004)

In a study conducted by the National Institute for Occupational Safety and Health, an analysis was conducted on the effectiveness of CWS technology. The research involved the use of FMCSA's Motor Carrier Management Information System (MCMIS) data from 2000 to 2002 and included more than 6,000 crashes involving large trucks equipped with a CWS and more than 380,000 crashes with no CWS (the control group). The CWS group and the control group were compared on several levels, including driver age, weather conditions, and crash severity. Although there was no correlation with weather conditions, road conditions, or crash severity, it was determined that trucks equipped with a CWS were involved in proportionally fewer multivehicle crashes and crashes with another moving vehicle. The percentage of multivehicle crashes involving trucks with a CWS was only 62 percent, compared to 67 percent in the control group. When comparing crashes with another moving vehicle, trucks with a CWS were involved in 40 percent of crashes, and the control group was involved in 49 percent. Therefore, it was determined that the use of a CWS can have a positive effect on driver safety and the safety of the motoring public.

2.1.3 FMCSA, "Mack Intelligent Vehicle Initiative Field Operational Test" (2006)

As part of USDOT's Intelligent Vehicle Initiative, Mack Trucks participated in an FOT that examined the efficacy and impact of LDWSs, with an emphasis on driver acceptance and safety.

The FOT was conducted over a 12-month period and included 22 trucks equipped with the system. Throughout testing, the systems were periodically switched off and the equipped trucks were used as control vehicles for comparison. All information was automatically uploaded and sorted for analysis. No crashes occurred during the test period; however, driver responses regarding system effectiveness were positive. For example, when a system was turned off on a particular truck, the driver complained. As a result of positive feedback, the carrier that participated in the study continued to utilize a LDWS.

2.1.4 Battelle, "Evaluation of Volvo Intelligent Vehicle Initiative Field Operational Test: Final Report" (2007)

Under the Intelligent Vehicle Initiative, Battelle and Volvo Trucks North America assessed the safety benefits of CWS technology, specifically driver behavior and rear-end crash reductions. The study employed a statistical analysis of rear-end crashes that could have potentially occurred during the FOT based on severity and frequency. The estimated percentage of rear-end crashes that could be reduced through the use of a CWS is 21 percent at a medium threshold. Therefore, according to FARS data, through expanded deployment throughout the United States, the number of rear-end collisions avoided is approximately 14,000, as a result of reduced exposure to this type of crash and improved driving behavior.

2.1.5 ATRI, "A Synthesis of Commercial Motor Vehicle Safety Technology Surveys: What Have We Learned?" (2007)

The purpose of this ATRI/FMCSA study was to synthesize the pre-existing data gathered through focus groups, surveys, and interviews and provide a summary of information surrounding OSS technology deployment and safety impacts. Questions from the various surveys were consolidated so that a statistical analysis could be conducted and industry trends could be identified. It was determined that, though technology installation is increasing, especially installation of Global Positioning Systems and remote communications systems, carriers were still hesitant to invest in OSS technologies due to a perceived lack of information and the desire for a faster return on investment (ROI). Many of the surveys focused on a single technology or involved a small sample size. Therefore, it was determined that additional research is needed, especially on the topics of OSS training, ROI per technology, and OSS evolution and production.

2.1.6 ATRI, "Incentives for Deployment of Onboard Safety Systems" (2007)

In a joint effort by ATRI and FMCSA, the researchers conducted an analysis of OSS manufacturing and utilization by carriers to determine appropriate incentives to increase adoption by carriers. To assess the needs of carriers, a survey was conducted with primarily larger companies, as they generally are the first to invest in safety technologies. Using industry stakeholders' opinions, eight specific categories of incentives and their benefits were outlined. Incentives rated to be of a higher success value included Federal income tax credit, dissemination of data, expert testimony, direct loans, and grants.

2.1.7 National Highway Traffic Safety Administration (NHTSA), "Statistical Analysis of the Effectiveness of Electronic Stability Control Systems—Final Report" (2007)

In this report, NHTSA assessed the effectiveness of ESCs through an examination of FARS data from 1997–2004 and seven State databases from 1997–2003. The study focused on crashes involving passenger and sport utility vehicles equipped with an ESC, specifically luxury vehicles, on which this technology is standard. An analysis was conducted through the comparison between a test group that contained a set of crash types that might have been prevented through the use of an ESC, and a control group, which included those accidents that would not have benefited from ESC technology. Through the use of a contingency table analysis, the researchers proved that ESCs produce a statistically-significant impact on single-vehicle crashes involving rollovers, running off the road, and culpability in multivehicle crashes. Overall, ESC use was calculated to reduce all single-vehicle crashes involving passenger vehicles by 36 percent and those involving light trucks and vans by 63 percent. It was also noted that if crashes involving property damage only were removed from the analysis, leaving only more serious crashes in the assessment, the statistical effectiveness of an ESC would be even greater.

2.1.8 UMTRI, "Tracking the Use of Onboard Safety Technologies Across the Truck Fleet" (2009)

This research initiative built upon previous findings that indicated a need to understand the magnitude of deployment across industry sectors and the issues encountered during investment decisionmaking. The objectives for this study were to assess OSS deployment levels and to document carrier experiences and knowledge bases for the various technologies, which included the following:

- Level of familiarity with the technologies.
- Proportion of current and future fleet use.
- Rationale for implementing OSS technologies and challenges faced.
- First-hand benefits measured.

2.1.9 ATRI & FMCSA, "Onboard Safety Technology Economic Analysis and Deployment" (2008)

The researchers analyzed the expected economic benefits of three onboard safety systems: A forward collision warning system (FCWS), a LDWS and a roll stability system (RSS). It is important to note that the benefit-cost analyses did not include an evaluation of the ESC system. Cost assessments incorporated into this study were payback periods and ROI calculations based on specific efficacy rates. For FCWSs, carriers can expect a $1.33 to $7.22 ROI within a payback period of 8–37 months. Carriers that purchase LDWSs would have an ROI range of $1.37–$6.55 in a 9–37 month period. Additionally, those with RSSs have an anticipated ROI of $1.66–$9.36 and a payback period of 6–30 months.

2.1.10 ATRI/North Dakota State University, Large Truck OSS Field Test (2008)

The development of research guidelines and statistical options for testing the effects of OSS technologies were completed through a naturalistic field test design. The research identified and presented various comprehensive and statistically relevant research design approaches. Research components included a literature review, the development of an OSS user database, surveys, and the identification and presentation of field test research design options. Of the four most effective approaches identified, the most effective was the "Pretest–Post-test with Nonequivalent Groups Design: OSS Users and Non-users." In this study, the research focused on safety challenges and crash data for both OSS users and non-users and for users before and after testing. In doing so, the safety outcomes between both groups could be examined.

2.1.11 UMTRI, "Integrated Vehicle-based Safety Systems Preliminary Field Operational Test Plan" (2008)

UMTRI is in the process of conducting an FOT study to evaluate increased deployment of CWSs across U.S. passenger vehicles and commercial trucks. System user-friendliness, expected safety benefits, and driver distraction are among the variables proposed for examination. Various forms of qualitative and quantitative data are to be collected, and the final reports will be documented so that audiences can fully understand the data collection process and elements.

2.1.12 UMTRI, "Integrated Vehicle-based Safety Systems (IVBSS): Human Factors and Driver-Vehicle Interface (DVI)" (2008)

The USDOT, in collaboration with UMTRI, sought to design and test integrated vehicle warning systems that were integrated properly, created a safe driving environment, and effectively communicated with drivers. The study consisted of a series of experiments, including crash simulations in which the driver was provided with a variety of warning signals. Driver behaviors were then compared to truck performance in such categories as speed and throttle position. Through these tests, several findings were noted, including:

- The need for auditory alarms that were easily recognizable and could be heard over background noises.
- The combination of different warnings did not increase driver responses.
- Most of the warning technologies were easy to use.

2.1.13 Virginia Tech Transportation Institute (VTTI), "Safety Benefit Evaluation of a Heavy Vehicle Forward Collision Warning System" (2009)

This study focuses specifically on use of a FCWS and associated implications for drivers involved in potential rear-end crashes. The researchers identified rear-end crash data through a series of algorithms that separated potential rear-end crash events from other crashes, introduced FCWS alarm data, and incorporated human response times. Then, using a Monte Carlo simulation, safety benefits were measured through a calculation of the number of crashes potentially avoided with a FCWS. It was determined that the number of rear-end crashes could be reduced by as much as 21 percent, or approximately 4,800 crashes per year. This may translate into a significant reduction in driver fatalities as well as improved traffic flow.

2.1.14 ATRI, "Onboard Safety Systems/Trucking Industry Demographics" (2009)

ATRI and FMCSA analyzed operational, safety and economic factors affecting OSS deployment across industry segments with a particular focus on small carriers. The research assessed the processes various fleet sizes undertook to gather information, conduct pilot tests, train employees, and evaluate maintenance issues. To assess deployment patterns, the investigation process included a literature review, surveys, case studies, and focus groups with stakeholders. The conclusion of the report included an analysis of possible incentives and strategies for promoting increased deployment, especially among small carriers.

2.2 ECONOMIC FACTORS

2.2.1 Motor Carrier Industry

Following deregulation, the trucking industry has become one of the most competitive sectors of the U.S. economy.[(12)] Consequently, various economic trends and critical industry issues over the past several years have been identified,[(13)] including: fleet consolidations and acquisitions, reduced freight capacity, new hours-of-service and other regulations, rate increases, fuel price fluctuations, and driver shortages, to name a few.[(14)] Large carriers have been favored on several factors, such as increased demand for real-time shipment tracking, because they are better capitalized with the information technology resources needed to function in the advanced system environment.[(15)]

Although exact percentages are very dynamic, it has been acknowledged that motor carriers typically operate on an extremely tight financial margin.[(16)] As a result, trucking has become a cost-driven industry where prudent investments in new technologies that improve service and reduce cost can make the difference between a successful carrier and a failed one.[(17)] However, small- and medium-sized truckload carriers are likely to lack the financial resources needed for more sophisticated information technology.[(18)] Cost-effectiveness and seamless integration with existing or planned infrastructure are cited as primary factors in information technology deployment decisionmaking within the motor carrier industry.[(19)]

2.2.2 Small Business Issues

According to several sources, issues surrounding the ability of small- and medium-sized carriers to purchase OSS technology are related to the fact that small businesses are characterized by limited capital resources and a lack of real-time access to data and information. Findings show that small businesses often expend a larger relative share of Federal regulatory costs, including environmental regulations and tax paperwork.[(20)] Environmental regulations cost small businesses 364 percent more than large companies, and tax compliance is 67 percent more costly. This disparity is due to the expenses needed to adhere to the regulation, which affect different sized businesses differently (such as hiring engineers, setting up equipment, and utility costs).[(21)]

For example, in comparing the cost of health benefits provided by employers by company size, smaller firms frequently make significantly larger contributions per employee than larger firms.[(22)] In small businesses, access to pension plans and retirement plans, paid sick leave, and other leave benefits are substantially lower for employees than they would be in large businesses.

For instance, 81 percent of employees in large firms have access to paid sick leave, compared to 65 percent in small firms. Even though insurance premiums are higher for large companies, the cost per employee is higher in small companies.

2.3 INDUSTRY OPERATIONAL FACTORS

Decisionmaking processes undertaken by truckload firms to buy or lease equipment were analyzed by FMCSA's Office of Information Management.[(23)] The analysis included the ability to adjust to the growth rate in the market and control equipment costs, as well as driver management issues. Slim profit margins were raised, and—according to the author—the net profit margin (net income divided by total operating revenues) in 2002 was 0.99 percent, with the profit margin in the three highest industry segments being only 2 percent.[(24)]

Aside from carrier cost and operating issues, other challenges include: median return on equity, competition between carriers on productivity measures, and operation costs.[(25)] In a separate study, the Federal Highway Administration identified and assessed challenges to the motor carrier industry according to industry experts.[(26)] The largest issue cited—rising insurance costs—had costs increasing dramatically, with primary rates increasing 32 percent in 2001. This resulted in the reduction of insurance coverage by most carriers as a cost-control measure. Additionally, many companies had been forced out of business and others faced a reduction in profitability. In order to maintain adequate customer service, transport rates had not increased, and competition between carriers was still strong.

In 2000, the USDOT proposed changes to the hours-of-service rules, creating another challenge in the motor carrier industry.[(27)] The changes proposed the addition of an onboard recorder to limit the ability of drivers to "stretch the truth" regarding the number of consecutive hours driven; it also modified the definitions and differences between "on duty" and "driving." It was proposed that this could possibly reduce driving time and increase prices for consumers.

Another challenge facing carriers is the variability of fuel prices.[(28)] According to both ATA and FMCSA, current profit margins are only 5 percent, so a dramatic change in fuel price often affects the ability of a carrier to deliver freight and only sometimes increases consumer prices.

A fourth concern cited was urban congestion and travel time reliability.[(29)] In order to compensate for this issue, drivers took alternate routes or avoided driving at peak congestion times. However, some carriers must comply with shippers' schedules and cannot avoid the congestion and route issues that may cause problematic situations, such as off-route safety issues or delayed deliveries.

Loading times at docks can also be challenging with carriers and shippers.[(30)] A loading holdup does not affect the shipper's prices, but rather the carrier's operation costs, which in turn drives up the cost of goods to the consumers. Delays at ports have a similar consequence, as longer wait times for drivers can cause an increase in the price of products.

On October 1, 2002, new fuel emission standards were adopted by Congress and promulgated by the Environmental Protection Agency (EPA).[(31)] Carriers, fearful of the regulatory compliance costs, avoided purchasing new engines and were buying older, used engines instead. In addition, carriers were keeping older tractors for longer periods of time. These standards could also raise the cost of producing fuel, ultimately affecting the entire motoring public.

FMCSA noted that security concerns are also a primary issue that carriers face.[32] In the post-9/11 world, security is a top priority for all industries. While carriers have addressed this issue, it has not resulted in major changes outside of hazardous materials or Department of Defense operations in any significant manner.

2.4 SAFETY FACTORS

In 2005, ATRI conducted a synthesis of existing surveys, interviews, and focus groups on the topic of OSS technology utilization in the trucking industry.[33] Cost concerns (including insurance costs, crash reduction savings, installation costs, training, and maintenance), as well as the need for additional information on measurable safety benefits were clear deployment barriers. As an aside, in 2006, ATRI identified cost, privacy, and lack of documented safety benefits as primary obstacles in electronic onboard recorder usage.[34]

Currently, there is debate within the trucking community related to the use of OSS technologies.[35] While some argue that the systems are a valid and useful tool in creating safe driving, others suggest that the systems could create additional safety concerns since the driver could become distracted or disengaged from the systems' warning alerts. For instance, in one study, the authors noted that the use of systems that have visual screens displaying roadway information caused additional driving distractions and decreased driver performance.[36] This was especially true when the driver depended heavily on the screen information presented while attempting to navigate curved roads. As a result, the authors suggested the creation of a system that would alert the driver of potential hazards and assist in correcting the vehicle by placing it back inside the proper lane or within a sufficient following distance of the next vehicle.

In addition, drivers and carriers have voiced concern that the OSS interaction places additional tasks on the vehicle operators. This, in addition to dealing with traffic and weather conditions, can place an undue burden upon drivers. However, there is an abundance of onboard systems available on the market, and many vendors are attempting to address the driver distraction concerns.[37] Finally, there are researchers who found that the systems actually reduce distraction. For example, several studies have shown that FCWSs and LDWSs are some of the more effective products available in reducing the likelihood of driver inattentiveness and visibility issues.

The 2006 chairman of the National Transportation Safety Board, Mark V. Rosenker, expressed his agreement on the issue of driver distraction while presenting at the annual International Consumer Electronics Show.[38] He stated that yearly roadway fatalities and injuries could be significantly reduced through the use of onboard safety technologies, and that it is important to provide "increased functionality, increased convenience, and increased safety."

In order to ensure that the new technologies are properly used, additional equipment testing could be implemented.[39] It is important to note that the life of a technology product is relatively short. This becomes an additional concern for carriers as the quality of the information obtained by the system needs to maintain a high level of accuracy in order to correct driving errors.

However, as the author suggests,[40] if carriers maintain OSS usage and support, the use of OSS technologies can be highly effective in preventing accidents.

Aside from these issues, several key OSS safety benefits can be realized. According to a study sponsored by FMCSA, each OSS technology would have specific safety benefits (see Table 3) if deployed by a carrier.[41]

Table 3. OSS ROI and payback.

OSS Type	BCA ROI	Payback
LDWS	$1.93 at 23% Efficacy	29 months
CWS	$2.33 at 37% Efficacy	24 months
SCS	$1.98 at 21% Efficacy	26 months

At a 23 percent efficacy rate, the number of rollovers causing property damage only could be reduced by as many as 275 annually when utilizing LDWSs. At that same efficacy rate, the number of injuries could be reduced by 343 and the number of fatalities by 9. In addition, at a 23 percent efficacy rate, the number of collision-caused property-damage-only accidents could be reduced by 828, injuries by 226, and fatalities by at least 15. According to another study by FMCSA, various types of crashes could be significantly impacted using LDWSs, including:

- 5,000 SVRD collisions with a fixed object.
- 3,000 SVRD rollovers.
- 9,000 sideswipes.
- 300 head-on collisions.

In a study conducted by the Research and Innovative Technology Administration, several safety benefits of a FCWS were identified.[42] It was found that when a truck is traveling at highway speeds of 55 mi/h, the number of rear-end crashes is reduced significantly. A test, conducted with trucks both equipped with the technology and with no FCWS, showed a considerable decrease in the number of accidents encountered by a truck with a FCWS installed. In fact, according to FMCSA, at a 21 percent efficacy rate, the annual number of property-damage-only rear-end crashes preventable by a FCWS is 5,813.[43] Furthermore, the number of injuries avoided is 2,735 and the number of fatalities mitigated is 49.

SCSs can also have a significant role in reducing the number of rollover accidents.[44] At a 37 percent efficacy rate, it was determined that the number of property-damage-only crashes that could be prevented with the use of a SCS was 602. The number of injuries that could be avoided was 769, as along with 51 fatalities potentially mitigated. In addition, in the FMCSA Large Truck Crash Causation Study, research determined that 29 percent of rollovers could have been prevented through the use of a RSS and 68 percent could have been avoided by using ESC systems.[45]

3. INDUSTRY DATA COLLECTION PLAN

3.1 OVERVIEW

As noted, there is considerable research underway that documents the safety benefits of different OSS technologies. Unfortunately, certain segments and sectors of the trucking industry may not have adequate knowledge or financial capabilities to garner the benefits associated with investing in an OSS. FMCSA has contracted with ATRI to investigate the issues, knowledge base, and financial capabilities of targeted industry sectors as a precursor to increasing the usage of proven safety technologies. Small carriers, in particular, have delayed the installment and use of new technologies for a variety of reasons. Understanding the discrete and unique issues of targeted sectors, including small carriers, can facilitate Government and industry investment solutions and programs.

ATRI worked with FMCSA to collect a variety of data on industry acceptance of OSS technologies, driver and carrier issues/perspectives associated with OSSs, and carrier- and driver-oriented adoption strategies for increasing OSS investment. This information-gathering process focused on a series of data collection activities and tools that are described below. In summary, the data collection plan is designed to generate quantitative and qualitative data for analysis as part of the overall OSS/ID initiative.

3.2 DATA COLLECTION APPROACH

A relatively large set of variables was examined to understand which factors assert influence over small-sized carriers considering investment in OSS technologies. The small carrier segment (sometimes defined as fleets with 20 or fewer power units, other times defined as 50 or fewer) comprises 90 percent of all carriers. In 2008, FMCSA sponsored ATRI to conduct a data collection and analysis approach that targeted small carriers. In this research, references to "small carriers" include owner-operators and carrier operations of up to 49 power units (including s-corporations, limited liability partnerships, and sole proprietorships).

The data collection process began with a literature scan of small carrier data sources, small carrier-oriented safety and economic studies, and other resources that provided relevant insight. This activity provided the key direction of the two Safety Technology Surveys that intended to identify discrete carrier and driver factors that influence technology deployment and utilization.

The OSS technologies assessed in the surveys included:

- LDWS.
- CWS.
- SCS.

To provide preliminary direction in survey development, the OOIDA Foundation and the ATA Small Carrier Conference conducted informal telephone interviews with carriers defined as owner-operators and small carriers. The interviews focused on OSS concerns relating to LDWSs, CWSs, and SCSs. Several of the questions and more common responses follow:

- What is your general view of the technologies?
  - "In addition to increased truck prices, it is unclear if any ROI will be received from installation of the new emission and safety devices."
  - "Many drivers have complained of false warnings with some of the systems. With lane departure warning devices, manufacturers assume that the truck is always centered in the lane. However, truck drivers often hug the right shoulder to create more space between the truck and oncoming traffic."
- What, if any, cost issues are preventing your company from purchasing an OSS?
  - "The trucking industry has been tough enough with fuel prices and maintenance costs. There probably would not be any discounts for small companies in purchasing the technologies."
  - "We have only one truck on the road due to cost reasons and could not afford to purchase any OSS."
  - "The biggest barrier would be the cost of the system."
  - "It is difficult to make a living now without the added cost of the system."
  - "Every corner has been cut so that money can be saved. Any additional costs would be a major problem. If we were to buy a system, the ROI would need to be really quick."
  - "We cannot afford any new devices."
- Do you have any safety concerns with OSS usage?
  - "Drivers want to be in control of the truck and adding an OSS might cause problems."
  - "Taking away driver control is a very unsettling issue."
  - "The drivers might become confused and distracted from all of the new gadgets."

All of the interview participants were aware of the systems, yet unfamiliar with how they operated or what the particular benefits were. Each respondent was concerned with the added equipment cost and the prospect of ROI.

3.3 SAFETY TECHNOLOGY: CARRIER SURVEY

ATRI developed a survey, with a focus on small carriers, to identify and measure critical OSS-related issues, measures, and attitudes. The Safety Technology Carrier Survey addressed the following research objectives:

- Identification of fleet characteristics and operating attributes.
- OSS attitudes, usage, and other OSS-related topics.
- Investment barriers and potential counter-strategies.

- Information, tools, and incentives that would motivate positive investment consideration.

The small carrier population, whose unique perspectives underlay OSS investment considerations, is financially, geographically, and operationally diverse. Thus, it was critical to obtain a broad sampling of carrier input to ensure a thorough and representative sample of respondents and their requisite perspectives. In an effort to increase the response rate, Safety Technology Survey 1 was relatively brief and was accomplished by fully utilizing the small carrier committee and the findings of the literature scan. As noted, the survey content was designed to collect key company and fleet demographic data, the status of OSS use/consideration within the company, and documentation of OSS usage impediments and incentives.

The respondent base was derived from the small carrier population across the United States with some representation from Canada. The ATA, the 50 State trucking associations, and OOIDA participated in the review and distribution of the survey. The survey tool was often published in industry media outlets.

3.3.1 Carrier Survey Items

Small carrier issues and attitudes were initially examined through the development and dissemination of the surveys. Important factors affecting the decision to install or expand OSS technologies were assessed through three survey sections: company/fleet characteristics, short answer, and industry attitudes. These key sections of Safety Technology Survey 1 were rationalized and developed as follows:

3.3.1.1 Company/Fleet Characteristics

Company and fleet characteristic questions were designed to collect carrier demographic information for two important objectives:

- To differentiate data (e.g., attitudes, characteristics, and issues) across respondents.
- To relate demographic carrier information to other responses within each survey.

Ultimately, OSS generalizations and trends within the small carrier population were developed through an analysis of comparative groupings and similarities.

3.3.1.2 Short Answer

The short answer section was comprised of open-ended questions that provided more in-depth and dynamic responses to OSS issues. The short answer section was particularly useful for understanding the potential program developments, future research, and/or needed incentives for small carriers. Every effort was taken to standardize open-ended questions and responses.

3.3.1.3 Industry Attitudes

This section was comprised of a Likert-type assessment that was used to identify the degree of importance that each OSS factor had on investment, expansion, and usage. Each factor/issue was rated on a six-point importance scale (1 = extremely unimportant, 2 = unimportant, 3 = moderately unimportant, 4 = slightly important, 5 = moderately important, 6 = extremely important) by checking the factor's corresponding number of importance. Six response choices were selected as part of the design to minimize neutral responses. In this assessment, eliminating the middle category was appropriate since the intended outcome was to differentiate between more important items and less important items. A six-option scale has been shown to be useful in strengthening response analyses and reducing "response pooling" that can occur when too few options are provided.

3.3.2 Carrier Survey Results

The initial targeted survey sample consisted of 50 participants; however, the final survey sample consisted of 44 participants. The surveys were distributed to small- and medium-sized carriers and to Board members of several State trucking associations. For the purposes of this study, carrier size was defined by the number of power units in a fleet, where small was 1–49 and medium was 50–250. It is understood that carriers associated with trucking association membership may be biased towards proactive safety programs.

3.3.2.1 Fleet Characteristics

Descriptive statistics were computed for the three fleet characteristic questions.

How many power units does your company operate, including owner-operator units?

Figure 1 shows the carrier size relative to the number of power units. The frequency of "small-sized carriers" was 25, followed by "medium-sized carriers" at 19.

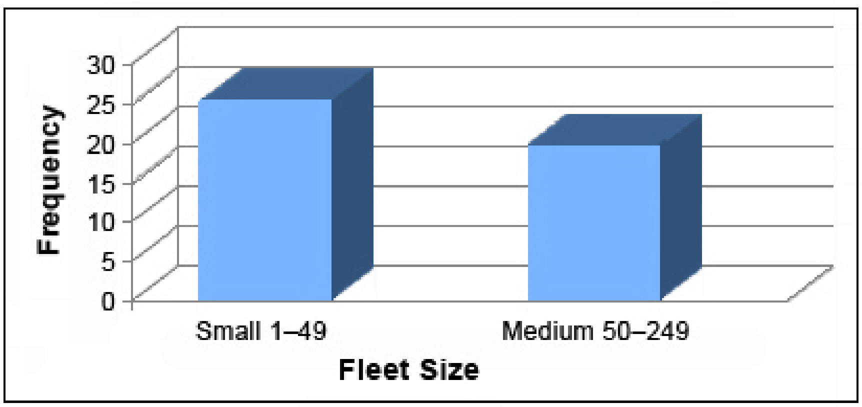

Figure 1. Bar chart. Carrier power units.

Please indicate your type of Carrier/Business (check all that apply):

The business type question had 40 valid responses. Almost three-quarters of the carriers were for-hire (73 percent), followed by private (22 percent) and owner-operator/independent contractor with operating authority (5 percent) as shown in Figure 2.

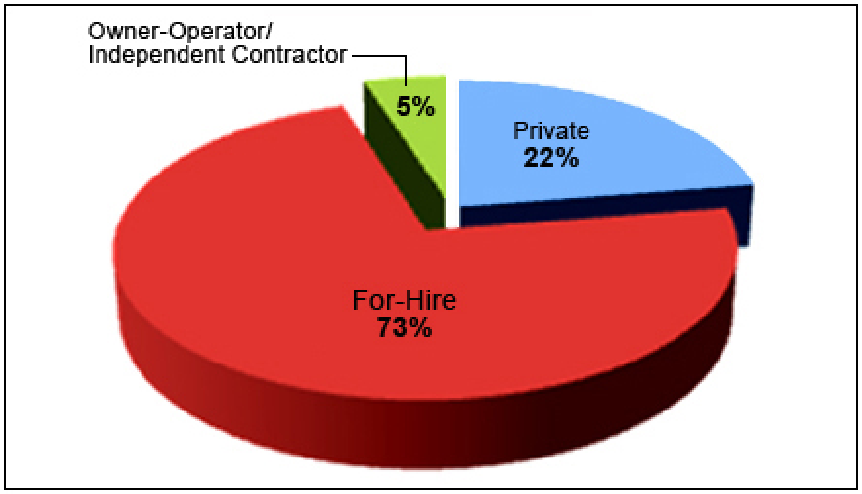

Figure 2. Pie chart. Type of carrier business.

Please check the technologies you currently use (check all that apply):

Table 4 below indicates the frequency of carriers that have had experience with each OSS technology. Note that the OSSs are not mutually exclusive to one another, so carriers may have checked more than one type of system. However, the majority of carrier respondents (88.6 percent) did not have any experience with OSSs.

Table 4. Carrier experience with OSS technologies.

OSS Type	Frequency	Percent
LDWS	1	2.3%
CWS	0	0.0%
SCS	2	4.5%
No Experience	41	88.6%
Total	**44**	**100.0%**

3.3.2.2 Short Answer

Please list the top three factors that would increase your likelihood of investing in an OSS.

Carriers were asked to provide their top three “motivators” for OSS deployment. The top five carrier “motivators” are listed in Table 5. Three out of five were cost-related, with the remaining two representing measures of safety. When several ties occurred, researchers identified the item that was rated highest most often.

Table 5. Top five carrier motivators for deployment.

Positive Influence	Rank	Frequency
Decreased Insurance Costs	1	18
Affordable Purchase Price	2	12
Improved Safety	3	10
Available Financial Incentives	4	9
Research That Documents Crash Reductions	5	8

Please list the top three issues or concerns that would decrease your likelihood of investing in an OSS.

The top five carrier "issues and concerns" for OSS deployment are listed in Table 6 below. Three out of the six indicated cost issues as a barrier to investment, which demonstrates major cost concerns across small- and medium-sized carriers that need to be addressed before investment is an option. The two items tied at fifth were rated the same in frequency and level of importance, thus both were included in the table.

Table 6. Top five carrier issues and concerns for deployment.

Negative Influence	Rank	Frequency
High Purchase Price	1	39
Not User-friendly	2	7
Low Reliability and Accuracy	3	5
High Installation Cost	4	3
Government Regulations	4	3

For each issue or concern listed above, please propose a solution, incentive or program that might resolve the issue, thereby increasing your willingness or ability to invest in OSS technologies.

Proposed solutions, incentives, and/or programs were provided to resolve the negative influences previously indicated in question 5. The results follow for the top five ranked items:

- High purchase price.
  - Systems need to be affordable.
  - Cost assistance could be provided through a rebate program.
  - Reduction of costs for systems.
  - Subsidized sharing of cost (Government/insurance carriers).
  - Cost could be covered.
- Not user friendly.
  - Ensure that setup and use are not complicated.
  - Systems need little or no learning curve.
  - Training should be provided for installation.

– Available training programs for managers and drivers.

- High ongoing maintenance cost—no comments.
- Low reliability and accuracy.
  – Display data and document effectiveness.
  – Allow a test period or trial units for carriers prior to purchase.
  – Additional studies to prove effectiveness.
- High installation cost.
  – Make standard on new vehicles.
- Government regulations.
  – Mandating use of OSSs would discriminate against small carriers.
  – Get the Government out of the mandate business.
  – Need way less Government interference.

How did you first become aware of OSS?

Approximately half (45 percent) of the carriers (see Figure 3) first became aware of OSSs through a form of media (Internet, television, magazines, and pamphlets), followed by truck sales (16 percent), this survey (14 percent), and Government/other sources (8 percent each), with drivers, carriers, and research trailing (3 percent each).

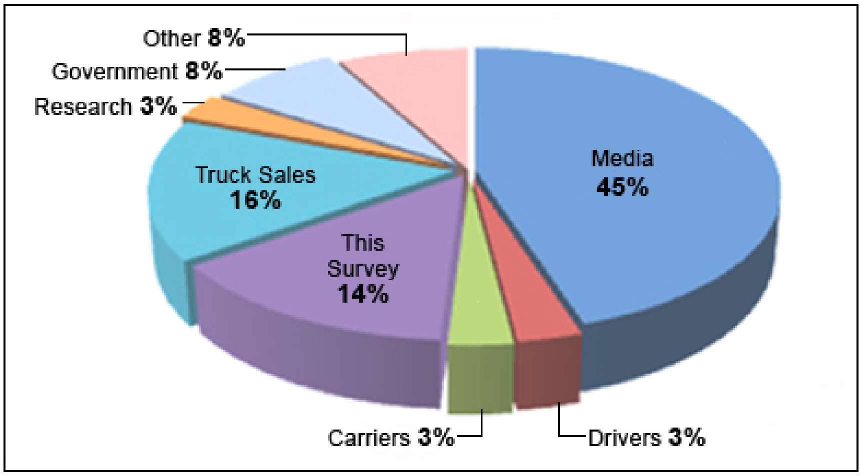

Figure 3. Pie chart. Source of OSS awareness.

How would you rate your familiarity with each of the OSSs listed below? (1 = very unfamiliar, 2 = unfamiliar, 3 = familiar, 4 = very familiar)

As can be seen in Figure 4, approximately 26 percent of the carriers were either familiar or very familiar with LDWSs, compared with 74 percent that were unfamiliar or very unfamiliar. The results are not surprising since most carriers (88.6 percent) have not had any experience with the OSS technologies.

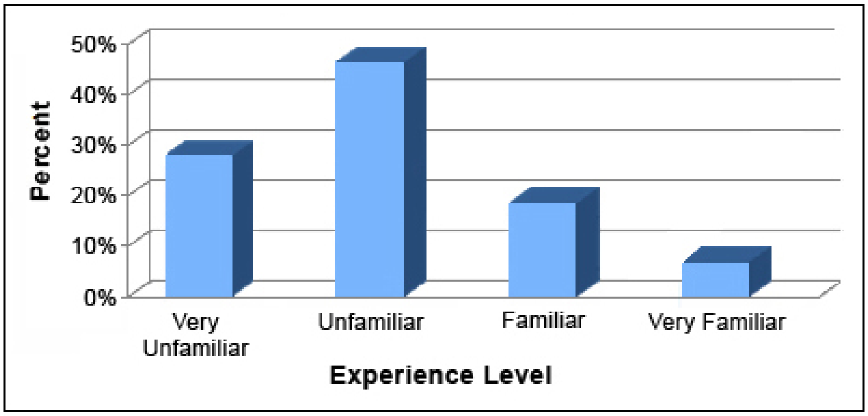

Figure 4. Bar chart. Level of carrier familiarity with LDWS.

Carriers were slightly more aware of CWSs than LDWSs. Almost 36 percent were either familiar or very familiar with LDWSs, compared with 64 percent that were unfamiliar or very unfamiliar (see Figure 5).

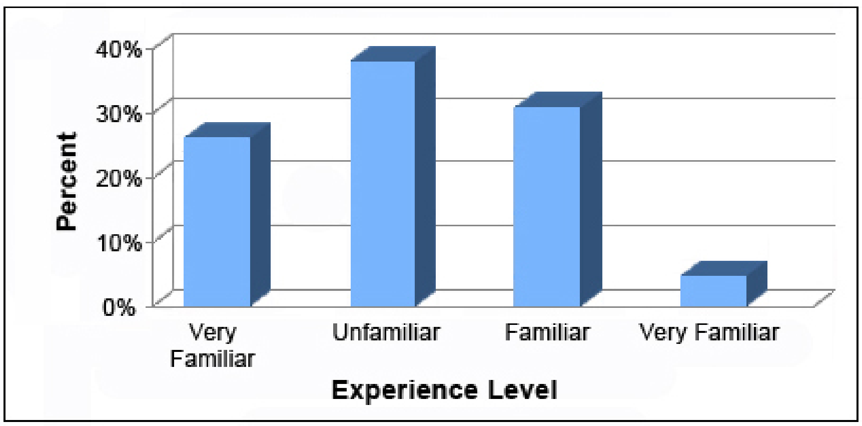

Figure 5. Bar chart. Level of carrier familiarity with CWS.

Carriers appeared to be most familiar with stability systems, where almost 43 percent were at least familiar, with approximately 57 percent at some level of unfamiliarity (see Figure 6).

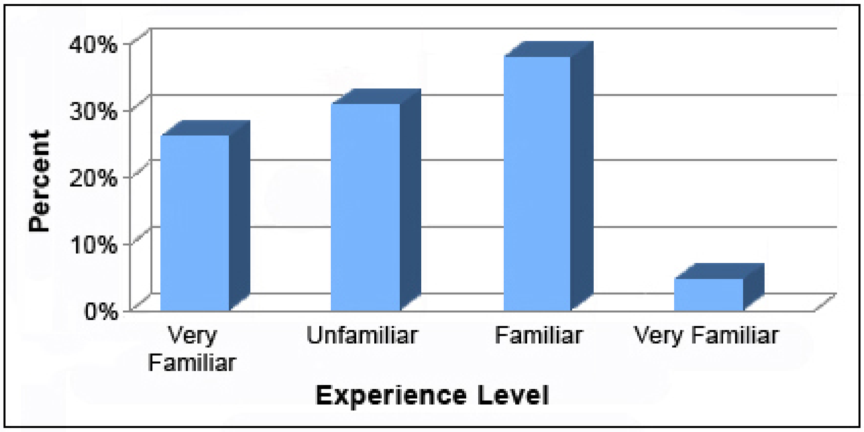

Figure 6. Bar chart. Level of carrier familiarity with SCSs.

3.3.3 Industry Attitudes

3.3.3.1 For each of the following items, rate the degree of importance each factor has on positively influencing your decision to buy or use an OSS technology. Please circle the number that best describes the degree of importance for each factor. (1 = extremely unimportant, 2 = moderately unimportant, 3 = slightly unimportant, 4 = slightly important, 5 = moderately important, 6 = extremely important)

Descriptive statistics were computed for each of the 14 OSS Likert scale factors to determine any characteristics that might identify a need for further analysis. Each item is listed below within a basic statistics table.

All 14 Likert scale factors were skewed toward the positive end of the scale with means ranging from 4.45 to 5.66. Table 7 below displays descriptive statistics for the OSS factors. According to mean values, the top five adoption factors (in order of importance) for carriers to deploy an OSS included: affordable purchase price, decreased insurance costs, reduced crash costs, low cost of installation, and reliable and accurate systems.

Table 7. Carrier descriptive statistics.

OSS Factor	N	Mean	Median
Affordable Purchase Price	44	5.66	6
Decreased Insurance Costs	44	5.61	6
Reduced Crash Costs	44	5.55	6
Low Cost of Installation	44	5.39	6
Reliable and Accurate	44	5.39	6
Low Cost of Ongoing Maintenance	44	5.27	6
Available Financial Incentives	44	5.25	6
Increased Privacy and Protection	44	5.09	6
Research That Documents Crash Reductions	44	5.07	6
Ability to Monitor Driver	44	4.91	5
Minimal Time Needed to Train	44	4.77	5
Ability to Integrate With Other OSS	44	4.55	5
High Driver Acceptance	44	4.50	5
Improved Business and Public Image	44	4.45	5

3.3.4 Carrier Reliability Analysis

Reliability analysis is a common strategy used to demonstrate the stability of a scale based on average correlations of the OSS factors. A split-half test is one common way to determine reliability, but it can be difficult to conduct since it requires two equivalent forms of the OSS survey. This study had one version sent out to all carriers, therefore, Cronbach's Alpha was used for the reliability estimate.

The formula, shown in Figure 7, is intended to identify similarities and differences of responses when compared across all OSS item results. In the following equation, *N* equals the number of OSS factors, c-bar is the average inter-item covariance of the OSS factors, and v-bar equals the average variance.[46]

$$\alpha = \frac{N \cdot c}{\bar{v} + (N-1) \cdot \bar{c}}$$

Figure 7. Equation. Cronbach's Alpha formula.

A total of 44 valid responses were received and used for the analysis, which resulted in a coefficient alpha value of 0.938. A high reliability value of 0.938 indicates a good reliability score, which means that the OSS factors are internally consistent and measuring the same underlying construct.

Often researchers will attempt to increase the reliability through the removal or addition of one or more items. In this case, the removal of any OSS factor would result in a lower reliability score or no change at all. Therefore, since the items were highly similar to one another, each of the 14 items remained in the reported analysis. Table 8 illustrates what the reliability score would be for the removal of any OSS factor. For example, if the measure of "available financial incentives" were eliminated from the assessment, the reliability score would be 0.938.

Table 8. Cronbach's Alpha level for carrier item deletion.

OSS Factor	Alpha if Item Deleted
Available Financial Incentives	0.938
Ability to Integrate With Other OSS	0.938
High Driver Acceptance	0.937
Affordable Purchase Price	0.935
Decreased Insurance Costs	0.935
Low Cost of Installation	0.935
Increased Privacy and Protection	0.935
Improved Business and Public Image	0.935
Minimal Time Needed to Train	0.933
Reliable and Accurate	0.932
Research That Documents Crash Reductions	0.932
Reduced Crash Costs	0.930
Ability to Monitor Driver	0.930
Low Cost of Ongoing Maintenance	0.929

3.3.5 Carrier Findings

The reliability analysis indicated that carriers essentially rated all of the OSS factors the same, with average OSS factor ratings ranging from 4.45 to 5.66. These results indicated that most carriers see all aspects surrounding OSSs as a potential motivator for purchase. However, this also implies that since carriers were predominantly unfamiliar with all of the technologies, they may be unaware of the specific OSS factors that would motivate the purchase of an OSS technology. Therefore, carriers may have ranked OSS factors the same due to their inability to pinpoint one or a few items that would be more motivating for deployment than the others.

3.4 SAFETY TECHNOLOGY: DRIVER SURVEY

Using OSS deployment factors identified by survey development activities and the literature review, ATRI developed a survey to measure driver issues and attitudes towards OSS technologies. The Safety Technology Driver Survey completed the following three research objectives:

- Document driver characteristics and driver awareness of OSSs.
- Identify OSS-related attitudes, issues, and user impediments that might affect usage or investment considerations.
- Identify driver-generated solution sets for raising awareness, comfort levels, and OSS usage among drivers and small carriers.

Driver perspectives are important factors in the use of OSSs since drivers are the *de facto* users and co-beneficiaries of OSSs. Furthermore, it is accepted that driver issues and perspectives differ by characteristics such as age, driving history, safety rating, and OSS experience/exposure.

By design, the respondents represented drivers of smaller carriers, independent contractors, and owner-operators compared to ATRI access to the populations via national and State driver and fleet owner associations. This included the use of OOIDA, which was contracted to assist in reaching components of the sample populations.

Survey distribution methods were selected based on the relevant venues for the participant sample. Since drivers were widely dispersed, multiple venues of survey distribution were employed, including paper versions disseminated at driver conventions, training meetings, and annual truck driving championships. Promotion of the driver surveys was done via printed media, fax broadcasts, and satellite radio programs that are conducted by OOIDA and ATRI. In addition, the Safety Technology Driver Survey was relatively short to increase response rates.

3.4.1 Driver Survey Items

As indicated, understanding driver issues and attitudes is a critical component of OSS utilization. Therefore, driver responses were examined through the development and dissemination of a second survey, which measured each survey participant's position on a variety of OSS deployment factors. Primary factors affecting the decision to utilize or accept OSSs were assessed through three categories of questions: driver characteristics and OSS awareness, driver issues and concerns, and driver-proposed solution sets.

3.4.2 Company/Fleet Characteristics

The driver characteristic questions were designed to collect baseline information on the types of driving conducted and the sector in which each driver operated. The answers were then used to separate carrier-oriented drivers from independent and owner-operator drivers.

3.4.3 Short Answer

The short answer section was comprised of open-ended questions focused on the positive and negative influences of OSSs. This was useful in the understanding of driver specific issues such as the development of training/safety programs and/or incentives. Every effort was taken to standardize open-ended questions and responses.

3.4.4 Driver Attitudes

Driver attitudes were examined through a Likert-type assessment consisting of the same six-point scale as the carrier survey (1 = extremely unimportant, 2 = unimportant, 3 = moderately unimportant, 4 = slightly important, 5 = moderately important, 6 = extremely important). The assessment allowed for each driver to express the impact that various incentives would have on acceptance and use of an OSS technology.

3.4.5 Driver Survey Results

The total survey sample consisted of 469 participants; however, from this group several respondents (33) were removed due to insufficient information. The final survey sample consisted of 436 participants; approximately 27 percent were generated through an OOIDA survey distribution, and the remaining 73 percent were drivers interviewed at trucking industry events such as State truck driving competitions, including those held in Georgia, Minnesota, North Dakota, and Tennessee.

3.4.6 Fleet Characteristics

Descriptive statistics were computed for the three fleet characteristic questions.

Please check the type(s) of driving you perform.

The majority of respondents (70 percent) indicated that they drive for a company (as shown in Table 9), while owner-operators and independent contractors combined were 30 percent.

Table 9. Type of driving performed.

Type of Driving	Frequency	Percent
Company	303	69.7%
O-O/Independent Contractor	132	30.3%
Total	435	100.0%

If a company driver, how many power units are operated by your employer?

Many drivers who participated in the survey were employed by a small set of "very large-sized" carriers, therefore a bar chart (see Figure 8) was created to display the overall responses received relating to employer size, as specified below. The frequency of "very large" carriers was 129, followed by medium at 42, and both large and small tied at 26.

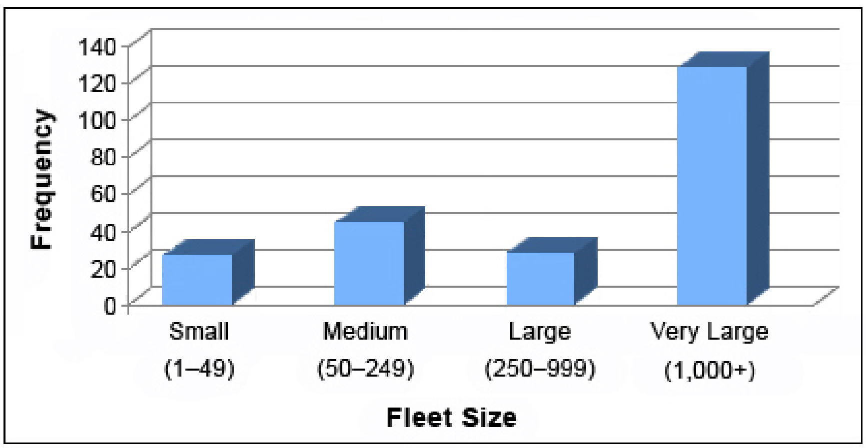

Figure 8. Bar chart. Power units operated by employer.

Who do you primarily drive for? (Check all that apply)

A related question was originally included that asked drivers to identify the type of business for which they drove. The responses had too much variation and overlap to conduct any meaningful analyses and, therefore, were not included.

Please check the technologies you have experience with. (Check all that apply)

Table 10 indicates the frequency of drivers who had experience with each OSS technology. Note that the OSSs are not mutually exclusive, so drivers may have checked more than one type of system.

Table 10. Driver experience with OSS technologies.

OSS Type	Frequency	Percent
LDWS	47	10.28%
CWS	54	11.82%
Roll SCS	27	5.90%
No Experience	329	72.00%
Total	**457**	**100.00%**

3.4.7 Short Answer

Please list the top three factors that would increase your acceptance and use of OSSs.

Drivers were asked to list their top three "motivators" for acceptance and use of OSSs. The top five driver "motivators" for acceptance and use of an OSS technology are listed in Table 11. Researchers tallied up the frequency and separated tied ranks by determining which factors were rated highest most often.

Table 11. Top five driver motivators for acceptance and use of OSS.

Positive Influence	Rank	Frequency
Research Showing Increased Safe Driving	1	145
Overall Affordability (Maintenance/Installation)	2	77
Reliable and Accurate Systems	3	56
Research That Documents Crash Reductions	4	37
User-friendly Units	5	24

Please list the top three issues or concerns that would decrease your acceptance and use of OSS.

The top five driver "issues and concerns" for acceptance and use of an OSS technology are listed in Table 12. As can be seen, three of the five issues are also previously indicated as motivators for system adoption (reliable/accurate, affordable, and user-friendly units.)

Table 12. Top five driver issues and concerns for acceptance and use of OSS.

Negative Influence	Rank	Frequency
Overall Affordability (Maintenance/Installation)	1	125
Low Reliability and Accuracy	2	106
Privacy and Protection of Data Collected	3	78
Driver Distraction	4	76
Not User Friendly	5	37

3.4.8 Driver Attitudes

For each of the following items, rate the degree of likelihood each factor may have on influencing your decision to increase purchase and use of an OSS technology. Please circle the number that best describes your response (1 = very unlikely, 2 = most unlikely, 3 = somewhat unlikely, 4 = somewhat likely, 5 = most likely, 6 = very likely).

Descriptive statistics were computed for each of the 10 OSS Likert scale factors to determine any characteristics that might identify a need for further analysis. Each item is listed below within a basic statistics table.

All 10 Likert scale factors were normally distributed, with means ranging from 3.48 to 4.45. Overall, drivers were slightly more accepting than not of OSSs for each of the 10 statements listed. Table 13 displays descriptive statistics for the OSS factors. According to mean values, the top five OSS factors (in order of importance) for drivers' acceptance and use included user-friendly units, reliable and accurate systems, documented results of decreased crashes, field research showing increased safe driving, and minimized driver distraction.

Table 13. Driver descriptive statistics.

OSS Factor	N	Mean	Median
User-friendly Units	430	4.45	5
Reliable and Accurate Systems	430	4.41	5
Documented Results of Decreased Crashes	431	4.33	5
Field Research Showing Increased Safe Driving	430	4.32	5
Minimized Driver Distraction	430	4.24	5
Increased Privacy and Protection	430	4.18	5
Receive Incentives/Rewards for Use	430	4.13	5
Overall Affordability	427	3.99	4
Minimal Time Needed to Learn	427	3.96	4
High Management Acceptance	432	3.48	4

3.4.9 Driver Reliability Analysis

Reliability analysis was used to demonstrate the stability of the survey. This assessment used the coefficient alpha formula to identify similarities and differences of responses when compared across all OSS item results. Figure 7 in Section 3.3.4 shows the Cronbach's Alpha formula used.

A total of 423 valid responses were received and used for the analysis, which resulted in a coefficient alpha value of 0.94. The high-reliability value indicates that the OSS factor responses were very similar to one another.

Table 14 displays the reliability scores as a result of the removal of any OSS factor. As an example, the removal of the rating "high management acceptance" would result in a miniscule increase of reliability by 0.001 to a value of 0.945. Reliability guidelines generally suggest that any value in excess of 0.95 is unacceptable or too high. Therefore, the high management acceptance item should remain in the reported analysis.

Table 14. Chronbach's Alpha level for driver item deletion.

OSS Factor	Alpha if Item Deleted
High Management Acceptance	0.945
Minimal Time Needed to Learn	0.942
Increased Privacy and Protection	0.940
Receive Incentives/Rewards	0.939
Overall Affordability	0.938
Increased Safe Driving	0.937
Decreased Crashes	0.936
Minimized Driver Distraction	0.936
Reliable and Accurate Systems	0.934
User Friendly	0.934

3.4.10 Driver Findings

The reliability analysis indicated that carriers rated almost all of the OSS factors the same. The average OSS factor ratings ranged from 3.48 to 4.55. These results indicate that most drivers are neutral to somewhat likely to view all aspects surrounding OSSs as potential motivators for purchase. Overall, drivers were more familiar with the systems than the carriers. This is possibly due to the fact that a higher number of drivers were exposed to the OSS technologies.

3.5 DATA MANAGEMENT AND QUALITY ASSURANCE ISSUES

There were several survey responses submitted with missing or partially completed data. Analysis of Likert-type assessments can be affected immensely by data that are missing or partially complete, and several strategies were considered to handle the issue. Three accepted approaches in dealing with missing data include list-wise deletion, item mean substitution, and person mean substitution.

- List-wise deletion involves the elimination of every participant response that contains any missing data. This typically is not the most desired approach since the end result reduces both sample size and power. Use of this approach might be permitted if few participants would need deletion, and doing so did not affect sample size to a considerable degree. There would also be a legitimate use for this approach if a certain number of participants had several missing responses to the degree that inclusion of data would provide inaccurate findings.
- Item mean substitution includes the calculation of a mean from all the responses entered for a particular question. For instance, the mean from all the participant responses on question 12 would be calculated and then placed in the empty cell. If the responses for question 12 happened to contain a low variance, there is logical reasoning for use of this approach.
- Person mean substitution includes the calculation of a mean from all the responses entered for the participant missing a response. For instance, the mean would be calculated from all responses received from participant number five and placed in the empty cell. If

participant number five responded similarly across each question, there is a logical reasoning for use of this approach.

Missing data were examined and handled appropriately according to the characteristics and distribution of data received. Therefore, a combination of person and item mean substitution methods was used to resolve missing data issues.

3.5.1 Panel Survey Comments

A validity assessment was utilized for the driver and carrier survey. The expert panel comprised of industry stakeholders provided comments on the carrier and driver survey analysis. Members were supplied a detailed comment form so that they could review the survey report and provide the researchers with feedback. Comments and suggestions were received, and the survey information was clarified. The specific comments received from expert panel members are included in the following sections.

3.5.1.1 Carrier Survey

- "I would like to see more attention placed on driver training. I believe that OSS can be helpful in the right circumstances, but without good solid training, a driver is still unsafe. I feel that OSSs might allow the driver to let his truck do too much thinking for him."
- "I was not surprised with any of the responses stating that many drivers and carriers were unaware of the OSS products on the market. As a driver of 26 years, I still believe that the best thing is a qualified, safe driver, which negates the use of OSSs. There are many small carriers on the road that make up a large percentage of the industry and I do not see them installing OSS products as quickly as large carriers."
- "Small one to two truck fleets may not experience the same safety benefits with the systems. This is due to the fact that they are so different from larger fleets containing hundreds of trucks."
- "While we research various aspects about why small/medium fleets do not utilize OSSs, we seem to miss a basic response: smaller fleets may not feel that they need the technology. For example, small fleet owners may feel that they do not have issues with the accidents these systems seek to prevent (never had a rollover). Or, they feel that their driving expertise does more to prevent these accidents than a system does."
- "With 89 percent of respondents having no experience with OSSs, it is clear that avocation is critical if the technology is to be accepted on a broader scale. Increased education may help to offset the affordability concerns (real or perceived). It was interesting that insurance costs were more important than initial purchase price."
- "It is obvious that the attributes are all positive motivations and the small sample size does not really allow any to float to the top."
- "The results are quite telling in that 86.6 percent of carriers have no experience with OSS items and carriers are all looking at fast ROI with minimum investment. There is little information in existence, other than statement by manifestation regarding ROI. If such data existed and was made available to the industry, we would see wider acceptance. In

today's market with a tight profit margin, financial incentives that are not complicated to obtain would be a help."

- "I agree that price would be the largest OSS barrier issue. From my knowledge of equipment, SCSs are mostly used on van trailers due to the high center of gravity."

3.5.1.2 Driver Survey

- "All of the motivators focus on top five adoption factors: cost, stability, reliability, durability, and accuracy. Only a select few are willing to take the risk in implementing a safety technology and potentially fail."
- "By selecting drivers from truck driving competition you have a convenience sample group, which is certainly not random."
- "The driver survey is good in that it helps determine the acceptability of the end user (driver) for the OSS device/system and assists employers in spreading the message regarding OSSs. One must be careful however, since negative comments regarding 'big brother' can also have negative effects on the progress of OSSs. As a former driver, I can say that the majority of drivers do not want less control of the vehicle nor do they want a 'tattle tale' system with someone in an office second guessing every decision they make."
- "It is interesting that drivers' overwhelming motivator was safety, while only 32 percent of carriers listed safety as motivator. If increased safety of the carriers was a focus, cost would be less of an issue."
- "Large companies tend to have more participation in the driver championships thereby skewing the sample group."
- "Seventy-three percent of the driver participants were interviewed at State driving competitions. Other than owner/operators, why ask a question regarding the 'purchase' of OSS technologies to drivers?"
- "If the purpose of the overall survey was to concentrate on small and medium fleets, why are drivers from larger fleets included?"

3.5.1.3 Additional Comments

- "My main concerns are the cost and reliability of this equipment. It seems to me that we are trying to substitute good trained drivers for technology. Another fear I have is that drivers will rely on this equipment too much so when there is an equipment failure, it would lead to a major accident. My opinion is that we need more training for drivers than more technology."
- "We see that cost, dependability and effectiveness of the OSS are the most important factors."
- "I am concerned that these two surveys are limited in respondents (small/medium fleet) which can lead to questions about statistical significance of the result. On the driver fleet, it appears that an overabundance of larger fleets' drivers skew results."

- "The surveys seem well thought out. One important fleet characteristic not covered was whether carrier segments mainly purchase new trucks or used trucks. If a major segment purchases used trucks, it might be interesting to determine the effect of an OSS on the price of used trucks."

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4. CASE STUDY FRAMEWORK

A targeted case study framework was developed to identify issues, solution sets, and final recommendations. Both OSS users and non-users comprised the framework, which ranged across small, medium, large, and very large carriers. Each size category of OSS "users" included a case study with a carrier that used SCSs, LDWSs, and/or FCWSs. In addition, real-time OSS deployment steps were documented for carriers that were involved in the deployment process at the time of the study. Table 15 identifies the number of participants within each fleet size and user stage. It is important to note that the case studies also included two carriers that were at the early phases of deploying OSS technologies (emerging users). These carriers were included so that researchers could gauge specific milestones encountered when first investing in OSSs.

Table 15. Industry case study matrix.

Fleet Size	Users	Non-users	Emerging Users
Small Fleet Carriers (1–49 Trucks)	2	1	–
Medium Fleet Carriers (50–249 Trucks)	2	1	–
Larger Fleet Carriers (250–999 Trucks)	2	1	–
Very Large Fleet (1,000+ Trucks)	2	1	–
User Evolution	–	–	2

The objective of conducting multiple case studies was to understand the comparative and contrasting investment factors that carriers of various fleet sizes consider when making OSS deployment decisions. The process that carriers undertake when investing in OSSs may be useful in providing non-users with a general set of adoption processes, issue resolution techniques, and an appropriate investment timeline. Case study outcomes focused on identifying critical issues and solution sets that small carriers encountered when considering whether to invest in OSS deployment.

4.1 CASE STUDY OUTLINE

The following components comprised the general case study outline and guided development of each case study. Specifically, the case study outline followed the five chronological "carrier adoption" steps.

4.1.1 Step 1: Initial Information Gathering

A carrier's information-gathering phase examines the process that carriers initially undertook to obtain the necessary materials before deciding to adopt OSSs and when preparing for OSS deployment. The issues and carrier responses were compiled and included:

- Ultimate objectives that carriers sought out to address (safety, financial, and other).
- Internal personnel involved, in addition to external contacts made.
- Information received as a result of the research and whether or not it was adequate.

4.1.2 Step 2: Internal Review and Evaluation

The second step focused on the internal review and evaluation of materials received during the information-gathering phase. Personnel involved during the information-gathering process, as well as the effectiveness of informational sources, were investigated. The following list is a compilation of the additional topics included in the case study section:

- Formal versus informal evaluation of information received.
- Top determining factors for influencing purchasing decisions.
- Whether internal testing or trials were conducted for the various OSSs.
- Results and/or benefits of testing performed.

4.1.3 Step 3: Budgeting and Approval

This section consisted of questions related to the budgeting issues encountered and the approval process utilized during the investment authorization. The primary purpose was to examine what steps were needed to obtain and secure funds for OSS implementation. Specifically, the need for financing, the personnel involved in the decisionmaking, and the timeline for completing the various phases were taken into account.

4.1.4 Step 4: Management

The management processes consisted of the OSS post-purchase activities that were carried out by the case study companies. This section was an essential component in understanding what new OSS investors could expect to encounter directly after installing the systems. The interview questions covered the following:

- Installation process and whether OEM or aftermarket installations were beneficial.
- Key components of training employed, such as time needed to educate employees on OSS usage.
- If the ultimate objectives prior to installation were met and if there were any specific benefits found.
- Issues encountered post-purchase and how each was addressed.

4.1.5 Step 5: Future Plans

The last set of interview questions was designed to collect information on case study participants' future OSS plans. In particular, expansion goals and the steps needed to accomplish the deployment process were examined, as well as any future changes that would need to be made to accommodate additional technology deployment. Respondents were also provided with an opportunity to voice any closing remarks.

4.2 METHODOLOGY

ATRI conducted a series of logical and chronological activities throughout the case study process. First, ATRI OSS databases were searched for carriers that met the criteria for case study involvement. All proposed carrier prospects met fleet size and OSS technology requirements as indicated in the statement of work. Carriers interested in OSS participation were given priority for the preliminary recommendations. Once approved by FMCSA and ATRI, proposed carriers were recruited for participation in the case studies.

This process included:

- Sending out a joint FMCSA/ATRI case study introduction letter.
- Developing and completing any required confidentiality agreements.
- Conducting an initial teleconference to provide carriers with the study background information and to schedule an interview.

A standardized case study outline was developed to accommodate user and non-user participants. The following case study components were included in each carrier case study interview guide:

- Description of carrier safety issues and objectives.
- Documentation of carrier safety solution sets and related processes.
- Rationale for selecting solution set (OSS or other for non-users) and implementation activities.
- Evaluation of outcome, including measures and monitoring activities.
- Post-test implementation activities.

The Small Carrier and Driver Safety Technology Surveys were utilized in the development of research questions as a means of facilitating the case study process. The first round of case study outline reviews was conducted by subject-matter experts including representatives from OOIDA and the ATA Small Carriers Conference.

After the Interview Guide was finalized, case study participants had two separate teleconferences scheduled. The first teleconference, estimated at 2–2.5 hours in duration, captured the primary components of the Interview Guide. The second teleconference was a review, clarification, and corroboration exercise that was scheduled after FMCSA review of the first case study draft. Interviews were conducted by two or three ATRI researchers, with occasional participation by the FMCSA project manager.

4.3 CASE STUDY FINDINGS

The case study findings have been divided into five main components, based on fleet size and OSS usage categories. These categories include: small, medium, large, very large, and emerging users. OSS non-user findings have also been incorporated into the following sections. The primary goal of conducting the case studies was to juxtapose carrier experiences and issues, and to provide preliminary guidance on the steps and processes that should be anticipated for carriers considering OSS deployment.

4.3.1 Sample Demographics

OSS usage and carrier demographics data were collected prior to conducting the full case study interview with participants. A total of 20 case study participants were included, which consisted of 5 OSS non-users and 15 that had experience with 1 of the 3 units (a SCS, a LDWS, and a FCWS). Emerging users were those in the early process of investing at the time of the interviews. Table 16 displays the distribution of interviewees.

Table 16. Case study participants by fleet size and user status, technology users.

Fleet Size	Users	Non-users	Emerging Users
Small (1–49 Trucks)	2	1	–
Medium (50–249 Trucks)	4	2	–
Large (250–999 Trucks)	3	1	–
Very Large (1,000+ Trucks)	4	1	–
Emerging (Varied)	–	–	2

The systems utilized by the participants are displayed in Table 17. It is important to note that carriers with more than one type of OSS deployed were interviewed for each of the systems to ensure that each specific OSS was represented appropriately.

Table 17. Case study participants by fleet size and system type.

Fleet Size	SCS	LDWS	CWS
Small (1–49 Trucks)	1	–	–
Medium (50–249 Trucks)	2	2	2
Large (250–999 Trucks)	2	–	2
Very Large (1,000+ Trucks)	2	1	1
Emerging (Varied)	1	1*	1*

*One of the emerging interviewees installed an integrated system that included both LDWS and CWS functions.

As can be seen in Figure 9, the case study sample primarily consisted of for-hire carriers (90 percent). Therefore, it is important to note that since the sample is predominately for-hire, the results presented in the assessment may not be wholly representative of the private sector.

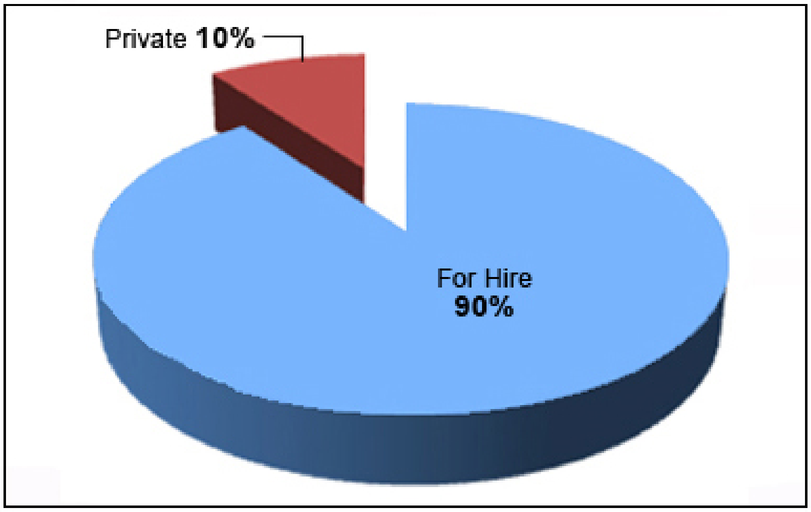

Figure 9. Pie chart. Case study participants by industry sector.

Figure 10 displays the percentage of aftermarket and OEM OSSs installed by fleet size. As can be seen, 67 percent of the small fleets purchased aftermarket systems compared to an OEM option at 33 percent. According to the case study data, small and very large carriers were more likely to invest in an aftermarket product than medium and large fleets. However, these results should be interpreted with caution due to the sample size.

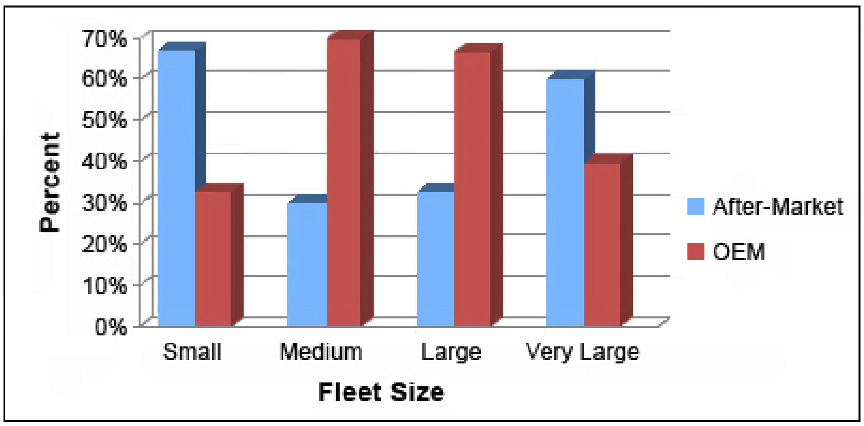

Figure 10. Bar chart. Percent of aftermarket and OEM purchases by fleet size.

4.3.2 Initial Information Gathering

Interviewees were asked what primary safety objectives were most important when considering the use of an OSS product. Carrier responses varied, but no specific patterns were identified across fleet sizes; therefore, all carrier results were combined and displayed. As can be seen in Table 18, more than two-thirds of the safety objectives identified consisted of either accident reduction or improved safety.

Table 18. Primary safety objectives for OSS products.

Safety Objectives	Frequency	Percent
Accident Reduction	15	37.50%
Improved Safety	12	30.00%
Lower Costs	5	12.50%
Improve Driver Behavior	3	7.50%
Fuel Savings	1	2.50%
Reduce Liability	1	2.50%
Promote a Safety Culture	1	2.50%
Insurance Savings	1	2.50%
Higher Resale Value	1	2.50%
Total	**40**	**100.00%**

Carriers were prompted to describe the information-gathering process and the variety of sources used; the most common being vendor salespersons at 50 percent (n=10), followed by company needs (25 percent), advertisements (15 percent) and peer feedback (10 percent). As can be seen in Figure 11, carriers varied on the amount of time that would be needed to gather sufficient product information. The general timeframe range did not vary across fleet sizes, but overall it appears that the majority of carriers would collect information anywhere between 2 and 9 months. One carrier response deviated considerably from the others, suggesting that a timeframe of 4.5 years would be needed for data collection. Therefore, the carrier was considered an outlier and was not included in the figure.

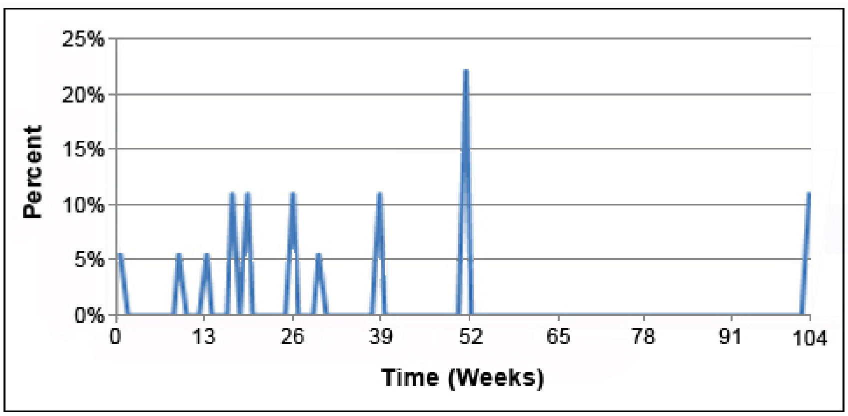

Figure 11. Line graph. Total decisionmaking process.

The information-gathering process for small, medium, and large carriers was primarily initiated by high-level personnel within the company (see Figure 12). Almost all very large carriers indicated that the safety director would have made the first contact with information sources. All carriers indicated that the vendor salesperson was or would be the first external contact made for obtaining OSS product information.

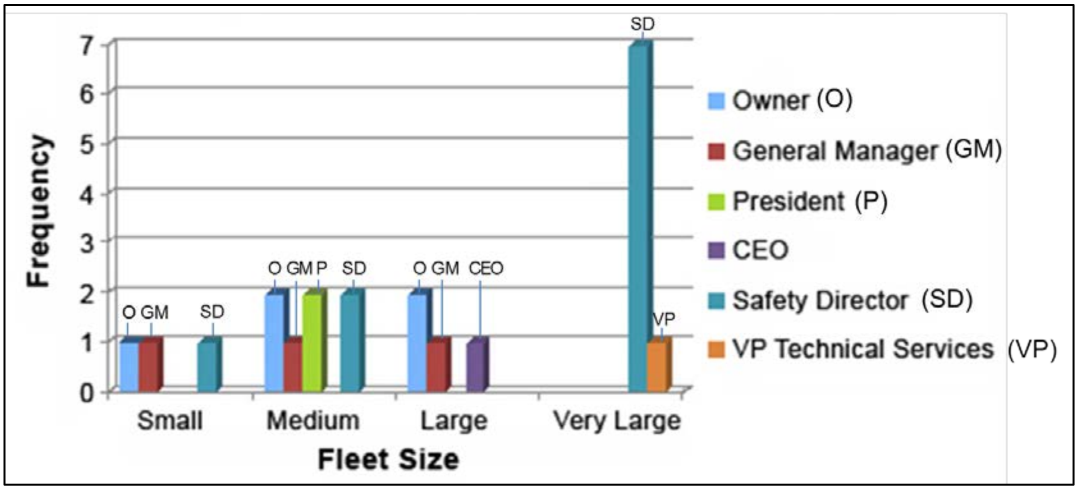

Figure 12. Bar chart. Personnel involved in information-gathering process.

The types of OSS information initially gathered and viewed by carriers as vital for the review and evaluation process are displayed in Table 19. As can be seen, the top five most common types of information collected consisted of product cost, description, and how the system works technically, in addition to capabilities and safety statistics. Although 73 percent (11) carriers believed that the information received was sufficient, 27 percent (4) did not. Carriers that invested in the systems early did not receive adequate information since research related to the systems was limited. Another carrier indicated that there were many technical glitches in the first OSS models that were not fully understood by the manufacturers of the products.

Table 19. Types of information gathered and received.

Information Gathered	Frequency	Percent
Cost	9	20.00%
Product Description	8	17.78%
How it Works Technically	8	17.78%
Capabilities	5	11.11%
Safety Statistics	5	11.11%
ROI	2	4.44%
Ease of Implementation	2	4.44%
Customer/Driver Satisfaction	1	2.22%
Driver Friendliness	1	2.22%
Efficacy	1	2.22%
Peer Feedback	1	2.22%
Reliability	1	2.22%
Systems Available	1	2.22%
Total	**45**	**100.00%**

Note: Does not add up to 100% due to rounding

4.3.3 Internal Review and Evaluation

As seen in Figure 13, the majority of carriers utilized informal procedures to review and evaluate materials gathered during the information-gathering step. Specific informal and formal procedures of assessing the information gathered varied across carriers and have been summarized below.

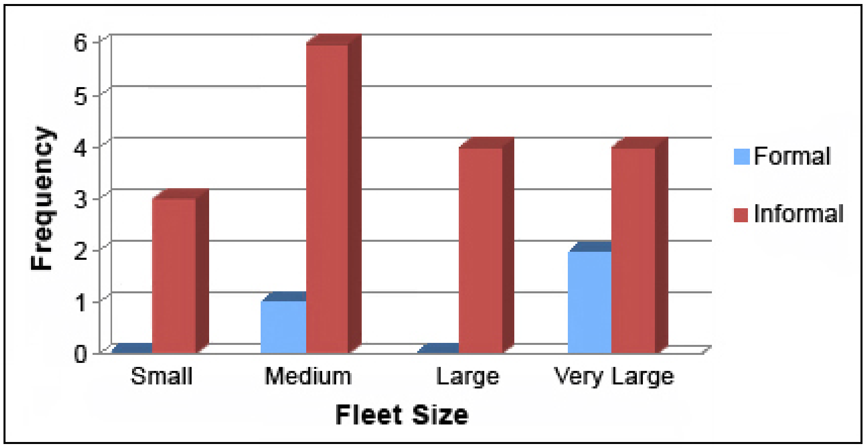

Figure 13. Bar chart. Internal evaluation procedures.

4.3.3.1 Informal

The following direct quotes from carriers detail the specific informal methods used by each company to gather information about OSSs:

- "An assortment of information would be gathered and organized for the company to evaluate. Specifically, the safety director and owner would conduct additional research on the products available and then make comparisons across the features and cost."
- "After receiving an opportunity to view demonstrations of the product and test-drive vehicles with the systems installed, past data was viewed to determine whether any accidents could be prevented. Therefore, the deciding factor was related to the benefits received above and beyond the system costs."
- "Information was discussed verbally and a decision to purchase was made based off of those conversations."
- "Cost data, warranty information, and installation procedures were presented to the corporate executive officer and then approved for deployment."
- "A decision was made on the basis of how many lives could be saved from accident reduction."
- "Information gathered was compared to other carrier findings and previous internal accident records to determine cost savings related to the product."
- "The owner made the decision to purchase a system immediately after seeing a demonstration from the vendor."
- "Data was examined and then companies were contacted that were using the systems for peer feedback."

4.3.3.2 Formal

The following direct quotes from carriers detail the specific formal methods used by each company to gather information about OSSs:

- "Our formal procedure involved internal testing through a 90-day test cycle and participation from department managers. To determine ROI information, data was downloaded weekly, conversations were held with drivers about the user interface, and an evaluation was conducted on accident rates before and after the technology was installed."
- "Compliance issues, product testing, driver satisfaction, and level of repairs needed would be evaluated."
- "Systems were tested to determine what benefits could be received first-hand."

OSS case study user participants were provided a pre-populated list of sources that were potentially used to gather initial information related to OSSs. The effectiveness of each source was rated on a scale of 1–6 with 1 being very ineffective and 6 very effective.

Table 20 displays the findings from interviewees who have used OSS technologies. The most effective source identified by the interviewees was product vendors, at an average rating of 5.12 (moderately effective), whereas the Government was identified as the least effective source, at an average rating of 2.67 (somewhat ineffective).

Table 20. Effectiveness of resources utilized by users.

Source	Rank	Level of Effectiveness
Vendors	1	5.12
Carrier/Peer Feedback	2	4.67
Online Web Sites	3	4.09
News/Media	4	4.07
Government	5	2.67

Interviewees who had not used OSS technologies had a slightly different view on which sources would be most useful for receiving preliminary information (as shown in Table 21). Carrier/peer feedback was rated the most effective source at a rating of 5.4 (moderately effective), whereas respondents expected the news/media to be the least effective source at an average rating of 3.0 (somewhat ineffective). The primary difference between the OSS user and non-user groups was the Government ratings. It seems that non-users anticipate Government sources (e.g., publications, research, and/or personnel) to be moderately effective for providing sufficient OSS information, while users of the systems found those sources to be somewhat ineffective after going through the process. Although these perception differences could be spurious and entirely due to the independent samples, they may be an important consideration in determining which information would be most useful for non-user deployment decisions.

Table 21. Perceived effectiveness of resources by non-users.

Source	Rank	Level of Effectiveness
Carrier/Peer Feedback	1	5.40
Vendors	2	5.00
Government	3	4.75
Online Web Sites	4	4.33
News/Media	5	3.00

The top five motivators for OSS purchase across all case study participants are displayed in Table 22. Frequency results indicate that accident reduction is a primary motivator for investment across carriers of all fleet sizes. Overall, cost was the next largest motivator, while data on OSS benefits, OSS capabilities, and improved safety were relatively equal in occurrence.

Table 22. Top five carrier motivators for purchase.

Factors Determining OSS Purchase	Rank	Frequency
Accident Reduction	1	44
Cost	2	25
Data on OSS Benefits	3	18
OSS Capabilities	4	15
Improved Safety	5	14

Table 23 displays the critical factors used to determine OSS purchase by fleet size. As can be seen, cost and accident reduction are among the top three motivators for OSS purchase across all four fleet sizes.

Table 23. Top carrier motivators for purchase by fleet size.

Fleet Size	Rank	Frequency
Small Fleet Cost	1	3
Small Fleet OSS Capabilities	2	2
Small Fleet Accident Reduction	3	1
Small Fleet Improved Safety	3	1
Small Fleet Insurance Savings	3	1
Small Maintenance	3	1
Medium Fleet Accident Reduction	1	6
Medium Fleet Cost	2	4
Medium Fleet OSS Capabilities	3	3
Medium Fleet Improved Safety	3	3
Large Fleet Accident Reduction	1	5
Large Fleet Cost	2	4
Large Fleet Data on OSS Benefits	3	2
Large Fleet Fuel Economy	3	2
Very Large Fleet Accident Reduction	1	6
Very Large Fleet Data on OSS Benefits	2	4
Very Large Fleet Cost	3	3

Carriers were asked how safety-related, cost-related, and other financial-related data were obtained and evaluated. The following bulleted quotes reflect the interviewed carrier responses. Although respondents utilized various forms of information, the most commonly cited included: vendor-provided data (system efficacy and maintenance information), industry publications, internal testing outcomes, and peer feedback.

4.3.3.3 Safety

- "We would examine the number of accidents a particular system would reduce."
- "The incident rate would be benchmarked to evaluate the current situation in terms of frequency and severity of accidents."
- "We would evaluate how the system would reduce crashes."
- "Information distributed by the vendor would be used."
- "Industry resources such as vendor publications and peer feedback would be used to determine the safety-related results."
- "Looked at the vendor analysis that documented the number of accidents a system would reduce."
- "Safety data would be gathered and used as a baseline for technology discussions and to validate our internal testing."
- "Information evaluated would be compliance driven (e.g., based on what it will do for us compared to other products)."
- "An experience-based approach was used, where pilot tests were conducted to evaluate the data."
- "Information would likely be collected using ATA and ATRI resources, vendor publications, and peer feedback from other companies."

4.3.3.4 Cost

- "Cost data would be assessed in a cost-benefit analysis where value and effectiveness would be the focus."
- "Price comparisons were conducted with other manufacturers."
- "A before-and-after analysis was conducted that analyzed the cost of a truck with and without the technology."
- "The cost of incidences and how much can be saved would be assessed."
- "We determined that prevention of one crash could pay for all of the units."
- "The probability of a crash occurring and the cost of a crash were compared to how much the technology could save us."
- "Purchase price and overall cost were used to determine whether installation was justified."

- "Other truck companies were used to evaluate the cost per million miles traveled and how adding the system would reduce overall costs."
- "Vendor data and a cost-benefit analysis would be performed."
- "Cost trends were plotted. Initially there was a cost, but now it comes as part of the system."
- "Evaluated what the ROI would be if products were purchased and examined the cost of human and public relations of not doing anything."
- "We examined the lifespan value of the product."

4.3.3.5 Other Financial

- "Financial data would be collected by discussing any rebate offers from the insurance provider."
- "Other financial information included the assessment of cost reduction in terms of insurance savings."
- "The data would include working with insurance providers to determine how a technology purchase could influence rates."
- "Received input from insurance company to determine the effect on our premiums."
- "We would work with our insurance provider to get information on how purchasing the technology would influence our rates."
- "We would examine the longevity of the manufacturer we intended on buying a product from for potential partnerships."

Carriers were asked whether any internal testing or trials were conducted as part of the review and evaluation process. As noted in Figure 14, all very large users conducted some form of internal testing. The fleet responses in other size categories, however, tended to have a combination of carriers that conducted internal testing versus those that did not.

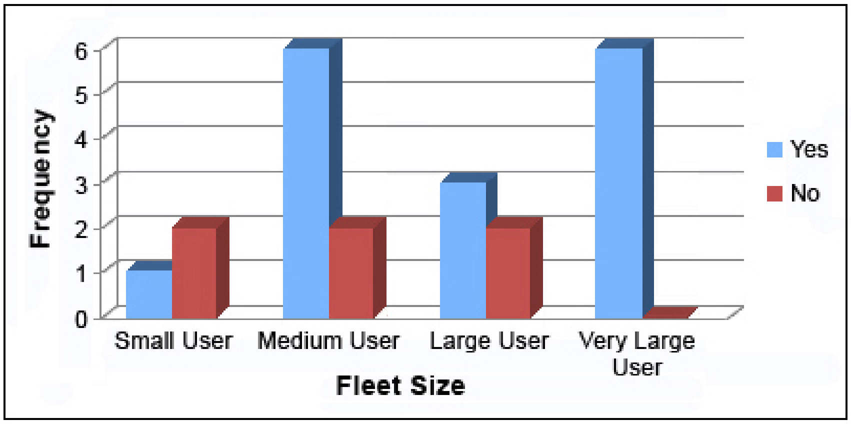

Figure 14. Bar chart. Internal testing by fleet size.

Interestingly, all non-user carriers indicated that internal testing or trials would be conducted prior to determining whether a system would be purchased (see Figure 15).

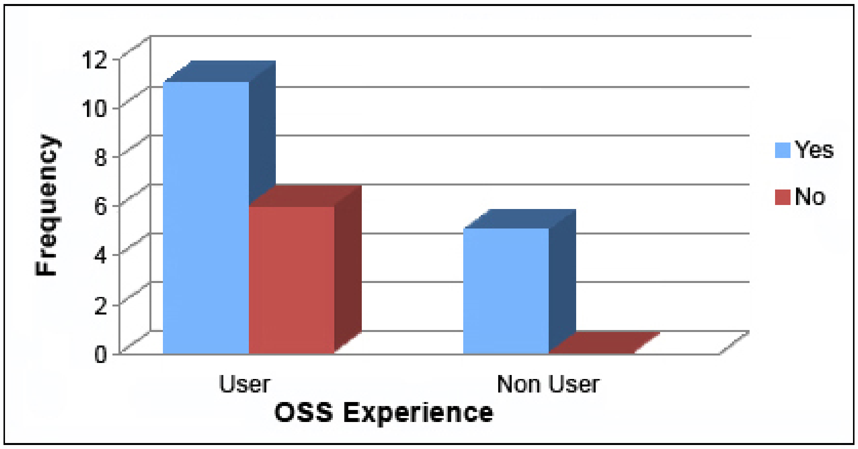

Figure 15. Bar chart. User and non-user internal testing.

Of the carriers that did (or would) conduct an internal assessment, the testing included the following components:

- "Collected driver feedback on the usefulness/acceptability of the systems."
- "Installed a few systems on our trucks and tested to see if we could determine the product benefits and how they affect the environment for drivers."
- "The drivers evaluated the systems and reported feedback to the safety director."
- "Gave the product to senior drivers and requested their feedback."
- "The testing would include installing the technology on three to six test trucks and then operating them for a period of time. Then we would check to ensure that they have a similar performance to what the vendor claims."
- "The vendors brought out a truck equipped with the ESC system to test out and activate the units. Drivers and decisionmakers were present for the demonstrations and were provided with an opportunity to activate and test the systems."
- "Tested four units. Received driver feedback and it was 75 percent positive."
- "We took several units and selected drivers and trucks to test them. Then we received feedback from the drivers on how the system worked and if they liked it."
- "Completed testing over a period of 1.5 years and included managers, drivers, maintenance and technical service personnel."
- "We chose a predetermined number of trucks and evaluated them weekly for functionality, user interface, frequency, and monetary loss of accidents."
- "We tested the systems ourselves to see the effects first-hand with test trucks."

Testing scenarios varied in complexity across the carriers. Therefore, it was not surprising that the findings displayed a mix of both positive and negative testing results as shown in Table 24.

Table 24. Positive and negative testing results.

Positive	Negative
• "Found systems to be relatively low cost." • "Improved driving due to increased awareness of following distance." • "Enhanced driving ability." • "Impressed with the way it worked." • "Reduction in those types of accidents." • "Were able to experience activation of the systems, which allowed testers to see firsthand that the systems operated as advertised." • "Worked well, positive feedback from drivers and no accidents occurred during testing." • "We had a high comfort level that we were investing in technologies to help the drivers and allowed us to have interventions with drivers." • "Rollovers had almost been eliminated."	• "Did not see any benefits during testing and drivers thought the systems should have been more sensitive." • "Thought it helped but could have been better." • "At the time, the testing seemed to be sufficient, but we later realized that we didn't get all of the effect of the OSS in testing. We learned we can't just put them on the trucks and that we should have invested more time." • "Have not seen the system engaged enough and they are too costly." • "Have not increased the number of systems installed on the trucks due to the high cost associated with the units." • "Have not seen any benefits yet." • "Vendor data does not consistently map to internal test results."

4.3.4 Budgeting and Approval

Most medium to very large carriers identified or authorized funding after the review and evaluation results were analyzed. However, small carriers appeared to be more likely to either have funding readily available, or make a preliminary funding decision shortly after the information-gathering phase. These findings may suggest that smaller carriers have limited funding available for the testing and evaluation of the OSS but have the ability/liquidity to quickly invest when the decision is made to do so. Medium- to very large-sized fleets appear to identify funding, commence funding approval processes, and confirm investment decisions after internal testing has been completed. It is important to note that at the start of the OSS adoption process, none of the carriers had a formal process in place to allocate funds for OSS investment and deployment (see Figure 16).

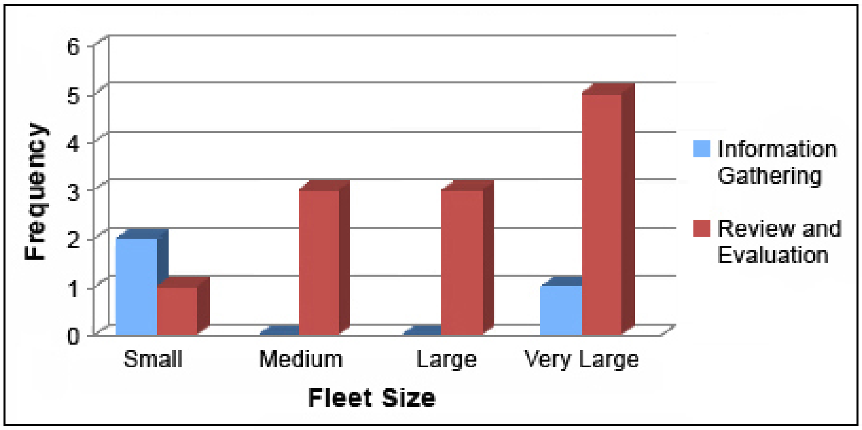

Figure 16. Bar chart. Funding identified for purchase and deployment.

The majority of medium to very large fleets did not have funding identified in the overall budget prior to the information-gathering process. Small carriers were hypothesized to follow a similar trend, but did not. Two out of the three small carriers did have funding available prior to this investment stage. This is likely due to the small number of carriers involved in the case studies and would not necessarily be representative of the true population (see Figure 17).

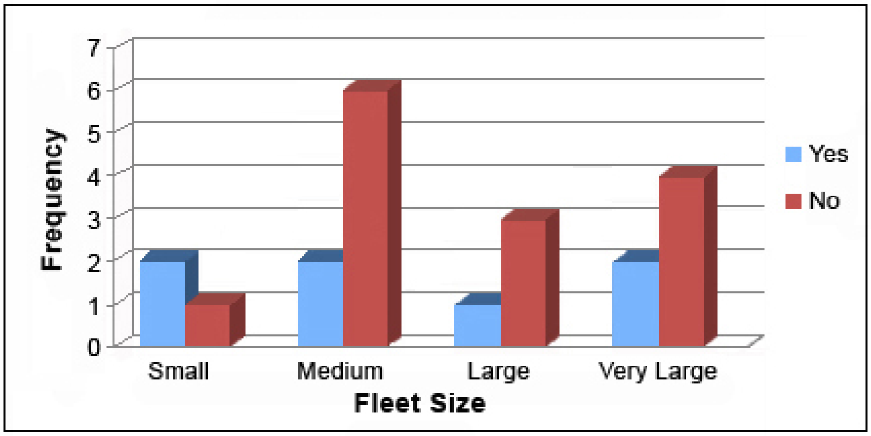

Figure 17. Bar chart. Funding available prior to investment.

There did not seem to be any trends or predictors for carriers that would use financing; therefore, carriers of all sizes would equally consider or utilize financing options for an OSS purchase. Participants indicated that the systems would be financed individually or as part of a new truck purchase (see Figure 18).

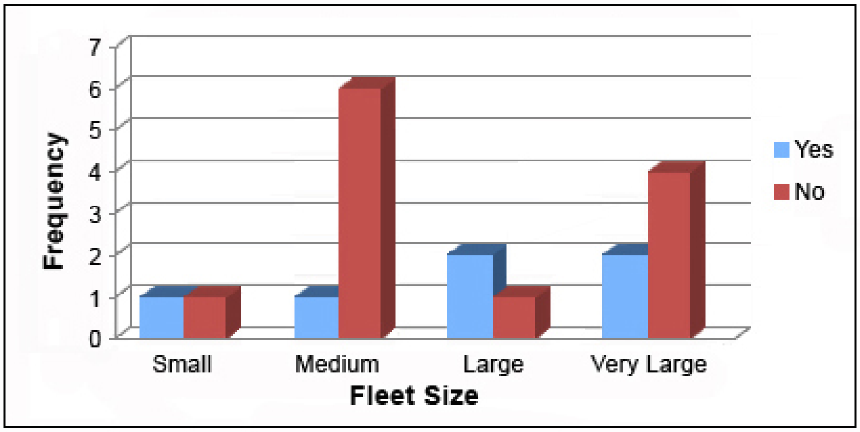

Figure 18. Bar chart. Use of financing for a purchase.

4.3.5 Management

Carriers were asked to describe any benefits associated with OEM and/or aftermarket installations. OEM systems were preferred over aftermarket by all carriers. However, one carrier suggested that aftermarket products may be beneficial if the systems were new and unavailable as an option on a truck purchase.

- Small carriers preferred OEM installations over aftermarket due to the small size of their companies and limited resources. One interviewee said that aftermarket products would not be purchased since OEM companies possess the software and knowledge to install particular systems.
- However, all medium carriers viewed OEM installations as more advantageous than aftermarket due to the vendor benefits of scale, knowledge, and previous experience.
- OEM systems were preferred by large carriers since it did not take time away from the maintenance department and because OEM systems tend to be more uniform than aftermarket products. Also, OEM systems were expected to be less costly, and benefits would include the immediacy of vehicle delivery with equipment installed. However, aftermarket units could have benefits if a product is new. For instance, innovative technologies may need some time to become available as an option on truck orders.
- Though three of the four very large users used their own maintenance staff to install the technology aftermarket, all preferred to have OEM installations. This is due to several factors, including proper electrical connections, cost effectiveness, and fewer maintenance issues.

Training requirements for OSS varied substantially among carriers within the same fleet size. This may imply that the OSS utilization does not require extensive training or that carriers are unfamiliar with the level of training needed for the systems. The following sections summarize the information received from participants.

4.3.5.1 Small

- Training provided to drivers was minimal and consisted of driver acknowledgement that the systems were installed and a brief description of system functionality. The total time needed to train drivers was only a few minutes, and maintenance staff was not provided with any system training.
- Following the installation, the safety director would become familiar with the product so that drivers could be properly informed on how to utilize the technologies. Other training requirements may depend on the system's user friendliness and whether the manufacturer provides any instructional sessions.
- Drivers attended meetings describing the products and watched a video prior to use. This carrier did not have any maintenance staff to train, and the total training time was approximately 1 hour.

4.3.5.2 Medium

- Driver and maintenance staff training was very minimal (1–2 hours maximum) and required only introducing the employees to the product and explaining the product functions.
- Training would consist of information on product functions and would likely take 1 hour.
- Classroom time (1 hour) and ongoing education would be used.
- Driver and maintenance staff training was noted as an important facet of system awareness.

4.3.5.3 Large

- Training for the systems, which was provided to maintenance personnel and drivers, included product information for one carrier and a video presentation for another. Training time took anywhere from less than 30 minutes up to an hour for everyone involved.
- OSS training would focus on driver and maintenance personnel. Drivers would receive information on how the system interfaces with the vehicle, what it is designed to do, and how truck operation influences performance. Maintenance training would be designed to address system preservation. Desired training time depends on the complexity of the technology, and vendors' and manufacturers' recommendations would be incorporated into the program.

4.3.5.4 Very Large

- For each carrier, driver training was no more than 1 hour and involved videos and online activities. Maintenance staff training was more in depth and included several hours of reading product materials and learning to repair system issues.

The biggest issues encountered after the purchase of an OSS were primarily related to driver acceptance. Driver resistance typically surfaced when the systems were first installed but became less pronounced upon implementation of approaches to mitigate driver resistance. Strategies to address the driver acceptance issues were similar regardless of fleet size. Carriers noted that it would be important to develop strong and open communication channels with drivers (and driver families) in order to ensure driver acceptance of the product's safety benefits. For non-driver personnel, other key messages included awareness of maintenance issues. One owner formally explained in a driver meeting how the system worked and why the company wanted to install the systems (safety benefits), while emphasizing that the product would continue to remain in use. Another carrier resolved issues through training, where drivers were approached on a one-on-one basis and provided with an explanation of all technology and operational aspects.

The second most important issue was related to electronic failure in trucks due to the OSS technologies, which was resolved through vendor cooperation. In most cases, however, carriers indicated that typical systems do not need maintenance other than regular system checks and occasional issues that surfaced directly after installation.

4.3.6 Future Plans

All carriers that have been using OSS products intend to expand investment. The systems would be integrated into the fleet as trucks are replaced with new trucks (equipped with OSSs). However, non-users tended to have mixed opinions regarding whether or not to invest. Reasons for not expanding the use of the three systems (LDWS, CWS, and SCS) included insufficient need due to low incident rates, high costs associated with use, poor economic conditions, and the potential to purchase a more efficient integrated system. That said, it should be noted that the recession of 2008–09 generated some pushback in carrier investment or investment schedules.

The most frequently desired methods to increase OSS adoption included financial incentives. These incentives consisted of tax credits/breaks, insurance reductions, ROI, vendor discounts, Government aid, and general cost savings (see Table 25). During closing comments, one carrier suggested that companies need to re-examine OSS products annually due to price decreases as more fleets invest in such systems. Another carrier recommended clearing up driver issues beforehand.

Table 25. Deployment incentives by fleet size.

Incentive	Small	Medium	Large	Very Large
Tax Credit/Break	–	1	3	5
Reduced Insurance	2	2	1	–
ROI	–	–	–	1
Vendor Discount/Rebate	–	–	1	–
Government Aid	–	1	1	1
Cost Savings	–	1	2	1
Cost Data	1	–	–	–
Carrier/Peer Feedback	–	–	–	1
Set Industry Standards	–	1	–	2
Mandate	–	1	–	–
Documented Safety Benefits	–	–	–	2
Total	**3**	**7**	**8**	**13**

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5. CASE STUDY VALIDATION

The case study validation task was conducted to verify the findings of the initial case study results. Case studies are critical to delving into underlying issues and opportunities associated with various topics. However, the case study samples typically consist of a relatively small population. Throughout the OSS/ID case study analysis process, it became clear that the small carriers that participated in the first set of interviews had several inconsistent OSS deployment patterns when compared to one another. Therefore, ATRI researchers attended the Mid-American Truck Show (MATS) to further clarify and expand on typical small carrier deployment activities.

The MATS was a significant key venue for interviewing various sized trucking companies—especially small carriers—because it is one of the largest U.S. truck shows. In 2009, more than 70,000 trucking company employees and stakeholders were in attendance. Using several exhibit hall booths, ATRI was able to interview 112 attendees.

5.1 METHODOLOGY

Prior to participating in the MATS, a respondent survey was developed, reviewed, and approved. Specific questions were used from the original case study interview guide so that case study findings could be corroborated. Additional questions were also created to expand upon results received.

The MATS survey was specifically designed for the interviewer to verbally administer, which ensured that adequate and complete participant information was received for each question. For example, if an interviewee did not understand the question posed, the researcher explained it in more detail and probed for the information needed. In addition, data entry issues were minimized since researchers did not have to interpret various types of handwriting for the open-ended questions. The survey guide also included directions prior to each question detailing which trucking personnel (employee drivers, owner-operators, and non-driver employees) were to respond, as well as the next question to pose.

Prior to the event, all participating staff members were instructed on proper interviewing techniques and the need to follow the instructions on the interview guide. While in attendance, the staff divided into separate booth areas within the exhibition hall in order to maximize participation from trucking representatives. The exhibition facility contained more than 1 million square feet of exhibit space. Therefore, during peak show hours, separating the researchers into different exhibition wings was a more effective strategy for reaching a broad audience.

For each interview, a potential participant was approached and provided with a brief introduction to ATRI and the FMCSA-sponsored OSS study. In addition, information related to the purpose of the interview and the time commitment was provided. The individual was then asked if he or she would like to participate. If the person agreed, the interview proceeded. During the interview, the questions were read aloud and the individual’s responses were recorded by the researcher. At the conclusion of the interview, each participant was handed the appropriate contact information and a brief study brochure.

5.2 INTERVIEW RESULTS AND COMPARATIVE ASSESSMENT

After completing interviews at the MATS, the collected data were entered into a data management program. Each completed interview was verified for accuracy of entry, and the results were tabulated using statistical analysis software. The resulting descriptive statistics from the 112 responses gathered have been included for each question. The primary focus of this analysis relates to the owner-operator and small carrier group; however, all responses collected have been included in the figures and tables.

5.2.1 Q1. Are you an employee driver, owner-operator, or non-driver employee?

The majority of those interviewed (see Figure 19) were owner-operators (60 percent) followed by employee drivers (35 percent) and non-driver employees (5 percent). Non-driver employees included maintenance personnel and company owners who did not regularly drive the trucks. This was a representative sample of the overall population of MATS attendees.

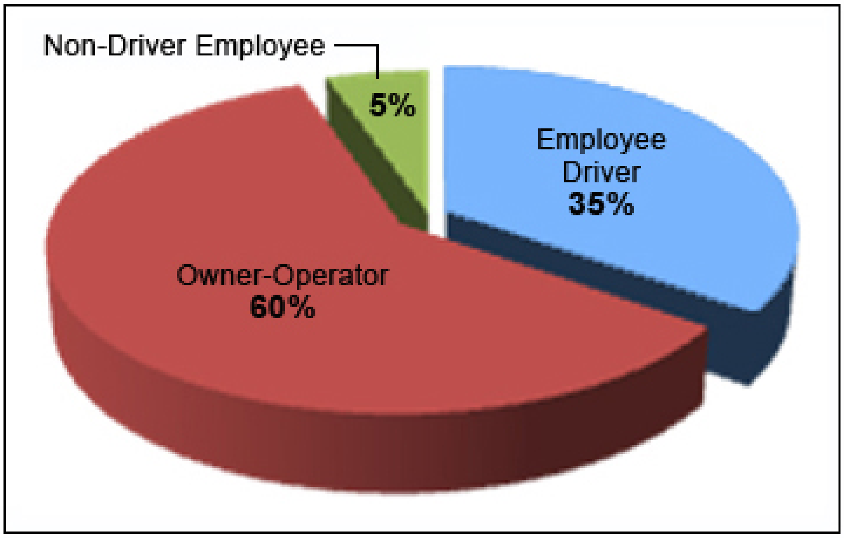


Figure 19. Pie chart. Personnel interviewed.

5.2.2 Q2. How many trucks or power units does your company use?

As can be seen in Figure 20, the majority of interview participants (82 percent) fell into the OSS study sample of interest. Therefore, 18 percent of the data consisted of responses from carriers with 50 power units or more.

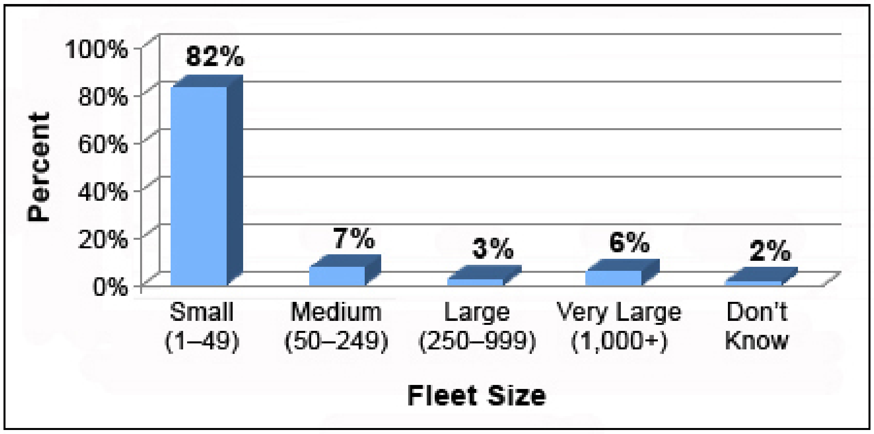


Figure 20. Bar chart. Percent of interviewees by fleet size.

5.2.3 Q3. What sector of the trucking industry do you primarily operate in?

According to ATA's 2007–08 issue of "Trucking Trends," the trucking industry contains three primary segments: private (49 percent); for-hire (28.2 percent); and other (22.8 percent).(47) The MATS sample is predominately for hire at 82 percent with no proportional differences across the various fleet sizes. Although the MATS sample is weighted toward the for-hire sector, "Trucking Trends" indicates that the large majority of small carriers are considered for-hire. In either case, the results provide a starting point toward understanding the small carrier attitudes and needs related to OSS deployment (see Figure 21).

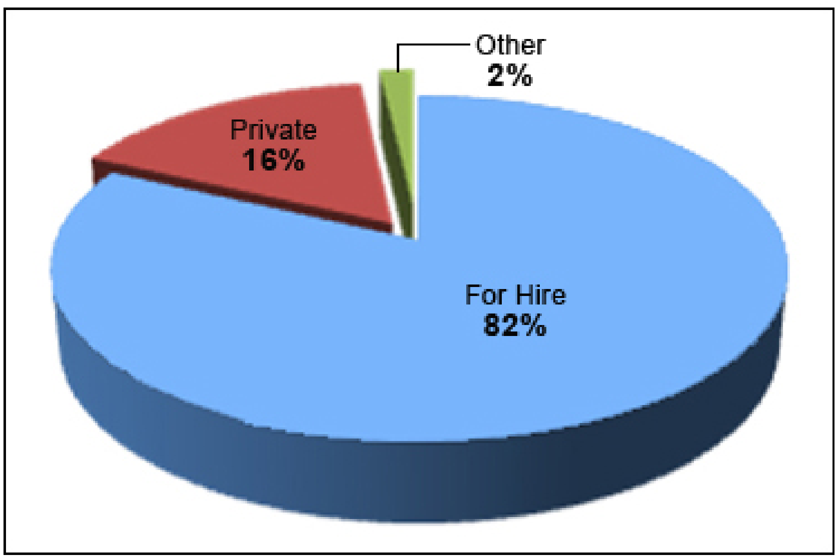


Figure 21. Pie chart. Percent of interviewees by industry sector.

5.2.4 Q4. Have you had any experience with any of the technologies previously mentioned: LDWS, RSS/SCS, and/or CWS?

It is not surprising that only a small percentage (15 percent) of the respondents had experience with the OSS technologies. Since most of the interviewees were small carriers or owner-operators (82 percent), it is apparent that OSS familiarity resides among larger motor carriers (see Figure 22). While the MATS sample was primarily representative of non-users, the feedback received through the MATS data collection effort provided insight into what type of OSS information would be needed and/or useful to those without much knowledge or experience with the systems—a key objective of the research.

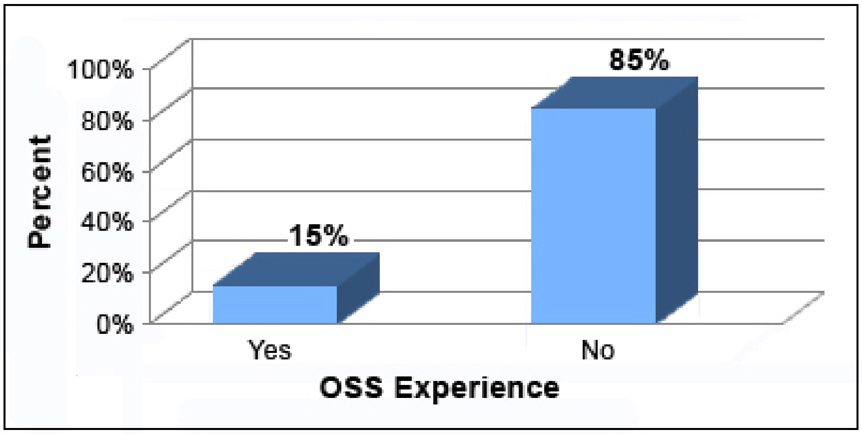


Figure 22. Bar chart. Percent of interviewees with OSS experience.

5.2.5 Q5. Please describe your onboard technology experience, including the type of systems installed, the total number of each system, year installed, and whether it came on a purchased truck (i.e., OEM) or was an aftermarket retrofit.

Interviewees who identified themselves as having had previous experience with OSSs were further probed to identify the system type, year, and method of installation. A total of 17 respondents indicated some experience with OSSs. None of the respondents could be classified as medium-sized carriers. Small carriers used systems that ranged in year (of use) from 1998 to 2008 with a median year of 2003. Large carriers used systems that were installed/used between 2003 and 2009 with a median year of 2006. Finally, very large carriers used systems from 2001 to 2002 with a median year of 2001.

It is clear from Figure 23 that the most widely-used OSS type among all carriers was CWS. The next most widely-used technology was LDWSs (which does not correlate strongly based on OSS units sold).

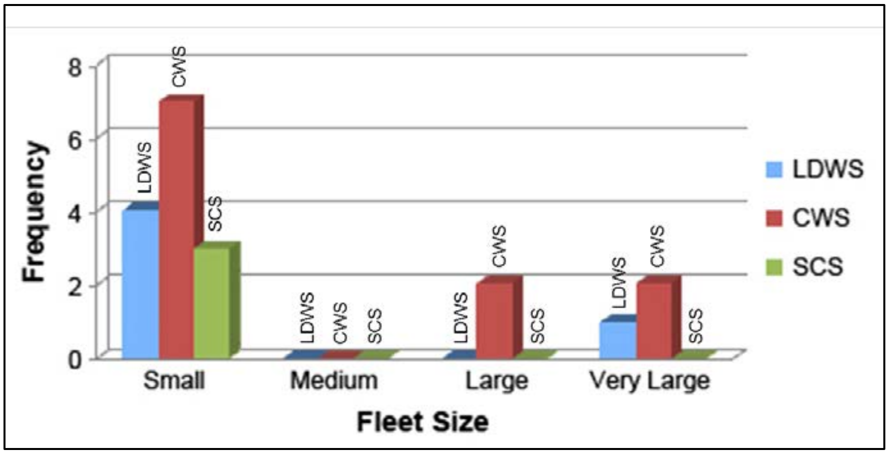


Figure 23. Bar chart. Technology used by fleet size.

As is evident in Figure 24, small carriers appear to be slightly more likely to use aftermarket products than OEM products. Although there was not a substantial sample of medium- to very large-sized carriers, it appears that small carriers are more apt to choose an aftermarket product as opposed to their larger-fleet counterparts.

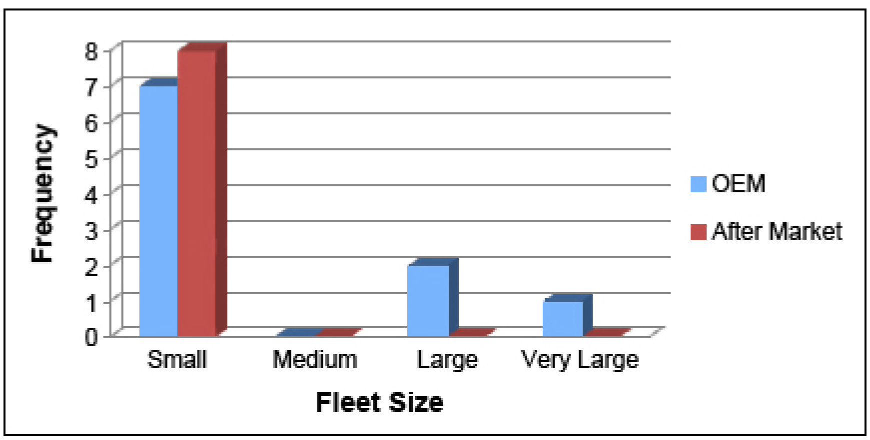


Figure 24. Bar chart. Install type by fleet size.

5.2.6 Q6. On a scale of 1–6 (1 = very negative, 2 = moderately negative, 3 = slightly negative, 4 = slightly positive, 5 = moderately positive, 6 = very positive)—Driver/Owner-operator: What is your attitude/perception toward the use of onboard technologies? Non-driver: What do you feel are the fleet drivers' attitudes/perceptions towards the use of onboard technologies?

As displayed in Figure 25, all three categories of interviewees (employee driver, owner-operator, and non-driver employee) had an average attitude that was more positive than negative. Owner-operators did not have a very strong positive attitude, only somewhat above "slightly positive." However, employee drivers tended to be more positive toward OSSs than owner-operators. This likely derives from a mental cost-benefit assessment whereby owner-operators typically pay for the technologies, and employee drivers do not.

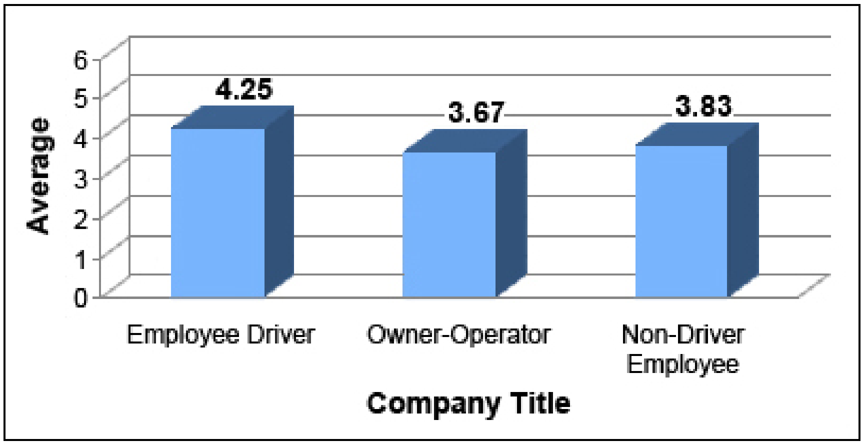


Figure 25. Bar chart. OSS attitude by personnel type, on a scale of 1–6, with 6 being very positive.

Non-driver fleet employees (maintenance staff, owners and other personnel) were asked to estimate the attitudes of their fleet's drivers toward OSS technologies. The estimations were relatively similar to the driver responses. On average, non-driver employees estimated that drivers have a slightly positive attitude toward OSSs at 3.83. The actual average of employee drivers was 4.25. It is interesting that motor carrier employees (e.g., maintenance and supervisor personnel) slightly underestimate truck driver acceptance of OSSs.

5.2.7 Q7. What product information did/would you initially seek out for the technologies?

As can be seen in Table 26, cost was one of the primary concerns for the lack of OSS deployment. This was also identified in the literature review, survey analysis, and case study activities. As a question in both the initial case study and MATS survey, it served to further elucidate the specific cost issues, product attributes, and safety statistics that would be of interest to carriers in the initial information-gathering phase of deployment.

It was hypothesized that cost would be a principal concern, and as expected it was the foremost issue for four out of the five most frequently occurring responses. Cost concerns included purchase price, overall costs, installation costs, and maintenance costs. The fifth most common type of OSS information sought was how the product worked technically. Interviewees wanted to gauge potential company benefits and whether the system could feasibly be implemented.

Table 26. Top information on OSSs sought by motor carriers.

Top Information Types	Frequency	Percent
Purchase Price	31	16.58%
Overall Cost	26	13.90%
Installation Cost	21	11.23%
Maintenance Cost	20	10.70%
How the Product Works Technically	19	10.16%
Product Features	13	6.95%
Product Effectiveness	10	5.35%
Safety Statistics	9	4.81%
Maintenance Requirements	7	3.74%
System Reliability	6	3.21%
User Friendliness	3	1.60%
ROI	3	1.60%
Installation Requirements	3	1.60%
Data Privacy	2	1.07%
Carrier/Peer Feedback	2	1.07%
Vendor Products and Contacts	2	1.07%
Insurance Costs/Savings	1	0.53%
Don’t Know	8	4.28%
Other	1	0.53%
Total	**187**	**100.00%**

Note: Does not add up to 100 percent due to independent rounding.

5.2.8 Q8. What were/would be the top three most valuable motivators, in order, for purchasing an onboard technology? Please describe specific aspects of each factor.

This question aims to address the specific motivators that would influence a carrier’s decision to purchase an OSS technology. Interviewees were asked in an open-ended format so as not to influence any responses. It was expected that various costs would contribute to the likelihood of a purchase; however, safety statistics were the top motivator for those interviewed (see Table 27). Various costs followed as the next top motivators.

Table 27. Top OSS purchasing motivators.

Top Motivators	Frequency	Percent
Safety Statistics	24	15.89%
Purchase Price	22	14.57%
Overall Cost	14	9.27%
Insurance Cost/Savings	12	7.95%
Product Features	11	7.29%
Reliability	10	6.62%
Product Effectiveness	9	5.96%
ROI	8	5.30%
Driver Friendliness	7	4.64%
Maintenance Requirements	7	4.64%
Installation Costs	6	3.97%
Maintenance Costs	5	3.31%
How it Works Technically	4	2.65%
Durability	3	1.99%
Data Privacy	2	1.32%
Peer Feedback	1	0.66%
Liability	1	0.66%
Don't Know	5	3.31%
Total	**151**	**100.00%**

Researchers then asked interviewees why/how each factor would influence a purchase. The detailed responses for the top five motivators follow:

5.2.8.1 Safety Statistics

- Provide assistance to ensure safety on the road.
- Documented accident prevention and lives saved.
- Serve as a backup product for crash liability purposes.

5.2.8.2 Purchase Price

- Needs to be lower than the current purchase price.
- There are many other expenses at this time and the prices are currently too high.
- Purchase price is too high without a guarantee that it will work properly.
- If the cost is higher than the benefit, there is no need for the system.

5.2.8.3 Overall Cost

- Needs to be lower than the current costs.
- Operating margins are so small that every penny needs to be monitored.
- Money still needs to be made and competition remains high.

- Money is hard to come by with the bad economy.

5.2.8.4 Insurance Cost

- Lower insurance premiums to justify cost.
- Price break.
- Immediate reductions instead of waiting for rates to decrease as a result of lowered crashes.

5.2.8.5 Product Features

- Should have the ability to easily turn on/off volume control (e.g., construction zones).
- Having cameras outside of the truck would increase visibility of blind spots while backing up.
- Truck warnings to determine what the object is (e.g., car) and whether the driver can control the situation.
- Notification of unsafe passenger vehicles during passing.

5.2.9 Q9. How long did/would each of the following decisionmaking steps/processes take in terms of weeks/months/years? Please describe.

The resulting sample for this question included only small carriers. Figure 26 shows the total length of time that interviewees expected decisionmaking processes to take from the initial information gathering to review and evaluation of materials to budgeting and financing. The central tendency measures had an average of 33.80 weeks and a median of 9.66 weeks. This indicates that the true decisionmaking time for OSS deployment is likely closer to slightly more than 2 months. The median value of time is more accurate due to the fact that there was one very extreme response (780 weeks) that tended to pull the mean value substantially higher than the true value. As can be seen, the majority of small carriers would likely invest within 6 months of investigating a product.

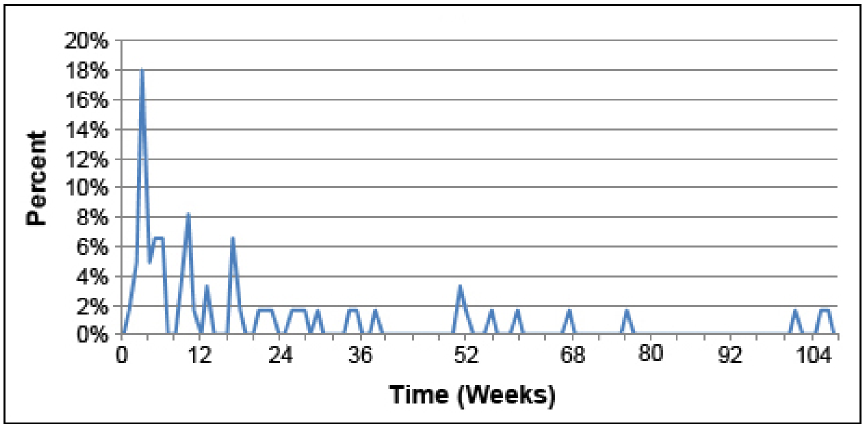


Figure 26. Line graph. Total decisionmaking time required before a motor carrier chooses to invest in an OSS.

5.2.10 Q10. What did/should onboard technology training consist of for drivers and maintenance staff?

Figure 27 displays the driver training methods that respondents thought would be most useful when installing an OSS. For small carriers, the top five included:

- Behind the wheel.
- Electronic media.
- Demonstration.
- One-on-one.
- Printed materials.

These methods also ranked high for interviewees from other sized carriers as well. A surprising number of small carriers stated that no OSS training was necessary for drivers (see Figure 27). This could indicate that these drivers perceived the equipment as driver-friendly or were unaware of the possible training needed.

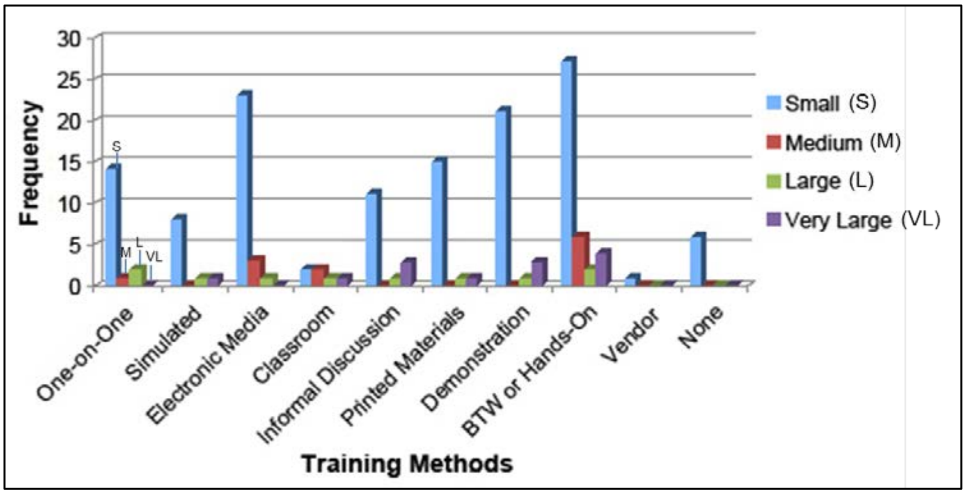


Figure 27. Bar chart. OSS training methods for drivers by fleet size.

Desired training methods for maintenance personnel were similar, but they were ordered differently (see Figure 28). Printed materials were the preferred method of training as most interviewees noted that the maintenance staff would need reference materials to use after training was completed. The next training methods mentioned included hands-on, electronic media, one-on-one, and simulated.

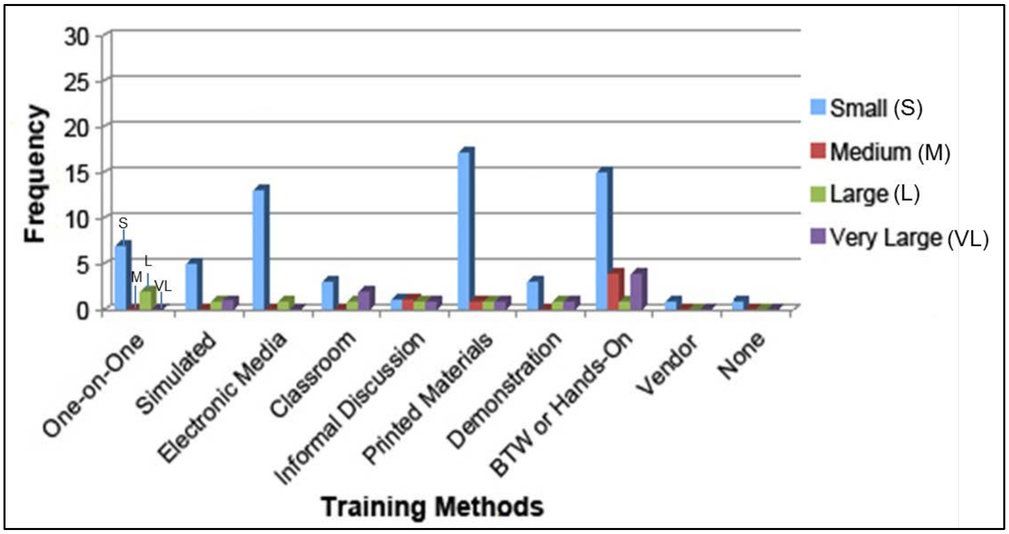


Figure 28. Bar chart. OSS training methods for maintenance by fleet size.

5.2.11 Q11. What was/ought to be the average length of onboard technology training time for drivers? For maintenance staff?

The majority of small carriers indicated that more than 2 hours was an appropriate training time for newly installed OSSs. Those carriers that said training time should be an hour or less for drivers tended to say that little training, if any, should be needed for the systems. With behind-the-wheel and electronic media as the top two training choices, an estimation of more than 2 hours training time needed would seem appropriate (see Figure 29).

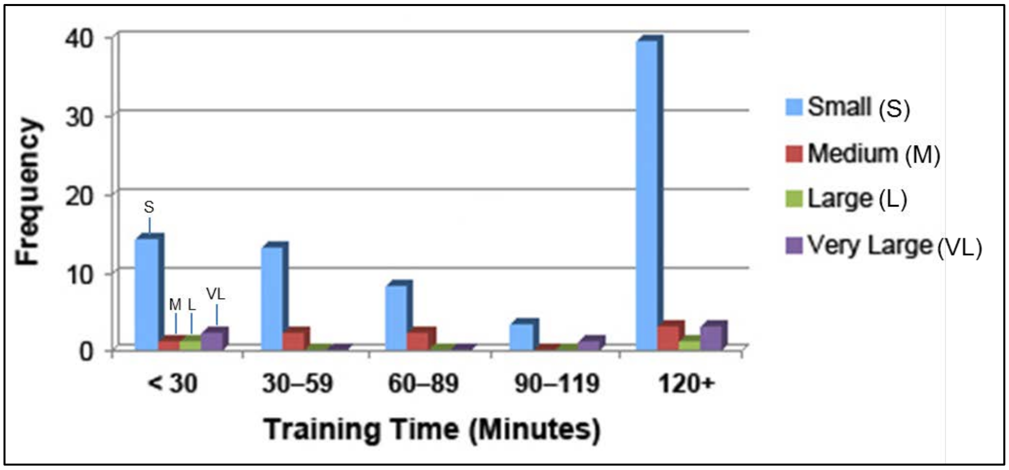


Figure 29. Bar chart. Driver training time for a newly-installed OSS.

Similarly, as can be seen in Figure 30, a larger number of small carriers tended to favor longer training times for maintenance personnel. Interviewees noted the possible complexities of learning how to repair and maintain the systems. Carriers suggesting an hour or less often stated that the systems should not require a substantial time requirement for maintenance.

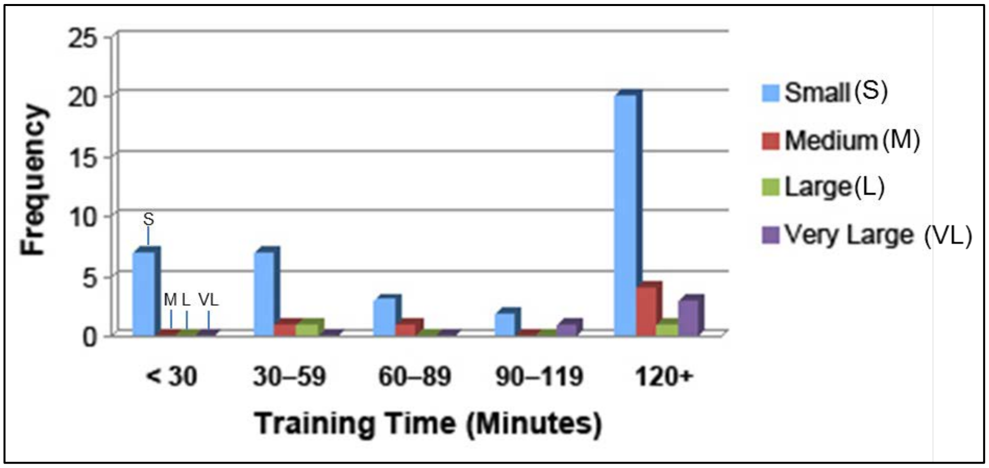
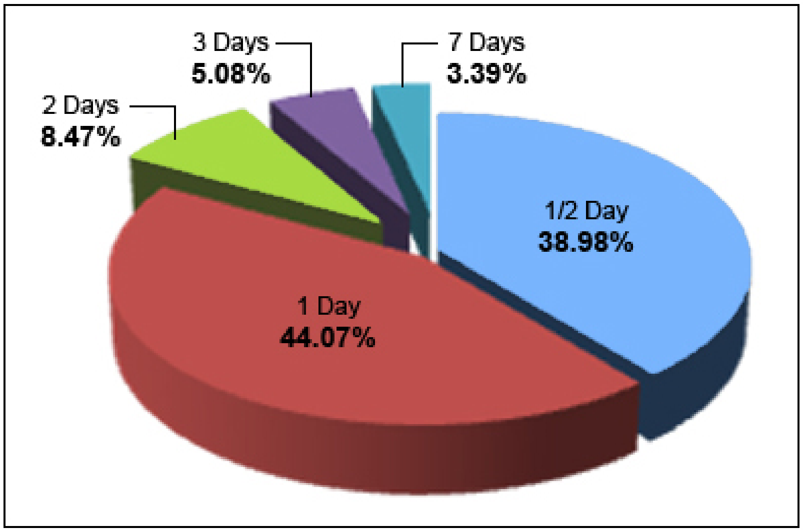


Figure 30. Bar chart. Maintenance training time for a newly installed OSS.

5.2.12 Q12. If an onboard technology needed maintenance, how long could a truck be out-of-service?

Figure 31 indicates that many carriers were strongly opposed to putting vehicles out-of-service for OSS maintenance. Some indicated that the systems probably would not get fixed since the company profitability would be more important than taking the truck off the road to fix an onboard system. Nearly 85 percent of the respondents indicated that 1 day is the maximum allowable amount of time a truck could be out-of-service for OSS repairs.



Note: Does not add up to 100% due to independent rounding.

Figure 31. Pie chart. Acceptable out-of-service time for OSS maintenance.

5.2.13 Q13. Do you have any suggestions for creating or increasing incentives for purchasing OSS technologies?

The most frequently cited incentive for increasing deployment was a tax credit/break for usage of the systems (see Table 28). Warranty factors, peer feedback, reduced insurance, and ROI were also among the top five suggested incentives. Despite the high concern for cost and safety benefits in previous questions, solutions to these factors did not rank very high in total counts. It is possible that carriers expect to see lower system costs and more safety benefits as a minimum requirement for purchasing OSSs and incentives as an additional motivator.

Table 28. Purchasing incentives by fleet size.

Incentive	Small	Medium	Large	Very Large
Tax Credit/Break	24	3	1	1
Good Warranty	21	1	1	1
Carrier/Peer Feedback	21	2	0	0
Reduced Insurance	20	3	0	1
ROI	14	0	1	3
Low Training Fee	13	1	1	0
Vendor Discount/Rebate	9	0	0	2
Lower Retrofit Cost	4	0	0	0
Government Aid	4	0	0	0
No Mandates	2	0	0	0
Financial Assistance	2	0	0	0
Fuel Savings	2	0	0	0
Reduce DOT Safety Levels	2	0	0	0
Manufacturer Accessibility	1	0	0	0
Vendor Demo and Training	1	0	0	0
High System Reliability	1	0	0	0
None	1	0	0	0
Mandate	1	0	0	0
Documented Safety Benefits	1	0	0	1
Total	**144**	**10**	**4**	**9**

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6. COMPREHENSIVE ANALYSIS AND CONCLUSIONS

Throughout this research, carriers identified the five steps of OSS adoption shown in Table 29. The stages were corroborated throughout the various data collection activities described previously. Separate from the adoption stages, central strategies or "themes" for increasing deployment were manifested through the research. These three primary themes are paramount to multiple industry stakeholders, sectors, and fleet sizes:

- Industry awareness and education opportunities.
- Overcoming deployment barriers.
- Creating/fostering carrier- and industry-wide safety cultures.

The research team has generally organized the findings and implementation steps using a matrix approach that maps the three "themes" to the stages/stakeholders identified in Table 29. This essentially creates a stakeholder-prioritized time and decision framework.

Table 29. OSS adoption steps.

Adoption Steps	Description
1. Initial Information Gathering	The process that carriers initially undertook to obtain necessary materials and background information to assist in the decisionmaking process for deploying OSSs. Carriers move from "hearsay and marketing materials" to information collection. Depending on the fleet size, this activity could commence with a manager through president.
2. Internal Review and Evaluation	An internal review and analysis of materials received during the information-gathering phase. This phase usually involves a relatively sophisticated assessment by several key personnel (e.g., safety director and CFO).
3. Budgeting and Approval	Assesses the budgeting requirements, issues encountered, approval processes, and steps needed to obtain and secure funds for OSS implementation. Initially involves mid-level managers and analysts and terminates with executive decisionmaking.
4. Management	Manages and evaluates post-purchase activities including installation processes, training requirements, monitoring benefits achieved, and issues encountered. Usually spearheaded by an appointed project manager or safety director with assistance from multiple involved parties.
5. Future Plans	Identifies future expansion goals and activities needed to accomplish any formal or informal deployment objectives. Involves most of the stakeholders required in the first four stages.

6.1 INDUSTRY AWARENESS OPPORTUNITIES

As is evident from the driver and carrier surveys as well as the case study validation activities, industry awareness of OSSs is lower than previously expected. For practical purposes, "awareness" can best be defined as something closer to familiarity since stakeholders have often heard of OSS technologies, but they have little to no understanding of the OSS functionalities, benefits, costs, and operational issues. In the driver and carrier survey, a question was posed asking participants to indicate any experience with the various technologies. Of those surveyed, 72 percent of drivers and 88.6 percent of carriers had never used any of the OSS technologies. A similar question was posed to drivers during the case study validation, and 85 percent had no experience. This strongly indicates a need for additional industry awareness opportunities.

Within the literature, many OSS-related studies are described and assessed for their pertinence to the factors highlighted in the study objectives. It is clear that many analyses have been conducted on OSSs over the past decade, and yet many drivers and carriers are unaware of the findings outlined in the reports. Several open-ended questions were posed to drivers and carriers regarding possible solutions to deployment barriers. One of the top carrier concerns—low reliability and efficacy—emphasized the extent to which participants felt apprehensive about investing in OSSs, yet believed that concerns could be allayed through additional research. In addition, another concern—user friendliness—reflected multiple underlying issues, such as convoluted installment processes, complex installation and maintenance, and lengthy training time.

The lack of knowledge related to actual usability and reliability of the system indicated a need for expanded dissemination of published research on the topic. Carriers of all sizes should be provided additional opportunities to assess the objective data available on each of the OSS products. This could take multiple forms, such as:

- Preprinted articles in targeted trade magazines.
- Abstracts in brochures at truck dealerships.
- Local seminars or meetings with other carriers.
- Onsite visits from vendors, Government officials, or the researchers themselves to discuss report results.

A leading concern among carriers and drivers was cost. However, multiple ROI analyses have been published on the subject. For example, an expert panel member commenting on the results of the survey mentioned the need for additional research regarding ROI so that carriers might be able to access the research and become more aware of the OSS technologies. Again, this concern indicates a lack of awareness of available resources. Another awareness opportunity could come in the form of education. Beyond dissemination of articles in trade publications, a formal OSS training curriculum could be developed and offered through the Technology and Maintenance Council (TMC), the Society of Automotive Engineers (SAE), or even the National Highway Institute (NHI.)

The benefits of OSS technologies could be illuminated through several outlets and media, including:

- Internet videos.
- DVDs or other electronic media.
- Formal classroom-type instruction.

- Demonstrations.

According to an expert panel member, with such high rates of carriers and drivers who have never used any of the OSS technologies, it is clear that education and increased awareness are the key to offsetting any real or perceived concerns that may be prevalent within the trucking community.

6.2 OVERCOMING DEPLOYMENT BARRIERS

In both the survey and the case study methodologies, several questions were posed that highlight specific OSS deployment barriers. One key question asked of participants related to possible motivators for purchasing OSSs. In the carrier survey, all forms of "cost," such as insurance costs and purchasing price, were ranked highly. The higher the costs, the less likely carriers were to invest; this seemed to be independent of net ROI due to the need for front-end capital/liquidity. Participants in the case study validation also noted similar barriers. The top four factors that would influence the decision to purchase in the case study validation were purchase price, overall cost, installation cost, and maintenance cost.

Finally, these issues were supported by the expert panel members, many of whom were OSS users. One participant suggested that deployment barriers would be easier to overcome if carriers were less risk-averse: "Only a select few are willing or able to take the risk of implementing a safety technology and potentially failing."

In open-ended questions, carriers and drivers were provided with the opportunity to give suggestions for ameliorating specific barriers to deployment. Such incentives included:

- Tax breaks/credits.
- Lower purchase price.
- Vendor rebates.
- Subsidized costs.
- Government assistance (e.g., grants, training programs, other tools).

As with most products, economies of scale often drive prices down after the product has been on the market for a length of time and/or enough product units have been sold. While a relatively high number of OSS units have been sold, the total discrete number of carriers purchasing OSS units is still relatively small. In summary, larger fleets are purchasing the systems, but for some reason prices remain high for the smaller carriers that are in a "waiting mode."

When asked, many drivers and carriers favored Government assistance to help improve their ability to realize OSS-related safety benefits. One specific suggestion was the establishment of a grant program. The program could take multiple forms, including:

- Targeting high-risk or conditional carriers by making the use of OSS technologies a requirement for improving their safety status.
- Bulk-purchasing of OSS units, with the grant program taking the form of an investment subsidy.
- Training grants to cover post-purchase costs such as maintenance and driver education.
- Small carrier grants through the Small Business Administration.
- Grants based on financial need.

In addition to funding issues, communication is key to overcoming deployment barriers. One expert panel member noted that the perception of OSS technologies at the managerial level has a significant impact on the end-user drivers. Once the proper information is utilized, carriers will be able to spread positive messages and attitudes to drivers. In turn, both drivers and carriers will be more willing to purchase an OSS technology.

6.3 CREATING CARRIER/INDUSTRY-WIDE SAFETY CULTURES

According to several studies, carriers that have a strong safety culture are often more willing to invest in high-potential, albeit speculative, safety initiatives.(48) Carriers that adopt OSS technologies have aspirations to improve the safety of their drivers and other vehicles sharing the road. However, often there is a disconnect between a carrier's interest in an OSS and the driver acceptance that is so critical to success. In addition, those carriers and drivers who have had no experience with OSS technologies seem to be focused on the issue of short-term cost containment over longer-term safety benefits. Therefore, both a carrier-centric and industry-wide safety culture needs to be fostered to facilitate the steps needed for trucking industry stakeholders to redirect safety priorities toward OSS investment. To do so, several steps to create a safety culture should be taken, including:

- Updating the definition of safety to make financial benefits an acceptable motivator.
- Developing a top-down approach to OSS acceptance.(49)
- Specifically addressing the carrier and driver barriers to OSS adoption.
- Utilizing the proposed awareness opportunities in Section 6.1.
- Increasing awareness of proven safety strategies through targeted training.
- Increasing communication between carriers and drivers and between carriers and Government.

6.3.1 Redefining Safety

Carriers should evaluate the underlying causes for the stagnant crash data as a way to provoke an industry discussion on the current condition of safety and how it can be improved. New definitions of safety should be created which incorporate all possible methods of improving safety and tools for implementation. Furthermore, there should be an acknowledgment and related documentation, that “good safety is good business.” OSSs should be a primary technology included in this definition.

The statistical analysis of the driver survey found that only 32 percent of drivers listed safety as a motivator for adopting OSSs. According to an observation made by an expert panel member, if safety as a motivator were not mentally separated from cost issues, carriers could analyze the issue more favorably and holistically.

6.3.2 Addressing Barriers to Accomplishing Safety Goals

As mentioned previously, the findings of the surveys, case studies, and the data validation process made it clear that many barriers hinder carrier investment in OSSs, as well as driver acceptance of OSS technologies. This could be addressed by first creating a hierarchal roadmap of concerns by stakeholder, issue, and short-, medium-, and long-term programs and strategies. The roadmap could be discussed and formalized through meetings, seminars, and discussions that further explain the components and implementation strategies for improved OSS adoption—all mapped to public- and private-sector safety and productivity goals.

6.3.3 Utilizing Awareness Opportunities

During the data validation process, drivers were asked to estimate their general attitudes toward OSSs. On average, employee drivers had a more positive attitude toward OSSs than owner-operators. In addition, non-driver employees’ estimation of fleet driver attitudes was relatively accurate. Overall, all drivers and fleet employees had a slightly more positive than negative attitude, but this level of acceptance could be dramatically improved. This indicates a need and opportunity to change perception through awareness and education activities.

Utilizing methods described in Section 6.1, awareness and education opportunities could be used to dispel any misconceptions about OSSs. In comparing driver attitudes toward OSS technologies (between OSS users and non-users), it is clear that non-user drivers have considerably more concerns that are unfounded in practice. A non-threatening solution for addressing this would be the development of truck driver peer-to-peer forums where driver users could share (positive) experiences and realities with driver non-users. Thus, disseminating real-world OSS information could eliminate any attitude that the technologies were threatening in one way or another. Having a non-threatening or risk-neutral view of OSS technologies by truck drivers would facilitate a safety culture that views technology as a mechanism for improving safety rather than hindering it.

6.3.4 Developing Safety Knowledge through Training

Comments and questions posed by expert panel members in reference to the driver and carrier surveys showed that not all participants fully supported OSS deployment. Some suggested that developing stronger training methods at both the carrier and driver levels was a necessary step to improving safety. Creating an industry-wide safety culture would necessarily require a large national education and training program as a follow-on to awareness and education campaigns.

6.3.5 Increasing Communication Between Carriers and Drivers

Finally, a safety culture cannot be developed without effective communication between carriers and drivers. An important component of OSS adoption beyond carrier acceptance is approval and use by drivers. In a strong economy where the driver shortage issue is paramount, carriers cannot afford to have negative driver perspectives. In all fleet segment sizes, communication is necessary to develop an understanding of OSS benefits and ways to implement the technology in a manner that is acceptable to all stakeholders.

6.4 CONCLUSION

6.4.1 Stages of Adoption

In conclusion, carriers have identified five stages that occur during OSS investment and deployment:

1. Initial Information Gathering.
2. Internal Review and Evaluation.
3. Budgeting and Approval.
4. Management.
5. Future Plans.

These five steps were recognized as an outcome of the research activities completed throughout this study, and they provide preliminary direction for understanding carrier and driver investment needs. The following sections summarize these overarching areas of need and proposed methods of addressing each.

6.4.1.1 Addressing Issues and Barriers

In order to fully understand the barriers and limitations that motor carriers face in adopting OSS technologies, there are several additional research opportunities that could support the OSS objectives. By understanding the factors that influence the decisionmaking processes and the "messages" needed to address such issues, a key impediment to OSS adoption could be minimized. For instance, one finding suggested that there may be differences in the likelihood of purchasing an OEM product or aftermarket product based on fleet sizes. The underlying motivations that influence carriers to choose a particular product are not completely understood and should be examined further. Finally, a continuously updated compendium of OSS technologies, key attributes, functionalities, and unit costs is likely required to minimize the need for each carrier to collect the same information.

- According to the case study findings, small carriers may be more likely to purchase a system without conducting internal testing, and they appear to have dramatically fewer budgeting requirements/decisionmaking steps. In addition, all non-user participants intended to conduct internal testing, but approximately one-third of those that have deployed OSSs did not ultimately perform internal testing. This appears to be related to two separate occurrences: that the actual testing of the systems is more expensive than originally planned, and that available information (including peer insight and support) provides adequate and valid information without having to set up a formal OSS evaluation process. A third indirect factor is that OSS costs typically require carriers to unroll OSSs in phases, and much is learned in the early stages of implementation. Finally, while carriers of all sizes would likely use funding programs, small carriers appear to have the highest need.

- The OSS training provided to drivers and maintenance personnel was found to be limited and inconsistent in anticipated time requirements and manner of information distribution among carriers. The data indicate that many carriers are unaware of what type and level of training would be necessary for successful implementation. By identifying and designing these training requirements, carriers would be able to implement OSSs more efficiently.

Developing Programs and Messages through Frameworks

Despite OSS research that documents likely reductions in truck-involved crashes, not all carriers have experienced those proposed levels of benefit after implementing the technologies. Carriers also have concerns related to both the affordability of the systems and the reliability of the equipment. While the systems have improved over time, there is still a need to improve the capabilities and functionality of the products currently available. A roadmap should be developed that identifies short- and long-term action items to mitigate concerns across trucking stakeholders.

At this time, research has focused on identifying methods of increasing deployment across different carrier types. However, the research has not specifically documented the precise strategies, approaches, and messages that are needed by carriers on a more individualized basis. For instance, a carrier's sector, fleet size, and region of operation may affect which type of OSS would be most feasible or realistic for implementation.

This individualized approach would ensure that carriers purchase appropriate systems and have the most relevant information applicable to their sector, cargo, and fleet size. The outcome of this framework exercise would be a more targeted approach (i.e. action plan) for increasing adoption across a diverse range of carrier types.

Awareness and Safety Perceptions

The internal testing of OSS technologies has identified a continuum of positive and negative outcomes. Although it is suspected that these differences may have been a result of selecting suitable testing scenarios and different levels of variable control, this supposition is not a certainty. Research (i.e., documented as part of the OSS effectiveness research) would illuminate the reasons for mixed testing outcomes and would aid carriers in the identification of appropriate testing methods in relation to carrier demographics (segment and size differences). Availability of such findings would increase the proportion of positive testing outcomes and would also alleviate or explain some of the negative findings.

Once findings, information, and key messages are developed or consolidated, a unified package or program should be developed (see Section 7 below). To highlight the information, solutions, and messages, the following action items could be considered:

- Industry events such as trucking shows, research conferences, and seminars could be utilized to distribute OSS product information and research findings to both carriers and drivers. It is important to note that trucking-related events are typically geared toward a particular population, and special consideration should be given to venues that attract small- to medium-sized carriers.
- Also, partnership efforts can be made with industry stakeholders that have longstanding relationships with carriers and drivers. Such partnerships may include but are not limited to: OOIDA, State trucking associations, ATA, and/or America's Independent Truckers' Associations. Each of these stakeholders provides its respective members with regular updates via industry magazines, newsletters, webcast conferences, and/or safety meetings. Hence, OSS brochures, articles, or technical briefs could be disseminated to carriers and drivers through these partners.
- Truck drivers frequently visit truck stops and rest areas. Therefore, there is an opportunity to develop and distribute product guides and brochures to these locations. This distribution would allow drivers to become more knowledgeable on the types of OSS products available, as well as develop an understanding of product functionality, safety statistics, and system specifications. Radio shows (e.g., Dave Nemo) have also been very successful methods for providing drivers with a peer-to-peer exchange of information.

Investment Incentives

Government has the opportunity to become more involved with carriers during the various stages of investment. Case study participants demonstrated that there may be a disconnect between perceived and actual effectiveness of Government resources. Specifically, OSS non-users perceived these resources to be moderately effective in providing product information; however, carriers that had completed the deployment process indicated that (on average) Government resources were somewhat ineffective. This may highlight the need for Government agencies to become more involved at the carrier level by distributing OSS information to carriers in a different, more targeted manner. For instance, executive summaries, brochures, and short pamphlets may be more accepted by carriers as opposed to full research reports.

Funding programs should be tailored around the particular investment incentives that were identified by carriers and owner-operators. Among those identified: tax credits or breaks, reduced insurance premiums, vendor discounts or rebates, Government aid, and other cost savings. One such program might offer carriers a vendor discount or rebate for purchasing an OSS; however, a specific set of requirements and guidelines would be needed to determine carrier eligibility. For instance, vehicle-type or revenue-based criteria might be selected to target carriers using specific truck types, commodities, or (small-carrier) revenue ceilings for the program's rebates or discounts.

Alternatively, carriers without any previous OSS purchases might be appropriate candidates for the program. The research herein suggests that carriers and drivers tend to become more accepting of OSSs after the initial benefits have been realized. Therefore, by targeting non-users, interested carriers would essentially be provided with an OSS trial period, which would facilitate the decisionmaking process and provide the early research findings that are desired.

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7. NEXT STEPS

The implementation strategies and "next steps" proposed in this section derive from the various OSS/ID findings and analyses that have been discussed herein. The resulting "Action Plan" can provide a high-level blueprint for increasing awareness, acceptance, and adoption of OSS technologies among the diverse stakeholders in the trucking industry. In synthesizing the multiple task findings identified throughout this study, increased OSS adoption can be best fostered through the three major program development areas, along with the addition of a fourth coordinating activity ("OSS framework"):

1. Develop and manage a framework of stakeholder OSS issues and related solution sets by decisionmaker, fleet size, sector, and technology.
2. Increase awareness and positive perceptions toward OSS technologies.
3. Develop formal investment incentives program.
4. Create an industry-wide safety culture that incorporates OSS technologies.

This chapter is further organized by short- and long-term action plan activities; this approach relates those strategies that have similar levels of planning, funding, and human capital for a given time frame. Within each section, the four proposed program development areas and subsequent implementation approaches are described.

7.1 SHORT-TERM ACTION PLAN

The short-term action plan consists of methods to increase industry awareness, develop incentive programs, and enhance an industry-wide safety culture that could be initiated and/or completed within a 12-month time period. A precursor to the specific, targeted activities is the development of an OSS stakeholder framework.

7.1.1 Short-term—OSS Stakeholder Framework

The research that has focused on OSS technologies, including this analysis, is relatively consistent in identifying the issues and high-level solution sets for the various industry stakeholders, sectors, and fleet sizes. While the detailed solution sets and messages for the various stakeholders are still in development stages, there is a need to more strategically target specific issues with specific strategies and solutions. Such a framework could be organized in the same fashion as this section, with short- and long-term solutions mapped to specific stakeholders by both issue and OSS technology. This framework should include detailed plans such as timelines, costs, and contact information (as relevant) and should include the following activities:

- Develop a short-term task that technically relates research findings to education, outreach, and marketing objectives using a matrix or framework approach.
- Utilize the findings to develop and fund an OSS outreach program.
- As needed, work with multiple stakeholders and agencies to obtain support/endorsements.

- Align the program to meet/support FMCSA and the industry's mutual safety goals and interests.
- Implement an outreach plan with initial campaign "kick-off" events.

7.1.2 Short-term—Industry Awareness Opportunities

Industry events such as trucking shows, research conferences, and training seminars are regularly scheduled throughout the year and could be utilized to target carriers and drivers. To do so, clear messages, coordinated materials, and industry subject-matter experts must be developed and/or utilized.

7.1.2.1 Coordinated Messages and Materials

The research team believes that a major awareness and education campaign, conducted over a 12–18 month period, could dramatically increase industry awareness and positive perceptions among all types and levels of stakeholders. A critical first step to this effort is the development of an awareness/education program. There are many relevant documents and materials already in use, so this task essentially requires communication and coordination of Government and industry materials. To minimize efforts and costs, an umbrella branding program could be developed (e.g., logo, folders, and handouts) to synthesize existing materials. This activity should coordinate FMCSA, National Highway Traffic Safety Administration (NHTSA), academic, and industry/supplier materials. Specific, targeted messages can derive from the OSS Stakeholder Framework. Two primary opportunities should be used to distribute the OSS product information and research findings.

- Create and staff an exhibit booth.
  - Outline a plan for an OSS exhibit booth.
  - Develop OSS materials for distribution.
  - Identify prospective venues and secure a booth location.
  - Provide hard copies of OSS reports, product specifications, and technical briefs to attendees.
- Sponsor or conduct breakout sessions and seminar presentations.
  - Select and invite potential speakers.
  - Develop session materials (handouts, PowerPoint presentation, and/or speaker biographies).
  - Leverage existing communication technologies to publicize upcoming events or research findings via the Internet and distribution lists.
  - Encourage attendance through online communication (Web sites, emails, etc.).
  - Collect feedback from attendees and assess future session needs.

7.1.2.2 Selected Industry Events

It is important to note that trucking-related events are typically geared toward a particular population, and special consideration should be placed on venues that attract drivers and carriers.

Potential carrier events that could have been utilized in 2010:

- ATA Technology and Maintenance Council (TMC) Annual Meeting and Transportation Technology Exhibition.
- ATA Winter Leadership Meeting.
- National Private Truck Council Annual Meeting.
- National Tank Truck Carriers 62nd Annual Conference and Tank Truck Equipment Show.
- ATA's Management and Conference Exhibition.

(Estimated Non-duplicated Carrier/Supplier Reach: 25,000–30,000)

The following venues typically attract drivers and owner-operators:

- 47th Annual Mid-West Truck Show and Convention.
- 39th Annual MATS.
- The Great West Truck Show.
- The Great American Trucking Show.

(Estimated Non-duplicated Carrier/Supplier Reach: 200,000)

7.1.2.3 Stakeholder Partnerships

Efforts should also be made to develop solid partnerships with industry stakeholders that have close relationships with carriers and drivers. These stakeholders provide their respective members with regular updates via multiple distribution channels, including industry magazines, newsletters, webinars, training curricula, management conferences, and/or safety meetings. Hence, OSS brochures, articles, or technical briefs would be disseminated to carriers and drivers to expand both industry outreach and message frequency.

The major partnerships should include:

- Associations.
  - State trucking associations.
  - ATA.
  - National Private Truck Council.
  - Truckload Carriers Association.
  - International Brotherhood of Teamsters.
  - Independent associations.
    - America's Independent Truckers' Associations.
    - OOIDA.

- Radio shows.
  - The Dave Nemo Show.
  - The Midnight Trucking Radio Network.
  - Road Dog Trucking Radio.
  - America's Truckin' Network.
  - Open Road on XM.
- Truck stops and/or rest areas.
  - Pilot Travel Centers/Flying J.
  - Travel Centers of America.
  - Petro Stopping Centers.
  - Speedco.
  - Love's Travel Stops.

7.1.3 Short-term—Incentive Programs

After a certain level of awareness and acceptance is reached, investment and financial decisionmaking comes to the forefront. At this point, most research identifies a strong need to move investment forward through incentives. While incentives do not have to take the form of direct financial support (although that appears to be the highest prioritized motivator), non-financial incentives must still generate a positive ROI or reduction in expenses (e.g., OSS training, user materials, insurance benefits, etc.).

Direct financial incentive programs should be directly or indirectly based on the particular investment incentives that were identified by carriers and drivers. These incentives generally consisted of:

- Tax credits/deductions.
- Reduced insurance premiums.
- Vendor discounts or rebates.
- Government grants and/or technical assistance.

Each incentive or financial program would be tailored toward those that would benefit most from receiving assistance. For instance, one could require a carrier to meet revenue-based criteria that ensure small- to medium-sized carriers receive the majority of aid distributed. Another could limit incentive benefits to carriers that are new OSS investors or those that have less than 50 percent of the fleet outfitted.

Indirect financial incentives could take the form of shipper credits, highlighting OSS users in the marketplace, and other strategies that create perceived value. The EPA Smartway program has many attributes that maximize partnerships, marketplace exposure, and technical information distribution with minimal cost to any one partner (including EPA).

7.1.3.1 Insurance Premiums

Commercial insurance companies do not currently offer a front-end premium discount for having a safety device installed on a commercial vehicle. This is due to the business model philosophy whereby safety systems will accrue safety benefits, and these safety benefits will manifest in fewer losses and payouts—thereby reducing a carrier's future risk and future premium expenses. However, Government initiatives might play a facilitative role by generating larger actuarial data sets used by insurers in developing risk formulas. Several key steps in moving this concept forward would include:

- Identify insurance subject-matter experts.
- Organize and prepare a roundtable agenda.
- Host individual or group meetings of insurance industry stakeholders.
- Identify actuarial data requirements needed to assess risk reductions.
- Propose limited, low-risk models or pilot projects to test formulas and discounts.

7.1.3.2 Low-interest Loans

This approach would provide low-cost (or no-cost) financing options for carriers interested in OSS investments. Similar to the tax credits described previously, carriers could qualify for the program based on characteristics such as revenue, percentage of fleet outfitted with the units, and/or safety status.

- Document and assess analogous financing options used in other programs.
- Identify sources and levels of financing support needed for the loan program.
- Convene separate safety and financing meetings with industry stakeholders to discuss program designs and opportunities.
- Create a pilot program with a limited group of carriers to test and determine the feasibility of a widespread initiative.

7.1.4 Short-term—Industry-wide Safety Culture

The majority of carriers that have trucks equipped with one or more OSS technologies have been methodically integrating the units as older trucks are replaced with new models. Truck replacement and OSS adoption declined dramatically in 2008–09.

The basis for integration delay by the typically proactive carriers is two-fold: first, the Nation's economic recession hit the trucking industry particularly hard, making OSS investments at any price a discretionary option rather than a sound financial investment. A second, more troubling finding is that a number of carriers who tested smaller numbers of OSS units were not seeing the same "dramatic" crash reductions as had been promulgated by the OSS suppliers. This appears to have created both skepticism among potential users and a slightly decreased rate of investment among those carriers who still intend to adopt OSS technologies.

A strong safety culture within a carrier appears to offset real or perceived "bumps in the road" associated with OSS investment and adoption. It can be discerned from the data that the majority of OSS adopters (of all sizes and sectors) had a strong safety culture in place; they often continue to invest in OSS technologies despite a lack of solid empirical data that justifies the capital investment.

7.1.4.1 Educate Stakeholders

Based on respondent data, OSS positive perceptions can be induced most easily at the management level. By educating upper-level management and owners of the benefits that can be realistically expected from OSSs, carriers would be more apt to positively promote an OSS. To simultaneously enhance carrier safety culture and OSS adoption, the following activities would be beneficial:

- Organize onsite and online forums to facilitate peer-to-peer exchange of OSS experiences.
- Disseminate articles, informational brochures, and literature to upper-level managers and owners (describing how OSSs fit within the context of a larger safety culture), and utilize executive-level media and publications.
- Develop a comprehensive, one-stop Web site for managers that includes both general safety culture-related concepts and OSS-specific tools.
- Identify and resolve inconsistencies between vendor data and carrier internal testing outcomes and relay the findings to management.

Additionally, although corporate change is more easily initiated at the management level, grassroots efforts at all levels strengthen and reinforce safety culture. To that end, a short-term ad campaign targeting drivers and owner-operators would be beneficial, particularly if real truck drivers with positive OSS messages are utilized. Specific action items may include:

- Developing a primary message focusing on the essential role of OSSs in safety and secondary messages to dispel rumors and issues.
- Determining appropriate distribution channels for materials (e.g., truck stops, etc.).
- Encouraging stakeholders to raise the issues in their respective corporate environments.

7.2 LONG-TERM ACTION PLAN

A long-term plan would generally encompass a timeframe of 12 months or longer. The long-term portion of the plan focuses on the following two objectives:

- Maintaining awareness and positive reinforcement for existing OSS users. This "maintenance" effort is critical given the high turnover rates among drivers and the continuous consolidations and failures at the carrier level.

- Generating a more industry-wide interest in safety culture—beyond that of the early adopters. At this stage, the OSS component is highlighted as a pivotal and low-cost component of safety culture.

Another assumption of longer-term activities, events, and messages is that they are more resource-intensive.

7.2.1 Long-term—Stakeholder Framework

The long-term agenda would finalize the research plan and complete the following studies:

- Initiate a study on the role that mandated OSS use could play in addressing unsafe or conditional carriers.
- Examine how OSS analyses and benefits can be built into new carrier training and requirements at both the State and Federal levels. The concept could be pilot-tested with one to three State Departments of Transportation.

Specific activities relating to the study outcomes would include the following:

- Expand framework to include more strategic and analytical OSS applications by sector, commodity, vehicle configuration, etc., so that carriers can make more sophisticated determinations of which OSS technology is best for each scenario or application.
- Organize results in a user-friendly software but sophisticated format (software or model) that could be distributed to a diverse audience of industry stakeholders (e.g., drivers, carriers, owner-operators, researchers, safety advocates, and/or Government).

7.2.2 Long-term—Industry Awareness Opportunities

7.2.2.1 Industry Events

As noted, longer-term awareness opportunities would focus on maintaining and continuously updating OSS data and materials to ensure that carriers and drivers are provided with the most current information. Specific action items would include the following activities:

- Provide yearly updates to the Web site and at select venues, focusing on OSS advances and new research findings.
- Ensure that carriers are kept abreast of OSS modifications, improvements, and new options by developing and distributing an OSS technology compendium.
- Beyond the OSS Web site, utilize research conferences, conventions, and truck shows to establish consistent locations where carriers would expect to locate OSS information.

7.2.2.2 Symposium

After short-term industry awareness activities have been completed (i.e., after the initial kickoff campaign), separate Government/industry-sponsored symposiums should be convened that will target carriers and drivers. The objective of the symposiums would be to summarize OSS benefits and include real-world experiences and outcomes. Action items would likely include:

- Presenting both individual carrier and driver experiences and a synthesis/summary of combined experiences.
- Collecting carrier and driver suggestions relating to which OSS system limitations have yet to be addressed.
- Identifying ongoing solution options available to resolve or minimize potential issues.
- Identifying or finalizing future industry “messages” that best resonate with stakeholders.
- Hosting a webinar to confirm which recommendations should be targeted in response to carrier and driver concerns.

7.2.3 Long-term—Incentive Programs

7.2.3.1 Financial Incentive Programs

Financial incentive programs would include tax credits/deductions and vendor discount/rebate options for carriers. Both types of programs would be Government-provided and would include eligibility requirements.

Tax Credit/Deduction

This multifaceted approach would seek to establish tax credits and/or deductions at the State and Federal levels, allowing carriers to receive some type of tax benefit for investing in OSS technologies. Furthermore, carriers could also be offered ongoing credits such as income tax deductions for previously installed units or faster depreciation schedules for the technologies. The proposed action plan for providing tax relief would include the following steps:

- Inform decision-makers (e.g., State associations) and safety advocacy groups of the quantifiable benefits of OSSs.
- Identify types of tax credits or tax exemptions available (e.g., State-level sales tax, Heavy Vehicle Use Tax credit).
- Determine the tax incentive value needed to encourage industry adoption across different segments of the industry.
- Detail which carriers would be eligible to participate in the program.
- Monitor and evaluate the tax credits/breaks that have been utilized most and ascertain any program changes that may be needed.

Vendor Discount/Rebate

This type of program would facilitate a vendor discount or rebate for purchasing an OSS. The following list specifies the steps to incorporate such a program:

- Identify total funding that would be authorized for Government-provided OSS discounts and rebates.
- Schedule onsite meetings with OSS vendors to identify partnership opportunities.

- Detail any eligibility requirements that would need to be met in order to be eligible for the program (e.g., revenue restrictions).
- Monitor industry interest and involvement in the program to determine if and where additional funding may be needed.

7.2.3.2 Insurance Premiums

Insurance-related research would be completed during the long-term phase. Specific information received from insurance providers during the short-term plan would be used to design a research agenda that would address actuarial and risk criteria needed to credit OSS investments on the front end:

- Formalize a draft work statement for insurance industry review/comment that proposes testing and/or analyses of data relating to carrier operations, insurance industry data, and OSS efficacy.
- Conduct the research assessment and provide detailed data to insurers and carriers in a format that supports actuarial analysis.
- Recruit insurers and carriers for a limited field test to document /validate actuarial outputs.
- Broadly disseminate research results and recommendations throughout the industry.

Ultimately, in this scenario, a negotiated arrangement may be needed where an entity assumes some of the risk of the insurance reductions—similar to the re-insurance concept.

7.2.4 Long-term Industry-wide Safety Culture: A Segue to Alternative Compliance

In order to expand an industry-wide safety culture, carriers and drivers need to be identified and recognized for having exceptional safety standards. This can most easily be accomplished through a branding initiative that aims to popularize and distinguish safe operations among carriers. Similar to the EPA Smartway award program, stakeholders throughout the supply chain (e.g., carriers, shippers, vendors) should be encouraged and provided with incentives to participate in the partnership. The branding should be comprehensive but still allow differentiation. A tiered system could identify generally safe members with a silver status; however, those that have deployed OSSs would be recognized as gold carriers.

- Create a formal umbrella brand and use it to promote the following implementation steps, as well as other strategies proposed within this chapter.
- Develop a reward or certification program that recognizes carriers and drivers that use OSSs and have a specified number of accident-free miles.
- As proposed under the Short-term Action Plan (Section 7.1), continue dissemination of information to carriers describing the benefits of OSSs.
- Provide opportunities for OSS-user carriers and drivers to highlight experiences and safety impacts during industry events to promote safe driving.

- Create a training guide geared toward carriers that demonstrates strategies that have been used to motivate safe drivers.
- Administer educational training sessions that target carrier and driver needs (i.e., driver use, maintenance training, safety impacts, and applications).

A more challenging but robust program would be an “alternative compliance” program that weights innovative safety efforts and offers carriers exemptions from traditional compliance for approved/certified “alternative compliance” programs. ATRI evaluated the possibility of an outcome-based “alternative compliance” certification program that could test the safety benefits of non-traditional safety compliance tools.[50] A comparative analysis was conducted to assess the effectiveness of such programs versus the traditional compliance system. As a result, compliance tools and safety measures were identified that could be utilized to assess carriers. Examples of such “tool box” items in are shown in Table 30.

Table 30. Traditional and alternative programs.

Traditional Compliance Activity	Alternative Compliance Activity	OSS	BCA ROIs	Payback
Highway Enforcement and Vehicle Inspections	OSS	LDWS	$1.93 at 23% Efficacy	29 months
Highway Enforcement and Vehicle Inspections	OSS	RSC	$2.33 at 37% Efficacy	24 months
Highway Enforcement and Vehicle Inspections	OSS	FCWS	$1.98 at 21% Efficacy	26 months
Driver Training	Simulator-based Training	*	*	*
Driver Annual Motor Vehicle Record Review	Employer Notification System (ENS)	**	**	**

*Entry-level drivers provided with simulator training had 45 percent fewer reportable crashes than those without the additional training.

**As a result of ENS, 6,700 crashes and 53.9 fatalities might be eliminated annually.

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