AMTA Alberta Motor Transport Association

PRO-TECH & PRO-ACTIVE

UNDERSTANDING AND LEVERAGING THE WORLD OF SAFETY TECHNOLOGY TO MOVE BEYOND COMPLIANCE-FOCUSED SAFETY MANAGEMENT

DAVE A. ELNISKI

Published by Alberta Motor Transport Association (AMTA) © 2025

Published June 2025

Alberta Motor Transport Association (Publisher)

285005 Wrangler Way #1

Rocky View, AB, Canada T1X 0K3

ISBN: 978-1-7781435-2-6

Author:

Dave A. Elniski (he/they) (AMTA), PhD student, MA, CTSP, CRSP, ATCL

-

No part of this document is to be considered legal advice. Neither AMTA or any of the individuals involved in the creation of this document are providing legal advice through their writing and contributions. Employers, employees, contractors, and all others should consult a lawyer for specific legal advice for their workplace.

-

-

For more information or help, contact AMTA through our website, amta.ca.

Thank You

This work was made possible through the collaborative efforts of AMTA with various external and internal contributors and industry leaders. Thank you all for your participation, contributions, and feedback.

Thank you to those who assisted in the review of and contributions to this document. Specifically, we're grateful for the assistance of Andrew Barnes (AMTA), Brittany James (AMTA), Cliff Litke (AMTA), Kelsey Hipkin (AMTA), Laurie Tod (AMTA), and Steve Keppler (Scopelitis Transportation Consulting) in assisting in the development and review of this book.

The author, Dave Elniski, thanks his wife Katy and children Mack and Susan who ever so patiently listened to much dinner table talk about trucking safety. He also thanks his mother Joanne Lavkulich and father Bruce Elniski for their lifelong encouragement and was happy his father was able to at least see the initial draft of this work before passing away unexpectedly in the months prior to its official publication.

For those who participated in the interviews, thank you for your leadership in sharing to help improve public safety for all on North America's roadways. Your voices are important to our industry.

Table of Contents

Executive Summary

This book, published by the Alberta Motor Transport Association (AMTA), was created to help carriers, safety professionals, safety technology and management product and service providers, insurance companies and their brokers, government representatives (both elected and staff), and other interested individuals understand the complex world of fleet safety management technology and related safety management practices. It is organized as follows:

Chapter 1 - Introduction: We open with a discussion on the differences between compliance-focused safety management and proactive safety management. This then leads into the introduction of safety technologies and management practices as an avenue for carriers to improve their safety performance beyond what they can expect to achieve through regulatory compliance alone.

Chapter 2 - Important Concepts and Methods: This chapter outlines the processes followed to produce this resource. This includes a summary of the qualitative research method and literature search processes conducted to learn more about safety technology and safety management efficacy and return on investment. We discuss the terms human safety intervention (HIS) and machine safety intervention (MSI) in this chapter.

Chapter 3 - Vehicle-Based Safety Technology Elements (STEs): This chapter presents a broadly comprehensive list of STEs and their descriptions to help the reader understand the language used in this part of the industry and to help in understanding the many options that exist for STEs that are installed directly into vehicles (whether by the manufacturer or through the use of an add-on device). These are further divided based on upon whether the STEs provide information only to drivers to help them make safer driving decisions or if the STEs also have the ability to actively intervene in how the vehicle is driven, taking control in some situations to avoid collisions when the driver fails to respond accordingly.

Chapter 4 - Office-Based Safety Technology Elements (STEs): This chapter presents a broadly comprehensive list of STEs and their descriptions to help the reader understand the language used in this part of the industry and to help in understanding the many options that exist for STEs that are implemented within the office environment of a carrier. These STEs may also have vehicle-based components, but the STEs described in this chapter are focused less on immediate driver assistance and collision mitigation and more on improving safety management activities in terms of efficacy and efficiency.

Chapter 5 - Safety Management Practices (SMPs): This chapter presents a broadly comprehensive list of SMPs and their descriptions to help the reader understand the language used in this part of the industry and to help in understanding the many options that exist for SMPs that carriers can use to bolster their safety management efforts. Some of these SMPs are specific to organizations with fleets (i.e., carriers) whereas others are applicable to any organization's safety management activities.

Chapter 6 - What Our Interviewed Carriers Are Doing (Thematic Analysis): This chapter presents the bulk of the results of the qualitative research conducted specifically for this resource. This research consisted of interviews with safety management representatives with large carriers with sophisticated safety management systems to understand their use of technology and their perceptions on safety technology efficacy.

Chapter 7 - Efficacy of STEs and SMPs: This chapter showcases the results of the literature searches done for this resource to describe the efficacies of various STEs and SMPs. In other words, this chapter presents data and our discussions of how effective the STEs and SMPs described in this resource are at improving carrier safety performance based on the data we found.

Chapter 8 - Return On Investment (ROI) of STEs and SMPs: This chapter presents data on ROI for STEs and SMPs. Unlike the chapter on efficacy, though, this chapter focuses more on the concept of ROI, how carriers can interpret ROI data, and how carriers can estimate their own ROI figures for safety management investments. We do also calculate ROIs for various STEs using the ROI calculator developed by the United State's Federal Motor Carrier Safety Administration (FMCSA).

Chapter 9 - Moving Beyond Compliance: This chapter further discusses the differences between compliance-focused safety management and proactive constant improvement-focused safety management. It also presents strategies for carriers at different stages of safety program development to move beyond compliance-focused safety and into proactive safety, leveraging the STEs and SMPs described in this resource.

Chapter 10 - Conclusions: We conclude with our final thoughts on the content of this resource and a call to action for carriers of all types and sizes to work towards proactive safety management and investing in safety-related technologies and practices applicable to their operations.

-

STEs and SMPs represent effective ways to improve carrier safety performance, and investing in them is likely to bring about a positive ROI. However, ROI is generally harder to determine than efficacy, and carriers should rely more on efficacy data and their own, internal safety performance data to estimate ROI themselves.

STEs and SMPs also represent a complicated part of the broader safety management field. The language used to describe them is not standardized in many ways, and it also changes rapidly as new technologies are introduced and their features refined. Safety professionals and other individuals working in this space should familiarize themselves with the overarching types of STEs and SMPs related to carrier safety management as part of their ongoing professional development. This AMTA book was written to support this process and further supplements the many services AMTA has to offer the trucking and busing industries in Alberta and beyond.

Chapter One – Introduction

If compliance alone guaranteed optimum safety performance, why do carriers (i.e., trucking/busing company or any other company operating vehicles on public roadways) that do well on compliance audits still experience preventable incidents?

This is an important question in a world where many carriers are struggling, from a safety management perspective, to achieve compliance. Much effort goes into maintaining compliance as a carrier and, for some, compliance represents the zenith of their expectations from their occupational health and safety management system (OHSMS).

Compliance is important. Not just because of the fines associated with noncompliance or because following the law is the right thing to do. These are both good reasons, but the best reason for compliance with safety regulations is that safety regulations represent good-faith efforts by industry experts and regulators to direct organizations to conduct themselves in such a way that the risk exposure to individual people from the organization's operations is reduced to a socially acceptable level. Every carrier must comply with such regulations that, when followed, reduce risk, like limiting work and driving time for professional drivers to reduce the risk of fatigue-related collisions. When viewed this way, the ethics behind safety compliance become clearer.

But, why do compliant carriers and other companies experience collisions and other incidents? Why isn't compliance enough?

Generally speaking, safety regulations are reactions to negative occurrences. Hours-of-service (HOS) regulations do not pre-date trucking as a means of mass freight transportation. Instead, trucking became a prominent method of moving freight in North America after World War I when trucks were first used at a massive scale to transport soldiers and supplies for the war. Once more and more vehicles were on the road and trucking became a profession, the problem of fatigued drivers causing collisions started to become apparent. The HOS rules were then created in response to the awareness being raised around this relatively new public safety hazard.

This is typical of safety regulations: they follow industry developments. However, this doesn't mean regulators simply wait for bad things to happen to then make new laws. Modern Canadian governments (municipal, provincial, and federal) are proactive in seeking to better understand different industries so they can legislate and educate accordingly. But, legislation is still generally slower to respond to changes than the pace at which an individual carrier can amend its own policies, procedures, and practices. Furthermore, legislation (and even the more specific regulations typically empowered by higher level legislation) is broad in its application and, as a result, should not be expected to contain all of the answers to what specific actions any individual carrier should take to improve its safety performance.

We could, then, have a safety law that says something like “carriers must proactively manage their safety performance to strive for demonstratable continual improvements” or something to that effect. There are some safety regulations that do tend to be nonprescriptive like this and require companies to do their own safety-related analyses. Canadian occupational health and safety (OHS) regulations, for example, generally contain provisions requiring companies to do hazard assessments, a process that requires companies to examine themselves to identify potential hazards in their operations and, then, to take steps to reduce the risk these hazards pose to their staff and anyone else who could be exposed to them either by eliminated or controlling said hazards. Such proactive regulatory tools are foundational to how modern OHSMSs function - at least at compliant organizations.

There's still a problem, though, with nonprescriptive regulations requiring companies to be proactive and self-evaluatory in their safety management activities: how do they do this? Unless the rule then contains provisions detailing specifically how a specific company should specifically address a specific hazard in every specific situation in which the hazard may be relevant, companies and the safety professionals that work for/with them must look beyond established regulations for solutions to safety performance problems. Even if the regulation in question was this specific, it would be following developments within industries which originate from new business opportunities, market changes, and innovations, all things that potentially introduce new forms of safety-related risk into organizations. Clearly, the law can't be expected to solve all of our problems when we consider "problems" to mean anything that is not ideal safety performance.

So, we may now perhaps propose an answer to the question at the start of this chapter: compliant carriers still experience preventable incidents because the law doesn't have all the answers for how a carrier should conduct itself to have no incidents. This doesn't mean compliance is meaningless; noncompliant carriers can be expected to have even worse safety performance than compliant ones as safety regulations form a useful safety management framework developed by experts with years of industrial safety experience whose intentions are to reduce incidents. But, what we have discussed above shows that safety regulations shouldn't be expected to contain all the answers for those striving for the best possible safety outcomes for their organization. Regulations define minimum standards and contribute to rising expectations for safety performance, but we need to look elsewhere for safety management guidance in moving beyond what benefits are conferred through compliance alone.

Further Guidance Beyond Compliance

Let's now turn to a different question: Where can carriers and associated safety professionals go for safety management guidance outside of the regulations themselves?

In some ways, this question has many easy and obvious answers. There are many professional training programs for safety and risk management, like university programs and professional designations. There are other players in the industry that can help, like insurance companies and brokers who have a vested interest in seeing the carriers they respectively insure and represent be safer and more profitable. There are industry safety associations, like the Alberta Motor Transport Association (AMTA), who, like insurers and brokers, want to see carriers safely thrive and offer such guidance in proactive safety management best practices. Then, there are organizations offering solutions to either specific or broad safety management problems, like consultants offering incident investigation and safety management services and companies offering technologies related to improving safety performance. But, a big challenge for many carriers is navigating the best path forwards for their operations from amongst these different options.

This AMTA book focuses on the potential safety management guidance sources described in the last sentence of the previous paragraph: technology and safety management best practices. We'll refer to these as safety technology elements (STEs) and safety management practices (SMPs), and we intend to address the following questions:

1. What does the current landscape look like with regards to STE and SMP options available for Alberta-based and other North American carriers?

2. Does it make sense for carriers to invest in

STEs and SMPs to improve their safety performance? In other words, are these fleet safety management tools effective, and is there any chance of receiving a positive return on such investments?

3. How can industry associations like AMTA position themselves to serve their members and other industry parties in the world of rapidly evolving technology and safety management practices?

There has never been a time with as many safety-related products and services available to carriers. Safety technology frequents front-page headlines, especially in the context of self-driving vehicles. Horrific collisions, safety-related convictions and resulting prison sentences, nuclear verdicts, stories of hardship from the worker's level, and business struggles also make headlines, demonstrating the importance of proactive safety management. The pressure to be a safe carrier is intense, and there are seemingly endless technological solutions to help carriers meet compliance requirements and go further in terms of driving down incident rates and improving their safety culture and working conditions. Safety is also tied to human resources issues like recruitment, retention, and pay, and it's tied to general management issues like business reputation and profitability.

Clearly, safety is important, complicated, and not lacking in potential solutions that, while promising, come together to produce a very confusing, challenging safety management environment. Let's now see how the use of technology and proactive safety management practices can take a safety program to the next level.

Reading and Using This Resource

This resource is meant to help carriers and safety professionals understand what STEs and SMPs are out there and what they do. It also explores the evidence related to the efficacies and business cases for these STEs and SMPs, presents the results of interviews we conducted with large carriers with sophisticated safety management systems that are already reaping the rewards of having invested in STEs and SMPs, and suggests approaches different carriers can take to make safety management improvements from an informed standpoint.

This book is structured in such a way that you do not need to read it cover-to-cover. If you're interested most in the business case for safety management technologies, go to the chapters on efficacy (chapter 7) and return on investment (ROI; chapter 8). If you're interested in learning about individual safety technologies and management practices (i.e., STEs and SMPs), go to those chapters (chapter 3, 4, and 5). Or, skim through the entire document like you would any book to get a sense of what it contains and decide from there how best to use the content.

Finally, reach out for more help! For example, AMTA can offer additional guidance on the content in this resource. Safety is a community full of people willing to freely share their experience and expertise, and, while the following pages can help carriers of all sizes expand and refine their safety management activities, no carrier/safety professional needs to take on such a journey alone.

Chapter Two –

Important Concepts and Methods

This chapter is meant to provide background information to assist in navigating the rest of this book. It includes:

- A list of abbreviations used throughout the resource as a useful reference;
- A list of key terms;
- A description of specific key terms created for this resource by AMTA including a discussion of the terms human safety intervention (HIS) and machine safety intervention (MSI), and;
- A methods section.

Consider this chapter an internal reference to assist in the reading of this book. The methods themselves are included for transparency should there be questions about how we collected data and what processes we used to come to the conclusions we present in subsequent chapters.

Abbreviations

ACC - Adaptive Cruise Control

ADAS - Advanced Driver Assistance System

AEB - Automatic Emergency Braking

AEBS - Automatic Emergency Braking System

AI - Artificial Intelligence

AMTA - Alberta Motor Transport Association

BBS - Behaviour-Based Safety

CEM - Critical Events Monitoring

CMS - Collision Mitigation System

COR - Certificate of Recognition

CTSC - Certified Transportation Safety Coordinator

CTSP - Certified Transportation Safety Professional

CVSA - Commercial Vehicle Safety Alliance

ECM - Engine Control Module

EDR - Event Data Recorder

ELD - Electronic Logging Device

ERP - Emergency Response Plan

ESC - Electronic Stability Control

FCW - Forward Collision Warning

FMCSA - Federal Motor Carrier Safety Administration

FMCSR - Federal Motor Carrier Safety Regulations

FMS - Fleet Management System

GPS - Global Positioning System

HOS - Hours of Service

HR - Human Resources

HSI - Human Safety Intervention

HUD - Heads-Up Display

IFTA - International Fuel Tax Agreement

ISA - Intelligent Speed Adaptation

IT - Information Technology

LCA - Lane-Centering Assist

LCV - Long-Combination Vehicle

LDW - Lane Departure Warning

LKA - Lane Keep Assist

LMS - Learning Management System

MSI - Machine Safety Intervention

NAFMP - North American Fatigue Management Program

NSC - National Safety Code (not the American safety organization National Safety Council)

NTSB - National Transportation Safety Board

OEM - Original Equipment Manufacturer

OHS - Occupational Health and Safety

OHSMS - Occupational Health and Safety Management System

OTR - Over-the-Road

PIR - Partnerships in Injury Reduction

PSP - Pre-employment Screening Program

ROI - Return on Investment

RSC - Roll Stability Control

SECOR - Small Employer Certificate of Recognition

SMP - Safety Management Practice

STE - Safety Technology Element

TA - Thematic Analysis

TDG - Transportation of Dangerous Goods

TFW - Temporary Foreign Worker

TFWP - Temporary Foreign Worker Program

TMS - Transportation Management System

TPMS - Tire Pressure Monitoring System

TSRS - Traffic Sign Recognition System

URL - Uniform Resource Locator

US - United States

USDOT - US Department of Transportation

V2I - Vehicle-to-Vehicle

V2V - Vehicle-to-Vehicle

VR - Virtual Reality

VTTI - Virginia Tech Transportation Institute

WCB - Workers' Compensation Board

Key Terms

Accident: A term that typically refers to vehicle collisions or other negative safety incident. The term "accident" is generally not used in safety management when its implication of non-preventability may be used to justify increased risk tolerance.

Alberta Motor Transport Association (AMTA): A nonprofit trucking and busing safety association in Alberta, Canada, that provides safety services to companies and individuals in addition to other services. AMTA is also the publisher of this resource and employs its author, Dave Elniski.

Analytics: The analysis of data to identify patterns, trends, and other insights to support evidence-based decision making.

Carrier: The term used to describe any organization that operates commercial vehicles whether as its primary business activity or to support tis primary business activity.

Certificate of Recognition (COR): A voluntary safety management program standard in Alberta that, when awarded to a company, identifies them as having a safety management system in place and entitles the company to financial rebates from Alberta

Workers' Compensation Board (WCB).

Collision: The preferred term used in this resource to describe negative safety incidents involving one or more vehicles striking an obstacle(s) or other vehicle(s) or leaving the roadway (also commonly referred to as a crash).

Collision Frequency: The rate at which collisions occur at a carrier typically measured by unit of time or distance travelled (i.e., how often collisions take place during operations).

Collision Severity: The amount of loss resulting from an individual collision whether loss is measured in injuries, fatalities, property damage, or a combination of these (i.e., how bad the collision was).

Company Driver: see Employee driver.

Competencies: The skills, knowledge, and abilities required to perform a task effectively and safely.

Competent: A label for someone who has the necessary training, education, experience, and skills to be able to perform a task without supervision or with minimal supervision.

Compliance: The act of following laws, regulations, company policies, or any other ruleset. In other words, compliance means following the rules, but its use is not restricted to regulatory compliance.

Data Analytics: See Analytics.

DOT (general use of the term): "DOT" is an abbreviation that stands for Department of Transportation, generally referring to the USDOT. While it is commonly used in Canada's trucking industry as an informal way to refer to any police officer and government enforcement agency involved in commercial vehicle safety regulation, Canada does not have a DOT structured the way the USDOT is structured.

Driver Inc.: The Canadian Trucking Alliance's term for an illegal and potentially exploitive business model where truck drivers incorporate themselves and work as contractors when they should be classified as regular employees or a personal service business. This often leads to employee misclassification issues and is considered a negative carrier practice, and it is used by carriers who often encourage its use amongst their drivers as a way to reduce the costs associated with taxes and other regular employment benefits while.

Efficacy: The degree to which a safety technology or management practice is able to bring about its intended results (i.e., how good something is at doing what it's supposed to do). See the chapter titled "Efficacy of STEs and SMPs" for more information.

Employee Driver: A professional driver who is an employee of a carrier (i.e., not a contractor) and, in Canada, receives a T4 tax form every year.

Employee Misclassification: The incorrect labeling of a worker as a contractor or an employee as a contractor. This typically occurs as incorrect classification of a worker as an independent contractor instead of an employee, often to reduce costs related to taxes, benefits, and labour protections.

Evidence: Data that can be used to describe, understand, and make predictions about a phenomenon. In fleet safety management, evidence refers to information that can be used to make better decisions to improve safety performance and can be further described as qualitative and quantitative, neither of which is better than the other but, rather, each represent different forms of data that provide different insights into issues.

- **Qualitative Evidence:** Non-numerical data such as written text used to develop deep understandings of complex issues.

- **Quantitative Evidence:** Numerical data used to measure and analyse trends in an area of interest.

Fatigue Management: Policies, programs, and technologies designed to mitigate driver fatigue and improve alertness beyond just hours of service (HOS) compliance.

Haptic: A term that means feedback is touch-based, such as vibration alerts in safety systems used to warn drivers of hazards that may come through the steering wheel, seat, or other device.

Hours of Service (HOS) Management: The tracking and enforcement of legally mandated driving and rest periods in accordance with HOS regulations.

Human Resources (HR): The professional field and practice related to managing employee relations, recruitment, training, and compliance with labour laws.

Human Safety Intervention (HSI): A safety action taken by a human (e.g., a supervisor coaching a driver or a driver reacting to a road hazard) rather than an automated system. See the section of this chapter titled “Understanding HSI and MSI” to learn more.

Incident: An unplanned event that may or may not result in injury, damage, or other forms of loss.

Lease Operator: A driver who leases a truck from a carrier or third party and operates as a contractor but generally hauls for a single carrier.

Machine Safety Intervention (MSI): A safety action taken by an automated system, such as automatic emergency braking (AEB) or lane departure warning systems. See the section of this chapter titled “Understanding HSI and MSI” to learn more.

Occupational Health and Safety (OHS): Within the broader field of public health, the field of study and practice focused on protecting people from hazards in the workplace.

Occupational Health and Safety Management System (OHSMS): A structured framework for managing workplace safety and regulatory compliance.

Operating Authorities: The general term for the legal permissions required by a carrier to operate commercial vehicles in specific jurisdictions. In Alberta, a Safety Fitness Certificate is one of the operating authorities required to operate commercial vehicles above specific weight or passenger capacity thresholds.

Over-the-Road (OTR): A trucking industry term that refers to long-haul trucking operations that involve extended trips across large distances and is somewhat synonymous with long-haul trucking.

Owner Operator: A driver who owns and operates their truck as an independent business who may procure work from carriers and/or directly from shippers. This term may also be used to describe lease operators who do not own their trucks or owner operators who own their trucks but work exclusively for a single carrier.

Regulator: The general term for any government at any level that prescribes laws (i.e., regulations) that govern aspects of a carrier's activities.

Return On Investment (ROI): A financial performance measurement that quantitatively describes the benefit gained relative to the cost of an investment. See the chapter titled "Return On Investment (ROI) of STEs and SMPs" for more information.

Safety: The condition of being protected from the risk posed by hazards.

Safety Climate: The shared perceptions of safety priorities and commitments among workers within an organization that can be measured more locally and are typically more easily influenced by management changes than safety culture.

Safety Culture: The overall values, attitudes, and behaviours within an organization related to safety. Safety culture represents the more deeply ingrained attitudes towards safety within an organization than those that represent safety climate.

Safety Management Practice (SMP): An individual component of a larger OHSMS that is meant to address a specific aspect of fleet safety management. See the chapter titled "Safety Management Practices (SMPs)" for the descriptions of the SMPs included in this resource.

Safety Performance: Any measure of an organization's OHSMS in terms of final outputs. This includes collision rates, injury rates, WCB costs, and any metrics, whether leading or lagging indicators, that an organization may create specific to its own operations.

Safety Technology Element (STE): A technological tool and/or service that is meant to improve safety, typically by addressing a specific aspect of fleet safety management. See the chapters titled “Vehicle-Based Safety Technology Elements (STEs)” and “Office-Based Safety Technology Elements (STEs)” for the descriptions of the STEs included in this resource.

Speccing: The activity of selecting specific features and specifications for a vehicle or other piece of equipment to ensure that it meets operational requirements and/or regulatory requirements.

Thematic Analysis (TA): A qualitative research methodology used on text-based data to create themes that summarize and contextualize typically social phenomena.

Vicarious Liability: Legal responsibility held by an entity for the actions of their employees, contractors, and other parties they may direct while performing work-related tasks.

Workers’ Compensation Board (WCB): A nonprofit organization that provides insurance for workers to ensure they receive financial compensation in the event of a work-related injury or illness that impacts the individual’s ability to earn a living. WCB coverage is mandatory for carriers and most other employers in Alberta.

Understanding HSI and MSI

This resource introduces two terms that are used throughout the resource and, therefore, are important to define. These terms are human safety intervention (HSI) and machine safety intervention (MSI), and we established these terms to describe key aspects of safety technology element (STE) and safety management practice (SMP) awareness and implementation carrier managers and safety professionals alike need to understand when working in this space.

Human Safety Intervention (HSI) versus Machine Safety Intervention (MSI)

HSI and MSI both have to do with how a specific safety technology bring about their intended benefits once they have been properly implemented into a carrier's operations. If, after implementation, a person has to do something for the technology in question to work, then we call it HSI-based because a human has to intervene at some point for it to work. If, though, there is no need for human intervention once it's been implemented, then we call it MSI-based because the machine(s) involved do everything necessary to bring about the intended safety outcomes. That's a bit of a vague description, so let's go through some examples.

For our first example, let's use automatic emergency braking (AEB) systems. AEB is described in more detail in future sections but, in short, AEB is a system installed on a vehicle that will apply the vehicle's brakes and bring it to a stop in response to a detected obstacle. Once an AEB system has been installed in a vehicle and activated, it will do its job without further human intervention, applying vehicle brakes in response to obstacles as per the specific system's configuration. Therefore, we would call such an AEB system MSI-based because the machine does everything.

Now, let's consider a forward collision warning (FCW) system. Like an AEB system, FCW detects obstacles in front of the vehicle. However, unlike AEB, FCW doesn't do anything beyond alerting the driver to the imminent hazard. In other words, FCW will detect an imminent collision, alert the driver, but then do nothing further. The driver must ultimately respond to the system's warnings and apply the vehicle's brakes (or take other appropriate evasive action) to prevent the collision. If the driver fails to take action, a collision will take place. Therefore, we would call such an FCW system HSI-based because human intervention is required at some point for the technology to function properly and bring about safety performance improvements.

Understanding HSI and MSI Together

The difference between HSI- and MSI-based STEs is whether or not a human has to actively do something at a specific time for the STE to be effective. We can also look at HSI and MSI as a bit of a spectrum, too, as some technology varies in the degree to which it is HSI/-MSI-based.

For example, consider a driver-facing camera system that uses artificial intelligence (AI) to detect unsafe driving behaviours like phone use and other forms of distraction to create real-time warnings for the driver and to then automatically, based on the individual driver's safety performance, assign training to the driver through the carrier's learning management system (LMS). This is a relatively sophisticated combination of various STEs that, together, work to improve safety performance by 1) alerting drivers when they are doing something unsafe and 2) improving driver competencies through targeted online training. Once this system is fully implemented, is it HSI or MSI based?

Well, first off, we have to look at what makes this system effective or not. None of the STEs described actually take control of the vehicle. Instead, they work to reduce collision frequencies and severities by improving driver response both immediately (i.e., through the real-time alerts which could potentially alert the driver to a dangerous situation they otherwise would have missed) and over time (i.e., by improving driver safety through ongoing, targeted training). So, this system is ultimately HSI-based as active human intervention is needed to bring about improved safety performance (i.e., drivers have to respond to both the real-time alerts and ongoing training).

However, we can also label this example STE combination as somewhat MSI-based. This is because many human activities have been automated, such as identifying unsafe driver behaviours (which most carriers would have not been able to do at all previously) and assigning training based on these observations. If we were only interested in the training aspect and ignore the vehicle, then we could say this is a training-related STE that is MSI-based.

Key takeaway: It doesn't matter if we completely agree or disagree on whether a technology is HSI-based, MSI-based, or somewhere in the middle. The importance of these terms is, instead, to help carriers understand that many STEs need other resources beyond their implementation costs. As we will see later in this resource, most STEs and all SMPs we discuss are largely HSI-based, requiring active human safety management activities to be effective. In order to make accurate budget and human resources decisions, carriers must understand the work required of them in managing safety technologies lest their strategy for improving safety fail due to costs associated with staff time for which they neglected to account.

How do we use HSI and MSI in the rest of this resource?

This resource uses the terms HSI and MSI primarily in the sections describing specific STEs and SMPs. They are included to provide carriers and anyone else reading this resource a general idea of whether or not the technology in question is largely functional right after being paid for and implemented or if significant additional costs - primarily staff time in managing the system - should be expected in order for the technology to be effective.

Methods

This section describes how we went about gathering the information to write this resource. It's been included for the sake of transparency and so that readers can independently determine its applications and limitations. It can be skipped, though, for those who wish to move on and learn about safety technology elements (STEs), safety management practices (SMPs), the results of our work on determining their efficacy, and on our discussion on return on investment (ROI).

Overall Methodological Approach

This resource set out to address the following areas of inquiry:

1. What does the current landscape look like with regards to STE and SMP options available for Alberta-based and other North American carriers?

2. Does it make sense for carriers to invest in STEs and SMPs to improve their safety performance? In other words, are these fleet safety management tools effective, and is there any chance of receiving a positive return

on such investments?

3. How can industry associations like the AMTA position themselves to serve their members and other industry parties in the world of rapidly evolving technology and safety management practices?

Our intended audience is as follows:

1. AMTA members: general trucking, busing, and fleet staff involved in management and safety-specific management for carriers of all sizes.

2. Safety professionals who are or may be involved in managing hazards and risk at organizations that operate vehicles.

3. AMTA supplier members: those involved in manufacturing, testing, selling, and marketing STEs, SMPs, and other fleet solutions.

4. Professional drivers curious about vehicle safety technology and how it may be managed by carriers.

Other audiences include researchers, government officials (elected and/or staff), industry associations, and anyone in the general public interested in this subject matter. In order to address the questions above for our intended audience, we chose a research and writing style for this resource that was designed to keep the content accessible and clear while retaining the rigour and trustworthiness necessary to contribute to the active discourse around the use of technology in trucking and busing operations. The following sections will provide details on how specific chapters in this resource were researched and written.

Identifying STEs and SMPs

Safety technology elements (STEs) and safety management practices (SMPs) were identified by:

- Initial discussions with internal AMTA staff to identify STEs/SMPs that immediately came to mind.
- Having multiple AMTA staff conduct their own, independent internet searches to identify as many STEs and SMPs as possible.
- Searching both primary and grey literature to

identify STEs and SMPs.

Once these preliminary lists were created, the author (who was also the primary researcher) combined and reviewed them to remove redundant items. Proprietary names for STEs/SMPs were exchanged with the general names for the type of STE/SMP in question to ensure language wasn't specific to any specific manufacturer and, instead, true to categories and attributes of STEs/SMPs. Various artificial intelligence (AI) programs (ChatGPT and Google's AI overview feature) were then used to create other lists of STEs/SMPs which the author then reviewed to identify potential new items; any new STEs/SMPs identified this way were then searched independently of the AI program that identified them to confirm they could be found outside of the specific AI program. All AI contributions to this book during this process were independently verified for accuracy and, if the contribution could not be verified outside of the AI program via a reliable source, the contribution was not included.

Interviews, Ethics, and Thematic Analysis (TA)

Qualitative research in the style of qualitative description and reflexive thematic analysis was conducted for this book to learn more about how carriers are using STEs and SMPs in their operations and their thoughts on their efficacy. The author contacted 18 carriers/safety consultancies managing safety programs for multiple carriers; 13 organizations agreed to participate. Inclusion criteria for participants were that they had to be in a senior safety management position at a carrier with a sophisticated occupational health and safety management system (OHSMS) using STEs and SMPs for continual improvement purposes (i.e., not just for compliance purposes) or have an equivalent relationship to one or more carriers as a safety consultant. The author and other AMTA staff who were knowledgeable about carrier safety management used their industry knowledge and experience to decide who would meet the above inclusion criteria.

Interviews were done virtually via Microsoft Teams with either one or two individuals from each organization, depending on who from the organization was deemed by the organization as the best person to participate in this project. The interviews were recorded and transcribed using Teams' recording and transcription features, and then the author reviewed each transcript for accuracy against the recording before proceeding to coding and thematic analysis.

The subject matter being discussed in the interviews wasn't anticipated as being controversial nor sensitive. Nevertheless, the following practices were used for all interviews and data handling to uphold a comparable ethical research standard to qualitative research being done at Canadian universities:

- Informed consent was provided in writing during initial participation solicitation emails, made accessible to participants in subsequent communications, and reaffirmed verbally at the start of all interviews prior to starting the recordings.

- Steps were taken to protect the confidentiality of both the participating organizations and the participants themselves by conducting interviews in a secure location with no one else present on AMTA's side. Furthermore, recordings, transcripts, and calendar invitations were all deleted once coding and thematic analysis were complete. Anonymity was not guaranteed, though, due to our lack of control over the communication channels on the side of the participants.

- Electronic files containing any information that could potentially identify participants and/or their organizations were password protected to be accessible only to the author (who was also the sole interviewer, coder, and analyst).

The interviews themselves were semi-structured in design, using the following questions as a guide with the interviewer still allowing for discussions and tangential conversations to capture important concepts:

1. How has your company invested in safety management technology and safety management best practices, and what benefits have you seen?

2. If you could go back, what would you do differently to potentially achieve better results or avoid challenges that came up?

3. What specific safety technologies do you recommend? Any that you do not?

4. What specific safety management best practices do you recommend? Any that you do not, or even management practices not specifically related to safety that are problematic to improving safety performance?

5. Do you have any ROI information? Can you quantify ROI and, if so, provide an estimate with context?

6. What future plans, short- or long-term, do you have for adding/changing safety technology and management best practices?

7. How best should a small versus large trucking company that is minimally compliant but wanting to improve their safety management start when it comes to investing in safety technologies and safety management best practices? What are some common pitfalls that should be expected? What are realistic timelines for seeing results?

8. What motivates your company to improve safety performance? What about you, personally?

9. How do you define "safety" in your role? What about your company?

The thematic analysis, from coding through theme development, was done manually using the program Scrivener to organize the interview transcripts, text, codes, and themes. Once the transcripts were scrubbed of information that could potentially identify the participants, they were uploaded into Scrivener. Each transcript was reviewed in detail and coded systematically. Prior to starting coding, a preliminary coding framework was created using the interview questions as a guide. As sections of transcripts were coded and organized, the codes were gradually organized to remove redundancy not relevant to this resource's guiding questions, and themes were then created based on these codes. Alongside coding, any data related to efficacy and ROI were specifically identified for inclusion in the appropriate sections of this resource.

The resulting themes and insights from the interviews are presented in the chapter titled "What Interviewed Carriers Are Doing (Thematic Analysis)" and then in the efficacy, return on investment (ROI), and moving beyond compliance sections where relevant. For example, **Table 1** in the chapter on efficacy presents information gathered during the literature searches conducted to explore STE and SMP efficacies. Relevant data from interviews were also included in this table where appropriate and in as much detail as possible balanced with concision.

Assessing STE and SMP Efficacies

We conducted literature searches to better understand the current knowledge on the efficacies of STEs and SMPs profiled in this resource. These searches were essentially scaled-back versions of academic literature reviews meant to provide AMTA with a foundation from which to better speak to the overall efficacy of investing in STEs and fleet-focused SMPs as a way to improve carrier safety performance.

To this end, we used a sampling strategy to scan the most relevant sources of efficacy-related information. Instead of searching for each individual STE and SMP, we grouped STEs and SMPs into somewhat-overlapping categories to help streamline the literature search process. Then, specific search phrases were written for each of these categories for both Google and Google Scholar searches. These STE/SMP categories, search phrases, and details on the search criteria for literature inclusion are presented below:

Primary and grey literature search criteria:

- Google Scholar as the search engine for primary literature review; Google search engine for grey literature review.

- 2020-2025 for publication years.

- Based on research conducted fully or partially on Canadian, American (i.e., USA), Australian, and/or European Union commercial trucking/fleet operations.

- Grey literature searches, while not exclusive of any specific websites, did not specifically include any particular organizations and their websites via the *site:* Google search operator. This was due to the issues in creating the list of organizations to include that would be realistic given the scope of this resource and would adequately address concerns related to bias in setting the criteria for any such inclusion. Not using the *site:* Google search operator was also seen as appropriate for the reviews done for this resource as the use of other search terms prioritizes discrete works based on the evidence they provide regarding efficacy, not based on their affiliation with any particular organization.

- **Note:** If a source was found during the search for one STE/SMP category that fit a different STE/SMP category, it was permitted to be included in the category where it made the most sense to include.

Phrases for Google Scholar primary literature search using Boolean search operators (*“”, AND, OR, ()*):

- Vehicle-based STE categories:
    - Collision avoidance systems:

(“collision avoidance” OR “crash avoidance” OR “collision mitigation” OR “crash mitigation”) AND (“technology” OR “system” OR “systems”) AND (“trucking” OR “fleet” OR “commercial vehicle”) AND (“efficacy” OR “effectiveness” OR “effective”) AND (“Canada” OR “Canadian” OR “North America” OR “America” OR “American” OR “US” OR “USA” OR “EU” OR “European” OR “Australia” OR “Australian”)

-
    - Driver monitoring and assistance systems:

(“driver monitoring” OR “driver assistance” OR “driver aid” OR “driver aids” OR “driver management”) AND (“technology” OR “system” OR “systems”) AND (“trucking” OR “fleet” OR “commercial vehicle”) AND (“efficacy” OR “effectiveness” OR “effective”) AND (“Canada” OR “Canadian” OR “North America” OR “America” OR “American” OR “US” OR “USA” OR “EU” OR

"European" OR "Australia" OR "Australian")

- ◦ Stability and traction control systems:

("stability" OR "stability control" OR "stability system" OR "stability systems" OR "traction control" OR "traction" OR "traction system" OR "traction systems") AND ("technology" OR "system" OR "systems") AND ("trucking" OR "fleet" OR "commercial vehicle") AND ("efficacy" OR "effectiveness" OR "effective") AND ("Canada" OR "Canadian" OR "North America" OR "America" OR "American" OR "US" OR "USA" OR "EU" OR "European" OR "Australia" OR "Australian")

- ◦ Information-only technologies:

("information" OR "information only" OR "information-only" OR "driver information") AND ("technology" OR "system" OR "systems") AND ("trucking" OR "fleet" OR "commercial vehicle") AND ("efficacy" OR "effectiveness" OR "effective") AND ("Canada" OR "Canadian" OR "North America" OR "America" OR "American" OR "US" OR "USA" OR "EU" OR "European" OR "Australia" OR "Australian")

- Office-based STE categories:

- Data analytics and reporting tools:

(“data analytics” OR “data reporting” OR “analytics” OR “reporting tool” OR “reporting tools” OR “data analysis” OR “analysis tool” OR “analysis tools”) AND (“technology” OR “system” OR “systems”) AND (“trucking” OR “fleet” OR “commercial vehicle”) AND (“efficacy” OR “effectiveness” OR “effective”) AND (“Canada” OR “Canadian” OR “North America” OR “America” OR “American” OR “US” OR “USA” OR “EU” OR “European” OR “Australia” OR “Australian”)

- Compliance and documentation systems:

(“document management” OR “documentation management” OR “compliance management” OR “regulatory compliance” OR “compliance” OR “file management”) AND (“technology” OR “system” OR “systems”) AND (“trucking” OR “fleet” OR “commercial vehicle”) AND (“efficacy” OR “effectiveness” OR “effective”) AND (“Canada” OR “Canadian” OR “North America” OR “America” OR “American” OR “US” OR “USA” OR “EU” OR “European” OR “Australia” OR “Australian”)

- Training and performance monitoring:

(“learning management” OR “training management” OR “learning monitoring” OR “training monitoring” OR “performance monitoring”) AND (“technology” OR “system” OR “systems”) AND (“trucking” OR “fleet” OR “commercial vehicle”) AND (“efficacy” OR “effectiveness” OR “effective”) AND (“Canada” OR “Canadian” OR “North America” OR “America” OR “American” OR “US” OR “USA” OR “EU” OR “European” OR “Australia” OR “Australian”)

- SMP categories:
    - Driver-oriented programs:

(“driver management” OR “driver engagement” OR “driver program” OR “driver safety” OR “driver health” OR “driver wellness” OR “driver wellbeing”) AND (“trucking” OR “fleet” OR “commercial vehicle”) AND (“efficacy” OR “effectiveness” OR “effective”) AND (“Canada” OR “Canadian” OR “North America” OR “America” OR “American” OR “US” OR “USA” OR “EU” OR “European” OR “Australia” OR “Australian”)

- Safety culture and engagement initiatives:

(“safety culture” OR “safety climate” OR “safety engagement” OR “safety program” OR “safety management" OR "safety practice" OR "staff safety" OR "workplace safety") AND ("trucking" OR "fleet" OR "commercial vehicle") AND ("efficacy" OR "effectiveness" OR "effective") AND ("Canada" OR "Canadian" OR "North America" OR "America" OR "American" OR "US" OR "USA" OR "EU" OR "European" OR "Australia" OR "Australian")

- ◦ Operational risk and hazard management:

("risk management" OR "risk assessment" OR "risk control" OR "risk identification" OR "risk mitigation" OR "hazard assessment" OR "hazard control" OR "hazard mitigation" OR "hazard management" OR "hazard identification") AND ("program" OR "practice" OR "best practice" OR "system" OR "systems") AND ("trucking" OR "fleet" OR "commercial vehicle") AND ("efficacy" OR "effectiveness" OR "effective") AND ("Canada" OR "Canadian" OR "North America" OR "America" OR "American" OR "US" OR "USA" OR "EU" OR "European" OR "Australia" OR "Australian")

Initial searches proved challenging as much foundational work on hazard and risk management in workplace safety (trucking and otherwise) was done before 2020, so earlier sources were permitted for the search immediately above this paragraph.

Phrases used for general Google grey literature search using Google search operators (*“”, OR, ()*):

- Vehicle-based STE categories:
    - Collision avoidance systems:

(“collision avoidance” OR “crash avoidance” OR “collision mitigation” OR “crash mitigation”) (“technology” OR “system” OR “systems”) (“trucking” OR “fleet” OR “commercial vehicle”) (“efficacy” OR “effectiveness” OR “effective”) (“Canada” OR “Canadian” OR “North America” OR “America” OR “American” OR “US” OR “USA” OR “EU” OR “European” OR “Australia” OR “Australian”)

-
    - Driver monitoring and assistance systems:

(“driver monitoring” OR “driver assistance” OR “driver aid” OR “driver aids” OR “driver management”) (“technology” OR “system” OR “systems”) (“trucking” OR “fleet” OR “commercial vehicle”) AND (“efficacy” OR “effectiveness” OR “effective”) (“Canada” OR “Canadian” OR “North America” OR “America” OR “American” OR “US” OR “USA” OR “EU” OR “European” OR “Australia” OR “Australian”)

- Stability and traction control systems:

(“stability” OR “stability control” OR “stability system” OR “stability systems” OR “traction control” OR “traction” OR “traction system” OR “traction systems”) (“technology” OR “system” OR “systems”) (“trucking” OR “fleet” OR “commercial vehicle”) (“efficacy” OR “effectiveness” OR “effective”) (“Canada” OR “Canadian” OR “North America” OR “America” OR “American” OR “US” OR “USA” OR “EU” OR “European” OR “Australia” OR “Australian”)

- Information-only technologies:

(“information” OR “information only” OR “information-only” OR “driver information”) (“technology” OR “system” OR “systems”) (“trucking” OR “fleet” OR “commercial vehicle”) (“efficacy” OR “effectiveness” OR “effective”) (“Canada” OR “Canadian” OR “North America” OR “America” OR “American” OR “US” OR “USA” OR “EU” OR “European” OR “Australia” OR “Australian”)

- Office-based STE categories:
    - Data analytics and reporting tools:

(“data analytics” OR “data reporting” OR “analytics” OR “reporting tool” OR “reporting tools” OR “data analysis” OR “analysis tool” OR “analysis tools”) (“technology” OR “system” OR “systems”) (“trucking” OR “fleet” OR “commercial vehicle”) (“efficacy” OR “effectiveness” OR “effective”) (“Canada” OR “Canadian” OR “North America” OR “America” OR “American” OR “US” OR “USA” OR “EU” OR “European” OR “Australia” OR “Australian”)

- ◦ Compliance and documentation systems:

(“document management” OR “documentation management” OR “compliance management” OR “regulatory compliance” OR “compliance” OR “file management”) (“technology” OR “system” OR “systems”) (“trucking” OR “fleet” OR “commercial vehicle”) (“efficacy” OR “effectiveness” OR “effective”) (“Canada” OR “Canadian” OR “North America” OR “America” OR “American” OR “US” OR “USA” OR “EU” OR “European” OR “Australia” OR “Australian”)

- ◦ Training and performance monitoring:

(“learning management” OR “training management” OR “learning monitoring” OR “training monitoring”

OR “performance monitoring”) (“technology” OR “system” OR “systems”) (“trucking” OR “fleet” OR “commercial vehicle”) (“efficacy” OR “effectiveness” OR “effective”) (“Canada” OR “Canadian” OR “North America” OR “America” OR “American” OR “US” OR “USA” OR “EU” OR “European” OR “Australia” OR “Australian”)

- SMP categories:
    - Driver-oriented programs:

(“driver management” OR “driver engagement” OR “driver program” OR “driver safety” OR “driver health” OR “driver wellness” OR “driver wellbeing”) (“trucking” OR “fleet” OR “commercial vehicle”) (“efficacy” OR “effectiveness” OR “effective”) (“Canada” OR “Canadian” OR “North America” OR “America” OR “American” OR “US” OR “USA” OR “EU” OR “European” OR “Australia” OR “Australian”)

    - Safety culture and engagement initiatives:

(“safety culture” OR “safety climate” OR “safety engagement” OR “safety program” OR “safety management” OR “safety practice” OR “staff safety” OR “workplace safety”) (“trucking” OR “fleet” OR "commercial vehicle") ("efficacy" OR "effectiveness" OR "effective") ("Canada" OR "Canadian" OR "North America" OR "America" OR "American" OR "US" OR "USA" OR "EU" OR "European" OR "Australia" OR "Australian")

- Operational risk and hazard management:

("risk management" OR "risk assessment" OR "risk control" OR "risk identification" OR "risk mitigation" OR "hazard assessment" OR "hazard control" OR "hazard mitigation" OR "hazard management" OR "hazard identification") ("program" OR "practice" OR "best practice" OR "system" OR "systems") ("trucking" OR "fleet" OR "commercial vehicle") ("efficacy" OR "effectiveness" OR "effective") ("Canada" OR "Canadian" OR "North America" OR "America" OR "American" OR "US" OR "USA" OR "EU" OR "European" OR "Australia" OR "Australian")

The first 10 entries for each Google and Google Scholar search phrase above were scanned for relevant sources which were then summarized in **Table 1** in the chapter on efficacy. This method was used so that the searches were done systematically and to help control for less-relevant results. While not done to the depth of an academic literature review, this approach allowed us to create descriptions of efficacy for each STE and SMP category to be able to better understand how average carriers can navigate this aspect of the transportation industry. Multiple AI programs were also used to conduct separate literature searches (ChatGPT and Google's AI overview), and the AI program ChatGPT was used to act as an additional proofreader for the logic used in the above searches. All AI contributions to this book during this process were independently verified for accuracy and, if the contribution could not be verified outside of the AI program via a reliable source, the contribution was not included.

Assessing STE and SMP Return On Investment (ROI)

This resource also discussed ROI for STEs and SMPs. We initially intended to conduct similar literature searches for ROI-related information for the same above STE and SMP categories. However, the following issues caused us to change our approach:

- Efficacy information is frequently presented in the literature as ROI data. For example, a source might say ROI in the title but then present information like percentage reductions in collision frequencies for an STE as ROI data. While efficacy is certainly related to ROI, we did not want to duplicate the work done to produce the efficacy chapter in this resource nor create confusion in the critical distinctions between ROI and efficacy.

- ROI data were not always presented consistently nor was information related to their calculations always clear. Since this resource is meant to help those working in the industry make better decisions with regards to investing in STEs and SMPs to improve their company's safety performance, we did not want to provide ROI data without appropriate background information for fear of unintentionally communicating problematically simplistic ROI figures.

We then changed our approach to presenting STE/SMP ROI information by writing content related to helping carriers understand how ROI works and how to interpret ROI data. The Federal Motor Carrier Safety Administration (FMCSA) has a free online tool to calculate ROI for multiple STEs that they built with the assistance of Virginia Tech Transportation Institute (VTTI), so we instead created a fictitious carrier to use this ROI calculator to present case study exercises to assist carriers in interpreting ROI data. Since we were able to find information on STE/SMP efficacy, we also decided to focus on helping carriers use efficacy information to estimate their own ROI and provided further examples of how to do this work. In other words, while the chapter on efficacy is about presenting efficacy data, the chapter on ROI is more about helping people understand the relationship between efficacy and ROI, how to interpret ROI, and how to use their own company's data to improve their ROI estimates for new safety investments.

Referencing System

Sources related to STE and SMP efficacy are listed in **Table 1** of the chapter "Efficacy of STEs and SMPs". Sources related to STE and SMP ROI are listed in the chapter titled "Return On Investment (ROI) of STEs and SMPs", which is essentially just the reference for the FMCSA/VTTI ROI calculator. The rest of this resource builds upon knowledge common to the trucking, busing, fleet, and safety industries.

In-text citations were not used like they would be in an academic article to balance rigour with readability. The author and/or AMTA can be contacted for more information about the sources used in the creation of this resource. This style was chosen because it allows for easier readability with references listed strategically by section as per above.

Chapter Three – Vehicle-Based Safety Technology Elements (STEs)

This chapter lists and describes various types of STEs that are specifically meant to be installed in vehicles. We've divided these further into STEs that:

- Provide information to drivers to help them make better decisions (section titled "Enhanced Driver Information"), and;

- Those that also have the ability to intervene in how the vehicle is driven to prevent collisions if the driver fails to take appropriate action (section titled "Advanced Driver Assistance Systems (ADAS) and Automation").

Introduction to Vehicle-Based STEs

Vehicle-based safety technology elements (STEs) are types of technologies that are meant to make it easier to be a safe, collision-free and attentive driver. They are limited to the commercial trucking and busing industries, and there are many examples of optional and standard STEs like the ones described in this chapter in ordinary personal passenger cars and other vehicles.

Historically speaking, vehicle-based STEs aren't new. They've been around ever since the first person thought to do something at all innovative to improve vehicle-related safety, and turn signals, brake lights, and even having brakes on each wheel all represent STEs that, at one point in time, were new. However, what's different in today's world is the rate at which vehicle safety technology is changing and the things that such technology are capable of doing, things that one time would have been considered science fiction.

Given how quickly vehicle safety technology now changes, it is harder than ever for carriers to keep up on this type of information. Therefore, this book was written with the intentions to help carriers understand the language used to describe these STEs and how they fit into fleet safety management.

In this book, vehicle-based safety technology elements (STEs) have been further categorized based on how they assist the driver in driving the vehicle: those that provide enhanced information to drivers but do not directly control how the vehicle is driven in any way, and those that may or may not provide enhanced information to drivers but do directly control the vehicle in some circumstances. In other words, *enhanced driver information STEs* have no ability to intervene in how the vehicle is driven and provide safety benefits by giving the human driver more information to make safer decisions; an example would be driver alerts for drifting out of a lane. The second category of *vehicle-based STEs* actually do intervene in how the vehicle is being driven by controlling steering, brake, throttle, and other vehicle systems based on their inputs; an example would be a system that detects when the driver has drifted out of their lane and then actually steers the vehicle back into its lane even if the driver doesn't do anything.

Are vehicle-based STEs HSI- or MSI-based?

Important note: *If you are not sure what the abbreviations "HIS (human safety intervention)" and "MSI (machine safety intervention)" mean or are confused about the concepts of human versus machine involvement in safety technology and safety* *management in general, the section in Chapter 2 titled "Understanding HSI and MSI" before continuing.*

One of the reasons why vehicle-based safety technology elements (STEs) are so captivating not only for drivers, safety professionals, industry representatives, and the general public is because many now have the ability to prevent negative outcomes like collisions without a human having to do anything immediate. It's true to say that the future once thought completely improbable by many is now here, and everyday vehicles on roads throughout North America are equipped with safety features that actually allow the vehicle to drive itself to varying degrees for the safety benefits of its occupants, other vehicles, and pedestrians.

That being said, heavy commercial vehicles still do not drive themselves in a mainstream sense. Most examples today that can be fully autonomous in most driving situations still aren't capable of operating with the versatility of a professional driver (consider all the non-driving activities a professional driver besides driving, too). Therefore, while discussions around self-driving vehicles can be interesting, they're not really practical for the typical carrier safety professional, manager, and driver when it comes to current business operations.

We should be having more practical conversations around what STEs are on the market or soon to be on the market, and also the place of these STEs in carrier safety management programs. In other words, safety professionals, business leaders, professional drivers, and anyone else interested in road transportation should be wondering:

1. How best can we incorporate vehicle-based STEs into our OHSMSs?

2. What is the role of the human in how a specific STE works?

This part of this resource is about both of these questions. The various sections on specific STEs each contain information about what the STE is, how it works, what potential benefits it may bring to a carrier's operations primarily from a safety perspective, and whether it is HSI- or MSI-based. Other parts address HSI versus MSI in a single section within the part but, for vehicle-based STEs, it's important to do this for each individual STE since they vary greatly in how involved management and/or the driver must be to make the STE function effectively.

Those who work or consult for carriers should, when reading this resource and thinking about introducing technology into fleet safety management, think about how much time and expertise from staff will be required to make the STE effective. Some STEs, like automatic emergency braking (AEB) systems, require very little staff resources; just pay for the option when speccing a vehicle, instruct drivers on how it works, ensure it's maintained as per manufacturer's specifications, and let it do its thing. Systems that provide drivers with information but do not actively intervene in how the vehicle is driven, will always require the driver to do their part, so proper driver training is key to ensuring that sort of technology is effective. Other STEs, like intelligent speed adaptation (ISA), do intervene in how the vehicle is driven but might require a great deal of management involvement to properly program the system, make sure it's functioning properly by reviewing reports, and then reprogramming it as-needed based on operational changes.

So, consider the management requirements for each STE when evaluating them to see where they may fit in a carrier's safety management program. Investing in STEs without a clear idea about how the technology works and what's required by staff to make it effective means a carrier might find their upfront costs for implementation are only a small part of the overall cost once staff time is taken into consideration.

Enhanced Driver Information

AI-Based Route Optimization

Description: AI-based route optimization tools analyze vast amounts of data—such as traffic patterns, road conditions, weather forecasts, and areas where collisions are particularly common — to determine the safest and most efficient routes for drivers. These tools aim to proactively reduce collision frequencies by placing drivers in areas where they are less likely to have collisions.

Benefits: By selecting safer routes, fleets can minimize the likelihood of collisions. Route optimization can also be used for additional benefits like reducing driver stress and finding the most efficient routes possible (both for regular route planning and for real-time adjustments).

Implementation: Fleets can integrate AI-based route optimization software into their existing fleet management systems or use standalone tools. Successful implementation requires ensuring the tool pulls accurate data from reliable sources, integration with other systems (if applicable), and the use of the information. Carriers will need to train drivers and dispatchers to understand and trust the system's recommendations, which may differ from traditional routing methods, without completely replacing professional judgement in these roles.

HSI or MSI? Route optimization technologies provide enhanced navigation information to drivers so they can take the best routes possible for safety, efficiency, and other operational reasons. However, they do not have control over how the vehicle operates and, therefore, are HSI-based.

Blind Spot Monitoring

Description: Blind Spot Monitoring (BSM) systems use sensors or cameras to detect vehicles in a truck's blind spots. These systems alert the driver through visual indicators, audible warnings, or haptic feedback like seat vibrations, typically when the signal light is activated while the system still detects another vehicle or obstacle in the blind spot. They provide additional awareness, especially during lane changes, to prevent side-swipe collisions that can occur when a vehicle is hidden from the driver's line of sight.

Benefits: For truck drivers, blind spots are a major safety concern, particularly on the passenger side where visibility is most limited. BSM helps mitigate this risk by providing real-time alerts, giving drivers extra reaction time before changing lanes or maneuvering in tight spaces. This is especially useful in urban driving and high-traffic corridors, and they provide their information to drivers typically within the sight lines of the mirrors, requiring no additional head/eye movement beyond what's normally required for safe driving.

Implementation: Carriers typically integrate BSM into their fleets by purchasing new trucks with built-in systems, but they may be able to retrofit existing vehicles with aftermarket solutions. The effectiveness of BSM depends on proper calibration and ongoing maintenance, so fleets should ensure the system is inspected regularly, particularly after collisions or repairs that might affect sensor alignment in accordance with manufacturer recommendations. Driver training is also essential to ensure operators understand how to interpret BSM alerts and incorporate them into their defensive driving practices so they are aware of how the system works before they enter traffic.

HSI or MSI? BSM systems provide the driver with more information about possible vehicles, pedestrians, and other obstacles that are otherwise hard to see with the conventional mirrors; by themselves, though, they do not control the vehicle and require the driver to take action to prevent collisions using the information they provide. Therefore, they are HSI-based.

Camera-Based Mirror Systems

Description: Camera-based mirror systems replace traditional side mirrors with cameras that provide real-time video feeds to monitors inside the cab. These systems are designed to improve a driver's visibility by eliminating blind spots and offering a wider, clearer field of view compared to conventional mirrors. Many systems also function in low-light and poor weather conditions, where traditional mirrors can struggle, so they have the capability to not only replace conventional mirrors but even represent an improvement over what traditional mirrors are capable of providing.

Benefits: Camera-based mirrors provide drivers with a safer driving experience by minimizing blind spots and improving situational awareness, particularly during lane changes or tight maneuvers. This technology is especially beneficial for large commercial trucks, where blind spots are a significant risk factor, and the interior placement of the display screens can be further optimized to improve the driver experience and reduce time spent with head/eye scanning movements. Finally, they have the additional benefit of reducing aerodynamic drag (which improves fuel economy) and overall vehicle width (through the elimination of the protrusions of conventional mirrors).

Implementation: Fleets can install aftermarket systems or purchase vehicles equipped with camera-based mirror technology. Proper implementation requires training drivers to adapt to digital monitors instead of traditional mirrors, which may take time for experienced operators. Routine calibration and maintenance of the system in accordance with the manufacturer’s recommendations are essential to ensure reliability and prevent issues like fogging or misalignment.

HSI or MSI? Camera-based mirror systems either replace or enhance conventional mirrors and may provide additional blind-spot coverage. However, they do not intervene to prevent a collision without the driver taking action, so they are HSI-based.

Collision Avoidance and Pedestrian Detection Systems

Description: Collision avoidance and pedestrian detection systems use cameras and sensors to identify potential collisions with vehicles, pedestrians, cyclists, and other obstacles. These systems can issue warnings to the driver to allow for quicker reactions, thereby helping to prevent collisions.

Benefits: Theses systems enhance safety by addressing a particularly high-severity collision type: collisions with vulnerable road users. Pedestrian detection is particularly valuable in areas with heavy foot traffic or unpredictable pedestrian behavior, reducing the likelihood of collisions that could have severe consequences for all parties involved.

Implementation: Fleets can adopt these systems by retrofitting existing vehicles or purchasing trucks with the technology pre-installed. Once implemented, the system will require maintenance in accordance with the manufacturer's recommendations.

HSI or MSI? Without integration with other technologies, these detection systems only provide the driver with more information to take the safest-possible course of action and do not intervene to prevent collisions. Therefore, they are an HSI-based type of safety technology.

Driver-Facing Cameras

Description: Driver-facing cameras monitor driver behavior and can provide alerts related to distraction, drowsiness, or other unsafe driving habits. Some systems use AI to detect behaviors such as phone use, eye closure, or erratic driving. They can also provide direct alerts to the driver themselves to draw attention to dangerous behaviours, serving as another system to provide drivers with additional safety-related information in real-time.

Benefits: By identifying fatigue and distraction early, these cameras help prevent collisions caused by inattentive driving. They also provide fleets with valuable data for coaching drivers and improving overall safety culture, and the footage they provide can also be used reactively during collision investigations and other incidents. Advances in AI have allowed these systems to not only do video recordings but also to detect dangerous driving behaviours and issue alerts, such as beeping to tell a driver to put their phone down.

Implementation: Driver-facing cameras can be installed as part of a broader telematics system. Carriers should clearly communicate their purpose to drivers, addressing privacy concerns and emphasizing that the cameras are meant to enhance safety and defend drivers during the investigations following collisions rather than micromanage behavior (and then, of course, be true to their word).

Carriers need to be cautious when implementing driver-facing cameras so as to not run afoul of privacy and employment regulations. Proper legal and HR expertise must be sought as part of the decision-making process.

HSI or MSI? Driver-facing cameras have many different ways in which they assist both drivers and fleets to encourage safe driving behaviours, and some systems provide drivers with real-time alerts for things like distracted driving and fatigue warning signs to encourage drivers act safely. They do not intervene to prevent collisions and are, therefore, HSI-based.

Electronic Inspection Capabilities (Critical Events Monitoring)

Description: Electronic inspection capabilities involve using sensors and software to monitor events such as hard braking, excessive speeding, or sharp cornering. These systems provide real-time alerts to drivers and store data for fleet managers to analyze later. This type of STE may also be referred to as "critical events monitoring (CEM)".

The term "electronic inspection capabilities" may also be used to describe systems that bring information directly to the driver regarding current vehicle condition. This is why this STE has been included in the enhanced driver information subsection of this resource, but it's important to dig into the details of any specific technology to determine precisely what it does for a carrier and/or driver since different manufacturers and suppliers may use similar language to describe products that are quite different.

Benefits: This technology allows fleets to proactively address unsafe driving behaviors before they result in collisions. Additionally, based on the various uses of language described above relating to this technology, these systems may also bring critical information to the driver's attention so they can take appropriate action, like identifying an immediate and safe place to stop for serious issues.

Implementation: Fleets can adopt this technology through advanced telematics systems that integrate event monitoring capabilities. Implementation requires equipping vehicles with the necessary sensors and training both drivers and managers on how to use and interpret the data. Furthermore, OEMs all have this sort of technology built into their vehicle designs, so it's important to understand specifically what information a vehicle is capable of relaying to the driver that's related to its mechanical condition when evaluating current vehicle system capabilities.

HSI or MSI? Critical events monitoring systems provide drivers with important information so they can take appropriate action to prevent collisions that may result from mechanical problems. However, unless integrated with other technologies, they do not intervene in how the vehicle is drive and are, therefore, HSI-based.

Electronic Logging Devices for HOS Compliance

Description: Electronic Logging Devices (ELDs) automatically track a driver's hours of service (HOS) to ensure compliance with the HOS regulations in the specific jurisdiction. These devices connect to a vehicle's ECM and record driving time, rest breaks, and off-duty hours in real-time, partially with driver input but also with ECM input that the driver cannot edit.

Fleets that operate interprovincially and/or internationally are required to use ELDs in Canada and the US. Other fleets that are exempt, such as those operating solely in Alberta at the time of this document's writing, may still choose to use ELDs as a safety and compliance management tool.

Benefits: ELDs help prevent driver fatigue by ensuring adherence to HOS limits, and they further help carriers in the management of HOS compliance across their operations with real-time information. They may also reduce administrative burden by replacing paper logs (although they still require active management and generally will require new processes to be put in place as a carrier transitions to them from paper logs).

Implementation: Implementation involves choosing a compliant device, installing it in all applicable vehicles, and training drivers and other staff on its use. Canada and the US each have online registers where carriers can identify what ELDs are approved for use, and carriers that operate in both countries must ensure their ELDs are legal in both jurisdictions. Fleets that elect to use ELDs when not required to do so should still choose certified devices, but they will likely have to carefully vet their potential suppliers to make sure they offer the HOS rules that apply to the carrier if they are different from the HOS rulesets required by law to be offered by certified ELDs. For example, an Alberta-based carrier that strictly operates provincially must follow Alberta's HOS rules, and not all ELDs offer Alberta's rules.

Regular updates and inspections are necessary to ensure devices remain compliant and functional. This is especially important for devices that require driver input for updates, like those that use the driver's personal smartphone as the ELD display. Carriers that use such a system won't have complete control over updates, so they will need to work with their drivers to make sure they understand how to update their phones.

HSI or MSI? ELDs assist drivers by providing real-time information related to HOS limits and help drivers make safer route-planning decisions to stay within HOS limits. They do not, though, intervene in how the vehicle is driven and are, therefore, HSI-based.

Forward Collision Warning

Description: Forward Collision Warning (FCW) systems monitor the distance between a truck and the vehicle ahead using radar, cameras, laser-based sensors, or other forms of technology. If the truck is approaching the leading vehicle too quickly and a potential collision is detected, the system warns the driver with visual, auditory, and/or haptic alerts. This gives the driver additional time to react and apply the brakes before an collision occurs.

Benefits: Rear-end collisions are among the most common truck crashes, often resulting from distracted driving, poor visibility, or sudden traffic slowdowns. FCW helps mitigate these risks by giving drivers extra time to respond and helping to focus drivers' attention where it's needed most in otherwise distracting cab environments. The system is particularly valuable in stop-and-go traffic and congested urban areas in terms of reducing collision frequencies, and particularly valuable in higher-speed driving conditions in terms of reducing collision frequency and severity.

Implementation: Carriers can implement FCW by equipping their fleets with aftermarket systems or purchasing vehicles that already include the technology; manufacturer requirements need to be adhered to in order to ensure the system is properly maintained and calibrated. Driver training should emphasize that FCW is a supplement, not a replacement, for active monitoring and defensive driving, and drivers should be given the opportunity to experience the specific alerts the system provides in a controlled training environment.

HSI or MSI? FCW-specific systems do not cause the vehicle to apply its brakes or take any other corrective action; they alert the driver only, requiring the driver to take action to prevent a collision. Therefore, they are HSI-based.

Heads-Up Display

Description: Heads-Up Displays (HUDs) project important driving information, such as speed, navigation, and safety alerts, onto the windshield in the driver's line of sight. This allows drivers to access essential data without taking their eyes off the road by displaying it in their field of view but in a transparent manner so the view through the windshield isn't obstructed.

Benefits: By reducing the need for drivers to glance at dashboards, HUDs improve reaction times and reduce distractions. This is particularly valuable in high-stress or fast-paced environments, where maintaining focus is critical to avoiding collisions, allowing the driver to view important dashboard information while reducing or eliminating the small periods of time where they would otherwise have to take their eyes off the road to view traditional dashboards

Implementation: HUD systems may be added to vehicles through aftermarket kits or as built-in features in newer trucks. Proper setup ensures the display is positioned correctly for the driver's height and seating position, and drivers should be trained on how to customize and interpret the projected information effectively.

HSI or MSI? HUDs allow for less driver eye movement to receive important vehicle information. They do not intervene to prevent collisions and are, therefore, HSI-based.

Lane Departure Warning

Description: Lane Departure Warning (LDW) systems use cameras and other sensors to track lane markings and detect unintentional lane drift. If a truck begins to leave its lane without using a turn signal, the system issues a warning—usually through audio alerts, vibrations in the seat or steering wheel, or dashboard notifications. Unlike active lane-keeping systems, LDW does not take control of the vehicle but provides an early warning to allow the driver to correct their course.

Benefits: LDW is particularly effective in preventing collisions caused by fatigue or distraction, two leading factors in highway trucking crashes. Long-haul drivers often experience lapses in attention, especially during overnight shifts or extended periods of highway driving. By alerting them when they veer off course, LDW helps keep trucks centered in their lanes, reducing the risk of often-severe roadway departure crashes.

Implementation: Trucking companies can implement LDW by selecting new trucks with the technology pre-installed or may be able to retrofit their fleet with aftermarket systems. Fleet managers must ensure that the system is correctly calibrated to avoid false alerts. Fleets will have to provide drivers with training on how the system works, emphasizing that LDW is an aid rather than a substitute for safe driving practices.

HSI or MSI? LDW systems provide an alert to the driver to take corrective action; they do not prevent crossing lane lines and associated collisions without the driver taking action. Therefore, they are HSI-based.

Mobile Fleet Safety Apps

Description: Mobile fleet safety apps provide real-time safety alerts, training modules, and compliance tracking directly on drivers' smartphones and/or tablets. Carriers may create their own apps or similar programs that could be extensions of their intranet systems. Apps like this may go by all sorts of different names and offer many different types of information to drivers.

Benefits: Apps on mobile devices provide another way for drivers to access critical safety information on the go, complete mandatory training, and report incidents efficiently. Specific benefits are dependent on the features of the specific app.

Implementation: This STE section is more about providing high-level information about custom/specialized apps as a tool for overall fleet safety management. The process for implementing a specific app will be specific to the app in question, but it will almost certainly involve installing it on specific devices and training drivers and carrier staff in its functions and management's expectations for use. Distracted driving risks must also be managed when any form of technology on mobile devices is introduced into operations, including apps drivers may elect to use on personal devices.

HSI or MSI? There are many types of apps that could fit within this category of safety technology. These apps do not control how the vehicle is driven and provide information to drivers only, meaning they are HSI-based.

Premium Clusters

Description: Premium clusters are advanced digital dashboards that consolidate key vehicle information—such as speed, navigation, safety alerts, fuel levels, and diagnostic warnings—into a single, easy-to-read interface. In practice, most carriers have little control over how a vehicle displays information to the driver, and OEMs are constantly improving their dashboards, so this section has been included mostly for general awareness purposes as the term "premium clusters" does appear in related literature at times.

Benefits: For drivers, premium clusters improve situational awareness by reducing the time spent searching for information across multiple gauges or displays. This leads to safer driving by allowing drivers to keep their focus on the road.

Implementation: Installing premium clusters involves equipping trucks with compatible hardware and integrating them with telematics and other vehicle systems, and the dashboard setup from an OEM is likely designed with this sort of functionality in mind. Whether an aftermarket or custom solution or the OEM dashboard, rivers should be trained to navigate the interface and take advantage of customizable options.

HSI or MSI? Premium clusters provide information to drivers to help them take safer driving actions and reduce distractions, but they do not intervene to prevent collisions. Therefore, they are HSI-based.

Real-Time Weather Monitoring Systems

Description: Real-time weather monitoring systems provide up-to-date information on weather conditions, including precipitation, temperature, visibility, and wind speeds. Many systems also issue warnings about hazardous weather like snowstorms, heavy rain, or fog, allowing drivers to make informed decisions, and they may additionally provide information on road surface conditions and real-time traffic speeds to indicate areas where traffic has slowed.

Benefits: Weather is a factor in many truck-related crashes, particularly during winter months or in regions prone to severe storms, and for every collision in which it's a factor there are going to be many more trips that were delayed or otherwise impacted. These systems enable drivers and carriers to anticipate and respond to changing conditions, improving safety for both drivers and cargo. They also help fleets to manage delays and reroute drivers as needed.

Implementation: Weather monitoring systems can be integrated into telematics platforms or accessed through standalone apps and dashboards. Fleets should ensure drivers receive training on interpreting weather alerts and understanding how to adjust their driving behaviors accordingly. Maintenance is likely not a major issue with these systems as the vehicle does not have to have sensors and must only receive information, but fleets will still need to plan for software updates and possible issues with integration with other systems.

HSI or MSI? Weather monitoring systems as described above provide additional information to drivers so they can make safer decisions, but they do not intervene in how the vehicle is drive. Therefore, they are HSI-based.

Rear Cross-Traffic Alert Systems

Description: Rear Cross-Traffic Alert Systems use sensors and cameras to detect vehicles or pedestrians approaching from the sides while a vehicle is reversing. When a potential collision is detected, the system warns the driver through visual or auditory alerts. It’s likely those reading this document have familiarity with these and similar systems as backup alarms have been common safety features on vehicles for many years, often in conjunction with a backup camera system.

Benefits: This technology enhances safety in areas with limited visibility, such as busy loading docks or urban streets. Rear cross-traffic alerts help prevent collisions with other vehicles, pedestrians, or objects, which are particularly common during backing maneuvers.

Implementation: Fleets can install aftermarket systems or opt for vehicles that include this feature. Ensuring proper installation and calibration is key to accuracy, and the manufacture is the authority on what maintenance requirements there may be for any given system. Fleets should also train drivers to use these systems as a supplementary tool rather than relying on them as a replacement for careful observation and situational awareness.

HSI or MSI? These systems provide enhanced information to drivers to help them make safer driving-related decisions, but they do not actively intervene to prevent collisions. Therefore, they are HSI-based.

Road-Facing Cameras (Dashcams)

Description: Road-facing cameras, commonly known as dashcams, record real-time video of the roadway ahead. These cameras generally are used when the vehicle is being driven, and their basic function is to provide video evidence in the event of a collision or other event where the carrier wants more information about what happened. They may be combined with other technologies to provide additional safety and operational benefits to both drivers and carriers.

Benefits: The original, and, still for many primary, benefit of road-facing cameras is the capturing of evidence. In the event of a collision, recorded footage can help determine fault and preventability, protecting drivers and carriers from claims and help dispute liability. These cameras also provide valuable insights into driver behaviour, allowing fleet managers to identify risky habits like tailgating or hard braking. They can also have their footage used for positive reinforcement, such as recognizing drivers who demonstrate excellent defensive driving skills.

Implementation: Installing road-facing cameras requires mounting devices securely on the windshield and, ideally, integrating them with fleet management software for data storage and retrieval. Fleets should establish clear policies on data usage to address driver concerns about privacy, and they should also develop policies and practices for the review of footage to avoid overwhelming staff with administrative tasks that may detract from more impactful work they could be doing to improve safety performance.

HSI or MSI? Road-facing cameras capture video and, sometimes, audio, and this information can be used both proactively and reactively by carriers. They do not, by themselves, change how a vehicle operates and require active human management to bring about their benefits; therefore, they are HSI-based.

Smart Parking Assistance Systems

Description: Smart parking assistance systems help truck drivers locate available parking spots in real-time using GPS, sensors, and connected databases. Due to the inconsistent use of language in the fleet safety technology world, similar language may also be used to describe vehicle technology that actually assists drivers in parking their vehicle.

Benefits: Finding safe parking is a major challenge for long-haul drivers, often leading to illegal/unsafe parking situations. Smart parking technology helps reduce driver fatigue, prevent parking-related collisions, and enhance compliance with rest break regulations by allowing drivers to make more accurate decisions regarding when to stop for their breaks.

Implementation: Carriers can integrate smart parking tools into existing telematics systems or use standalone apps designed for truck parking networks. Carriers will need to be clear on the proper use of the system by drivers since using a device while driving constitutes distracted driving. Generally speaking, the parking spot information can either be accessed when parked as part of the driver planning the next leg of their trip, or it can be provided in real-time in a way that is consistent with distracted driving regulations and best practices.

HSI or MSI? These systems typically provide the driver with information on where to find parking to assist with route planning, but they do not otherwise take control of the vehicle. Therefore, they are HSI-based.

However, the term “smart parking assistance system” or similar language may also be used to describe technology that assists the driver by automatically steering and otherwise controlling the vehicle during parking. In this use of this language, they would be MSI-based as they intervene in how the vehicle is being driven (or possibly take over completely once the driver activates the system) to help reduce collision risks during tricky parking situations which represents a form of autonomous vehicle technology.

Tire Pressure Monitoring Systems

Description: Tire Pressure Monitoring Systems (TPMS) are electronic systems that continuously monitor the air pressure in a vehicle's tires. If the pressure drops below a safe level, the system alerts the driver through a dashboard warning or through a different display, depending on how the specific system works.

TPMS are also capable of being installed on trailers, meaning that a driver of such a vehicle combination can receive real-time information on the tire pressures for every tire on the vehicle. These systems may also be part of a larger system that provides additional information to the driver and/or carrier, such as hub and brake temperatures, and they are also typically included on vehicles that have systems that also adjust tire pressures automatically, too.

Benefits: Properly inflated tires are important for safety and efficiency in trucking. TPMS helps prevent tire blowouts, but they also go a great deal to improve fuel efficiency and extends tire life by ensuring tires are always within the recommended pressure range - if the carrier/driver responds appropriately to system information by adjusting tire pressures. Of course, TPMS that are part of systems with tire inflation/deflation capabilities further benefit the carrier and driver by allowing for tire pressures to be adjusted within certain parameters without having to stop the vehicle (or even being involved at all if the system makes such adjustments automatically, which some do).

Implementation: TPMS can be installed as an aftermarket solution or purchased as part of a new vehicle package. Fleets should ensure that sensors are compatible with their vehicles and conduct regular maintenance to replace failing or damaged sensors. Drivers should be trained to respond to TPMS alerts promptly.

Carriers and drivers also need to understand the system's capabilities. Some TPMS may only warn the driver when the pressure in a tire drops below a specific pressure. These sorts of systems, while useful, do not provide as much information as systems that provide a specific pressure reading and are less useful from a fleet maintenance perspective. On the other extreme, a TPMS may be coupled with an automatic inflation/deflation system that corrects pressures on an ongoing basis. Training will be needed to ensure that the carrier and driver understand how to use the system and that leaks must still be addressed (i.e., the system can't be used as an excuse to neglect repairing a leaking tire).

HSI or MSI? TPMS that monitor pressure but have no mechanism to adjust tire pressures provide information only to drivers, requiring drivers and carriers to take action in response to said information. Therefore, they are HSI-based and do not intervene to prevent collisions.

If the TPMS is part of a system that also adjusts tire pressures automatically, the system is more MSI-based. However, even if the system can compensate for a minor air leak, it will still require human intervention to repair the leak or otherwise find the issue, so the degree to which TPMS requires active human intervention is very specific to the individual system in question.

Traffic Sign Recognition Systems

Description: Traffic Sign Recognition Systems (TSRS) use cameras and image processing software to detect and interpret road signs, such as speed limits, stop signs, and other traffic control signage. The information is displayed to the driver in real-time to enhance situational awareness, and it may also be used by other vehicle systems as a data source, such as providing real-time speed limit information to adaptive speed limiters.

Benefits: TSRS ensures that drivers are aware of critical road signage, even in unfamiliar or poorly marked areas. This reduces the likelihood of violations, collisions, and missed turns. It also helps drivers remember information from past signs that are no longer visible, such as what the current speed limit may be.

Implementation: TSRS may be integrated into existing fleet management systems or purchased as a feature in new trucks. In terms of maintenance, the carrier will need to consult with the manufacturer for details. Drivers should be trained to rely on the system as a supplementary aid rather than a replacement for direct observation.

HSI or MSI? TSRS systems enhance the driver's ability to see what's on road signs so they drive in accordance with the rules of the road. They do not intervene to prevent collisions and are, therefore, HSI-based.

Advanced Driver Assistance Systems (ADAS) and Automation

Adaptive Cruise Control

Description: Adaptive Cruise Control (ACC) builds on traditional cruise control by automatically adjusting the truck's speed to maintain a safe following distance from the vehicle ahead. The system uses sensors to monitor traffic ahead and slows the truck when necessary, resuming the set speed when conditions allow and certain distances between the vehicle and the vehicle in front of it. ACC systems are often integrated with other STEs, such as AEBS and CMS, due to sharing many of the same types of sensors and vehicle driving intervention capabilities.

ACC or similar language may also be used in the broader industry to refer to speed limiting systems (i.e., speed governors) that adapt to local speed limits as opposed to just having a single maximum speed. Such systems prevent the vehicle from driving under its own power above the local speed limit or other speed limit set by the carrier.

Benefits: ACC improves highway safety by addressing tailgating and reducing the risk of rear-end collisions. It may also reduce driver fatigue by automating speed adjustments, allowing drivers to focus on steering and situational awareness. In stop-and-go traffic, some advanced ACC systems can bring the truck to a complete stop and resume movement automatically; carriers must consult with the specific vehicle/system manufacturer to understand how their system works.

Implementation: Many modern trucks come with ACC pre-installed, but aftermarket systems may be available. Carriers implementing ACC should ensure that the system is properly calibrated and train their drivers on how it interacts with other safety features like AEBS. Maintenance will be as per the manufacturer's instructions and may include things like regular testing and software updates.

HSI or MSI? ACC systems can control the vehicle's speed in response to external information, like following distance from the vehicle ahead, and they do this without additional driver input once the system is turned on. They are, therefore, MSI-based when they are active, but are still largely HSI-based as the driver has to choose to use the system in accordance with carrier training and policies.

Adaptive Steering

Description: Adaptive steering systems automatically adjusts the steering ratio based on the vehicle's speed and driving conditions. At lower speeds, it makes steering more responsive, while at highway speeds, it provides greater stability by reducing excessive steering input.

It's worth noting that adaptive steering has been a feature on vehicles for decades. Older systems used speed input to adjust resistance in the mechanical power steering system to provide greater power assist at lower speeds than higher speeds. Modern adaptive steering, though, offers greater versatility and ratio adjustments, and carriers should get the details for the specific systems in use in their vehicles and if there are ways to customize settings for their specific operations (and if this would even be advisable).

Benefits: For truck drivers, adaptive steering enhances maneuverability at low speeds, making tight turns and docking easier, while improving directional stability on highways. This reduces driver fatigue and helps prevent overcorrections that can lead to loss of control.

Implementation: Forms of adaptive steering are already common in vehicles. However, carriers provide driver training to adapt to the system whenever the driver is new to the vehicle or there is reason to believe the adaptive steering system differs significantly from other vehicles.

HSI or MSI? Adaptive steering is typically just a part of how the vehicle operates and does not require driver input. Therefore, they are MSI-based in that they do their job without additional human actions, but they do not, without integration with other technologies, actually intervene to prevent collisions, making them best thought of as HSI-based.

ADAS Integration Platforms

Description: ADAS integration platforms combine multiple safety technologies—such as collision warning, lane-keeping assist, and automatic braking—into a single system. These platforms use AI and real-time data to improve overall driver safety and efficiency.

In other words, an “ADAS integration platform” is just a term that means all of the driver assistance features built into any given vehicle. It’s likely that a manufacturer won’t use the term “ADAS integration platform” and just refer to their specific vehicle’s suite of safety features in their own, proprietary language.

Benefits: ADAS integration provides a comprehensive safety net by ensuring that different technologies work together instead of operating in isolation. This helps reduce the risk of system conflicts and ensures a seamless experience for drivers as opposed to multiple systems working alongside each other that do nothing to support or augment each other.

Implementation: Carriers will most likely experience this form safety technology as the suite of driver assistance features in their vehicles as they came from the factor. However, there may be ADASs that can be purchased through the aftermarket for specific applications, and the way these aftermarket systems interact with existing vehicle technologies is something of which the carrier will need to be mindful. Proper driver training is essential to help operators understand how multiple systems interact.

HSI or MSI? Whether these systems are HSI- or MSI-based depends on the specific technologies included within the system. ADAS integration platforms are, therefore, better thought of as a concept within vehicle safety and less of a standalone safety device.

Automatic Emergency Braking

Description: Automatic Emergency Braking (AEB) systems use sensors to detect obstacles in the vehicle's path and apply the brakes if the driver does not respond in time. The system is designed to prevent or mitigate collisions by slowing the vehicle down automatically when a crash is imminent. AEB systems may also be referred to as collision mitigation systems (CMS), or language like CMS may be used to describe AEB systems that are integrated with other technologies.

Benefits: Rear-end collisions are often caused by driver distraction, following too closely, or sudden stops by other vehicles. AEB helps reduce the frequency and severity of these crashes by providing an automatic response when the driver doesn't react quickly enough.

Implementation: AEB may be installed as an aftermarket system or purchased as part of a new vehicle's safety package. Carriers must adhere to manufacturer maintenance requirements to ensure proper system operation. Drivers need training to understand how the system works and to avoid over-reliance, as AEB is a last-resort intervention rather than a replacement for attentive driving.

HSI or MSI? AEB systems not only detect forward obstacles but will also apply the vehicle's brakes even without driver input to prevent collisions (or at least lower their severity). Since they can act without the human driver taking action, they are MSI-based once properly activated.

Automatic Trailer Coupling Systems

Description: Automatic trailer coupling systems streamline the process of connecting a truck to a trailer by using automation to align, lock, and verify the connection without requiring manual input from the driver. They may do all or most of the coupling/uncoupling work. They are quite uncommon at the time this document was written and have been included for general awareness since safety technologies are rapidly advancing. What was science fiction yesterday may very well be reality for some carriers today, and this STE would, in some form, be present in vehicles like autonomous shunt trucks.

Benefits: This technology reduces the risk of coupling errors, which can lead to trailer detachment incidents. It also improves efficiency by saving time during trailer swaps, reducing delays in shipping schedules, especially when they are used with other automation. However, likely the greatest benefit is the potential they have for reducing injuries that can result from the repetitive movements involved in trailer coupling and reducing the likelihood of significant injuries that can take place when people work alongside heavy equipment.

Implementation: Automatic coupling systems need to be carefully evaluated directly with the manufacturer to understand how to implement them into operations. It's likely they would benefit from additional technology adoption.

HSI or MSI? Automatic coupling systems are can be considered MSI-based or HSI-based depending on how they are applied to a carrier's operations and the type of vehicles on which they are installed. For example, shunt trucks typically have hydraulically raisable fifth wheels to eliminate the need for the driver to manually raise and lower trailer landing gear when shunting trailers. If we take this as a form of automatic coupling (which many would not), then it's mostly an HSI-based system as it's just making a human-performed task easier. But, the coupling mechanism on a fully autonomous shunt truck would be MSI-based along with the rest of the vehicle as there would be no human operator directly involved in the vehicle's movements. Regardless, consider this specific STE as something to just be aware of moreso than a safety solution applicable to most carriers' operations.

Autonomous Yard Vehicles

Description: Self-driving shunt trucks and other automated yard vehicles are designed to move trailers within warehouses, ports, and distribution centers without requiring a human driver. These vehicles use sensors and AI to navigate their environment safely. They may have a cab and have the ability to be autonomous, or they may be completely autonomous and lack a cab, functioning as a robot.

Benefits: Automated shunt trucks improve efficiency in yard operations by reducing the need for human intervention. They can operate continuously without breaks, leading to faster trailer movements and fewer bottlenecks, and also reduce the likelihood of some types of injuries associated with shunting operations.

Implementation: Self-driving yard trucks likely require investment in smart infrastructure, such as geofencing and advanced docking systems, and can only operate within private facilities and yards unless regulations are in place to permit their operations on public roadways. Carriers must also train personnel on how to interact with and oversee these autonomous systems including how to quickly disable them in emergencies.

HSI or MSI? By its very definition, an autonomous shunt truck or other autonomous vehicle is MSI-based: the machine is responsible for all actions related to avoiding collisions within the specific parameters of its design and setup. It may not always be this clear, though. If the vehicle in question also has a cab and the ability to be driven by a human driver, then they could be anywhere along the HSI-MSI spectrum based on how their specific autonomous features work alongside the human driver. If, though, an autonomous vehicle lacks a cab and operates without a driver once properly set up, they would be considered MSI-based.

Electronic Stability Control

Description: Electronic Stability Control (ESC) is an advanced version of Roll Stability Control (RSC) that not only prevents rollovers but also helps maintain directional stability during sudden maneuvers. It automatically applies brakes to individual wheels to correct skids and prevent loss of control in response to input from vehicle sensors, and such systems are typically able to do their work without driver input, allowing them to control for driver inattention and error.

Benefits: By improving vehicle stability, ESC systems reduce the risk of both rollovers and loss-of-control collisions. They may offer further benefits when integrated with additional technologies in a larger ADAS.

Implementation: Forms of ESC may be standard on many newer vehicles, but there may be retrofit options for carriers on the aftermarket. Regular maintenance and software updates are crucial to ensure proper functionality. Driver training should emphasize that while ESC enhances safety, it does not replace the need for professional, defensive driving.

HSI or MSI? ESC systems intervene in how the vehicle is driven within their specific parameters, meaning they are MSI-based. However, they may also be considered HSI-based in that they may be overridden by the driver or otherwise require human input to be activated in order for them to do their job.

Intelligent Speed Adaptation

Description: Intelligent Speed Adaptation (ISA) systems automatically adjust a truck's speed based on road speed limits and conditions. These systems can issue warnings to the driver or, in some cases, actively limit acceleration to keep the truck within legal speed limits or limits preset by the carrier for specific conditions. These systems may also be referred to as adaptive speed limiters/governors.

Benefits: ISA reduces the risk of speeding-related crashes, ensuring compliance with posted speed limits in changing road conditions. It also helps drivers maintain safe speeds in work zones and high-risk areas (depending on the capabilities of the system).

Implementation: ISA is available in some modern trucks and may be added as an aftermarket system, often with GPS and geofencing technology to allow the carrier to provide additional speed limits for specific routes based on safety data. Carriers should establish policies on override capabilities and provide training to ensure drivers understand system limitations.

HSI or MSI? ISAs are like advanced speed limiters: they will intervene without further driver input in how the vehicle is being driven to lower its speed based on system input, like current speed limits. This means they are MSI-based.

Lane Keep Assist

Description: Lane Keep Assist (LKA) is an advanced version of Lane Departure Warning (LDW) that not only warns drivers when they drift out of their lane but also actively steers the truck back into its lane if no corrective action is taken. The system uses cameras to detect lane markings and automatically applies steering adjustments when necessary.

Benefits: LKA helps prevent unintentional lane departures, a common issue in trucking due to driver fatigue, distraction, or poor visibility. This reduces the risk of side-swiping other vehicles, drifting off the road, or colliding with median barriers.

Implementation: LKA is usually built into vehicles from the factor, but some aftermarket systems may be available. Proper implementation requires maintenance as per the manufacturer's specifications. Drivers should be trained on how the system intervenes and understand that it is a supplement, not a substitute, for safe, professional driving.

HSI or MSI? LKA systems not only provide alerts to drivers of lane drift but will also control the vehicle's steering to put the vehicle back in its lane, potentially avoiding collisions that would otherwise have taken place without driver intervention. They are, therefore, MSI-based. However, some may be largely HSI-based depending on the degree to which the driver is required to activate the system in accordance with their carrier's training and policies.

Lane-Centering Assist

Description: Lane-Centering Assist (LCA) is a more advanced version of LKA that continuously keeps the truck centered within its lane, rather than only intervening when lane departure is detected. It provides subtle steering inputs to maintain alignment, reducing the need for driver corrections.

Benefits: LCA benefits are the same as those for LKA systems but with the added benefit of ongoing lane centering instead of allowing the vehicle to drift from side-to-side. By keeping the truck centered instead of just responding to imminent lane departures, it can also reduce jerky and unpredictable movements, enhancing driving stability.

Implementation: LCA is typically a factory-installed feature on many modern trucks and is sometimes integrated with adaptive cruise control for a semi-automated driving experience (although there may be aftermarket options for some vehicles). Regular maintenance and calibration are necessary to ensure accurate performance, and drivers should be educated on how to interact with the system properly.

HSI or MSI? LCA systems not only provide alerts to drivers of lane drift and use the vehicle's steering system to prevent line crossing, but they also partially control the vehicle's steering to keep the vehicle centered properly in the lane without driver intervention. They are, therefore, MSI-based. However, some may be largely HSI-based depending on the degree to which the driver is required to activate the system in accordance with their carrier's training and policies.

Rain and Light Sensors

Description: Rain and light sensors automatically activate windshield wipers and headlights when they detect rain, fog, or dim lighting conditions. These systems ensure that visibility-enhancing measures are engaged without requiring driver input. This type of technology is common on vehicles, both commercial and personal, and has been on the market for decades.

Benefits: Poor visibility contributes to collisions, particularly during rain, snow, and fog. By automatically engaging wipers and lights, these systems improve reaction times and ensure compliance with lighting laws in various jurisdictions with less reliance on driver input.

Implementation: Most new trucks come equipped with rain and light sensors as standard features, while aftermarket kits may be available for older models. Regular sensor maintenance is important to ensure proper sensitivity and response times. Drivers also need to be trained on how the system works, how to manually operate the features otherwise controlled by the system, and that they are still responsible for their lighting and safe driving behaviours.

HSI or MSI? These types of sensors active various vehicle controls, like lights and windshield wipers, without the driver taking action as long as the system is turned on. Therefore, they are MSI-based when activated but can also be considered HSI-based when the driver is required to activate the system (or could deactivate it).

Roll Stability Control

Description: Roll Stability Control (RSC) is a system designed to reduce the risk of truck rollovers by automatically applying the brakes and/or reducing engine power when it detects a high risk of tipping. It uses sensors to monitor vehicle speed, load weight, lateral acceleration, and other parameters depending on the system, intervening when necessary to maintain stability.

Benefits: Rollover crashes are among the most severe collisions in trucking, often resulting in significant cargo loss, injuries, and fatalities (especially for truck drivers themselves). RSC helps prevent these incidents by actively responding to sharp turns, steep inclines, or sudden maneuvers that could cause the truck to tip over. It is particularly useful for tankers, high-center-of-gravity trailers, and fleets operating in areas with winding roads or high crosswinds.

Implementation: RSC is available as a factory-installed feature in many newer vehicles but may possibly also be added to older vehicles through aftermarket retrofits. Carriers should ensure drivers understand how the system works and that they continue to exercise caution, as RSC is a preventive measure that does not replace safe, professional driving. Regular maintenance as per the manufacturer's specifications helps ensure sensors remain accurate.

HSI or MSI? RSC systems actively intervene in how the vehicle is being driven to prevent or reduce the likelihood of a rollover collision. Therefore, they are MSI-based within the specific situations in which they would operate, but they do not otherwise intervene in how the vehicle is being driven unless they are part of a larger ADAS. This means they may also be considered HSI-based in that they may be overridden by the driver or otherwise require human input to be activated in order for them to do their job.

Speed Governors/Limiters

Description: Speed governors, or speed limiters, are electronic devices that restrict a vehicle's maximum speed. They are typically programmed by carriers to prevent drivers from exceeding a predetermined speed, often set based on fuel efficiency and safety considerations. However, some jurisdictions require them to be demonstrably installed on commercial vehicles over certain weight thresholds, so carriers may require this technology if they operate in such areas.

It's important to note that speed limiters/governors typically just limit engine power when at the preset maximum speed. This means they will not prevent the vehicle from going over its maximum speed when going down a hill unless the system also uses the vehicle's brakes and engine/transmission dynamic brakes as part of its operations.

Benefits: Excessive speed is a major factor in many trucking collisions, particularly on highways. Speed limiters help reduce crash severity, improve fuel efficiency, and lower maintenance costs by reducing wear and tear on tires and brakes. They also ensure compliance with fleet policies and regulatory requirements in jurisdictions where speed limiting is mandated.

Implementation: Modern vehicles typically come with built-in speed limiters, which can be activated and configured through onboard software (in other words, it's better thought of as a setting than something additional the carrier must purchase). Fleets retrofitting older vehicles may be able to install aftermarket devices. To ensure compliance, fleet managers should establish policies on speed settings and monitor data through telematics. Drivers also need to be trained on how the system works, if the maximum speed on cruise is the same as on the pedal, and what the carrier's policies are related to speeding.

HSI or MSI? Speed limiters prevent the vehicle from exceeding a certain speed by limiting throttle input at the set speed, and some may also apply brakes as part of a larger ADAS. This is done without driver input, meaning they are MSI-based safety technologies that do their job without driver intervention.

Vehicle-to-Infrastructure Communication

Description: Vehicle-to-Infrastructure (V2I) communication allows trucks to interact with roadside infrastructure such as traffic lights, road signs, and smart highways. This system provides drivers with real-time traffic updates, weather warnings, and work-zone alerts to enhance safety and efficiency. Perhaps more importantly, though, is that V2I systems provide local road safety authorities with real-time information from vehicles, such as speed, congestion information, and even road surface condition and weather information, depending on what information vehicles are able to transmit to the broader system.

Benefits: V2I improves safety by enhancing the information available to individual drivers, road safety authorities, and carriers. Its benefits are the result of many vehicles being able to send and receive information through connected infrastructure, which can then result in more accurate real-time information for all road users who have access to the system.

As an example, GPS-based mapping services like Google Maps can tell drivers where traffic is slower than normal by changing the colour of the road in question, allowing drivers to make safer, more controlled decisions about how they drive and what routes they take. This is an example of a V2I system where individual vehicle data (vehicle speed sent to Google by vehicles containing people with phones that are connected to Google's system) can be used to show everyone in the area real-time details about traffic conditions.

Implementation: V2I technology may be built into new vehicle models, but it can also be integrated with existing telematics systems or even just through phones and similar devices carried in the vehicle like in the Google Maps example above. Carriers should ensure their software is updated to support communication with smart road infrastructure as it becomes more widely available: both so they can send and receive critical information. Drivers will also need training on how to use the information provided by the system.

Carriers implementing V2I should ensure interoperability between their vehicles and infrastructure/communication systems where they operate, and they also need to understand that this type of technology is new and requires immense collaboration between OEMs and vehicle users. In other words, V2I is more of a concept for most carriers to pay attention to in the coming years to see how it may play a role in their fleet safety management.

HSI or MSI? V2I systems communicate with infrastructure without driver input, meaning they are MSI-based. However, they only share and collect information. So, depending on how the information is then used, they could also be considered HSI-based if they perhaps provide warnings to the driver but otherwise to not intervene to prevent collisions. If they are coupled with other vehicle systems that could intervene without driver input to prevent a collision, they could be further considered MSI-based. It could also be the case that the system provides information to infrastructure for public safety purposes, like providing road safety professionals with information on current road conditions so they can adjust closures and issue public safety notices. Therefore, they may not by themselves do anything to reduce collision risk at the level of the individual vehicle but still contribute to safer roadways by providing the road safety system with more information and take actions, like adjusting speed limits in variable speed limit zones.

Vehicle-to-Vehicle Communication

Description: Vehicle-to-Vehicle (V2V) communication technology enables trucks to share real-time data with other vehicles on the road. V2V systems exchange information about speed, braking, road conditions, and upcoming hazards, helping drivers react to potential dangers more quickly. This is similar to V2I systems except that the communication is directly between vehicles.

Carriers may have their own version of V2V technology where they take information from one of their vehicles and share it with others. For example, a carrier may be able to highlight to all its drivers that one of its vehicles has crashed or is disabled in a certain area, allowing for rerouting or for sending help.

Benefits: V2V technology enhances situational awareness, particularly in low-visibility conditions or heavy traffic. It reduces the risk of collisions by alerting drivers to sudden stops, lane changes, or hazards ahead before they become visible. This is especially useful for preventing chain-reaction crashes on highways.

Implementation: Many modern vehicles come equipped with V2V communication as part of their advanced safety systems. Carriers implementing V2V should ensure interoperability between their vehicles and other vehicles on the road, and they also need to understand that this type of technology is new and requires immense collaboration between OEMs and vehicle users. In other words, V2V is more of a concept for most carriers to pay attention to in the coming years to see how it may play a role in their fleet safety management.

HSI or MSI? V2V systems communicate with other vehicles without driver input, meaning they are MSI-based. However, they only share and collect information. So, depending on how the information is then used, they could also be considered HSI-based if they perhaps provide warnings to the driver but otherwise to not intervene to prevent collisions. If they are coupled with other vehicle systems that could intervene without driver input to prevent a collision, they could be further considered MSI-based.

Chapter Four – Office-Based Safety Technology Elements (STEs)

This chapter lists and describes various types of STEs that are implemented within the office environment of a carrier. In other words, they're not vehicle-based, and drivers typically have little or no interaction with them.

Introduction to Office-Based STEs

Office-based safety technology elements (STEs) are any type of technology that is meant to help carriers with their safety system management and that also exist primarily in the office environment of the carrier. In other words, these technologies are meant to assist carrier management in office-related duties.

This doesn't mean, though, that office-based STEs have nothing to do with vehicle safety. Everything in this resource is about improving carrier safety performance through the reduction of collision frequencies, collision severities, incidents that result in injuries and illnesses, and through the improvement of carrier safety culture to reduce negative practices working conditions that contribute to chronic health, safety, and wellness problems. However, it was important to specifically isolate office-based STEs from those that are meant for vehicle and driver applications to help clarify and organize the information in this rapidly evolving area of fleet safety management.

So, the STEs presented in this part may or may not be directly related to vehicle performance and driver behaviours. They all, though, will interact with staff in office environments. Some represent the office component of technologies that also have a vehicle component, like how ELDs have the in-vehicle aspect along with an office-based dashboard. Others have no direct connection at all to vehicles and drivers and are, instead, meant to address safety issues in other parts of a carrier's operations, like tools meant to help carriers organize documentation to prepare for potential audits and investigations.

Are office-based STEs HSI- or MSI-based?

Important note: *If you are not sure what the abbreviations "HSI (human safety intervention)" and "MSI (machine safety intervention)" mean or are confused about the concepts of human versus machine involvement in safety technology and safety management in general, it's recommended you go the first part in this resource and read the section titled "IMPORTANT - Understanding HSI and MSI" before continuing.*

In general, office-based STEs are HSI-based. This is because they tend to work on the principle of providing carrier management with better information to make safer decisions, but they do not actually bring about improved safety performance without human action being taken in response to the data they provide.

For example, the HOS information from an ELD system doesn't do anything other than exist to be interpreted and put to use by carrier management - or by regulators during an audit or a prosecutor during litigation. The data, like violation rates of various types, are only useful for safety management purposes when the data are interpreted by someone who can then, in some capacity, take action to make changes to improve future safety performance. Without carrier management taking such action, the data do nothing to improve safety performance, demonstrating how such a system is very much HSI-based.

Other types of office-based STEs, though, can appear to be more MSI-based. For example, one carrier interviewed for this resource described a system they have that uses telematics data to apply progressive discipline action to drivers with risky behaviours. In this example, the system used data from driver-facing cameras that can track risky behaviours like phone use and fatigued driving, issue automated warnings and training modules to drivers, and eventually highlight the driver to management in accordance with the company's HR policies. In this sort of sophisticated telematics-to-safety/HR system, no human intervention is required once the system is operational until the system identifies high-risk drivers to management for next steps. Clearly, automation in such a system has taken away many previously human actions and so, up until management is involved, the system can be thought of as MSI-based. Overall, though, carrier management ultimately decides on critical actions like what to do for repeated offenders and when to fire a driver. Therefore, the system requires active human management and activity to be effective - albeit with much less staff time than would have otherwise been the case without the automation. This example further shows that HSI and MSI, as concepts, are more of a spectrum than mutually exclusive categories.

That being said, some office-based STEs can be pretty much completely MSI-based as far as carrier management is concerned, and these are most commonly found in the cybersecurity category. All throughout the day and night, cybersecurity systems automatically detect and mitigate cybersecurity threats to carriers, and they do not require human action for the majority of the steps they take to mitigate these threats. Since cybersecurity activities take place in a digital environment, it makes sense that they do not need to rely on human action for much of what they do. However, it is still likely the case that such a system will still generate reports for management so they can consider improvements to their cybersecurity infrastructure to mitigate threats.

This is when such systems tip back towards being HSI-based, although a cybersecurity service provider may further remove the requirement for carrier staff to have to actively manage this aspect of their program like how any contracted service provider removes certain duties from an organization's list of things its staff have to do.

The main thing for fleet management individuals reading this document to understand is this: *safety-related technologies that operate solely out of the office or have an office aspect will require active human management to varying degrees to be effective*. Sometimes, STEs are marketed in ways that give the impression that all management needs to do for the technology to bring about safety and operational improvements is to purchase and implement it. This is almost certainly not the case, so be skeptical when shopping around for office-based STE solutions and consider getting additional, independent opinions when making purchasing decisions.

Office-Based STEs

Audit Preparation and Document Management Software

Description: Audit preparation and document management tools automate (partially or fully, depending on how the carrier defines automation and the type of software purchased) the storage and organization of compliance records, safety inspections, and regulatory documentation. These programs and systems generally are setup in a way that reflects the requirements of a specific type of audit so that the information needed for an audit is quickly accessible and presented in a logical manner.

A word of caution, though: no third-party service provider can truly relieve the carrier of its safety and compliance obligations, so be wary of suppliers that claim their solution takes care of everything. Carriers still need to know what makes the system appropriate and compliant, and they need to be able to respond to regulators (i.e., auditors) who are not obligated to navigate the program.

Benefits: These tools simplify audit processes, reduce the risk of missing documents, and improve overall fleet compliance. They may also have features where they alert management to missing documents, approaching expiration dates, and customized features based on the nature of the carrier's operations.

Implementation: Carriers may purchase these programs or elect to design their own if they have the resources to do so. They may also use off-the-shelf software, like standard office computer programs, to create their own document management systems.

Collision Reconstruction Software

Description: Collision reconstruction software uses vehicle data, telematics, and AI-driven analysis to recreate crash scenarios. These tools help fleets understand the causes of collisions by analyzing factors like speed, braking, steering inputs, and environmental conditions. These software programs can be very useful in not only making collision investigations quicker and to produce neater-looking diagrams, but they can also offer additional analysis tools to help carriers better understand incidents to work towards preventing future reoccurrences.

Benefits: By providing clear and accurate reconstructions of crashes, this software helps carriers identify root causes, improve safety measures, and defend against fraudulent claims. This is additionally beneficial when there are compliance requirements for carriers to investigate their collisions.

Implementation: Some collision reconstruction tools integrate with telematics and event data recorders (EDRs). Carriers should establish protocols for reviewing reconstruction reports and using insights to enhance driver training, and they will need to ensure the staff they have using such programs are competent collision investigators and not simply trust the program to replace staff training. Therefore, if a carrier implements this STE but does not already have a competent investigator on staff, they will have to account for the hiring of such an individual or training of staff into such a role as part of the total cost of implementation.

Contractor Safety Management Tools

Description: Contractor safety management tools help fleets monitor and enforce safety standards for independent contractors, ensuring they meet appropriate safety standards as required by regulations and by carrier policy. They are tools that are meant to standardize and simplify the processes around identifying, vetting, and managing contractors (both individuals and other corporations) that do work on behalf of the carrier.

Benefits: The main benefit of this technology is to simplify safety program management at the carrier level. Depending on the program purchased or service provider sought, the carrier may see significant staff time savings along with reductions in process errors.

Implementation: Carriers will purchase this software and then train their staff on how to use it. They may also choose to use a service provider for this task, though, instead of operating the software themselves, thereby bringing a third party in place to manage their contractor safety and compliance.

Cross-Border Compliance Software

Description: Cross-border compliance management tools help fleets navigate the complexities of operating in multiple regulatory jurisdictions, such as Canada and the US. Depending on the cargo in question, cross-border compliance requirements may be well beyond the scope of a typical carrier's staff resources, so software can assist with these requirements.

Benefits: These systems help ensure compliance with varying rules related to carrier operations and may be able to integrate with other fleet management software systems. They can reduce the staff time needed to process cross-border loads.

Implementation: Carriers purchase such software which often contains other features, so they should be well aware of what programs they already have in their operations to avoid paying for duplicate features and services. Carriers can also elect to use a customs brokerage service (a common practice) which handles most of the cross-border cargo requirements on behalf of the carrier and liaises with the applicable border authorities. It's also common for shippers to choose and, therefore, mandate a customs broker to use for their freight which effectively means the carrier must use said broker.

Customizable Reporting Engines

Description: Customizable reporting engines allow fleets to generate detailed reports on safety, compliance, maintenance, and operational performance based on specific criteria. In short, they are programs the carrier uses to track metrics to make safety and operational decisions, and they typically present the information in intuitive ways to make it as easy and quick as possible to get the necessary information with the minimum amount of work.

Benefits: These tools provide actionable insights tailored to a carrier's unique needs, improving decision-making and accountability. Custom reports also simplify compliance audits and safety reviews when used for safety management purposes.

Implementation: Reporting engines are typically included in fleet management systems, such as the standard metrics generated in a typical ELD dashboard. Fleets must define their reporting needs and train staff to generate and interpret the dashboards and reports effectively.

Cybersecurity Management Tools

Description: Cybersecurity and data privacy tools protect fleet management systems, telematics data, and driver records from cyber threats and data breaches. There are systems that may be specifically designed for carriers and logistical operations in mind to help address the more likely risks present in such operations.

Benefits: As carriers rely more on connected technology, protecting sensitive data from hacking, fraud, and unauthorized access is critical to maintaining operational security. Cybersecurity programs provide defense against malicious intent by those who try to steal from companies and individuals using the internet and social engineering.

Implementation: Cybersecurity software may be purchased specifically for fleet operations, or it could be the case that more general software is suitable for a carrier. Carriers need to ensure their software stays updated, and it is recommended that carriers regularly work with an IT service provider to assess their operations to make sure their cybersecurity program is effective.

Driver Risk Profile Monitoring Systems

Description: A driver's attitude towards risk and how they drive in response has a large impact on their likelihood of being involved in a collision (or other incident). These systems assess driver behavior over time to create risk profiles that help fleet managers identify high-risk drivers before they are involved in collisions.

Benefits: These tools allow carriers to built individual risk profiles for all of their drivers based on information from individual drivers, like speeding, hard braking events, and violations received from law enforcement. They can then identify their highest-risk drivers for the purpose of providing coaching, training, and potentially even progressive discipline to help the individual improve their driving behaviours and improve the carrier's overall safety management efforts.

Implementation: Driver risk monitoring integrates with telematics and safety management platforms, requiring ongoing analysis and follow-up actions. Carriers will also need to be sure that they manage the information for individual drivers with care and confidentiality.

Electronic Logging Devices for HOS Information

Description: Required in Canada and the US for federally regulated carriers, Electronic Logging Devices (ELDs) automatically track a driver's hours of service (HOS), replacing traditional paper logs to ensure compliance with federal regulations. Just like how they provide drivers with real-time HOS information for themselves, their office-end programs allow carriers to access real-time HOS information on their drivers without having to rely on drivers handing in paper log sheets.

Benefits: ELDs can help reduce HOS violations, minimize paperwork, and may contribute to improving fleet safety by preventing driver fatigue. They also simplify the audit process by providing electronic records of driving hours, rest periods, and off-duty time, all without delays in getting paperwork from drivers. They also allow for freight planners and dispatchers to make better choices that are appropriate for their drivers given current HOS limits.

Implementation: Implementation involves installing compliant devices in all vehicles, training drivers on their use, and ensuring managers know how to interpret ELD data. Carriers also need to train their office staff about the importance of never coercing drivers or presuming that, because a driver has remaining time, the driver is fit for duty (i.e., hours remaining on the clock doesn't mean the person isn't tired and in need of rest).

Emergency Response Management and Planning Software

Description: Emergency response plan (ERP) software helps fleets prepare for and manage crisis situations, including collisions, hazardous spills, and severe weather events. The software may provide templates to assist in designing ERPs, or it could be specific to some types of emergencies, like those involving dangerous goods.

Benefits: ERPs are important for safety management. Software that can help carriers make robust ERPs and communicate the information to staff as efficiently and clearly as possible naturally helps with overall emergency management.

Implementation: Carriers should integrate emergency response software with dispatch and telematics systems when it makes sense to do so, ensuring that managers and drivers receive proper training on emergency procedures. They can also use such programs to create non-driving-specific ERPs as required as part of general OHS requirements.

Fatigue Management Software

Description: Fatigue management is the management of risk resulting from people being tired. It's different from HOS management, which is strictly compliance-oriented and just a single part of an overall fatigue management program, as it looks beyond minimum and maximum work/rest times to better identify operational risks resulting from fatigue.

Some fatigue management software systems may use biometric monitoring, hours-of-service data, and AI-based assessments to detect and prevent driver fatigue before it becomes a safety issue. Other programs may be less tailored to individuals and, instead, help carriers modify their safety and operational activities to more proactively address fatigue.

Benefits: Fatigue-related crashes are a major concern in trucking, and this is in addition to the concerns fatigue creates in non-driving tasks, like operating loading equipment and planning routes. These systems may help reduce the risk by alerting drivers and managers when fatigue levels become unsafe for individuals when the system in question works on the individual level, and other programs can help reduce fatigue-related risk by guiding carriers in the modifications of aspects of their operations that increase fatigue amongst their drivers and other staff.

Implementation: Carriers first need to decide on the type of program they wish to implement and then follow the manufacturer's/supplier's instructions. They may be able to integrate fatigue monitoring with existing telematics systems and provide training on recognizing and responding to fatigue alerts.

Carriers can also take advantage of free fatigue management programs, like the North American Fatigue Management Program (NAFMP) that is, as of the writing of this document, being operated by the Commercial Vehicle Safety Alliance (CVSA). The NAFMP offers training and guidance on reducing fatigue risks which are specifically tailored to trucking companies.

Fleet Management System

Description: Fleet Management Systems (FMS) are comprehensive software solutions designed to oversee and optimize carrier operations. These systems typically include tools for vehicle tracking, maintenance scheduling, driver monitoring, fuel usage analysis, and compliance management. They are generally best known for their logistical benefits (i.e., simplifying aspects of dispatching vehicles given the current loads available to the carrier), but they are also related to safety management as the dispatching of vehicles impacts driver health and safety (and collision risks).

Benefits: FMS improves operational efficiency by centralizing data and automating tasks like route optimization, maintenance reminders, and safety reporting. It also helps fleets reduce costs by identifying inefficiencies in fuel consumption, vehicle usage, and driver behavior. The degree to which any individual FMS program provides these types of benefits is based on the specific feature of the FMS in question, so carriers need to understand the details for their chosen FMS.

Implementation: FMS requires integrating the software with telematics devices in vehicles and ensuring all staff trained to use the system. Regular software updates and consistent use of data insights are important, and it may be beneficial for carriers to purchase additional software services specifically for the purpose of making the integration of multiple systems easier and more reliable.

Fuel and Emissions Reporting Software

Description: Fuel and emissions reporting software tracks fuel usage and carbon emissions, helping fleets monitor efficiency and meet environmental regulations. Depending on the program in question, some may be more specifically about reducing fuel costs whereas others more about assisting with environmental regulatory compliance.

Benefits: These tools identify fuel-saving opportunities, ensure compliance with emissions standards, and support sustainability initiatives, which can also improve a carrier's reputation. In addition, since carriers are generally accustomed to collecting data related to fuel costs and quantity and then distances driven in different jurisdictions, it is more straightforward to compare the cost benefits of using such technologies by comparing adjusted savings year over year after making operational changes to improve fuel economy.

Implementation: Carriers should integrate these tools with telematics and fuel management systems. Managers need to review reports regularly and implement recommended changes to reduce fuel consumption if they are to see benefits from using this technology.

General Safety Management and Compliance Software

Description: General safety and compliance management software solutions help fleets track and manage anything related to fleet safety management, including both compliance requirements and best practices. These platforms centralize safety data and automate routine tasks like preparing for audits and managing specific hazards like fatigue.

This is a very broad and general type of safety technology. Some programs are marketed as being specific to a single aspect of the regulations, like assisting with transportation of dangerous goods (TDG) paperwork, and others are marketed as being able to assist with practically all safety considerations a carrier may require. Therefore, it's extremely important that carriers 1) understand their compliance obligations and what constitutes due diligence from a safety perspective and 2) understand that such software programs don't allow a carrier to delegate their OHS and other safety-related obligations to third parties (the carrier is still ultimately responsible at the end of the day even if a third party is doing most of the routine safety work). Common areas of compliance and safety management assistance offered by such programs include (but aren't limited to):

- NSC (i.e., Canadian trucking-specific safety regulations)
- USDOT (i.e., American trucking-specific safety regulations)
- TDG
- Incident investigation
- ERP management
- Fatigue management
- OHS (federal and/or provincial)
- Policy and procedures organization and management
- Training
- Fleet maintenance

These programs often also include dashboards and other reporting tools to help carriers track their metrics and identify areas requiring attention. They may also integrate with other software programs, like an ELD program.

Some will also offer predictive analytics. Predictive analytics are a feature of a software program where the program uses current data and existing information from the broader industry to predict the likelihood of certain events taking place. For example, a predictive analytics feature related to general safety and compliance management systems could be the identification of drivers who are more likely to receive a violation ticket related to speed or be involved in an at-fault collision. Another example could be programs that can predict the financially best time to replace certain parts of a vehicle to avoid the downtime associated with a surprise failure.

Benefits: Digitizing safety records and compliance documentation along with analytical software can help carriers ensure they meet regulatory requirements and reduce administrative burden. These tools also help identify trends, allowing managers to address risks proactively before they lead to losses.

Implementation: Safety management software is typically cloud-based and can be integrated with existing fleet management systems, and carriers may want to have their own on-site data storage as another form of backup. Carriers should ensure all managers and drivers receive training on how to use the platform effectively, based on the features, and they must understand all of their compliance and due diligence requirements before investing in such programs so as to avoid purchasing incorrect programs which easily lead to false senses of security.

Incident Reporting Systems

Description: These systems streamline the process of documenting and investigating safety incidents, including crashes, near-misses, and regulatory violations. They may be tailored to specific types of incidents and use a variety of input methods, such as having those immediately involved with the incident use their phone to put complete the incident report or allow for the scanning and digitization of existing paper-based incident report forms.

Benefits: By standardizing and digitizing reporting processes, these tools may improve incident response times. They may also similarly benefit incident investigators working for/at carriers by providing them with the information they need quickly and in a single program.

Implementation: Incident reporting tools can be integrated into existing software programs or be purchased as a standalone product/service. They may also be something a carrier creates on its own using standard office software programs.

Integration Platforms

Description: Readers of this document will notice how many different software programs a carrier could potentially have as they comply with regulations and invest in their safety programs beyond compliance requirements, and it can be the case that each individual program has its own dashboard, portal, and login requirements for its accounts. This creates a new problem: information overload and the requirement to manage many different software programs (and understand what they all do).

Integration platforms are software programs that allow multiple software programs from different suppliers to be accessed and used in a single account/program. They can also facilitate communication between different programs and may include AI features to allow for the synergistic use of data, such as using ELD and incident reporting information to better inform those working to address issues related to driver fatigue.

Benefits: Integration platforms help carriers suffering from IT overload by allowing different software programs to be accessed through a single account and, potentially, even display all of their information in a single dashboard that makes it easier to use the information. This can reduce administrative burden and help with the management of office-based technologies.

Implementation: Carriers will need to find software suppliers who offer integration platforms that can integrate the programs the carrier is already using and/or plans to add to their operations. Some larger companies may choose to create their own, but doing so requires staff and/or contractors who are competent software engineers and have a solid understanding of what the carrier is trying to accomplish so compliance obligations are not missed (along with opportunities to improve safety performance beyond regulatory compliance).

Learning Management Systems

Description: Learning Management Systems (LMS) provide digital platforms for delivering, tracking, and managing training programs. They often can be modified to suit particular user needs, and some are more focused on workplace safety and transportation than others.

Benefits: LMSs can help a carrier ensure that drivers complete mandatory training and receive updates on safety protocols and regulatory changes by organizing the company's training program. They also allow carriers to customize training based on specific needs and develop their own training, or they can offer a suite of previously developed courses, saving the carrier the time it would otherwise have to invest in developing all of their training internally.

Implementation: LMS platforms may be able to integrate with fleet management systems, allowing managers to assign and track training progress. Drivers need access to devices (tablets, smartphones, or computers) to complete courses, and it might be the case that the carrier implements the LMS completely independently of other systems, choosing to have more oversight in delivering training.

Regardless of the LMS being used, carriers need to understand what training is required by regulations and what training should be provided as part of being duly diligent. So, while an LMS can help in this task, the carrier still needs to have a solid understanding of the purpose of the LMS and the role it plays in developing overall driver and staff competencies. Furthermore, carriers must also vet the contents of all training they provide to their staff so that it is clear if the training is sufficient for its intended purpose.

Pre-Employment Screening and Hiring Tools

Description: Pre-employment screening and hiring tools help fleets evaluate potential drivers by analyzing their driving records, background checks, and qualifications. Some forms of background checks are required by regulations whereas others are elective; pre-employment screening programs and their associated software tools provide a way for carriers to digitize these processes and manage the resulting information.

Benefits: These tools reduce the risk of hiring unqualified or unsafe drivers, improving fleet safety and compliance. They also streamline the hiring process which can alleviate administrative burdens.

Implementation: Carriers may be able to integrate these tools with their safety and HR systems. They also need to be aware of legal requirements for various types of background checks and how to store the information.

Predictive Maintenance Software

Description: Predictive maintenance platforms use data analytics and AI to forecast when truck components are likely to fail, allowing fleets to perform maintenance before breakdowns occur. These programs may be standalone software products or part of a larger FMS/TMS.

Predictive maintenance software is based on the acceptance of preventative maintenance as a good business strategy. The goal of preventative maintenance is to ensure vehicles do not have breakdowns by pre-emptively replacing parts that are still functional but at a point in their duty cycle where the risk of failure is high enough to justify their early replacement, thereby reducing costs associated with unanticipated down time and the safety risks that go hand-in-hand with breakdowns.

Benefits: The trick with preventative maintenance is to replace parts at a time that balances the costs associated with early component replacement against the costs associated with breakdowns and accompanying downtime (and operational disruptions). OEMs have been providing preventative maintenance schedules for their vehicles for decades, but the introduction of AI and analytical software into the fleet maintenance world has allowed companies to move beyond one-size-fits-all preventative maintenance schedules into the schedules that take more carrier-specific information into account, like areas of operations, vehicle types, and driver behaviours. The overall benefit from these programs is a more accurate preventative maintenance program that reduces both costs associated with replacing parts too early and costs associated with breakdowns.

Implementation: These programs can end up being highly customized to a specific carrier. Implementation, therefore, involves working closely with the product supplier and vehicle OEMs as-needed to ensure the system is working to the best of its ability.

Simulators and Virtual Reality

Description: Simulators and virtual reality (VR) systems are training tools that allow for specific work-related tasks to be practiced in an artificial environment. This artificial environment is removed from the worksite where the tasks would typically take place. While there are far more detailed sources of information on these types of technologies and both create simulated training environments, we can generally distinguish between the two as follows: both are simulators, but VR systems have the user wear equipment that generally includes a headset that covers the eyes and ears to provide a more immersive training experience.

Driving simulators typically have a seat, realistic vehicle controls, screens that provide visuals (like looking out a windshield), speakers for sound, and sometimes even features like seats on moving platforms to simulate vehicle movements. There are other types of simulators carriers may use, too, such as simulators that provide a training environment for slippery surfaces to let staff practice walking and falling in a safe environment (typically while also wearing fall protection harnesses). Simulators and VR systems also aren't necessarily completely different types of technology. Some simulators may include VR headsets as an option or even as a replacement for screens and speakers (which shows how these STEs can overlap with each other).

Benefits: Simulators and VR systems allow specific skills to be practiced in a low-risk environment. For example, a driving simulator will let drivers practice entering ditches, avoiding rollovers, and other emergency driving maneuvers that would otherwise not be safe to practice in actual vehicles on actual roadways. This allows for actual, systematic training on skills that drivers would otherwise never be able to practice repeatedly, allowing for the building of competencies that can greatly improve a driver's ability to avoid a collision and/or reduce a collision's severity.

Simulators specific to certain types of vehicles also allow drivers to become familiar with features and handling characteristics of new vehicles. Furthermore, they can typically be tailored to individual carrier operations, such as being used to simulate specific routes or conditions, or even outfitted with specialized equipment like snowplow controls.

Implementation: These types of STEs are generally implemented one of two ways. They may be purchased by a carrier and installed either in a fixed location or mobile trailer. Or, they may be rented from organizations like safety associations. For example, AMTA has simulator rentals that offer a variety of options for different training scenarios. Since simulators and VR equipment can be very expensive, it's common for smaller and medium-sized carriers to rent whereas larger organizations may choose to purchase their own units.

Simulators and VR systems also require a corresponding training program and plan to be effective. The carrier will need to decide how to train their drivers in a way that makes the best use out of the equipment. For example, carriers that operate snowplows often rent or use their own simulators in the late summer or early fall to systematically put all their drivers, regardless of seniority, through basic snowplow refresher training in preparation for winter. Organizations like AMTA that offer simulator rentals will often further assist carriers by providing instructional assistance to help the carrier get the most out of their rental.

Telematics (General Concept)

Description: Advanced telematics systems use GPS, information from the vehicle's ECM and other sensors, and any other source of related information to monitor vehicle performance, driver behavior, and real-time location. These systems provide valuable insights into safety, efficiency, and compliance. Many different STEs rely on telematics to function properly, and so it's a common term in modern fleet safety management.

Benefits: Telematics provide information that can be used to improve safety by identifying risky driving behaviors, informing preventative maintenance programs, and supporting other technology types identified in this document. Fleet managers can use this data to coach drivers and enforce safety policies. Additionally, real-time tracking improves dispatch efficiency and emergency response.

Implementation: Most carriers already have access to basic telematics through their ELD system, but more advanced systems integrate multiple data sources and can be paired with predictive technology. Implementation requires training for both drivers and other staff to ensure data are used effectively and that people understand the ways in which the technology impacts their daily tasks.

Transportation Management Systems

Description: Transportation Management Systems (TMS) focus on optimizing the planning, execution, and tracking of freight movements. They provide tools for load matching, route optimization, freight billing, and customer communication, and the term TMS is generally used more in a logistical and operational sense than a safety one. However, the term TMS is often used interchangeably with terms like FMS and other language in this document, so carriers should carefully examine the features of any such system to fully understand what it can and can't do.

Benefits: TMSs can help a carrier optimize its operations by helping dispatchers, salespeople, and other staff maximize loaded distance driven (or whatever other metrics are used by a carrier to track revenue generation). A TMS also has safety management benefits when information related to safety and compliance, like HOS data for drivers and real-time weather reporting, are used in the freight planning process.

Implementation: TMSs may integrate with fleet management and logistics platforms or may be standalone systems; it is recommended that carriers explore integration options to ensure systems talk to each other and to get the most value out of their investment. Training is needed to help dispatchers and drivers use TMS features effectively.

Chapter Five – Safety Management Practices (SMPs)

This section of this paper presents a list of safety management practices (SMPs) that help prevent collisions, staff injuries, and other negative safety-related incidents. This paper treats a single SMP as a unit or component of a larger overarching occupational health and safety management system (OHSMS). This allows for a more detailed examination of individual OHSMS components, but that also doesn't mean that an OHSMS is simply the sum of its parts: OHSMS development and administration represents another area of professional knowledge that is not addressed in this book. You can contact AMTA for information and guidance on how individual SMPs and their overarching OHSMS can be implemented and tailored to a specific organization.

So, why does this resource that contains so much information on safety technology have a part dedicated to management practices which are more about human activities than technology? This is because safety technologies are aids for carrier safety management, not replacements.

Technology is exciting. Technology is promising. Technology holds potential solutions for the frustrations and tragedies of today. However, sometimes the hype and marketing around various safety technologies paints an overly optimistic picture. Without active safety and general management practices, technology meant to improve operational and safety performance will generally fail due to improper implementation, a lack of understanding about what it can do and its limitations, and improper post-implementation management and evaluation (among other factors).

Safety technologies are capable of great things in terms of eliminating some forms of administrative burden, giving us access to better information, and improving the experience of driving vehicles. Most importantly, they're giving us the option of empowering ourselves to improve safety performance in ways previously not possible.

Safety technologies don't make us smarter, though; that's up to us. Therefore, it's critically important to think about the human activities involved in fleet safety management alongside technological advancements. When we manage our safety systems and programs, we must continue to be experts in minimum compliance requirements, what best practices exist in our part of the industry, how we can be duly diligent in our safety activities, and what are the most effective ways to prevent collisions, injuries, and improve working conditions within our industry. To do this to the best of our abilities, safety professionals and other industry leaders need to also develop skills related to technologies so we understand where the capabilities of a specific type of technology can help us in these efforts. In other words, carriers should invest in the ongoing professional development of their staff alongside investments in STEs and SMPs.

This part of this resource is meant to explain individual SMPs. There is no point to investing in safety technology without an OHSMS and the staff to manage it, so carriers should be aware of their current safety management strengths and weaknesses before contacting safety technology providers so that they can remain in control over the procurement process and see the best possible results.

Are SMPs HSI- or MSI-Based?

Important note: *If you are not sure what the abbreviations "HSI (human safety intervention)" and "MSI (machine safety intervention)" mean or are confused about the concepts of human versus machine involvement in safety technology and safety management in general, it's recommended you go the first part in this resource and read the section titled "Understanding HSI and MSI" before continuing.*

By definition, safety management practices (SMPs) require human intervention to work. None of the individual SMPs discussed in this section are things that can be purchased and implemented without then also investing in ongoing management and refinement.

The terms HSI and MSI aren't applicable for SMPs like they are for safety technology elements (STEs). We created the language "human safety intervention" and "machine safety intervention" specifically to help further explain and categorize all the new STEs that are available or soon to be released. The SMPs presented in this resource aren't explained in terms of their use of technology; instead, we present them as concepts so that their purpose and objectives are clear so that carriers and other readers can see how they form aspects of, and eventually a whole, OHSMS.

That being said, it's not the case that SMPs are not compatible with technology. All of the STEs in earlier parts are related to one or more SMPs; after all, the technology discussed in this resource is meant to assist in fleet safety management. However, it's important to understand what an OHSMS and its individual components are if one wants to be able to implement a specific STE. So, don't think of technology and management practices as mutually exclusive. They all can work together to produce better safety performance, and carriers have all of the various STEs and SMPs in this resource (and more, given how fast innovation takes place) to consider as options to help them build an OHSMS that is unique and well-suited to their specific operations.

Safety Management Practices (SMPs)

Active Management of STEs

Description: Most safety technologies require active management to be effective, such as critical incident detection systems or HOS data from ELDs, and this document has indicated which are of this type by describing them as HSI-based (i.e., they require human intervention to be effective). This SMP ensures that the carrier actively uses the technology to its full benefit.

In other words, it's rarely the case that safety-related technology can be purchased, implemented, and then left alone to he effective: carrier staff still need to take action based on how the specific technology works. So, carriers will need the staff resources (or third-party assistance, like a fractional consultant) to actually benefit from their investments in safety management technologies.

Benefits: By actively managing safety technologies, carriers can maximize their effectiveness, ensuring that they contribute to a safer working environment and reduce the risk of incidents. Without this SMP, many technologies will be of little or no value.

Implementation: This SMP is specific to each technology, requiring identification of the technology, proper management practices, and evidence that the carrier is using the technology effectively. The amount of staff resources needed will vary, and carriers should consult with suppliers, manufacturers, and safety professionals/associations for further guidance.

Active Program or System Administration

Description: Active system administration ensures that the safety program is not just a binder on a shelf but reflects the carrier's day-to-day activities and is actively managed to address safety concerns. The goal of active administration is that safety procedures and are key for the system to bring about safety benefits are being followed because management has set the example that it is the right thing to do, not just something that is portrayed as a side-of-desk task or otherwise implied to be only important during audits and investigations.

Benefits: By actively managing the safety program, carriers can ensure that safety protocols are followed, concerns are addressed, and the program evolves with the organization's needs. Without this SMP, the safety system never truly functions as a system.

Implementation: This SMP is demonstrated by regular documentation showing that the safety program is actively managed, with traceable pathways from safety concerns to implemented solutions. Evidence should also include proof that all policies and procedures are actively followed and that the person or department responsible for the SMP is competent and engaged.

For example, the tracking and use of quantitative metrics which would be part of the evidence for this SMP, whereas tracking metrics but not responding to them would be evidence against.

Advanced Driver Substance Abuse Programs

Description: Advanced driver substance abuse programs go beyond legal compliance to proactively manage the risks associated with drug and alcohol abuse. In short, this SMP is any form of substance abuse risk mitigation beyond minimum compliance requirements, such as providing proactive counseling services and working to actively address corporate cultural issues that may contribute to substance abuse. This can also include hair testing or other screening processes for identifying impairment.

Benefits: These programs help address substance abuse issues before they lead to unsafe driving behaviors. They can also help improve general organizational culture by addressing stressors that could be contributing to substance abuse issues if this SMP is used firmly yet compassionately.

Implementation: This SMP is evidenced by the use of service providers or an internal system that promotes awareness, clarifies reporting requirements, informs drivers of their rights and responsibilities, and meets compliance requirements. The carrier also needs to demonstrate its competency in this area so that information is handled with care and in accordance with privacy regulations.

Competency Assessments - Initial and Ongoing

Description: Employers are, generally speaking, required to ensure all of their drivers, some types of contractors, and other staff are competent to do the work assigned by the employer. While definitions of competent vary, the OHS use of this term is typically along the lines of ensuring an individual has the training and experienced necessary to be able to do their work with minimal or no direct supervision. This SMP is the specific program carriers should have that allows them to assess the competency of their individual drivers and other staff, both initially upon hiring or reassignment to a new role and on an ongoing basis.

This is distinctly different from SMPs related to assessing and managing contractor qualifications and competencies. They are related, but contractor qualification management SMPs often are not thorough to the degree necessary to assess competency and are more about providing a base level of vetting as part of the employer's due diligence when selecting contractors who are otherwise not their direct responsibility.

Initial competency assessments are typically one-time events that must take place as part of hiring someone, when adding additional duties to someone's role, and when someone is reassigned to a new position (like moving from a local driving role to an OTR position). Ongoing assessments, on the other hand, are tests, observations, and other assessments of individual staff/driver skills done routinely based on time (like annual defensive driver training) or other strategic moments (like refresher training and assessments done for hauling a new type of cargo for an infrequent customer). Carriers are generally better at initial assessments than ongoing ones, but never reassessing safety-sensitive skills is a gap in an OHSMS and is evidence a carrier is not being duly diligent. After all, skills fade, people's abilities change, and equipment and job duties evolve. These are just a few reasons why ongoing assessments of competency even for people who do not have changes in their positions are important for safety management.

Benefits: Besides meeting various compliance requirements and providing evidence of due diligence, initial and ongoing competency assessments help carriers make sure they have the right people in their various positions. Competency assessments can be as thorough and detailed as needed to ensure that individuals are capable of performing the various duties associated with their role. Drivers especially benefit from initial and ongoing competency assessments because there are many professional driver skills that are important but infrequently used in some operations, like putting on tire chains or mountain driving. A system for regular competency assessments at key times, like reassessing tire chain and winter driving skills annually in the fall, enhance the skills of individuals while providing greater reliability for the carrier.

Implementation: Carriers can demonstrate they have implemented this SMP by having documented policies and procedures related to what types of initial and ongoing competency assessments they do and when they are done. Implementation will also require the carrier to be able to demonstrate they have documented all occurrences of training and that they are in compliance with their own policies and any applicable regulations.

Competent Safety Professionals

Description: Carriers need to have competent people running their individual safety programs and overarching safety management system. Having competent safety professionals in place to do this work is critical, just like how any other job can only be done well by competent individuals.

This SMP is about carriers being able to demonstrate they have competent safety professionals in place. There isn't a single licence or qualification needed for a safety professional working in trucking or other fleet safety positions, but there are still many options, from individual courses to professional designations like AMTA's CTSP and CTSC designations. Having training like this, along with documented experience, helps show that a carrier has competent staff in charge of safety.

Benefits: Competent safety professionals provide greater confidence to management that they are indeed operating safely and compliantly. Having competent people in these positions naturally leads to more efficient operations and also allows more junior staff to benefit through mentorship.

Implementation: Carriers have to be able to show that specific individuals have defined scopes of work and the training/experience/skills to do this work. There are many ways this could look, but training is one aspect that typically comes with documentation like certificates, and these are evidence of staff competency as long as the carrier can show how the specific training contributes to the individual's overall competency as a safety professional.

Compliance Management

Description: A compliance management program ensures that carriers are proactively complying with current laws and taking steps to stay ahead of regulatory changes relevant to their operations. While compliance is the key, this SMP is more than just being compliant with current rules: it involves processes where the carrier actively and routinely seeks out information related to current and upcoming regulations to ensure any actual changes in regulatory requirements are being met and that the carrier is aware of and planning for proposed changes to regulations.

Compliance should be intentional and ongoing, not left to chance or past actions. Carriers must actively monitor their compliance status and anticipate future requirements. While this can be a daunting task for those who are unfamiliar with how the industry's regulatory systems work, compliance isn't optional, so carriers might as well be proactive with their compliance instead of ignoring requirements and changes only to find out later the hard way through tickets, violations, incidents, and other liabilities.

Benefits: Carriers can maintain compliance, avoid legal penalties, and ensure the safety of their operations by developing a system of compliance management. Proactively working to ensure compliance has the added benefit of allowing the company to work upcoming compliance changes into their operations in a predictable manner instead of finding out too late and then having to make rushed changes and, if the new rules impact operations, potentially lose profitability due to the costs associated with adhering to new regulations that were not considered in past rate quoting and contract negotiations.

Implementation: This SMP is demonstrated by regular audits of operations for compliance, involvement in industry associations to stay ahead of regulatory changes, and documented evidence of proactive compliance management. The ways in which a carrier performs the activities associated with this SMP are largely dependent on the specific types of regulations and nature of the carrier's operations, but active engagement with external organizations like government, law enforcement, and industry safety and compliance associations are likely mandatory to truly be able to demonstrate this SMP has been implemented.

Contract Driver Safety Management

Description: Trucking relies heavily on contracted labour, from dependent contractors leasing vehicles to true owner-operators with their own insurance, registration, and operating authorities. Even though contractors typically are more separated and independent from the carrier than employee drivers, the carrier still is generally responsible for their actions and will have some degree of vicarious liability should a contractor be involved in a collision, injure themselves or others, damage customer property, or otherwise cause issues that if they were a company driver would require disciplinary action from the carrier.

Important: Some forms of contract labour are actually forms of employee misclassification, like claiming a driver is an independent contractor when, in reality, they would be classified as an employee for tax purposes. Misclassification, whether intentional or unintentional, has serious negative consequences for the individual driver and carrier, and carriers must be aware of how to legally employ/contract their labour and the corresponding legal requirements related to safety, pay, WCB, and labour.

Benefits: By carefully managing contractor relationships, carriers can ensure that safety is not compromised and that they are compliance with laws related to labour, pay, and taxes. Proper oversight can help prevent the incentivization of unsafe behaviors, leading to better safety outcomes for all involved.

Implementation: This SMP requires carriers to critically examine their use of contractors, ensuring that these relationships do not inadvertently promote unsafe behaviors. They also need to be able to justify their use of contractors, especially when the contractor’s regular duties are similar to what would be expected of an employee. Implementation also includes proper employment/contractor agreements (i.e., contracts), clear policies and procedures on responsibilities related to safety, and analysis of agreements and policies to ensure they do not encourage unsafe behaviours.

Driver Compensation Structure

Description: The way drivers are paid can have a significant impact on both on-road and in-yard safety performance, influencing behaviors related HOS compliance, risk taking, and participation in safety program requirements. While a controversial issue at times, productivity-based pay (i.e., pay by the mile, pay by percentage of revenue, pay by number of loads, etc.) incentivizes risky behaviours like violating HOS rules, cutting corners and rushing through tasks like cargo securement and vehicle inspections, and speeding. Driver pay is, therefore, a hazard that needs to be considered in safety management, and various ways of structuring driver pay deals can address this type of hazard.

As a result, it is now typical for carriers to have some aspects of their driver pay structures that pay drivers based on time, not just on their productivity. Some carriers pay hourly or by salary (which is especially common amongst private fleets), and others create hybrid pay systems that may pay drivers based on distance traveled but also include provisions for paying drivers for non-driving tasks (like time spent loading and doing inspections) and for delays not within the driver's control, like being stuck in heavy traffic, waiting for a load that wasn't ready, vehicle breakdowns and repairs, and road closures.

Benefits: Properly structuring driver compensation helps ensure that pay systems do not inadvertently encourage risky behavior, both while driving and during non-driving tasks. By critically examining compensation structures, carriers can reduce the risk of collisions and improve overall safety performance. This SMP also helps carriers meet compliance and due diligence requirements related to OHS where regulations require employers to address psychosocial hazards in addition to physical, chemical, biological, and other classes.

Implementation: This SMP does not require carriers to adopt a specific compensation system. Instead, it requires a critical examination of the existing compensation structure for both employees, contract drivers, and even subcontracted businesses to ensure that methods of pay are not incentivizing risky behaviours that could create negative safety outcomes and increase carrier liability.

Driver Engagement Programs

Description: Driver engagement programs are initiatives by the carrier to involve drivers in the safety program to attempt to prevent opposition to the program and safety practices. These programs also typically address other aspects of drivers' roles, seeking to improve engagement in terms of overall job satisfaction and company culture. Furthermore, they should have some process in place where drivers can provide feedback to help in the creation and refinement of safety rules.

Engagement programs, generally speaking, are traditionally associated with the HR world. With psychological health and safety now being a component of OHS, though, the fields of OHS and HR have a great deal of overlap while professionals in each discipline have varying degrees of skill overlap and distinctness in training and competencies. So, it often makes sense to have a carrier's safety and HR departments/people collaborate on engagement programs to make sure the program is benefiting from the skills each discipline brings to the project.

Benefits: By involving drivers in safety decisions and processes, carriers can foster a culture of safety where drivers feel valued and responsible. This allows carriers move towards a positive safety culture and benefit accordingly.

SMP Implementation: This SMP is demonstrated by evidence of driver involvement in the safety program, such as active safety committees, documented consideration of driver suggestions, and positive responses to safety-related complaints. Implementation can also be assessed through the use of surveys and interviews to assess metrics related to engagement before and after program implementation.

Driver Health and Wellness Programs

Description: These programs encourage and support the adoption of healthy habits among drivers, contributing to their overall well-being and safety. While these programs can vary greatly, they generally all address exercise and diet in ways that are reasonable given the job demands of a professional driver. Modern programs also tend to include elements related to mental health and take a more holistic approach to health and wellbeing.

Health and wellness programs vary greatly from one to another. Given the unique working conditions of professional drivers like long-haul truckers, the offerings from such a program have to be realistic. For example, some wellness programs might include gym membership discounts, but that is not useful for a long-haul trucker who would rarely be in the vicinity of a gym. Instead, exercise programs that can be done in a sleeper cab make more sense, along with food recommendations that reflect the resources the driver has on-hand in their vehicle in terms of storage and preparation.

Benefits: Promoting health and wellness among drivers can lead to fewer health-related incidents on the road, improved driver performance, and a reduction in collisions caused by health issues. More directly, though, these programs can improve driver retention and recruitment if they contribute to overall improvements in carrier culture and working conditions.

Implementation: This SMP is evidenced by a documented program that is accessible and meaningful, with evidence of driver participation. If the program is purchased from another organization, there must be evidence that it is actively used and not just for show.

Emergency Response Planning

Description: An Emergency Response Plan (ERP) is a plan created proactively for specific negative events like fires, collisions, hazardous spills, and other emergencies, to ensure a coordinated and effective response. They contain key information related to initial actions for drivers and staff, have contact information for the applicable people and organizations and the order in which they should be notified (including external assistance, like fire or police), and details on hazards specific to the incident being covered by an individual ERP.

ERPs are a component of safety management, and there are typically compliance requirements for basic ERPs for all carriers which vary based on jurisdiction. However, they also represent an opportunity to be proactive, improve due diligence, and improve overall carrier safety culture. ERPs also require training for all applicable staff on an ongoing basis in order to be effective, and they also require the careful placement of targeted information in key locations for specific individuals to speed up initial actions. For example, while a carrier's ERP for collisions may be a very detailed document, there should be a quick reference version in every vehicle that contains just the information the driver needs to know for their part of the ERP so they do not have to waste time sifting through large documents during an actual emergency.

Benefits: Well-prepared ERPs help carriers minimize the impact of emergencies, protect lives, and reduce damage to property and the environment. They provide opportunities for active safety management during training, and they can greatly ease anxiety in individuals by providing clear information on what actions the company takes for various incidents, demonstrating to staff that their employer is concerned for their wellbeing and is proactive in doing so.

Implementation: This SMP is evidenced by a documented ERP system, with regular reviews of existing plans, the creation of new ERPs as needed, and training exercises (e.g., drills or tabletop exercises) to ensure staff can effectively implement the plans in stressful situations. It is fairly easy to find generic ERPs online to solve immediate compliance problems, so proper implementation requires evidence that the ERP in question is tailored to the carrier and updated.

Fatigue Management

Description: A fatigue management program recognizes the impact of fatigue on safety, both on-road and in-yard. It includes measures to proactively and reactively ensure that individuals are fit for duty, and such programs also generally involve an analysis of a carrier's operations to identify high fatigue-risk areas where operational changes or additional safety precautions should be implemented.

It's very important to understand that fatigue management is not the same as HOS management. HOS management is the management practice of ensuring the carrier complies with the applicable HOS regulations for their operations. However, HOS management ends with compliance whereas fatigue management goes further than HOS compliance to actively apply sleep-related best practices to reduce associated risks. In other words, HOS management is part of fatigue management, but fatigue management is much more than HOS management.

Note: Although sleep apnea management can be part of a fatigue management program, it is considered a separate SMP in this book to allow us to further explain each concept.

Benefits: Managing fatigue helps prevent collisions by ensuring that drivers and other personnel are alert and capable of performing their tasks safely. This leads to fewer incidents and a safer and healthier working environment. Additionally, fatigue-related collisions are often higher-severity due to the driver being less alert and, therefore, likely to take more time in responding to prevent a collision which can result in the vehicle leaving the road or hitting other vehicles/obstacles at higher speeds than if the driver had been more attentive and taken earlier action to slow the vehicle prior to impact. In this way, fatigue management can contribute to both reduced collision frequencies and severities.

Implementation: The SMP is evidenced by the existence of policies and procedures related to fatigue management, with documented proof that these are actively followed; additional implementation evidence could be the use of services from a third-party. Only verifying HOS compliance is not evidence the carrier has a fatigue management program.

Hazard Identification, Assessment, and Control

Description: The process of hazard assessment is foundational to any safety management system. While there are different methods, the general process a carrier follows is:

1. Identify all jobs/positions within the organization, including contractors.

2. Identify all the tasks individuals are expected to perform in their positions.

3. For each task, identify all hazards associated with the task. Also identify hazards related to the carrier's operations that could negatively impact people who may come in contact with the carrier's operations but aren't employed by the carrier (i.e., hazards to the general public, neighbouring businesses, etc.).

4. For each identified hazard, identify ways to either eliminate the hazard or reduce the risk it poses to people by identifying specific controls.

5. Implement the controls or take action to eliminate hazards based on the above steps.

6. Monitor the effectiveness of the hazard controls and repeat this entire process regularly and as conditions/operations change.

This SMP requires ongoing and regular action by the carrier's management and safety staff in order to be effective. Hazard assessments are not effective when done only once or just for the purpose of compliance or obtaining a voluntary safety standard certification, like a COR.

Benefits: By anticipating and controlling hazards, carriers can prevent collisions and protect the health and safety of their workers and the public. In addition, there are regulatory OHS requirements for carriers to have a system in place to do this sort of safety management, so this SMP also assists with meeting compliance requirements.

Implementation: This SMP is demonstrated by documentation of a formal hazard assessment program that identifies appropriate safety controls, with evidence that these controls are actively implemented and regularly evaluated. In addition, the carrier's identified hazards should reflect their operations and also hazards generally associated with the industry.

HR and Safety Collaboration

Description: Safety and HR, as disciplines/professions, are well-established as essential organizational elements in any business, and carriers are no exception. Smaller organizations may not have formal HR and Safety departments, and it is common to see these roles merged into a single department or even a single individual, based on the size of the organization and its operational complexity.

While they are different fields and professions, Safety and HR have overlapping responsibilities, especially with the requirement for employers to address safety risks regarding psychological safety, an area that used to be seen as strictly within the HR realm. Therefore, proactive safety management should include collaboration between Safety and HR so that the strengths of each can compliment the other and so that decisions made by one are considered in terms of their impact on the other.

Benefits: Intraorganizational collaboration, in general, improves communication and cross training within a carrier's operations. Duplicated work processes may be discovered, improving efficiency, while problems within either Safety or HR may benefit from the alternate viewpoint of the other, including assistance with compliance requirements.

Implementation: Assessing the implementation of this SMP will vary greatly between carriers, especially when they differ in size. Small carriers where a single person handles Safety and HR issues (and potentially even other duties) would not be expected to implement this SMP since the same person is handling both, and large carriers with separate HR and Safety departments would need to show evidence of collaboration (like meetings, communications, and even policies related to collaboration) to show they have implemented this SMP.

Incident Investigation Program

Description: A systematic approach to incident investigation ensures that all incidents are thoroughly examined, with recommendations brought back to management for action to prevent reoccurrences. For carriers and any organization operating a fleet, the investigation program also needs to specifically address collision investigations and the unique skills and practices related to these types of incidents.

Incident investigation methods vary greatly. In general, though, they should all have some form of root cause analysis and pathway for corrective actions to take place. Based on the carrier's operations and jurisdiction, there may also be specific compliance requirements regarding incident investigations that will have to be included in this SMP. Finally, carriers will have reporting requirements for incidents based on their type and severity, such as when a collision needs to be reported to police or when an incident on employer property needs to be reported to the applicable OHS authorities.

Note: For complex investigations, the carrier may retain external organizations or consultants to ensure thorough and unbiased analysis. This is generally recommended for most organizations besides the truly massive as some investigations, like those involving violence and harassment or environmental damage, require specific skill sets that investigators with collision and general OHS investigation training and experience likely lack. Carriers must define the scope of their investigation resources and know when to reach out for external support.

Benefits: By investigating incidents thoroughly, carriers can identify root causes, implement corrective actions, and prevent future occurrences, leading to improved safety. Investigations can also contribute to compliance requirements and are part of being duly diligent.

Implementation: This SMP is evidenced by policies and procedures for incident investigation, proof that these are followed, and recognition that different incidents require different investigation techniques. Evidence should also show that investigation reports identify true root causes, recommendations are made, and management addresses these beyond simply disciplining those involved.

Industry Engagement

Description: This SMP ensures that carriers do not operate in isolation but actively engage with other carriers, regulators, and industry associations to share and improve safety management practices. It may look quite different from carrier to carrier, but examples of what industry engagement looks like include active membership in safety associations, having staff participate on committees and similar activities at the industry level, volunteering at events, taking regular training not just for compliance purposes, and attending meetings and conferences for networking and professional development purposes. These sorts of activities, for this SMP, are them formalized by the carrier to become a routine aspect of safety and overall management.

Benefits: By engaging with the broader industry, carriers can learn from others, share best practices, and contribute to the overall improvement of safety standards in the industry. Safety associations in particular can empower carriers to stay updated on the latest safety practices, contribute to the development of industry standards, and improve their own safety management practices. So, not only are there direct benefits to the carrier, but there are also the benefits that come from participating in larger activities meant to provide overall industry improvements, allowing individuals and carriers to leave their own, positive legacy on the industry.

Implementation: This SMP is evidenced by involvement in government working groups and industry associations, an established professional network for key safety decision-makers, regular reviews of relevant incidents from other carriers, and other demonstrations of industry engagement related to safety. Implementation of these activities as part of the carrier's OHSMS can look like policies and budget for participation.

Integrated Safety Frameworks

Description: Holistic safety management considers all aspects of safety, including NSC/USDOT (i.e., transportation-specific) regulations alongside OHS regulations, ensuring that different safety programs work together rather than in isolation or even in conflict. This SMP involves formally examining the various regulatory frameworks that apply to the carrier first to ensure compliance, then identifying applicable best practices to develop a proactive safety program, and then working to ensure that the individuals responsible for their management within the carrier talk to each other and have a reasonable degree of cross-training to ensure the institutional knowledge related to safety isn't siloed.

Even though carriers may choose to isolate aspects of overall safety management, there are risks in doing so. For example, the NSC/USDOT aspects of safety management require compliance with HOS rules and that the carrier enforce their proper use in its driver (and other staff populations as applicable, like dispatch) population. However, if the carrier chooses to take an aggressive approach to dealing with noncompliance that involves harsh language and shaming for noncompliance, then they risk introducing psychosocial hazards into their operations such as bullying, harassment, and interpersonal conflict between those enforcing the HOS rules and those subject to the enforcement.

In the above example, the NSC-side of the carrier is doing its work to ensure HOS compliance, which isn't wrong. However, their approach is wrong from an OHS and HR perspective, meaning that while they may be solving NSC problems they are creating OHS/HR ones. Ensuring that NSC/USDOT safety management is done with OHS and HR considerations in mind allows carriers to, first, avoid having one part of the organization create problems and risk for another and, second, to leverage the strengths of different safety management frameworks to improve overall carrier culture.

Benefits: By integrating all relevant safety frameworks, carriers can create a cohesive safety program that addresses all potential risks and prevents conflicts between different safety initiatives. Another significant benefit is that individual staff members will have more awareness and knowledge in what their coworkers are doing, reducing the risk of significant institutional knowledge loss should a key individual leave the organization or take leave.

Implementation: This SMP is evidenced by systems that integrate all regulatory and SMP frameworks, with documented collaboration between those managing different safety programs to ensure synchronized actions. This might be evident in the organizational chart, or it could be demonstrated perhaps by interdepartmental meeting minutes and documented cross-training, like ensuring those responsible for NSC compliance also have basic OHS and HR training (and vice versa).

Journey Management

Description: Journey management involves optimizing routes for safety and profitability. Journey management programs typically include policies that requiring drivers to check in regularly with the carrier (including staff who aren't professional drivers but are traveling for work purposes) and to check on road conditions prior to their departure.

There is much more to journey management, though. A journey management program may include evaluating specific stretches of road and intersections to perhaps prevent past incidents and proactively identify areas of congestion and high-risk driving, and it could include the use of technology to insert real-time road and weather conditions into trip planning to make safer and more efficient decisions, like receiving notification when a particular mountain pass requires tire chains so they can alert their drivers in the area to stop and wait for conditions to improve. Another example could be a carrier that decides to prohibit its drivers from making left turns at uncontrolled intersections on major highways and in urban areas to reduce collision risk and even speed up deliveries if significant delays can be expected from trying to attempt such left turns.

Benefits: Carriers can reduce the risk of collisions and ensure that drivers have safe, efficient routes to follow by implementing a journey management plan. In addition, this SMP can help a carrier meet safety compliance requirements related to working alone (depending on their jurisdiction).

Implementation: This SMP is demonstrated by evidence that the carrier works with drivers, shippers, and other stakeholders to optimize routes for safety purposes. Such evidence typically includes polices and procedures but would also include the carrier being able to demonstrate how it uses, for example, real-time weather and construction information to adjust trips.

Management Commitment

Description: Management commitment to safety is essential, with safety being held as a core value within the organization. Any organization where top management isn't committed to safety or is perceived to be noncompliant with their own rules will struggle to improve safety performance beyond what those directly responsible for safety are able to do with their own resources.

A common example of a lack of management commitment creating safety problems in the trucking industry is when safety and operations are set up antagonistically. It's an unfortunately common dynamic within trucking to have drivers be caught between these two aspects of their employer where they receive direct or indirect messaging from operations to push or even break safety rules while simultaneously receiving messaging from safety to adhere to the rules. In such a situation, top management will have to take action to address this intraorganizational tension as no one else will have the authority to do so. The existence of such dynamics is evidence that management is not truly committed to safety or is unaware of the problem because they are somehow too distant from their front-line individuals and managers/supervisors.

Benefits: When management is actively involved in safety, it sets the tone for the entire organization, leading to a stronger safety culture and better safety outcomes. It is generally a requirement companies wishing to achieve a voluntary safety standard certification, like a SECOR or COR. It is also a critical aspect of due diligence and, without it, may increase liability for senior managers and owners.

Implementation: This SMP is evidenced by documentation, such as signed policies stating management's commitment to safety. Additional evidence includes documentation of senior management and ownership being involved in safety-related activities, like participating in workplace inspections and safety committees, taking timely action to address safety issues, and investing appropriately in the safety program and the professional development of its staff. Evidence that management actively breaks safety rules or does not prioritize safety is evidence this SMP has not been implemented.

Metrics

Description: Metrics is a term that means any sort of number that tells us something about an organization's effectiveness. For example, the rate of employee turnover in driver positions over a specific period of time is a metric. Safety-specific metrics include injury rates, collision rates, insurance loss ratios, and regulator-issued safety scores, like the R-factor from an Albertan Carrier Profile.

Safety management can use metrics to track effectiveness in many different ways. Furthermore, it's extremely important that the metric is well-understood and makes sense in how it's interpreted. For example, a simple metric is the overall number of collisions a carrier had in a year. While it is useful to some degree to know how many collisions are taking place every year, such a metric is probably too simple to be of much use for active safety management purposes. This is because total numbers of collisions don't tell us if more or less collisions in a given year is an indicator of a positive or negative trend if we don't also know things like overall distances traveled and areas of operations over the same time period and, then, take this additional information into account in our analysis on how we can make future improvements.

For example, a carrier might have a higher number of total collisions last year than the year before but still argue it has improved its collision performance if it greatly increased its fleet size and distance traveled last year in greater proportion to the increase in collisions. This is why a metric for collisions that also takes distance traveled into account is more useful. It would likely also be important to track collision information separate by area of operations as the collision rates for the off-highway logging division of a carrier compared to on-highway collision rates should be understood to make more targeted improvements.

Metrics are important and useful, but they are also misleading if not properly established and understood. They also can be manipulated by individuals involved in their tracking which might take place when there are bonuses, performance reviews, and other aspects related to individual or departmental incentives tied to specific metrics. Carriers have to evaluate these types of data carefully to ensure they truly are making the best decisions to improve safety performance.

Note: This isn’t really a specific SMP. Instead, metrics are better thought of components of individual SMPs (like the rate of driver participation in a sleep apnea program) or indicators of overall safety performance (like the distance-adjusted annual collision rates for specific terminals).

Benefits: By relying on measurable data, carriers can make informed decisions that improve safety outcomes, ensuring that efforts are directed toward the most effective strategies. When done well, metrics provide information needed to better control factors related to safety performance.

Sometimes, metrics are related to compliance requirements, like how all carriers with a Safety Fitness Certificate in Alberta will have a Carrier Profile and, therefore, their own R-factor. Since this metric already exists for the carrier, they might as well understand how it works and use it to their advantage; otherwise, they are not fully taking advantage of information that is freely available to them (and that is used to potentially identify them for enforcement action).

Implementation: This SMP component is evidenced by well-defined, actively measured metrics that are used for decision-making purposes. Carriers also have to be able to explain their metrics, why they are being used, and how to properly interpret them; if they can't, then they may just be tracking some things for no real purpose which is not evidence of active safety management.

Proactive Inspection Program

Description: A proactive inspection program involves inspecting all worksites, including vehicles, to identify health and safety hazards before an incident occurs. This goes beyond basic compliance and is meant to ensure the safety of staff and the public by addressing dangerous situations before an incident takes place.

In the fleet world, driver-vehicle and preventative maintenance inspections are compliance requirements. These inspections form part of this SMP but, by themselves, do not represent a proactive inspection program. This SMP requires the inspection of facilities, yards, and potentially even customer sites, like checking first at a new customer to make sure there is room for the carrier's vehicles and that washroom facilities are available for its drivers if long wait times are expected. It could also look like the proactive inspection of public facilities, like rest areas and truck stops, to assess if there is adequate room for parking, especially if the carrier operates LCVs and/or hauls over-dimensional freight.

While some of this may seem excessive or unreasonable to some readers, it's critically important to remember that the carrier is responsible for the health and safety of its drivers and other staff wherever they go to do their jobs, and they are also responsible for the health and safety of members of the public and staff of other companies should it be the case that they could be impacted by the operations of the carrier. Haulers of extremely large oversize loads often are required to scout out routes ahead of time as part of the permitting process on the logic that leaving it all up to the driver to figure out in the moment is unfair, unrealistic, and unsafe. There's no reason why this mentality cannot be adopted by other types of carriers to ensure the safety of their workforce, the public, and infrastructure, so questioning the extent and scope of proactive safety inspections can also be part of this SMP.

Benefits: By conducting thorough inspections, carriers can identify and address hazards before they lead to incidents, ensuring a safer work environment and reducing the likelihood of incidents. This SMP also helps meet inspection-related compliance requirements and bolsters a carrier's demonstratable due diligence.

Implementation: This SMP is demonstrated by a documented inspection program that exceeds compliance requirements, with proof that inspections are carried out according to policies and procedures. Evidence should also show that management and all levels of the organization are involved, that problems are reasonably identified, and that they are corrected in a timely and documented manner.

Risk Management

Description: Risk management goes beyond hazard assessment by adding a probability component, allowing carriers to evaluate and better understand the relative risk posed by different hazards. At its most basic level, a risk assessment will require the carrier to decide upon the likelihood and severity of a specific hazard or type of incident to come up with a number or other label that can be used to rank the issue against others that have been evaluated using the same system.

Often, safety/compliance management programs are meant to achieve compliance with the law or a specific standard, like a basic NSC or OHS program. Such a program uses the law or standard as a framework, and does not really tend to inform the carrier of the degree of potential loss associated with noncompliance or specific incidents beyond, perhaps, the dollar value associated with a fine. Risk management differs in that it evaluates the chances of things going badly and also the consequences to the carrier and other parties if things do go badly.

In other words, a basic NSC program can tell management when they are compliant or noncompliant with the law. A risk management program, though, will go further and inform management of things like the costs they could expect to suffer if they lost certain cargo to water damage (as an example).

Risk management programs are also more effective when the risk assessment is done under different scenarios. The most common way of doing this is to do a risk assessment of a specific hazard before and after a potential control has been implemented or combination of controls, like the safety risks from falling in the yard on ice without anything being done, with traction aids provided to staff, and with traction aids provided to staff along with routine salt and sand spreading.

Risk assessment methods can be devised by the carrier, adapted from other sources, or even purchased (like buying specific risk assessment software or retaining an appropriate consultant). Like hazard assessments, they need to be done regularly and with diverse staff input.

Note: Carriers must still eliminate or control all hazards they identify within their operations and to those who could be affected by their operations, like members of the public (this is typically a compliance requirement). So, while risk ranking is valuable in the prioritization and organization of work, it is not appropriate to use risk ranking as a justification to not take any action at all for a specific hazard or type of hazards.

Note: Risk assessments and risk ranking are inherently subjective. Even methods that use quantitative data from similar operations and/or past experiences still have a degree of subjectivity involved, and the severity or probability someone assigns to a specific risk or hazard will typically vary between individuals based on personal attitudes towards risk and experience in the industry. Therefore, it's important that a robust and consistent system is used for risk assessments that takes inputs from diverse individuals in a psychologically safe space, not just those in safety or leading the risk assessment activities. It's also important to accept this inherent subjectivity, see risk assessments as a guiding process, and not get too bogged down and create conflict that can happen when people disagree on some aspect of an assigned risk.

Benefits: By understanding and managing risks, carriers can focus their resources on the most significant threats, reducing the likelihood of incidents and improving overall safety. These activities also create strong institutional knowledge by having multiple people - including management - take the time to think about all aspects of operations, what could go wrong, and what they can do to prevent things from going wrong and, if they do go wrong, mitigate their severity.

Implementation: This SMP is demonstrated by a formal hazard assessment system that includes risk assessment, with the use of established methodologies or a well-documented and clear internally developed process, and through the involvement of diverse individuals so that all aspects of the carrier's operations are represented. This also isn't a one-and-done sort of activity, so ongoing risk assessment activities in accordance with policies and in response to incidents is also required to demonstrate this SMP has been implemented.

Safe Driver Hiring Practices

Description: Safe driver hiring practices involve systematic safety-related screening processes to ensure that individuals placed in driving positions are competent for their role. This SMP could be seen as just a part of the overall competency assessment SMP, but it has been broken out on its own since this resource is aimed at fleet operators who should be aware of specific ways to further improve safety when it comes to hiring drivers.

This SMP typically involves using elective screening services, like the Pre-employment Screening Program (PSP) offered by the FMCSA for carriers with US operations. Third-party support may be used, like a fit-for-duty company that specializes in matching individuals with the specific demands of a specific driving position. This is a common approach for aspects of the screening process that relate to physical and cognitive abilities.

Carriers can also create their own programs for safe driver hiring in areas more related to specific work-related skills by specifically listing the competencies and demands for each type of driving job they have and then assessing individuals during the hiring process to make sure they are capable of doing the job or can reasonably be brought up to an acceptable standard through initial training. For example, they may choose to hire a driver who lacks experience with flatbed cargo securement because the carrier knows they can provide that training and mentorship to the new hire before sending them out on their own. However, the same carrier may choose not to hire someone who lacks driving experience with a Class 1 licence even though they have their Class 1 because the carrier knows they lack the resources to provide the level of in-depth trainer-trainee training needed to bring this person up to their standard.

Note: Carriers must be aware of regulations and best practices related to labour and HR when hiring individuals so that they are respectful of confidentiality and make or rescind offers legally.

Benefits: By thoroughly vetting drivers before they are hired, carriers can reduce the likelihood of collisions caused by unqualified or unfit drivers. This practice enhances overall safety on the road.

Implementation: This SMP is demonstrated by meeting compliance requirements and implementing policies and procedures that ensure consistent, thorough vetting of driver competencies before they fully enter their roles. Whether a third-party is used, the carrier develops its own program, or uses a combination of the two, they must be able to demonstrate they understand their screening criteria.

Safety-Centric Procurement and Sales

Description: This SMP refers to systematically involving safety people and equipment users in the decision making process of purchasing equipment and seeking work for the carrier. Safety doesn't necessarily need the final say unless the decision introduces significant risk or noncompliance into the carrier's operations, but their input is a formal requirement in this SMP when procuring new equipment and facilities and when soliciting new customers.

For equipment procurement, it could be the case that simple changes to new equipment during the purchasing process can contribute to better safety performance. For example, speccing trucks and trailers so that no one needs to climb on the catwalk to connect the trailer electrical and air lines based on feedback from drivers and the safety department demonstrates how safety in procurement can lead to reduced risk.

For sales, involvement from safety can contribute to stronger revenue. For example, let's say a carrier is in the process of working out a contract for hauling cargo for a particular shipper where the carrier claims they can deliver the load in a single day. However, during negotiations, the carrier fails to consider aspects of the specific routes that impact the ability of drivers to be able to get the trip done within their HOS limits for the day, such as extreme grades or routine weather-related delays. Now the carrier is contractually obligated to provide a service for a set price, but they will likely not be able to deliver on the contract, resulting in less profitability and, potentially, significant penalties or even litigation. When negotiating and otherwise soliciting work, input from drivers and safety can help the carrier ensure it only makes commitments that are realistic.

When it comes to sales and procurement, changes are far easier to make at the start of the process than at the end. Safety concerns resulting from bad sales and procurement decisions will eventually be identified once the equipment and work become operational, but making changes then is typically far more difficult and often comes at a greater cost.

Benefits: Safety's involvement in procurement helps prevent carriers from buying inappropriate equipment and can also allow them to identify and solve safety issues simply by purchasing better equipment right from the start. Similarly, safety's involvement in sales decisions helps the carrier make more accurate cost predictions and commitments.

Implementation: This SMP is evidenced by documentation showing that safety staff and affected workers are involved in applicable decisions, both by policy and through documentation that demonstrates the carrier is following its policy.

Safety Committees and Representatives

Description: Most carriers are required to have safety committees (or representatives, for smaller organizations) under OHS regulations. However, this SMP ensures that these requirements are met meaningfully, meaning the representatives/committees are actually functional and responsive and not just in place because management knows they have to.

Since organizational culture can vary greatly between companies, the ways in which representatives do their work and how committees are structured and operate can also be diverse, such as having subcommittees for specific locations or type of work being done and then having these subcommittees work with the larger parent committee. This approach, which is just an example, helps ensure that hazard identification and control suggestion work is done by those close to and most knowledgeable of the specific hazards. It also allows the higher-level work of bringing recommendations to management and working with management on their implementation is done by people better positioned to do more administrative work. This allows people participating in the committee to use their specific skills and experience while sharing the workload.

Benefits: By having competent and engaged safety committees or representatives, carriers can better address safety concerns, involve staff in safety decisions, and create a stronger safety culture. Safety committees in particular are tools that can be used to improve trust in an organization and to learn more about specific safety concerns from those doing the work that management might otherwise miss.

Implementation: This SMP is evidenced first by the carrier being able to demonstrate they are compliant with the law. Then, there must be documented evidence that the committee or representative actively works to identify safety concerns and brings these issues to management, and then that management's response is reasonable. Committee membership should be diverse in that all aspects of the carrier's operations are represented in the committee. If a representative is used, this person should be appropriate for the role in that they have the relevant experience and training to be effective.

Safety Incentive Programs

Description: Safety incentive programs are designed to positively reinforce behaviors that improve safety performance both on the road and in the yard by providing money, recognition, or other benefits as a reward for what the carrier considers positive safety performance. A classic example is a safety bonus paid out in response to safe driving (i.e., no collisions and violations) and then not paid out in the event the driver has an at-fault collision. This type of SMP is within the broader area of safety management known as Behaviour-Based Safety (BBS).

In trucking and fleet operations, safety performance is largely tied to driver behaviour unlike in other industries, like manufacturing, where the work all takes place within the company's facilities and where the company can do things like install machine guards and organize work processes to reduce the risk of injury. Professional drivers share the road with the public, and they also often do work at non-company sites, like when delivering to a customer or when stopping for a break at a truck stop. Therefore, safety incentives are often seen as a good way to improve safety performance.

However, safety incentives can also create problems.

For example, if bonuses are paid out based on metrics like no reportable collisions for a specific period of time, it then becomes in the best financial interests of those at the organization to not report collisions so as to preserve their bonus. Also, safety incentives need to be clearly explained and somehow differentiated from regular pay (if the incentive is financial). If a safety bonus is seen as wages, management should expect to have conflict with people over safety performance, and it could also be the case that labour and HR issues are created if taking away a bonus is seen as disciplinary action or overly punitive.

Carriers can use safety incentive programs to improve safety performance and to contribute to building a better safety culture, but they must do so with care to avoid creating new problems and even potentially adding new risks to the organization, like encouraging non-reporting. HR and labour regulations need to be consulted when implementing such a program, and the incentives also need to be realistically achievable lest drivers and other staff come to see the program as lip service and accordingly ignore it.

Benefits: When implemented correctly, these programs can motivate staff to engage in safe practices, leading to fewer incidents. They can also contribute to an improved safety culture if the incentives are realistic and not seen as management being deceptive.

Implementation: This SMP is demonstrated by having a documented program with achievable incentives and evidence that these incentives are regularly distributed appropriately to staff.

Sleep Apnea Programs

Description: Sleep apnea is a sleep disorder that can significantly impact driver safety if not properly managed. This SMP refers to a specific program to address this health issue for the purpose of providing healthcare services to affected drivers and, thereby, reducing the risk of fatigue-related collisions. These programs are typically managed through a third-party due to the specialized knowledge needed to be effective at identifying and treating sleep apnea and complying with privacy- and labour-related regulations concerning drivers' medical information.

Note: This SMP could be part of a broader fatigue management program, or it could be a standalone initiative.

Benefits: Carriers can reduce the risk of collisions caused by driver fatigue that is related to sleep apnea by implementing this SMP. Professional drivers are a group of workers more likely to be negatively affected by sleep apnea and the severity of fatigue-related collisions is significant, so that is why it can make sense to have a program specifically addressing this single medical issue.

Implementation: Implementation can be demonstrated through appropriate policies and then documentation demonstrating the carrier is following its policies. Evidence may also be as simple as a service agreement with a sleep apnea treatment provider.

Temporary Foreign Worker Safety Management

Description: Temporary Foreign Workers (TFWs) are common in the trucking industry, but they can present safety challenges due to the increased power employers have over these workers and the cultural differences that are likely present for those new to Canada.

TFWs typically work under a closed work permit, meaning they cannot easily change employers. Therefore, their current employer has more power over them than they do other drivers who have the option of quitting. While this should not be a problem at a carrier that follows the rules and provides appropriate safety training and resources, it does mean that carrier treatment of TFWs can vary based on the values – both professed and practiced – of the organization, its management, and of individual staff members. Since some carriers see reducing training and other safety practices as a cost-saving strategy, they could be placing TFWs into driving positions for which they're not competent and also not easily able to resist due to fears of deportation. TFWs also come from outside of Canada, so there are issues related to language, communication, basic knowledge that those originally from Canada take for granted, and experience in Canadian driving conditions that deserve special attention in order for these drivers to be able to enjoy similar safety protections as their non-TFW drivers.

This SMP represents actions taken by carriers to specifically address these issues. Specifics would vary based on operations and TFW countries of origin. However, such a program involves analyzing the carrier's current OHSMS and HR/labour systems to make sure they are appropriately communicated and accessible to TFWs and that training is tailored to their unique needs. This helps protect the health and safety of TFWs and also the general public sharing the roads with them by ensuring safe driving behaviours and expectations are clear regardless of previous experience.

Benefits: By addressing safety issues specific to TFWs, carriers can prevent labour abuse and ensure that all workers operate in a safe environment.

Implementation: This SMP requires a critical examination of how such labour is used and evidence that the carrier understands the specific safety concerns related to these workers. Then, there should be evidence the carrier has taken steps to address potential issues that are specific to the TFWs and other staff it currently employs.

Chapter Six – What Interviewed Carriers Are Doing (Thematic Analysis)

At this point in this resource, we've discussed many different types of technology (the safety technology elements, or STEs) and management practices (the safety management practices, or SMPs) related to fleet safety management. The rest of this resource changes tone to now focus on STE and SMP efficacy, return on investment (ROI), and how carriers can move from safety programs that are based mostly on compliance with the law into the area of proactive safety management. Before we get into those topics, though, this section will present the major ideas and takeaways (i.e., the themes) from the interviews AMTA did for this project with large, well-established carriers with sophisticated safety management programs. Details on how these interviews were conducted can be found in this resource's Methods section in chapter 2.

We did these interviews alongside the literature searches for this resource to help flesh out details related to implementing STEs and SMPs that aren't always easily accessible in academic articles or other sources related to safety management. While companies are often tight-lipped about many aspects of their operations for competitive reasons, information related to safety is generally - and fortunately - freely shared. All companies benefit when such information is shared freely as we all share the same roads, meaning safer competitors means safer roads for everyone else, too.

A thematic analysis was done on the interview transcripts and related notes to identify important information for our sections on efficacy, ROI, and ways in which carriers can move beyond compliance into proactive safety management. Other themes didn't necessarily fit entirely within those sections, though, and will be presented and discussed below. The next section in this chapter (Thematic Analysis Details) contains a more detailed list of interview codes and how they correspond to the themes below and/or other aspects of this resource, information we've included for transparency and to allow the reader the opportunity to further interpret our findings.

Theme 1: With more data comes more responsibility

STEs tend to generate large amounts of data. Consider, for example, ELDs. Even the most basic ELD system still collects relatively enormous amount of data on a carrier's vehicles and drivers when compared to the data the same carrier would have access to when using paper logs. Other STEs similarly collect large amounts of data, and SMPs also require carriers to collect data for the SMPs to be effective, like how an incident investigation program will generate investigation reports, recommendations, and metrics, all of which represent forms of data the carrier then has to manage.

The carriers interviewed tended to express the importance of managing this data and not ignoring it. They warned that carriers implementing new types of STEs should expect to suddenly become aware of safety-related problems in their operations and, at that point, have the choice to either ignore it or do something about it (with the latter being the right thing to do).

The challenging aspect of collecting all this data is that the collection is the easy part and managing the using the data responsibly is the hard part. Carriers will need to prepare to handle this data and use them in safety management decision making. If, for example, a dashcam system with traffic sign recognition capabilities creates alerts for things like drivers not stopping for stop signs, the carrier will then need to address these alerts by, first, reviewing them to see if they are indeed valid, second, understanding why these unsafe driving acts are happening, and, third, taking the necessary action in accordance with their policies (which may need updating) to improve their safety performance.

This theme ultimately stresses the importance of fleets having post-implementation plans for new STEs and SMPs that allow them to responsibly manage incoming data in ways that demonstrate due diligence and, hopefully, improve their safety performance.

Theme 2: Technology is allowing fleets to focus on immediate causes of collisions with reported success

Within the world of safety management, incident investigation best practices generally require investigators to do root cause analyses to identify higher-level causes for incidents. The logic is that, by addressing systemic problems in a system, the outputs will improve. For example, let’s say a collision investigation identified root causes that included not assessing the driver competency for their roles to see if more training was needed and unrealistic delivery expectations. Firing the driver after such a collision does little to prevent future occurrences since underlying contributing factors do not get addressed by the firing.

We are not disputing the importance of conducting root cause analyses, and nor did any of the people interviewed. However, participants repeatedly provided examples of how they are using STEs and SMPs to shine a brighter light on immediate collision causes. Examples include technology that directly attempts to prevent collisions (or at least reduce their severity), like automatic emergency braking and lane keep assistance systems. SMP examples included carriers using driver-facing cameras with AI to alert drivers in real-time when they do things like pick up their phone or show signs of fatigue. Carriers interviewed spoke highly of such approaches to safety management, including providing specific examples of efficacy (see **Table 1** in the chapter on STE and SMP efficacy).

This theme is ultimately about how new technology and corresponding safety management practices are paving the way for carriers to more directly influence immediate collision causes. This does not take away from the importance of identifying collision root causes and addressing systemic issues that negatively impact safety. But, it does show that carriers have more options for addressing causal factors related to collisions that were previously either not possible to address or could only have been addressed through awareness and training.

Theme 3: Fleets are concerned about their safety culture and how it's perceived by drivers

The carriers interviewed for this resource all spoke highly of the importance of both having a positive safety culture and their use of technology in contributing to building a positive safety culture. While it was acknowledged in some interviews that the use of technology could lead to issues of micromanagement that would ultimately degrade a carrier's workplace and safety cultures, this was described as a management issue, not an issue with the technology itself. Many of the carriers interviewed were confident in describing how they have used STEs not only to improve their safety performance but also to improve safety culture by demonstrating that management is investing in safety for the betterment of everyone.

Interviewees also expressed concern regarding how their safety culture and use of technology is perceived by their drivers. The approaches to safety management described in the interviews was overwhelmingly collaborative, with carriers wanting to work with, not against, their drivers and other staff in successfully implementing new STEs and SMPs.

Theme 4: ROI lags, efficacy leads

Somewhat surprisingly, no interviewee

described ROI as a factor in whether or not management would move forward with a particular safety-related investment. The importance of recognizing fiscal limitations of companies was emphasized, and some interviewees did describe having to make a business case to their management to proceed with a particular STE procurement. However, such business cases were more about ensuring there was adequate budget for successful implementation, not about providing management with the confidence that they would see a positive return on such an investment.

Efficacy, on the other hand, is what was described as most important in whether or not a carrier would move forward with a particular safety-related investment. Interviewees discussed the importance of being able to provide evidence for the effectiveness of a specific technology or other safety expense, but they generally described their management as being willing to invest in safety simply because they believe it's the correct way to run their business (which leads nicely into the next theme on motivations for improving safety).

This doesn't mean ROI wasn't important at all. Instead, though, ROI was described in the interviews as more of an attractive lagging indicator to better understand safety performance. More specifically, some described how they would track costs associated with new STE implementation against changes to incident and/or collision frequency and severity changes to then calculate ROI internally. These ROI data were then used to help carriers decide on which STE to proceed with when there are multiple options with similar efficacies. It was also used to further emphasize the importance of investments in safety in overall profitability, as some of the carriers interviewed described how ROI figures show that, without continual evidence-backed safety investments, profits will suffer even if some immediate costs could be saved.

Theme 5: Safety performance improvements are motivated by finances and ethics

When asked what motivated them to improve safety performance, carriers generally cited a sense of ethical responsibility and good business practices as the reasons why. In other words, ongoing safety performance improvements were described as financially beneficial to the carrier and also the right thing to do.

Carriers had different ways of expressing this theme. For example, publicly traded carriers mentioned that they have constant pressure from their own shareholders to improve against their past safety performance on a regular basis which is, in turn passed down from senior management as a directive to bolster safety to boost profitability and share prices. One particularly large carrier stated that their ROI data on past STE and SMP implementations and improvements has been so positive that senior management considers their safety program to be a long-term profit driver, dedicating significant funds annually just to explore new potential safety projects to further improve their safety performance against both industry peer comparisons and their own past performance.

More specific to ethics, some carriers described family values from family ownership involved in operations as creating a culture of caring. Others commented on how they have a sense of duty to ensure that the general public driving alongside their trucks are better off than being alongside the trucks of other companies. One carrier described their ethical feelings towards improving safety performance as providing their drivers with a job at a safe company: should they not exist as a carrier, then their drivers would be driving for other, likely less safe, companies.

Finally, this theme also points to the fact that each carrier interviewed considered ongoing, constant safety improvements to be an aspect of their safety management system. In other words, they all consider safety performance to be an ongoing journey to a destination of no incidents and loss. Whether this destination is something that can ever be reached is philosophically debatable but, regardless, it's a destination towards which proactive companies should always be working.

Theme 6: Carriers of all sizes and types can likely move from basic compliance into proactive safety management

This theme was more implicit than explicit in the interviews. In short, the comments made by interviewees suggested that there are ways involving different combinations of STEs and SMPs that any carrier, regardless of their size and type of operations, can use to improve their safety performance. Proactive safety management and the performance gains it can bring aren't just for the very large and very sophisticated carriers of the world; the many options on the market today in terms of technology and the variety of safety management approaches and expertise available have created a world where even very small carriers with limited resources can still do things to attain some of the benefits seen by the carriers interviewed during the writing of this book.

This theme will be explored in greater detail in the chapter on Moving Beyond Compliance. In that chapter, more specific examples of the ways in which carriers can adopt different STEs and SMPs are provided.

Note: Please see the next section in this chapter (Thematic Analysis Detail) to view more detailed data from the interviews done during the writing of this resource.

Thematic Analysis Details

The creation of this resource involved qualitative interviews conducted with participants from large Canadian and American carriers and carrier safety services providers (see the Methods section for details). The data in this section are codes taken from the interviews and organized in-part by interview question and by topic similarities. Each code represents an idea stated by the interviewees during the interviews, and these codes were used to create the themes that were presented in the previous section and used elsewhere in this document.

Codes may or may not be in complete sentences as their intention is to capture an idea from the interview transcripts in enough detail to be of use in later data analysis and interpretation. We have listed the codes as they were written prior to completing the thematic analysis here to provide the reader with additional insight from the interviews and the opportunity to conduct their own interpretation. The order in which they are presented is not important, and the main intention of this section is additional transparency into the research methods used.

Ways carriers interviewed have invested in safety technology:

- Effective safety investment strategies include inward- and outward-facing cameras and ELD systems for their telematics coupled with active coaching and then collision mitigation technology that actively assists with driving and intervenes to reduce collision severities and frequencies

- Driver-facing cameras with AI effective at identifying driver fatigue and distraction, but false positives are a problem requiring intelligent management to best use data

- Long history of investing in STEs and associated SMPs (pre-dating current popular fascination with truck safety technology)

- Carriers focusing on the implementation of STEs to improve driver situational awareness (cameras, alert systems, improved sight lines, cab hygiene, collision mitigation systems)

- Vehicle turnover key to implementing many forms of STEs when retrofitting is impractical

- Predictive analytics is a common area carriers identified as where they want to do more work (the potential future of fleet safety management)

Elements of safety program management from carriers interviewed:

- Ongoing experimentation with new STEs a component of active fleet safety management (actively search out new things, try new things to validate internally, always be looking to invest in new things)

- Active coaching based on data from STEs is effective, typically with a properly configured LMS

- OHS, NSC, and other forms of safety should be integrated; in other words, dividing up different aspects of safety is an impediment to communication and holistic safety management

- American carriers less hesitant to adopt enhanced substance abuse testing (typically hair over urine testing to screen out habitual drug users) and driver-facing cameras due to less perceived privacy concerns

- Safety should not be seen as disciplinary

- Do not approach STE/SMP suppliers without doing research first
- Trucking associations valuable for networking, training, and industry news to improve collective safety
- Safety isn't proprietary (carriers generally willing to share safety information when they would otherwise not share operational information)
- Evaluate preventability, not just fault, in collision investigations
- Must engage with drivers regularly and constantly strive to have a proactive safety culture (safety committees useful for this)
- Move slowly and intentionally (do not rush into new things, do not overwhelm staff)
- Work on one thing at a time
- Safety incentives can be problematic if they encourage nonreporting

- Don't let STEs become an avenue for micromanagement
- Accounting/finances should not dictate safety interventions as long as safety management is financially literate and reasonable
- Top-down management commitment essential for positive and proactive safety culture
- The participation of the underrepresented and vulnerable can be improved through SMPs that address their specific psychosocial needs
- Re-evaluating existing STEs/SMPs important, not just seeking out the new since things change
- Multiple STE/SMP systems creates new challenges related to system overload (i.e., STEs just to help manage many STEs are needed) - integration
- Safety is a journey to never-reached destination (paradoxically and intentionally working towards zero incidents while

recognizing such a goal isn't likely obtainable/reasonable)

Problems that should be anticipated when investing in safety technology in fleet safety management:

- Contracts with STE providers an impediment to progress due to rapid pace at which STEs often improve

- Implementation at too fast a pace and without enough internal training a common regret

- Cookie-cutter approach to training and the use of technology a common regret

- Poor communication during change a common regret

- Lack of psychosocial hazard awareness in fleet safety management an impediment to optimal STE and SMP implementation (AMTA's resource on this mentioned as a useful resource)

- Collision mitigation systems like AEB with high false positive rates are problematic so research is encouraged for carriers for specific systems being considered (newer generally better)

- OEMs inconsistent in offerings

- Vehicle types (large trucks versus smaller courier vehicles) have inconsistent OEM STEs

Return on Investment (ROI):

- ROI loosely defined and not consistently interpreted

- ROI not a deciding factor in STE/SMP implementation: too complicated and subjective (no real way of knowing if a significant loss was prevented due to a specific aspect of an fleet OHSMS)

- ROI not a deciding factor in STE/SMP implementation: morals supersede rigid ROI requirements

- ROI not a deciding factor in STE/SMP implementation: not sure why, just not something safety has to consider

- ROI different from budgeting: SMP/STE requests/projects/implementations/changes must be reasonable, but returns not required

- ROI seen as an ideal metric to be able to define, something to which carriers aspire to be able to speak to

- ROI not used to say yes or no to STE/SMP but, rather, to decide between similar STEs/SMPs when all else is equal

- ROI useful to demonstrate efficacy and encourage ongoing investments in safety (most sophisticated carriers have used ROI to show that reductions in safety expenditures and not continuing to invest in safety would be bad for profits)

Safety performance improvements motivation:

- Shareholders expect safety performance improvements, not just compliance

- Safety performance improvements motivated by shareholder pressure

- Safety performance improvements motivated by insurance
- Safety performance improvements motivated by family values (perceptions of family-owned businesses)
- Safety performance improvements motivated by creating safe jobs within the industry (can't make all driving jobs safe but can make ours safe)
- Safety performance improvements motivated by sleeping well at night (done everything we can; people get home safely to their loved ones)
- Safety performance improvements motivated by wanting to be a part of an effective team that does meaningful work
- Safety performance improvements motivated by providing clarity on issues (no grey areas)
- Safety performance improvements motivated by top-down management commitments to safety (safety is an expectation and value)

- Safety performance improvements motivated by being ethical

- Safety performance improvements motivated by not causing harm to others on the road (the public, the innocent)

- Safety performance improvements motivated by litigation mitigation, especially with American operations and exposure to nuclear verdicts

- Safety performance improvements motivated by problem-solving

- Safety performance improvements motivated by innovation

Numerous strategies exist for carriers to move from compliance-focused safety to proactive safety that leverages technology:

- Carriers can move from compliance into proactive safety by getting ownership/management buy-in

- Carriers can move from compliance into proactive safety by getting involved with trucking safety associations

- Carriers can move from compliance into proactive safety by getting a COR/SECOR (voluntary safety standard)

- Carriers can move from compliance into proactive safety by reviewing internal data they already have like regulator safety scores, incident reports, and hazard assessments

- Carriers can move from compliance into proactive safety by measuring against their past performance, not others

- Carriers can move from compliance into proactive safety by embracing/using features in vehicles and systems (like ELDs) they already have

- Carriers can move from compliance into proactive safety by using STEs but being careful to be intelligent in how they manage it (don't just pay for and trust STEs)

- Carriers can move from compliance into proactive safety by providing coaching/training specific to individual drivers based on specific information/events/behaviours

- Carriers can move from compliance into proactive safety by measuring sources of information (fuel costs, revenue, existing/regulator safety metrics, etc.)

- Carriers can move from compliance into proactive safety by managing bottom 5-10% of their drivers

- Carriers can move from compliance into proactive safety by making reasonable plans that do not overload staff

- Carriers can move from compliance into proactive safety by using loudest/influential staff/drivers to champion safety (get them on board first)

- Carriers can move from compliance into proactive safety by doing their research and not reaching out to suppliers first

- Carriers can move from compliance into proactive safety by getting cameras with AI (forward and driver-facing)

- Carriers can move from compliance into proactive safety by picking the most obvious issue and starting there (pick something, focus on it, see improvements, get under control, move onto the next thing)

- Carriers can move from compliance into proactive safety by expecting driver/staff pushback and working on improving culture

- Carriers can move from compliance into proactive safety by expecting glitches/problems with their STEs (do not expect perfection, be willing to work with systems to tailor and optimize them to operations)

- Carriers can move from compliance into proactive safety by being willing to eventually remove those who are contrary to positive safety cultures

- Carriers can move from compliance into proactive safety by creating and tracking appropriate metrics that make sense for their specific operations

- Carriers can move from compliance into proactive safety by expecting to see positive results of some kind within a year or less

- Carriers can move from compliance into proactive safety by using third-party expert service providers for things to help existing staff focus on what they do best (for smaller carriers)

- Carriers, when investing in STEs, will likely become aware of issues and can choose to address or turn off and ignore; addressing issues is the morally correct choice

- Carriers of all sizes can improve safety management by using technology to take on administrative, non-strategic tasks to free up staff time for directly impactful safety activities

- ELDs typically come with telematics, and this is something all carriers should use (low hanging fruit)

Chapter Seven – Efficacy of STEs and SMPs

This chapter presents an evaluation of whether safety technology elements (STEs) and safety management practices (SMPs) are effective in terms of improving safety performance and to what degree. The Methods section in Chapter 2 has more details on how we went about researching and writing this chapter.

Introduction to Efficacy

Efficacy refers to how good something is at its intended purpose. It's the same as describing how effective something is. In the context of safety technology elements (STEs) and safety management practices (SMPs), efficacy means how capable a specific STE or SMP is at improving safety performance. For example, we know that seatbelts are effective at reducing injuries during collisions and help with safe driving by keeping drivers in their seats during emergency maneuvers so, as a type of safety technology, we can generally describe them as effective. An SMP example could be that, if a collision investigation discovers a root cause and contributes to successfully challenging a claim related to a fault determination, we could say the investigation and its methods were effective.

Usually, we discuss efficacy casually and in terms of if something was or was not effective. However, efficacy isn't an all-or-nothing concept, and there can be great nuance to determining the degree to which something is effective. Furthermore, efficacy can be subjective, too, depending on how it's being described and in what setting. Therefore, this section is meant to provide some information on how efficacy can be complicated to understand and apply to different applications.

Let's go over some examples of how we use language regarding efficacy to help people navigate quantitative information about certain STEs or SMPs. First, let's say a hypothetical driver-facing camera uses AI to detect signs of driver in-hand phone use and correctly identifies drivers holding their phones 90% of the time a driver picks up their phone. Let's say the same camera system also incorrectly flags drivers 20% of the time as holding their phones when the driver did something that was not holding their phone and permitted by the carrier's policies, like picking up their travel mug or snack.

There are several different ways we might see how the above camera system's efficacy is presented in advertising and in studies. Someone might claim the system detects driver phone use 90% of the time, but this is somewhat misleading because we know that it will flag drivers as holding their phones incorrectly 20% of the time when the driver was doing a different activity. In reality, we don't know the number of driver movements expected over a period of time, how many of them are related to driver phone use, nor do we even know what a driver movement is that the system detects.

Another way the camera system from above's efficacy could be described is in terms of its relatively low false positives rate to refer to the 20% of the time a driver's movements will be incorrectly labeled as phone holding. Sure, 20% may seem like a low percentage, but we need to know more about the specific technology and what constitutes a driver movement that the system could flag to better understand how many false positives are being generated. If the criteria for the system detecting driver movements as phone holding or not are quite sensitive, it might be making a very large number of detections over the course of a shift and, while most were correctly not forwarded to the carrier as phone holding, 20% of them were, likely then requiring individual follow-through from management to review the recordings to decide on next steps with the drivers in question. This could potentially be an enormous administrative burden for the safety folks at the carrier who could be providing value elsewhere.

As we see greater and greater use of STEs in our safety management, we will continue to have more and more data. More data aren't necessarily a good thing and could even be a liability if we find ourselves unable to manage it, though. When we therefore describe the efficacy of an STE or SMP, we have to understand it to the specific enough detail to be able to relate it back to our own operations to understand the implications. At a surface level, 90% is a high percentage and 20% is a low percentage, but just the percentages by themselves with only basic descriptions of what they mean do not tell us enough to say with much confidence how effective the camera system really is to the level of detail we'd want when making a purchasing decision.

There isn't a standard way of describing efficacy for the STEs and SMPs in the industry in general, so part of the challenge in writing this resource was making sure evidence included is described in enough detail to make it relatable for a general trucking audience. The next sections are written to make the argument that carriers need to make investments in safety due to the overwhelming evidence such investments are part of good carrier management, not identifying any one specific STE or SMP as the right solution for a specific carrier application. Before these sections, though, let's discuss some basic strategies for interpreting information related to efficacy that may be seen from STE and SMP suppliers and service providers.

Interpreting Efficacy Information

We encourage carriers and safety professionals reading this resource to contact organizations like trucking associations and other industry resources to help them better understand these concepts. We will, however, provide a quick list of things to consider when interpreting ROI information, like when a product or service provider advertises a specific ROI for going with their solution:

1. **Confirm the definition of "efficacy".** This means asking whatever questions are necessary to understand specifically what benefits an STE or SMP may have to offer, like whether it is meant to reduce collision rates, improve data management efficiency, improve safety culture, etc.

2. **Get the details on metrics being used.** If numbers are used to express an STE's or SMP's efficacy, be sure to identify specifically what the metric means and how it was calculated so that more accurate comparisons can be made to real-world situations.

3. **Compare information with other sources.** Don't just go with one source of information on an STE's/SMP's efficacy, especially when that one source is from a supplier. Separately identify sources of information to get a broader perspective on the specific product or service in question,

such as by using resources like this book, searching academic databases, asking for anonymized data from suppliers and customers, and contacting a trucking association.

4. **Consider specific carrier applications.** The reported efficacy of an STE or SMP may be completely valid for some types of carriers but not for others, so ask whatever questions are needed to confirm if the product or service in question is likely to be as effective as advertised at your specific organization.

5. **Ask about factors that may impact efficacy.** This means asking questions related to what might cause the product or service in question to not perform as well as advertised, such as time of year, region of operation, type of operation, vehicles being used, etc.

The above list is just a suggested guideline on things to consider when presented with data related to efficacy, especially when it's coming from a supplier interested in selling a product or service. Questions crafted with the above in mind can help carriers better understand the real-world potential value any given

STE or SMP may have for their operations.

Note: *Each of the following sections on STEs and SMPs categorizes them based on common attributes. To learn more about a specific STE or SMP, please go to the applicable part of this resource as each STE/SMP listed in the following sections has been described in greater detail earlier in this resource.*

Efficacy of Vehicle-Based STEs

This section examines the general efficacy of vehicle-based safety technology elements (STEs) in improving safety outcomes for carriers. See the Methods section of this resource for details on how this information was gathered.

Vehicle-based STEs typically either assist drivers with more information or they actually intervene in how the vehicle is driven to avoid collisions or whatever else the specific technology is meant to do. Some of these do both, like systems that will provide a warning and then also operate vehicle controls (steering, brakes, and/or throttle) if the driver fails to respond.

We've categorized the STEs presented earlier in this resource into broader categories below which were chosen due to them being common ways technologies are described in the vehicle safety industry. By using these categories, we're attempting to show how different STEs can contribute to similar aspects of safety performance at a higher level while still respecting the subtler differences between individual STEs.

Each category presents an overview of key information related to efficacy for each general type of STE, and each category also contains a list of specific STEs from this resource that belong to the category. Some STEs may fit within more than one category. The purpose here is to provide general information on how effective these types of STEs are at improving safety performance at general trucking companies so carriers and safety professionals reading this resource can be more strategic in how they approach this aspect of fleet safety management.

Efficacy: Collision Avoidance Systems

Technology in this category specifically provide immediate assistance to drivers to avoid collisions. They do this by providing the driver with alerts to take corrective action to avoid collisions, actually intervene in how the vehicle is being driven to avoid collisions, or both. STEs that fit within this category include:

- Adaptive cruise control
- ADAS integration platforms
- Automatic emergency braking
- Blind spot monitoring

- Collision avoidance and pedestrian detection systems
- Forward collision warning
- Lane departure warning
- Lane keep assist
- Rear cross-traffic alert systems

This type of technology has the most quantitative (i.e., numerical data, like percentages and other forms of statistics) evidence demonstrating its effectiveness compared to the other STE and SMP categories in this book. In **Table 1**, various research results have been summarized, highlighting specific claims related to how effective these types of STEs can be at doing things like reducing the frequency of certain types of collisions.

However, carriers need to be cautious in interpreting quantitative data. While the data are valid based on the design of the specific study that generated them, an STE that has been shown to reduce backing collisions by X% won't necessarily provide the same X-percentage of backing collision reductions at a carrier adopting the technology. This is because the studies that test technology take place within a certain context, like region, type of operation, time of day/year, driver experience level, vehicle type, etc. It shouldn't be presumed that a carrier will see exactly the same results: they might see better or worse performance from the specific STE.

What we can say, though, is that various types of technologies in this category tend to be effective at improving safety outcomes for carriers by both reducing frequencies of collisions and the severities of collisions that do end up taking place. Some STEs, like AEB, have even been the subject of talk amongst regulators as becoming mandatory, and decisions like that are only appropriately made when there is substantial evidence of the technology's benefits.

So, typical carriers should be considering this sort of technology in their vehicles, both during the speccing of new vehicles and through retrofitting where it's possible to do so. Furthermore, collisions are generally rare events in the sense that carriers travel the vast majority of their distances collision-free, so small- and even medium-sized carriers don't often have the number of collisions in a year where they can start doing robust statistical analyses to identify trends. It's better for most companies to adopt the mindset of continuous improvement and consider this sort of technology as part of this mindset knowing that, in general, there is evidence to support such action as a logical way to improve their safety performance.

Efficacy: Driver Monitoring and Assistance Systems

Technology in this category provides drivers with assistance in driving in both emergency and routine driving situations and, therefore, will tend to overlap with the category immediately above regarding collision avoidance. However, they are also meant to provide driver assistance in more than emergency situations. They also provide information to the carrier about driver performance and behaviours, both positive and negative, to assist the carrier in managing driver safety. STEs that fit within this category include:

- Adaptive cruise control
- Adaptive steering
- ADAS integration platforms
- Automatic trailer coupling systems
- Autonomous yard vehicles

- Blind spot monitoring
- Camera-based mirror systems
- Collision avoidance and pedestrian detection systems
- Driver-facing cameras
- Electronic logging devices for HOS compliance
- Forward collision warning
- Intelligent speed adaptation
- Lane departure warning
- Lane keep assist
- Lane-centering assist
- Rain and light sensors
- Rear cross-traffic alert systems
- Road-facing cameras

- Smart parking assistance systems (when referring to systems that help with the driving of the vehicle)

- Speed governors/limiters

- Traffic sign recognition systems

Safety technology in this category is generally seen as effective at improving safety performance where safety performance means collision severity/frequency reductions and improvements in safe driver behaviours that represent leading indicators for collisions. These types of STEs are more about promoting safe driving behaviours, perhaps through alerting the driver to unsafe actions on their part, or perhaps through keeping the driver's environment as conducive as possible to safe driving.

The concept of leading indicators is especially important for the technology in this category since these STEs are not as active in collision prevention as the category above this one. In other words, these STEs assist drivers in avoiding collisions in the first place further upstream in the collision causal pathway. Since many of them do this by encouraging safe driving behaviours, like alerting the driver when the driver-facing camera detects fatigue or distraction (as an example of leading indicators for collisions), they may generate data useful to carrier safety management to identify which drivers are higher risk in terms of at-fault collision likelihood so management can act accordingly.

There is comparatively less quantitative evidence for efficacy for this category of STEs than there is for Collision Avoidance Systems. This is in-part due to the fact that human factors play a greater role here, meaning that the environment in which the study took place is a much greater factor in trying to see if a specific STE will be as effective in practice as it was during a study. Also, studies examining these STEs tend to also rely on qualitative data. In order to interpret qualitative data, a person needs to review the research results and see, based on how the study was done in terms of similarities and differences with their own carrier operations, if they can expect to see similar results.

So, we can say that STEs of this type are generally effective based on available, current research. But, carriers will have to have review the specifics of an STE they're considering, compare it to recent research (like sources listed in **Table 1**), and see if they're in a position to implement and manage it effectively.

Efficacy: Stability and Traction Control Systems

Technology in this category help with driving the vehicle typically through the use of sensors that alter aspects of the vehicle's handling. This assists the driver in operating the vehicle, and these systems tend to work behind the scenes without much or any driver involvement (although they can often be manually disabled by drivers). STEs that fit within this category include:

- ADAS integration platforms
- Electronic stability control (ESC)
- Intelligent speed adaptation
- Lane-centering assist
- Roll stability control (RSC)
- Speed governors/limiters

This category of STE is more defined than the ones above since systems like ESC and RSC have been studied for longer periods of time as distinct systems when compared to other, more recently introduced, types of vehicle safety technology. In terms of efficacy, these types of systems are generally considered effective at reducing collisions by keeping vehicles within their safe operational limits, and recent research tends to build from a basic understanding that they are effective and focus on refining them further. **Table 1** contains research summaries related to this type of STE for further reading.

Carriers that operate tractor-trailer units, especially with more than one trailer, need to pay special attention to this type of technology in their operations. Trailers can be equipped with systems like RSC which may operate at the unit of the specific trailer, not the entire combination. Carriers should consult with manufacturers (i.e., trailer OEMs) to see if they need to take special precautions in mixing different trucks and trailers and also train their drivers on how the system works so they understand what to expect in practice.

Efficacy: Information-Only Technologies

Technology in this category provides information to drivers and carriers to assist with route planning and driving-related decision making. However, these systems are not meant to provide emergency last-moment intervention information, like an immediate forward collision warning. STEs that fit within this category include:

- AI-based route optimization
- Electronic inspection capabilities (critical events monitoring)
- Electronic logging devices for HOS compliance
- Heads-up display
- Mobile fleet safety apps
- Premium clusters
- Real-time weather monitoring systems
- Road-facing cameras (dashcams)
- Smart parking assistance systems (when referring to navigational aid only)
- Tire pressure monitoring systems
- Traffic sign recognition systems
- Vehicle-to-infrastructure communication

- Vehicle-to-vehicle communication

The research related to the efficacy of STEs in this category are a little more mixed in terms of overall sentiment (**Table 1** provides some targeted readings further exploring the degree to which such technology can be expected to improve or even hinder safety performance). In general, systems that provide drivers with enhanced information are considered beneficial and effective at improving safety, but there are also concerns that multiple sources of information for drivers can lead to distractions and complacency that can defeat the purpose of the technology or, in worst-case scenarios, potentially contribute to reducing safety performance.

In other words, technology that provides drivers with additional information to support them (and their carriers) in making safer decisions is generally considered effective. However, this efficacy is greatly impacted by how the technology is implemented, what the current in-cab environment is like for the driver, and the degree to which the carrier will support their drivers and consider their feedback in implementation.

Conclusions

This section has provided evidence to support the argument that, in general, modern vehicle-based safety technology is effective at improving safety performance, especially safety performance related to collisions on public roadways. When properly implemented, carriers can expect to see improvements.

What is harder to determine is the degree to which a carrier will see safety improvements from any specific plan of action. Research takes place within specific environments and, even though the work represented in **Table 1** tends to take place using real industry data and in natural settings, the actual effectiveness will vary from carrier to carrier due to the complexity of carrier operations.

In general, carriers will need to approach the implementation of specific type of technology by first reviewing research information related to its efficacy that's independent of the technology provider. It's important to understand the research enough so as to see what similarities and differences there are between the setting in which the research took place and the carrier's own operations. Regardless, though, it's safe to say that modern vehicle-based safety technology presents an opportunity for companies to further improve their safety performance.

Efficacy of Office-Based STEs

This section examines the general efficacy of office-based safety technology elements (STEs) in improving safety outcomes for carriers. See the Methods section of this resource for details on how this information was gathered.

Office-based STEs assist carriers by providing them with more information and/or higher quality information to support safety system improvements, overall operational efficiencies, and maintaining compliance with record retention requirements. Some STEs here are focused more on back-end office safety performance, like helping carriers pass compliance audits. Others are intended to provide information to support day-to-day safety activities, like managing incidents or helping coordinate operations for preventative maintenance purposes. Regardless, though, they all generally require active management on the part of the carrier to be effective.

We've categorized the STEs presented earlier in this resource into broader categories below which were chosen due to them being common ways technologies are described in the carrier safety industry. By using these categories, we're attempting to show how different STEs can contribute to similar aspects of safety performance at a higher level while still respecting the subtler differences between individual STEs.

Each category presents an overview of key information related to efficacy for each general type of STE, and each category also contains a list of specific STEs from this resource that belong to the category. Some STEs may fit within more than one category. The purpose here is to provide general information on how effective these types of STEs are at improving safety performance at general trucking companies so carriers and safety professionals reading this resource can be more strategic in how they approach this aspect of fleet safety management.

Efficacy: Data Analytics and Reporting Tools

Technology in this category is meant to help carriers make sense of complex safety data and to be able to present such information in intuitive, easy-to-understand formats to make safety and operational decision making simpler. STEs that fit within this category include:

- Audit preparation and document management software
- Collision reconstruction software

- Customizable reporting engines
- Cybersecurity management tools
- Driver risk profile monitoring systems
- Fleet management system
- Fuel and emissions reporting software
- General safety management and compliance management software
- Incident reporting systems
- Integration platforms
- Predictive maintenance software
- Telematics (general concept)
- Transportation management system

From an industry perspective, technology in this category is generally regarded as effective in terms of being beneficial to overall carrier management. Grey literature, in the form of industry blogs and material from technology providers describes the use of data analytics and the use of data reports more as a standard practice all companies should be doing, not as a new concept companies should consider (**Table 1**).

In terms of improving safety performance, research shows this category of technology to generally be effective as long as the carrier has plans for using the data. These plans need to be specific to the type of data and how such data can benefit the carrier. In other words, implementing the systems to begin to collect and analyse data is only the start of investing in this type of safety technology. Carriers have to then respond to the data.

Responding to data means the carrier understands what the data means, uses appropriate metrics, and can interpret the data to make better decisions. One common example is through the use of data based on driver behaviours and performance. Alone, such data don't benefit the carrier; the carrier will only see benefits by adjusting training to specific issues for specific drivers that were identified by the data. Effectiveness in such an example would be the measurement of driver improvement in response to the training that was adjusted based on the original data from the system.

This is where efficacy can be challenging to interpret from research. An article might report that a particular data analytics system is effective X% of the time at accurately identifying driver distraction. However, this percentage doesn't tell the carrier anything about how specifically effective the program will be at improving driver distraction rates since the carrier will have to take action or otherwise enable driver alert features in the system to then bring about the desired improvement of reduced rates of driver distraction. Therefore, the way in which the carrier manages their data and reasons why they generate reports are just as important as the specific technology in terms of overall effectiveness.

Efficacy: Compliance and Documentation Systems

Technology in this category is specifically meant to assist in the task of managing documents. Depending on the specific STE, this documentation management may be for regulatory compliance purposes, like having driver files that contain the minimum information requirements for a specific jurisdiction. They could also be intended more for general safety management assistance purposes to assist in day-to-day carrier management. STEs that fit within this category include:

- Audit preparation and document management software

- Contractor safety management tools
- Cross-border compliance software
- Electronic logging devices for HOS information
- Emergency response management and planning software
- Fuel and emissions reporting software
- General safety management and compliance management software
- Incident reporting systems
- Pre-employment screening and hiring tools

This category of safety technology is more straightforward to assess in terms of efficacy when we understand efficacy as the ability of the technology to simplify a carrier safety or operational management task. It's no secret that digital document storage and organization has greatly improved the ability of companies of all sizes to better handle information and describing how effective such systems are is sort of like describing how a word processor program on a computer is a faster way to write a document than a typewriter: it's well-accepted.

So, it's better to consider efficacy for these STEs specifically in terms of 1) how much time they save individual carrier staff member time and 2) how many work processes the systems can eliminate. For example, a benefit to ELDs is the office access part of the program can do both these things if the carrier leverages its features during HOS compliance reviews and by eliminating the manual handling of paper log sheets.

The effectiveness of these systems appears to be most commonly described in grey literature (**Table 1**) coming from general business management sources and technology providers themselves. Generally speaking, software to make document management and access easier are considered to be a cornerstone of modern business practices. The use of technology to digitize document handling for compliance and operational purposes is accepted as an effective way to improve management processes.

Where effectiveness can become reduced, though, is when the programs themselves introduce new challenges to operations. For example, a carrier with staff well-trained in manual document handling for a specific task may not see immediate benefits from using technology to digitize this same task unless staff are also well-trained in the use of the new system.

Furthermore, multiple systems can create confusion, so carriers should not only see if a new technology can solve the problem it was created to solve but also see if it can be integrated with existing programs. Existing programs may also already have the features to solve the new problem, but no one has taken the time to see if that's the case. ELDs, for example, typically generate telematics-related data even if just being used for HOS compliance purposes, so a good understanding of what features the carrier has in the programs it already uses is important in preventing duplicate programs and unnecessary costs.

A final note on this category: all of these STEs assume they will operate on good IT equipment (i.e., reliable computers with relatively current operating systems, storing data robustly). Carriers with computer issues like outdated servers or carriers that are using paper documents for these tasks will have to work on their IT systems first before they are ready to implement these (and many other) STEs.

Efficacy: Training and Performance Monitoring

Technology in this category is intended to help carriers in the management of information related to driver, staff, and/or contractor training records and general performance. In terms of performance, this could mean adherence to carrier policies and jurisdictional compliance requirements, or it could mean monitoring aspects of individuals' work tasks as part of providing information related to general safety management performance. STEs that fit within this category include:

- Audit preparation and document management software
- Contractor safety management tools
- Driver risk profile monitoring systems
- Electronic logging devices for HOS information
- Fatigue management software
- Fleet management system
- General safety management and compliance management software
- Incident reporting systems

- Learning management system (LMS)
- Simulators and virtual reality (VR)
- Telematics (general concept)
- Transportation management system

At its core, this STE category is about tracking driver/staff performance for the purpose of providing better, targeted training to encourage safe behaviours. Since driver behaviour is a causal factor in most collisions and safe driving behaviours can be taught, training as a general concept is an effective way to improve behaviour-related safety performance. So, when approaching efficacy from this perspective, a carrier with an effective training program (i.e., a program that allows the carrier to improve the competencies of its drivers and staff) will have an even more effective training program when it can use more accurate information to tailor the program to specific issues within its operations.

Some STEs in this category can help improve the training process itself, typically through the use of software that improves the organization of training courses and records and improves staff access to training. An LMS is a tool that helps carriers manage their training program and, in some cases, provides the overarching framework and courses for most of the program. Similar to document management programs, grey literature on this topic generally regards LMSs as effective, although non-LMS-provider-specific evidence notes that carriers should not just go with any LMS. Instead, they need to understand their training needs and select the best LMS for their purposes to be most effective (**Table 1**).

Efficacy with training and monitoring tools can also be thought of in different ways. We can look at efficacy from an overall safety performance perspective to attempt to isolate the effects of better training on lagging indicators like collision and injury rates, but such evidence is difficult to find and/or relate to a specific carrier due to the complexities involved.

Efficacy for these STEs can also be described in terms of operational/administrative gains, such as the amount of time saved to provide the same level of training to the same number of people. These gains are often greatest when first implementing technology in this area that eliminates a significant number of work processes, like moving a type of training to an online LMS and eliminating the need to teach that topic in-person. Such efficiencies need to be balanced against the effectiveness of the training itself, though. For example, a carrier may save a lot of time moving from hands-on vehicle inspection training to an online course, but aspects of vehicle inspection training should be done in a hands-on manner. In this case, it wouldn't be accurate to say the online training was effective overall if it results in a lower quality of vehicle inspections being done by drivers (and, potentially, increases in equipment issues and on-road violations), regardless of how much time was saved. Therefore, STEs in this category are generally considered effective in terms of generating data and streamlining processes, but carriers still need to monitor the final outcomes of their training programs as part of how effective they deem such technology to be overall.

Conclusions

Office-based STEs naturally require greater office-level management resources to be effective when compared to vehicle-based STEs that improve safety performance by responding to immediate pre-collision warnings. However, these two broad types of STEs (vehicle- versus office-based) are meant for different aspects of fleet safety management and are mutually complimentary.

The office-based STEs explored in this resource can generally be regarded as effective within technology-specific definitions of what effective means. Some types are most beneficial, from a safety performance perspective, by improving safety management efficiency which, in turn, allows safety staff to focus their efforts elsewhere. Other types are more directly related to improving safety performance by providing carrier staff with data to help them make decisions that are more likely to improve safety performance, such as by identifying specific high-risk drivers for additional training or by helping identify root causes for particular incidents so future occurrences can be prevented.

The main challenges carriers will have to manage when implementing these sorts of technologies are 1) understanding how the technology works, 2) understanding where it fits within the overarching safety system, 3) understanding its limitations, and 4) acting in response to the technologies' benefits (whether that means redirecting saved time to more directly impactful safety efforts or by making intelligent decisions based on new data). Additionally, increasing numbers of STE products and services on the market today add the additional challenge of managing multiple systems and accounts. Carriers have to be mindful to avoid duplicating services through multiple products and should, at times, take stock of the technologies they use to see if there are things that can be further refined. For example, a carrier that has an annual practice of auditing its safety program could add to their audit an inventorying of all related software to see if all programs are being used appropriately.

Regardless of what STEs are in place in a carrier's office, carrier staff still must make the decisions and take the necessary actions to operate the company and drive safety improvements. These technologies are effective in helping with this process when decisionmaking comes from a data-driven place of genuine understanding.

Efficacy of SMPs

This section examines the general efficacy of safety management practices (SMPs) in improving safety outcomes for carriers. See the Methods section of this resource for details on how this information was gathered.

SMPs encompass organizational policies, training programs, and cultural initiatives to promote safer practices. They represent direct field-level activities like workplace inspections, and they represent higher-level strategies related to continuous improvement efforts. Naturally, they require human management to be effective, although all of the various safety technology elements (STEs) described in this resource all contribute to this management either by improving management efficiencies, providing management with more and better data to make better decisions, or by providing management with new and innovative tools for tackling specific risks within the trucking and fleet management world.

We've categorized the SMPs presented earlier in this resource into broader categories below which were chosen due to them being common ways such practices are described throughout various niches within OHS management and related literature. By using these categories, we're attempting to show how different SMPs can contribute to similar aspects of safety performance at a higher level while still respecting the subtler differences between individual SMPs.

Each category presents an overview of key information related to efficacy for each general type of SMP, and each category also contains a list of specific SMPs from this resource that belong to the category. Some SMPs may fit within more than one category. The purpose here is to provide general information on how effective these types of SMPs are at improving safety performance at general trucking companies so carriers and safety professionals reading this resource can be more strategic in how they approach this aspect of fleet safety management.

Efficacy: Driver-Oriented Programs

Practices in this category are specifically meant to handle aspects of fleet safety management specifically concerning drivers. Since *driver*, as an occupation, tends to have specific types of hazards and issues related to the nature of the work, there are some practices in safety that are specifically meant for companies employing and/or contracting drivers as part of their operations. SMPs that fit within this category include:

- Active management of STEs
- Active program or system administration
- Advanced driver substance abuse programs
- Competency assessments - initial and ongoing
- Contract driver safety management
- Driver compensation structure
- Driver engagement programs
- Driver health and wellness programs
- Fatigue management
- Journey management
- Metrics
- Safe driver hiring practices
- Safety incentive programs
- Sleep apnea programs

- Temporary Foreign Worker safety management

Compared to other STE and SMP categories explored in this resource, there is a lot of research available on truck driver health and wellness concerns and on programs intended to address these concerns. Evidence is mixed in terms of the efficacy of such programs, though (**Table 1**). While there is evidence to suggest general effectiveness for programs that encourage healthier behaviours (like improved exercise and diet habits) for drivers, programs are also criticised in the literature when they fail to address systemic issues and place the majority of the responsibility on the driver to fit healthier habits into a rigid work routine.

Pairing these types of SMPs with technology and one-on-one support from professionals was also noted as a way to improve their efficacy. For example, exercise programs that use a driver's smartwatch and provide access to fitness and diet professionals through in-person or virtual means were noted to be more effective at producing better health outcomes for drivers than programs that relied on training and awareness alone.

Driver-oriented SMPs more focused on engagement and safety outcomes instead of health and wellness were reported to be more effective when management and leadership styles were taken into consideration. While it was challenging to find robust statistical data on the efficacy of such approaches, general management and leadership studies provides many examples of leadership styles and their appropriateness for different workforces, some of which will be more effective than others for specific carriers.

It's likely that the purported efficacy from much of the supplier-driven grey literature on driver programs is based on the logic that the underlying idea of the program is sound and, therefore, enhancing it will only contribute to better safety outcomes. For example, certain forms of driver pre-screening are required by carriers, requirements which vary based on the carrier's jurisdiction. If a specific activity is required by law, such as getting documentation of a driver's previous and safety-related employment history, simply going above and beyond law could be enough of an argument for a carrier to implement an enhanced version of an SMP regardless of if doing so actually produces better safety performance in terms of collision and injury reductions. This isn't a criticism of the law but, rather, a comment made to encourage carriers to critically evaluate what they consider to be "effective" when deciding on various approaches to safety management. Going above and beyond the law is a common approach to demonstrating due diligence; but, being able to demonstrate that safety management activities produce better safety outcomes on the road and in the yard is even better as such outcomes are the intended purpose of safety management in the first place.

Efficacy: Safety Culture and Engagement Initiatives

Practices in this category refer to aspects of safety management that are meant to produce a positive safety culture and engage staff in productive, collaborative ways. They are not compliance-based and are, instead, meant specifically to encourage safer and low-risk behaviours. SMPs that fit within this category include:

- Active management of STEs
- Active program or system administration
- Competent safety professionals
- Driver engagement programs
- Driver health and wellness programs

- Fatigue management
- HR and Safety collaboration
- Industry engagement
- Integrated safety frameworks
- Management commitment
- Metrics
- Proactive inspection program
- Safety-centric procurement and sales
- Safety committees and representatives
- Safety incentive programs
- Temporary Foreign Worker safety management

There is much evidence on the overall effectiveness of positive safety cultures and safety climates on overall safety performance, and some of the evidence provided in **Table 1** quantifies this efficacy in specific trucking contexts. It is very challenging to predict with much confidence a specific rate of collision or injury reduction a carrier may see after implementing a specific SMP, but there is ample evidence suggesting that overall efforts in safety management that prioritize open communication, management commitment to safety, the proactive and evidence-informed use of technology, workforce engagement, and moving safety from being a subjective operational priority into a core value are effective ways to improve safety performance.

Safety management is also something, especially in a carrier environment, that should be inclusive of all aspects of a person's role within an organization. Canadian OHS generally includes the employer's responsibilities to take action to protect psychological wellbeing alongside physical wellbeing. In addition, much of the literature presented in **Table 1** (and the literature referenced within those publications) draws connections between aspects of a person's occupation like how they are paid or their culture and their safety performance. While there is much more work to be done to increase the accuracy of predicting potential safety improvements in response to specific changes in safety management, holistic approaches to safety are generally considered to be more effective than safety being isolated from other aspects of an organization.

Efficacy: Operational Risk and Hazard Management

Practices in this category specifically relate to the active identification and management of risks and hazards. While all SMPs support this concept to some degree, an SMP that falls under this category will be specifically focused on reducing organizational risk either based on the identification of hazards at a specific carrier or common-to-carriers hazards. SMPs that fit within this category include:

- Active management of STEs
- Active program or system administration
- Advanced driver substance abuse programs
- Competency assessments - initial and ongoing
- Competent safety professionals
- Compliance management
- Contract driver safety management
- Emergency response planning
- Fatigue management

- Hazard identification, assessment, and control
- Incident investigation program
- Industry engagement
- Integrated safety frameworks
- Metrics
- Proactive inspection program
- Risk management
- Safe driver hiring practices
- Safety-centric procurement and sales
- Sleep apnea programs
- Temporary Foreign Worker safety management

SMPs related to risk and hazard management are generally considered effective at improving safety performance from a perceptions perspective, but there is less statistical evidence of the same kind

(**Table 1**). This can be largely explained by the complexities in fields like safety management. These same complexities also make quantitative data related to efficacy difficult to replicate outside of the study environment as the implementation of an SMP at a carrier will rarely be similar enough to be able to reliably expect similar results.

However, efficacy for risk management practices should not be interpreted as an X% reduction in a specific type of incident in a study will result in a similar percent reduction in a carrier adopting the same risk-related SMP. It's not realistic to expect numbers to match between such trials when there are so many variables that cannot be controlled. Instead, the X% reduction should instead be interpreted as evidence of overall efficacy of the SMP to support carrier implementation. The carrier can then, if it so chooses, attempt to measure its own % as a measurement of efficacy, but this should be done against its own performance year-over-year unless there is great confidence in making comparisons between different companies and environments.

Furthermore, risk management practices are based on the fundamental principle of understanding a system in granular detail to assess the negative impacts of failure at specific points in the system. Once a system is understood to such a degree, that understanding is enough for those in the industry to make recommendations to reduce risks without requiring additional data.

An example of this is doing a risk assessment on a carrier's OHSMS and identifying that there is no reliable language support available for a group of drivers whose English isn't likely to be good enough to understand a specific emergency response procedure at the current level of training being provided. A rational response to such a finding would then be to improve the training and its assessment specifically for this group of drivers to ensure they are as prepared as their peers. This is a rational and obvious solution to the identified problem that can be logically expected to improve this aspect of the carrier's safety performance.

This example above is meant to demonstrate how SMPs related to addressing hazards and risk are more about helping carriers develop deeper understandings of their operations so they can make better decisions. Carriers can determine for themselves if such an SMP is effective enough for their uses by trialing it and seeing if it indeed leads to detailed understandings of potential risks, and they will know they have reached this level of understanding when solutions to problems start to become obvious.

Conclusions

Determining the efficacies of various SMPs is, in some ways, more complicated than for many STEs due to the complexities in organizational behaviour and cultural differences between companies and research environments. However, the evidence in both primary and grey literature generally supports the conclusion that carriers should be investing safety management, and that the SMPs described in this resource all present various options for carriers to do so.

Factors that will impact SMP efficacy include carrier staff size, the structure of driver and staff employment and pay structures, management's commitment (or lack thereof) to safety, worker perceptions of their leaders' integrity and compassion, and the internal competencies of staff tasked with making safety management decisions. In addition, safety management isn't static, and carriers should expect their OHSMS efforts to be an ongoing, never-ending refinement moreso than an elusive destination that, once reached, will result in stress-free excellent safety performance.

Efficacy is consistently linked to management's willingness to internalize safety as a company value at all levels and to prioritize safety management efforts beyond compliance requirements. Even though this resource is intended to assist carriers in navigating the increasingly complicated safety technology space, it seems to be the case that safety performance improvements can't be easily bought and, instead, result from the intelligent merging of technology and management practices that are appropriate to the specific carrier's operations and culture.

Table 1 - Sources and Key Information for the Efficacies of STE and SMP Categories

The following table (**Table 1**) contains the detailed information from the literature search done to compile information for the sections in this resource regarding efficacy for the types of safety technology elements (STEs) and safety management practices (SMPs) discussed earlier in this resource. Detail and concision were both considerations in Table 1's creation. As a result, only key information from each source is listed, but the source citation is also provided so readers can independently verify the information in this table. Please see the Methods section of this resource for more information on how the literature search was conducted for this resource.

Category of Vehicle-Based STE	**Key Findings:** • **Source:** • **Source type: Primary* | Grey** | Interview*****
Collision Avoidance Systems	**Key findings:** Statistically significant collision reductions of 22% overall (police-reported crashes per vehicle miles traveled) and 44% reduction in rear-end crash rate for FCW; crash reductions of 12% overall and 41% for rear-end for AEB. FCW and AEB described as effective. FCW noted to have

	additional benefit of easier installation due to more accessible retrofit options. • **Source:** Bocanegra, J., Medina, J. C., & Boyle, L. N. (2021). Evaluating the effectiveness of advanced driver-assistance systems (ADAS) on crash reduction: A case study of lane departure warning and lane-keeping assist. *Traffic Injury Prevention, 22*(4), 315-320. https://doi.org/10.1080/15389588.2021.1893700 • **Source type:** Primary **Key findings:** Scoping literature review done on advanced vehicle technologies claiming that, overall and generally, evidence supports the claim that such technologies are effective at improving driving safety but that it is challenging to provide precise quantitative data at this level due to the complexities in various study designs and measurements being used to measure efficacy. • **Source:** Martin, J., Wu, K., & Porter, R. J. (2021). Evaluating the effectiveness of automated driver assistance systems in reducing crash severity. *Accident Analysis & Prevention, 153*, 106032. https://doi.org/10.1016/j.aap.2021.10603

	2 • **Source type:** Primary **Key findings:** Various collision avoidance STEs paired with V2V systems described as effective, with FCW+V2V reaching 72% effectiveness, AEB at 18-72% effectiveness from previous literature, and AEB varying from 64-85% effectiveness depending on the degree to which the driver interacted with the system. However, specifics as to what these percentages mean were not described. Overall conclusion largely that V2V improves collision avoidance systems and that these systems are still generally effective without V2V. • **Source:** Zhao, X., Li, X., & Zhang, Y. (2021). Effectiveness of advanced driver assistance systems in reducing crashes: Systematic review and meta-analysis. *International Journal of Environmental Research and Public Health, 18*(17), 9228. https://doi.org/10.3390/ijerph18179228 • **Source type:** Primary **Key findings:** Efficacies reported for various STEs with frontal collision reductions between 16-45%, lane departure collision reductions at 30%, blind zone-related collision reductions between 8-32%,

	and backing collision reductions between 19-82%, all while attempting to adjust for multiple potentially confounding and/or interacting variables. • **Source:** Sandt, L., Combs, T., & Harmon, K. J. (2019). *A systemic review of the effectiveness of road safety countermeasures*. U.S. Department of Transportation, Federal Highway Administration. https://rosap.ntl.bts.gov/view/dot/44159 • **Source type:** Grey (government technical report) **Key Findings:** Collision mitigation technologies described positively in terms of efficacy, with a 26.1% reduction in lane/road departure crashes and 20.7% reduction in serious injuries to drivers taken from other sources, and fleet adoption encouraged. • **Source:** Geotab. (2021). *Crash avoidance: The impact of fleet safety technology on reducing accidents*. https://www.geotab.com/blog/crash-avoidance/ • **Source type:** Grey (technology provider blog article)

	Key Findings: Describes NTSB recommendations to US regulators to implement various STEs (among other recommendations) based on evidence support their general efficacy. • **Source:** Canadian Trucking Alliance. (2023). *NTSB recommends truck speed limiters, collision avoidance, cameras*. https://cantruck.ca/ntsb-recommends-truck-speed-limiters-collision-avoidance-cameras/ • **Source type:** Grey (association news article) **Key Findings:** Describes improvements in AEB performance at preventing forward collisions in passenger vehicles with late-model (i.e., 2024) vehicles seeing a 100% forward crash prevention rate at 35 mph during tests compared to a 51% rate from early-model (i.e., 2017-2018) vehicles. AEB performance was better at lower speeds, and no late-model vehicles tested could prevent a forward collision using AEB at 55 mph, although severity would still be lessened. • **Source:** American Automobile Association (AAA). (2024). *Progression of automatic emergency braking (AEB) technology: Full research report*. https://newsroom.aaa.com/wp-

	content/uploads/2024/10/REVISED-10-17-24-Full-Research-Report-Progression-AEB-Technology.pdf • **Source type:** Grey (association technical publication) **Key Findings:** AEB, driver warning systems, and other STEs of this type described in numerous interviews as effective tools to reducing collision severities and frequencies, especially for rear-ending collisions. • **Source type:** Interview **Key Findings:** A large (>1,000 power unit) carrier reported 68% frequency and 94% severity reductions in rear-end collisions (i.e., carrier's vehicles hitting other vehicles) in their vehicles that are equipped with a suite of collision mitigation STEs (including AEB and FCW). Same carrier also reported a 33% reduction in rear-end collisions (i.e., carrier's vehicles being hit by other vehicles) in a pilot project testing brake-activated amber strobe lights on some of their trailers. • **Source type:** Interview
Driver Monitoring and Assistance	**Key Findings:** Various driver alert-issuing STEs were tested in a naturalistic (i.e., on the job) setting resulting in anywhere from 22-81% of drivers

Systems	receiving less alerts after using the systems (meaning they adjusted their driving behaviour), depending on which specific STE was in use. The authors state the STEs generally had a positive impact on driver behaviour and position the STEs as tools for encouraging safe driving behaviours. • **Source:** Wu, C. Cao, J., Du, Y. (2022). Impacts of advanced driver assistance systems on commercial truck driver behaviour performance using naturalistic data. *IET Intelligent Transport Systems, 17*(1), 119-128. https://doi.org/10.1049/itr2.12242 • **Source type:** Primary **Key Findings:** Quantitative survey approach used to assess acceptance and use of driver assistance STEs recommending that carrier management needs to involve drivers, provide adequate training, and provide a sufficiently long enough implementation time when introducing such STEs into vehicles to avoid driver disengagement and potentially having drivers manually deactivate systems. • **Source:** Gruchmann, T., Grenzfutner, W., Salzmann, A. (2024). From inside the cabin - truck drivers' technology acceptance of driving assistance systems. *Logistics*

	Research, 17(1). DOI_10.23773/2024_1 • **Source type:** Primary **Key Findings:** Approximately 77% of Northern European drivers surveyed indicated they are accepting of ADAS, but acceptance subsequently varied greatly and tended to be lower when drivers cannot manually deactivate the system or when there are privacy concerns related to driver-facing cameras providing distraction warnings. • **Source:** Innamorati, A. (2024). *Digitization in the transport sector: a quantitative investigation of the adoption of ADAS Technology in trucks from the perspective of the Technology Acceptance Model.* (Master's thesis, University of Twente). https://essay.utwente.nl/103738/1/Innamorati_MA_BMS.pdf • **Source type:** Grey (Master's thesis) **Key Findings:** General discussion around driver monitoring systems including quantitative data purported to be from major US carriers reporting a 50-70% reduction in collisions and their associated costs, 10% fuel economy improvements, and 30% improved driver performance (although the criteria for these percentages were not defined).

	• **Source:** Positrace. (2023). *Driver monitoring systems: How they improve fleet safety*. https://positrace.com/en/blog/driver-monitoring-systems/ • **Source type:** Grey (safety service provider website article) **Key Findings:** Information presented to positively highlight ADAS benefits, including estimates of American annual reductions of 11,000 collisions, 7,700 injuries, and 170 fatalities with adoption of these systems. Also noted 5-19% collision reductions for various STEs. • **Source:** Federal Motor Carrier Safety Administration. (2022 (from URL)). *ADAS safety guide: Advanced driver assistance systems for commercial vehicle operations*. U.S. Department of Transportation. https://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/2022-02/ADAS_SAFETY_GUIDE_DRAFT6_081621_508-FINAL.pdf • **Source type:** Grey (government resource) **Key Findings:** Driver- and forward-facing cameras

	with AI to detect unsafe driver behaviours described as being effective at reducing unwanted behaviours, collision frequencies, and collision severities. • **Source type:** Interview **Key Findings:** ELD systems with telematics used to identify and correct unsafe driving behaviours consistently described as effective for improving safety performance when paired with active coaching and targeted training. • **Source type:** Interview **Key Findings:** Driver-facing cameras with AI to detect unsafe driver behaviours described as being effective when paired with active coaching, reducing by 80% collision frequencies and eliminating rollovers (which previously took place every 1-2 months) in the year immediately after implementation at a livestock hauling division of a carrier operating >1,000 power units overall. • **Source type:** Interview **Key Findings:** In a current pilot project of right-side obstacle detection systems, a large (>1,000 power units) carrier reported 20-22% reduction in right lane change and right turn collisions and an average of 18% reduction in cost per collision. They also reported a nearly 160% ROI for the technology

	used in this pilot project where 100% is their ROI break-even point. • **Source type:** Interview
Stability and Traction Control Systems	**Key Findings:** Author discusses using trailer roll angle instead of lateral acceleration in trailer ESC/RSC systems and found evidence that doing so can slightly improve early rollover detection in truck-trailer combinations and, therefore, provide a system with more advanced warning. Efficacy of ESC/RSC systems assumed and this work endeavoured to identify improvements for future systems. • **Source:** Van Kat, Z. R. (2022). *Experimental Evaluation of Roll Stability control System Effectiveness for A-double Commercial Trucks*. (Master's thesis, Virginia Polytechnic Institute and State University). https://vtechworks.lib.vt.edu/server/api/core/bitstreams/a3e0c919-b759-4ebe-a8eb-4b9a3ca880a5/content • **Source type:** Grey (Master's thesis) **Key Findings:** Authors evaluate potential ways to improve stability systems in LCVs through computer simulation, operating from the assumption that such

	systems are generally inherently effective to varying degrees (efficacy assumed). • **Source:** Zhu, S., & Amirfazli, A. (2021). On dynamic stability evaluation methods for long combination vehicles. *Vehicle System Dynamics, 59*(12), 1–20. https://doi.org/10.1080/00423114.2021.1986223 • **Source type:** Primary **Key Findings:** Authors examine US fatal collision data to determine efficacy of ESC systems, concluding that such systems are likely not as effective in reducing fatalities as have been previously estimated (still effective but other approaches to traffic safety needed beyond such systems to continue reducing collision fatalities). • **Source:** Wåhlberg, A.A., Dorn, L. (2024). The effects of Electronic Stability Control (ESC) on fatal crash rates in the United States. *Journal of Safety Research, 88*, 217-229. https://doi.org/10.1016/j.jsr.2023.11.008 • **Source type:** Primary **Key Findings:** Article advertises ESC benefits in

	reducing fatalities when describing the safety features they continue to implement in their vehicles. • **Source:** Penske Truck Leasing. (2025). Safety technology: Advanced safety systems for commercial trucks. https://www.pensketruckleasing.com/resources/resource-library/safety-technology/ • **Source type:** Grey (industry service provider and carrier website article) **Key Findings:** RSC specifically mentioned by one interviewee representing a large carrier (i.e., >1,000 power units) as effective at reducing critical events in their telematics system considered to be leading indicators for trailer-induced tractor-trailer rollovers. • **Source type:** Interview
Information-Only Technologies	**Key Findings:** Authors describe the positive results of a study where advanced weather and road work warnings were provided to professional truck drivers in a simulator setting as evidence of system efficacy when alerts are also paired with recommended course of action (i.e., alert plus notification to reduce speed due to work zone ahead); however, authors noted that systems must

	also be designed so as to minimize driver distractions that result from over-notification. • **Source:** Raddaoui, O., Ahmed, M.M., Gaweesh, S.M. (2020). Assessment of the effectiveness of connected vehicle weather and work zone warnings in improving truck driver safety. *IATSS Research, 44*(3), 230-237. https://doi.org/10.1016/j.iatssr.2020.01.001 • **Source type:** Primary **Key Findings:** Authors argue that enhanced driver information systems, as a concept, are effective and worth further evaluation, but also that the way the system interacts with the driver is critically important in terms of efficacy and that manufacturers should consider integration of systems to reduce distraction and complacency. • **Source:** Horberry, T. Mulvihill, C., Fitzharris, M., Lawrence, B., Lenné, M., Kuo, J., Wood, D. (2021). Human-Centered Design for an In-Vehicle Truck Driver Fatigue and Distraction Warning System. *IEEE Transactions on Intelligent Transportation Systems, 23*(6), 5350-5359.

	https://doi.org/10.1109/TITS.2021.3053096 • **Source type:** Primary **Key Findings:** Multiple interviewees described the benefits of addressing driver environments by providing important information while mindfully reducing distractions to reduce unwanted behaviours. • **Source type:** Interview
Category of Office-Based STE	**Key Findings:** • **Source:** **Source type: Primary* | Grey** | Interview***
Data Analytics and Reporting Tools	**Key Findings:** Literature review on fleet data analysis systems to produce model workflow for carriers to allow for integration of multiple data sources and the cleaning of data prior to analysis. Major takeaways are the importance of carriers understanding their data analytics systems and ensuring their systems talk to eachother when appropriate. • **Source:** Brunheroto, P.H., Pepino, A.L.G., Deschamps, F., de Freitas Rocha Loures, E. (2022). Data analytics in fleet operations: A systematic literature review and workflow

	proposal. *Procedia CIRP, 107*, 1192-1197. https://doi.org/10.1016/j.procir.2022.05.130 • **Source type:** Primary **Key Findings:** Authors constructed a route planning model using AI that was able to predict real-time conditions with an 88-95% accuracy rate which they use to highlight the importance of this technology in carrier operations to enhance outcomes in terms of real-time route planning. • **Source:** Hu, W.-C., Wu, H.-T., Cho, H.-H., & Tseng, F.-H. (2020). Optimal route planning system for logistics vehicles based on artificial intelligence. *Journal of Internet Technology, 21*(3), 757–764. https://doi.org/10.3966/160792642020052103023 • **Source type:** Primary **Key Findings:** Carrier driver training deemed to be more effective at producing safe driving behaviours when tailored to specific fleets using telematics data from that same fleet. • **Source:** Gresham, T.R., Kim, J., McDonald, J., Scoggins, N., Mostafavi, M., Park, B.B.

	(2021). *Safe and Sustainable Fleet Management with Data Analytics and Training*. From conference *2021 Systems and Information Engineering Design Symposium (SIEDS)*. https://doi.org/10.1109/SIEDS52267.2021.9483746 • **Source type:** Grey (academic conference paper) **Key Findings:** Numerous internet articles from STE providers describing the effectiveness of carrier data analytics in terms of safety and operational efficiency as selling points for their products and services. • **Source:** Multiple • **Source type:** Grey (STE service provider articles) **Key Findings:** Multiple interviewees described the effectiveness of using predictive AI-based software in their preventative maintenance programs to reducing downtime and improving equipment reliability (although this was also reported as a relatively new area in their overall fleet safety management programs).

	• **Source type:** Interview
Compliance and Documentation Systems	**Key Findings:** General business article on documentation, compliance, and data management practices stating 91% of data professionals consider data quality issues to be harmful to company performance, 48% of employees stating they struggle to find key documentation when needed within their employers' systems, 45% of small/medium-sized businesses still rely on paper records with 11% having no system at all in place for their management, 80% of businesses struggle to integrate apps/programs into their operations, 59% of Chief Information Officers say investing in cloud-based document management systems are top priorities, 69% of IT departments plan to increase cybersecurity investments, and e-signatures can improve sales close rates by >28%. • **Source:** Business.com. (2024). 7 statistics that will make you rethink your document management strategy. https://www.business.com/articles/7-statistics-that-will-make-you-rethink-your-document-management-strategy/ • **Source type:** Grey (general business/management online best practices article)

	Key Findings: Numerous internet articles from STE providers describing the effectiveness of compliance and documentation management software (and when, to varying degrees, coupled with the provider's safety and compliance management services) as selling points for their products and services. • **Source:** Multiple • **Source type:** Grey (STE service provider articles) **Key Findings:** Interviewee involved in the safety and compliance management for numerous small (i.e., 1-50 power units) carriers described the benefits to carriers for using document and compliance management software to allow office staff to focus on more impactful activities. • **Source type:** Interview
Training and Performance Monitoring	**Key Findings:** Authors note that 80.6% of collisions involving commercial trucks result from driver factors and advocate for the creation of truck driver personas as a way to better apply safety interventions which currently often fail to account for the driver's personality and similar factors. • **Source:** Li, H., Wang, W., Yao, Y., Zhao, Z.,

	Zhang, Z. (2024). A review of truck driver personal construction for safety management. *Accident Analysis & Prevention, 206*, 107694. https://doi.org/10.1016/j.aap.2024.107694 • **Source type:** Primary **Key Findings:** Study on emergency vehicle fleet operators provides evidence for addressing driver behaviour and acceptance related to technological implementations that are specific to the drivers in question (i.e., understanding specific driver groups is important when deciding how to implement safety technology and in providing associated training to bring about potential effectiveness). • **Source:** Muir, C., Newnam, S., Newstead, S., Boustras, G. (2020). Challenges for safety intervention in emergency vehicle fleets: A case study. *Safety Science, 123*, 104543. https://doi.org/10.1016/j.ssci.2019.104543 • **Source type:** Primary **Key Findings:** Exploration of the use of LMS' in online workforce training in logistics operations identified that organizations within this industry

	tend to adopt LMS' without much consistency or not adopt them at all; the author suggests improved used of training best practices and ensuring a prospective LMS meetings the requirements of a specific workforce as industry recommendations to improve training outcomes. • **Source:** Karapetian, M.B. (2024). *Universal Design for Learning (UDL) and Learning Management System (LMS) Considerations to Facilitate Online Learning Outcomes for Logistics Workforce Development*. (Master's thesis, California State University). ProQuest. https://www.proquest.com/openview/0ffabb88c15750c455749bdea3307909/1?pq-origsite=gscholar&cbl=18750&diss=y • **Source type:** Grey (Master's thesis) **Key Findings:** Numerous internet articles from LMS providers describing the effectiveness of LMS' as selling points for their products and services. • **Source:** Multiple • **Source type:** Grey (STE service provider articles) **Key Findings:** Multiple interviewees stated

	telematics typically found within ELD programs coupled with tailored training interventions (i.e., active coaching) to be effective at identifying and reducing unwanted driver behaviours, with one carrier (500-1,000 power units) crediting this approach with reducing their fleet-wide daily overspeeds (i.e., exceeding posted or governor speed limit by 11 km/h) from 150-200 per day to <10 per day. • **Source type:** Interview
Category of SMP	**Key Findings:** • **Source:** **Source type: Primary* | Grey** | Interview*****
Driver-Oriented Programs	**Key Findings:** Meta-analysis of literature on programs meant to improve truck driver health-related behaviours such as increasing exercise and fruits/vegetables consumption and decreasing weight and smoking. Authors found some evidence of programs resulting in increases in healthy eating behaviours and noted the comparative lack of research on this topic compared to similar programs in other occupations. • **Source:** Virgara, R., Singh, B., O'Connor, E., Szeto, K., Merkx, Z., Rees, C., Gilson, N., & Maher, C. (2024). Keep on truckin': How effective are health behaviour interventions on truck drivers' health? A systematic

	review and meta-analysis. *BMC Public Health, 24*, Article 2623. https://doi.org/10.1186/s12889-024-19929-1 • **Source type:** Primary **Key Findings:** Authors identified programs specifically meant to improve health/safety/wellbeing outcomes in ageing drivers to be a gap in the industry and that such programs (whether related to age or not) tend to place the bulk of the responsibility on the individual worker instead of other levels of the system/organization taking greater responsibility for creating positive change. • **Source:** Batson, A., Newnam, S., Koppel, S. (2022). Health, safety, and wellbeing interventions in the workplace, and how they may assist ageing heavy vehicle drivers: A meta review. *Safety Science, 150*, 105676. https://doi.org/10.1016/j.ssci.2022.105676 • **Source type:** Primary **Key Findings:** Author notes that while programs meant to improve truck driver health and wellness

	remain a gap in the industry, drivers and fleet managers both are generally interested in such programs; the use of wearable technology (i.e., smartwatch) was identified as a key component of such programs in terms of interest from drivers and managers. • **Source:** Guest, A. (2022). *Assessing the implementation of a multicomponent health intervention in truck drivers and its interacting with psychophysiological responses to stress*. (Doctoral thesis, Loughborough University). https://doi.org/10.26174/thesis.lboro.20488509.v1 • **Source type:** Grey (Doctoral thesis) **Key Findings:** Scoping review of global truck driver health intervention programs, noting that programs tend to place the majority of the responsibility on the individual without addressing systemic psychosocial factors that are causal in negative health outcomes for drivers. • **Source:** Amoadu, M., Sarfo, J.O., Ansah, E.W. (2024). Working conditions of commercial drivers: a scoping review of psychosocial work factors, health outcomes, and interventions. *BMC Public*

	Health, *24*, 2944. https://doi.org/10.1186/s12889-024-20465-1 • **Source type:** Primary **Key Findings:** Multicomponent health intervention programs using one-on-one coaching with wearable fitness technology identified as effective at helping drivers in a pilot study extend their USDOT medical certificates through improved health metrics. • **Source:** Snyder, P., Carbone, E., Heaton, K., & Hammond, S. (2024). Program evaluation of Fit to Pass®, a remotely accessible health promotion program for commercial motor vehicle truck drivers. *Workplace Health & Safety, 72*(1), 6–12. https://doi.org/10.1177/21650799231193587 • **Source type:** Primary **Key Findings:** Authors note the research demonstrating the relationship between driver pay and safety with higher rates of pay being associated with better safety outcomes through a variety of mechanisms, encouraging carriers to offer pay packages to drivers that have a variety of financial

	and non-financial incentives that take driver motivations into account (which cannot be assumed to be the same from one carrier to the next, or from one driver to the next). • **Source:** Meyer, L., Goedhals-Gerber, L.L., De Bod, A. (2025). A systematic review of inventive schemes and their implications for truck driver safety performance. *Journal of Safety Research, 92*, 166-180. https://doi.org/10.1016/j.jsr.2024.11.023 • **Source type:** Primary **Key Findings:** A summary of existing health and wellness programs at American carriers that identified best practices in such programs for them to be considered effective as per interviews with carriers. Best practices include having systems in place for data privacy concerns, driver-to-driver program advocacy, healthy competitions, rewards for personal progress, and top-down management commitment to the program (and overall safety culture). • **Source:** Glenn, T.L., Mabry, J.E., Hickman, J.S. (2022). *A Catalog of Health and Wellness Programs for Commercial Drivers*. Virginia Tech Transportation Institute on behalf of National Surface

	Transportation Safety Center for Excellence. https://vtechworks.lib.vt.edu/server/api/core/bitstreams/71dbb8bd-0c74-4e2e-b02e-78f5d73ecec3/content • **Source type:** Grey (technical report) **Key Findings:** Author describes management interventions to improve truck driver retention at small American carriers through servant leadership, improved work-life balance, and addressing compensation structures. • **Source:** Cooper, D.K., Jr. (2024). *Strategies for Driver Retention at Small Trucking Companies*. (Doctoral Thesis, Walden University). ProQuest. https://www.proquest.com/openview/e3bf4ceab2fea8896abe49aab9b5fce6/1?pq-origsite=gscholar&cbl=18750&diss=y • **Source type:** Grey (Doctoral thesis) **Key Findings:** Author describes management interventions to improve truck driver engagement and safety outcomes through adjusting leadership style to match remote workforce preferences (passive avoidant leadership better than transformational leadership styles for remote,

	introverted, and self-reliant driver workforces), suggesting personality testing for leadership and drivers to better match the two to improve safety outcomes. • **Source:** McMahon, J.F. (2021). *Effects of Transformational Leadership on Safety Performance in the United States Commercial Trucking Industry*. (Doctoral thesis, Louisiana Tech University). https://digitalcommons.latech.edu/dissertations/908 • **Source type:** Grey (Doctoral thesis) **Key Findings:** Numerous internet articles from various types of driver program providers describing the effectiveness of said programs as selling points for their products and services, with these programs tending to focus on health (diet, exercise, mental health) with various options for driver engagement such as carrier delivery, virtual coaching, and programs that include the use of wearable fitness technology (i.e., smartwatches). • **Source:** Multiple • **Source type:** Grey (SMP service provider articles)

	Key Findings: Multiple interviewees described the importance of involving drivers in change management, using influential drivers to champion safe behaviours and encourage the embracing of STEs, and striving to demonstrate appreciation for drivers throughout all aspects of their jobs. • **Source type:** Interview
Safety Culture and Engagement Initiatives	**Key Findings:** Safety programs may reduce collisions by up to 60% noted during literature review, and structured safety program elements along with management actions and commitment as a first step related to improved carrier safety performance. • **Source:** Nævestad, T., Blom, J., Phillips,. R.O. (2020). Safety culture, safety management and accident risk in trucking companies. *Transportation Research Part F: Traffic Psychology and Behaviour, 73,* 325-347. • **Source type:** Primary **Key Findings:** Up to 51% reduction in total number of serious injury or fatality collisions involving commercial trucks in Norway predicted with implementation (industry-wide) of structured OHS management system.

	• **Source:** Nævestad, T.-O., Phillips, R., Hovi, I. B., Jordbakke, G. N., & Elvik, R. (2022). Estimating safety outcomes of increased organisational safety management in trucking companies. *Safety, 8*(2), Article 36. https://doi.org/10.3390/safety8020036 • **Source type:** Primary **Key Findings:** 93% of study participants at carriers rated group-level safety climate as high when leader-member exchange and psychological ownership in their positions, and safety climate generally related to leaders' abilities to have high-quality communications with their subordinates and show integrity and when the employer provides employees with greater autonomy and psychological ownership in their positions. • **Source:** Huang, Y., He, Y., Lee, J., Hu, C. (2021). Key drivers of trucking safety climate from the perspective of leader-member exchange: Bayesian network predictive modeling approach. *Accident Analysis & Prevention, 150*, 105850. https://doi.org/10.1016/j.aap.2020.105850

	Source type: Primary **Key Findings:** Safety climate measurements are known to be good predictors of safety performance, and AI models were trialed to use safety climate inputs to predict safety performance at trucking companies with promising results, especially if carriers were to pool data for the purpose of better model training. **Source:** Sun, K., Lan, T., Kam, S. H., Goh, Y. M., & Huang, Y.-H. (2024). Predicting trucking accidents with truck drivers' safety climate perception: An in-depth evaluation of the pretrain-then-finetune approach. *Transportation Research Part F: Traffic Psychology and Behaviour, 106*, 72–89. https://doi.org/10.1016/j.trf.2024.08.009 **Source type:** Primary **Key Findings:** Numerous internet articles, reports, and other resources describe safety culture and safety climate as effective for managing risk in a trucking environment. **Source:** Multiple **Source type:** Grey (government reports,

	technical reports, carrier/service provider blogs, etc.) **Key Findings:** Multiple interviewees reported that safety committees as effective means to engage staff and champion new STE/SMP implementations, encouraging other carriers to use these committees for more reasons than OHS compliance. • **Source type:** Interview
Operational Risk and Hazard Management	**Key Findings:** Authors conducted a detailed literature review of the efficacy of hazard/risk/safety management practices on safety performance, finding that various elements of safety management programs, including risk analysis in a heavy vehicle context, to affect safety. There is little statistical evidence of their efficacy compared to perception-based (and similar) evidence, but they also note the difficulties in quantifying safety outcomes due to the complexity of the systems involved and the challenges they pose in isolating specific variables. • **Source:** Mooren, L., Grzebieta, R., Williamson, A., Olivier, J., Friswell, R. (2014). Safety management for heavy vehicle transport: A review of the literature. *Safety Science, 62*, 79-89. https://doi.org/10.1016/j.ssci.2013.08.001

	• **Source type:** Primary **Key Findings:** Numerous internet articles, reports, and other resources describe hazard and risk management to be integral to safety management in a trucking environment and as effective management practices for improving safety performance. • **Source:** Multiple • **Source type:** Grey (government reports, technical reports, carrier/service provider blogs, etc.) **Key Findings:** Multiple interviewees reported on the importance of adopting risk management practices that move the carrier beyond compliance-focused safety management. • **Source type:** Interview

* - "Primary" refers primary literature, which means evidence from peer-reviewed publications found in research/academic journals and other information sources that have been similarly vetted.

** - "Grey" refers to grey literature, which means evidence from non-primary sources. Grey literature includes industry news, industry publications (like a white paper from an association), documented comments from industry representatives (such as transcripts or slides from a conference presentation), government reports, and information from technology and/or safety management product and service providers.

*** - "Interview" refers to information specifically received during the interviews conducted as part of the creation of this resource. Any information of this type included in this table was provided to the interviewer in a robust manner (for example, by a participant stating they are getting their information from an official company document that reflects a specific internal project's results).

Chapter Eight – Return On Investment (ROI) of STEs and SMPs

This chapter turns the discussion to the ROI of safety technology elements (STEs) and safety management practices (SMPs) presented in earlier chapters. Unlike the chapter on efficacy, this chapter focuses more on what ROI is, how it's calculated, and on practical exercises meant to demonstrate how it can be applied to carrier safety management.

ROI: An Overview

This resource has so-far described many different types of safety technology elements (STEs) and safety management practices (SMPs). It has also presented data related to their general efficacy, both from the interviews done specifically for this resource (presented in the chapter on what the carriers interviewed had to say) and the targeted literature reviews (presented in the chapter on efficacy). We also wanted to specifically examine STE and SMP return on investment (ROI), and that is the subject of this chapter.

The first part of this chapter will provide an overview of what ROI means along with details related to calculating and interpreting it. The intent here is to provide some basics on this topic as it's commonly used in discussions around technology in trucking and fleet management, but it's also commonly misunderstood and incorrectly communicated between organizations. Then, subsequent sections of this chapter will explore ROI data for STEs and SMPs and information on how carriers can leverage efficacy data and their own internal safety data to more accurately calculate their own ROIs.

What is return on investment (ROI)?

Return on investment, or ROI, is a metric that's used by organizations to measure the financial performance of a specific investment. The way ROI works is that it measures how much money is earned or lost based as a function of how much was spent in the first place. It's expressed mathematically as follows:

ROI = [[[Net Benefit from Investment] - [Cost of Investment]] / [Cost of Investment]] x 100%

Since ROI is typically reported as a percentage, the ROI calculated using the above formula would then be multiplied by 100% to give the final ROI metric.

Here's a simple example of an ROI calculation. Let's say a company invests $1,000 into a service that ends up directly boosting their profits by $2,000. Here is how the ROI for that investment would be calculated using the above formula:

ROI = [[[Net Benefit from Investment] - [Cost of Investment]] / [Cost of Investment]] x 100%

ROI = [[[$2,000] - [$1,000]] / [$1,000]] x 100%

ROI = [$1,000 / $1,000] x 100%

ROI = 100%

So, the company could say that the ROI for their investment was 100%, meaning they earned in profit 100% of the same amount of money they invested in the new service. Another way this could be worded is that for every $1 spent on this service, $2 are earned back, giving a net profit of $1 for every $1 spent.

Here are some important concepts when discussing ROI:

- Positive ROI (>0%): Any positive percentage for an ROI means that the investment is making the company more money than it spends on the investment (a good thing).

- Negative ROI (<0%): Any negative percentage for ROI means that the investment actually ends up costing the company more than it originally spent on the investment in the first place.

- An ROI of 0% means that the company broke even on the original investment.

Inconsistencies and Important Considerations with ROI

The above is a simple and standard way of calculating and discussing ROI that's well-accepted in the business and economics communities. However, ROI is not always expressed in the above terms. This can lead to confusion in interpreting information on ROI.

The break-even point in ROI calculations may vary from organization to organization. Sometimes, an organization calculates ROI in such a way that 100% is the break-even point, which would be the same as 0% using the formula presented at the start of this section. So, if such a company reported an ROI of 150%, it would actually be an ROI of 50%, meaning they earned $1.5 for every $1 spent on the specific investment. Either way, this is a positive ROI, but there's an enormous difference in a 50% ROI versus 150% ROI, so it's important to be clear on how any ROI was calculated so that appropriate comparisons and interpretations can be made.

Time matters greatly with any investment, and it's not something that's necessarily reflected in an ROI number. An investment that doubles has an ROI of 100%, but just that percentage alone doesn't tell us how long it took for the investment to double. Naturally, we will want to know how long we should expect an ROI to materialize, especially since carriers generally make investments based on budgets with set time frames, like annual or monthly budgets.

Contextualizing ROI

An ROI percentage by itself doesn't tell us much about the details surrounding the specific investment. This means that we generally need more information to accompany any ROI metric to fully understand the specific context around the investment.

Think of ROI like a scientific experiment. An ideal experiment takes place in a very controlled setting so that we're only testing the effects of one specific thing on an outcome. Ideally, we would be able to do the same with ROI: keep everything else about the business the same while the only change is the specific investment, meaning that the resulting change in profit is completely attributable to the investment and, therefore, our ROI is an accurate description of the financial performance of the specific investment.

In reality, though, things don't work this way. Carriers are complicated, and there are always things going on that can potentially influence the financial performance of an investment. The greater the uncertainty in what impacts profits, the less accurate the ROI metric.

That doesn't mean we can't take steps to improve the accuracy of an ROI calculation, though. Carriers and any other type of business can take steps to isolate the effects of a specific investment to better test its ROI performance. Large carriers, for example, can do this in-part by rolling out a new technology to a specific division of their operations, randomly installing it in in half of the division's vehicles, and then measuring the results. This allows for greater confidence in the resulting ROI figures because there will have been vehicles without the technology doing the same work as the ones with the technology, meaning that any difference in financial performance between the two samples of vehicles can more reliably be attributed to the specific technology instead of other factors.

So, when evaluating anything based on ROI, it's important to understand the context in which the advertised ROI was calculated. If, instead, a carrier is attempting to calculate its own ROI, then it's important for said carrier to establish its methods for measuring and calculating ROI ahead of time so that the results are as reliable as possible given the means the carrier has at its disposal.

Short-Term versus Long-Term ROI

As noted above, an ROI percentage by itself doesn't tell us how long we need to wait to see the specific return. Both short-term and long-term ROIs are important and have their own place in helping carriers decide on how to make an investment in safety. A large carrier that adopts camera and collision mitigation technology will see a high short-term ROI if the new technology quickly reduces certain types of collisions, like rear-ending collisions. However, investing in safety technology and/or management practices that are meant to improve safety culture will likely take a longer period of time to see a positive ROI simply because changing company culture takes time, and so the corresponding cost savings like reduced tickets and improved fuel economy from safer driving behaviours will also then take longer to appear.

Direct versus Indirect ROI

ROI can also be discussed in terms of how directly we're measuring the costs related to a specific investment. Direct costs associated with carrier safety include immediate costs for collisions (like tow bills, repair costs, and tickets) and having to pay additional staff to cover for the productivity losses that result from a driver or other staff member not being able to do their job as a result of an injury. These costs are typically the easiest to calculate.

Indirect costs, though, are more challenging to calculate but are still important to consider. For example, a collision could result in reputational damage to a carrier that damages the company's safety scores and contributes to the loss of a customer that uses these scores annually to determine which carriers will haul their freight. Or, perhaps investing in safety technology and proactive management practices results in improved driver retention, which means reduced costs associated with driver turnover. These types of costs are much harder to calculate and specifically attribute to any single, specific safety intervention, but they are still real costs.

ROI versus Efficacy

ROI and efficacy are not the same thing. ROI measures the financial performance of an investment, and efficacy refers to how effective something is at its intended purpose. Therefore, if the thing in question is a purely investment-related financial product, ROI can be viewed as a way to measure its efficacy. After all, the percent return of an investment is generally how we would decide how effective the investment was at making us more money - the only other key piece of information missing is the amount of time it took or is expected to take for the ROI to materialize.

However, this resource is about safety technology (STEs) and safety management practices (SMPs), not financial investments. ROI is not directly related to the efficacy of STEs and SMPs. Instead, we evaluate efficacy of a specific STE or SMP based on safety-related outcomes, like reductions in injury and collision rates and their severities. Yes, it's true that reducing injury and collision rates and severities implies reduced costs for the carrier; but, looking at incident costs adds another layer of complexity to evaluating an STEs or SMPs efficacy, so it's better to just focus on rates, severity, and other measures directly related to safety performance to assess efficacy. Then, if we can say that a specific STE or SMP results in a reduction of a certain type of incident, we can then do the math to figure out the potential financial benefits to the carrier on top of the health and safety benefits by using the carrier's own data.

ROI can be indirectly related to safety performance, though. For example, some aspects of workplace safety management are concerned with insurance costs, whether vehicle insurance or workers' compensation insurance. Reductions in insurance premiums are generally considered to be a sign of positive safety performance improvements. If we can attribute changes in these types of costs to an STE or SMP, then ROI becomes more of an indicator of safety performance.

The content above on short- versus long-term and direct versus indirect ROI add further complexities to comparing ROI and efficacy. It could be the case that an action plan for the implementation of some STEs along with corresponding SMPs is expected to be effective at measurably reducing collision and injury rates by a certain percentage within a year. The upfront cost for implementation might be quite high, and then there are the long-term costs associated with staff resources for managing and maintaining the STE. In this type of example, the short-term and direct ROIs might not look so great since the carrier will be spending money upfront immediately but not seeing safety performance improvements for a longer period of time. Then, ROI will start to improve as collision and injury rates drop. However, collision and injury incident costs also impact carriers in different ways. Collisions will have immediate costs, like tow and repair bills, but then there will be longer-term and harder to calculate costs, like impacts to insurance premiums. Similarly, injury costs to companies are also complicated, typically having direct costs associated with the immediate impacts of someone not being able to do their job (like the deliveries not being made that day) and then the longer-term costs like increases to workers' compensation premiums.

Carriers should not solely look at ROI as an indicator of how effective a particular safety intervention may be. Instead, measures of efficacy that make sense for the specific technology or practice should be used to determine efficacy. ROI is still useful, though, especially for budgeting purposes, and it can also be a sign of safety-related efficacy once the context around the specific ROI calculations is understood.

Interpreting ROI

It's beyond the scope of this resource to detail how a carrier can calculate ROI for specific STEs and SMPs for their own, unique operations. Instead, carriers are encouraged to contact organizations like trucking associations and other industry resources to help them craft a plan that makes sense for them. We will, however, provide a quick checklist of things to consider when interpreting ROI information, like when a product or service provider advertises a specific ROI for going with their solution:

1. **Ask about efficacy.** When evaluating potential safety technologies and services,

remember that ROI isn't going to tell the whole story when it comes to how effective the services and products may be. So, it's important to ask about other measures of efficacy, like if there are study data providing information on things like anticipated reductions in incident occurrences and their severity.

2. **Verify the ROI calculation method.** This means asking the source of the ROI information questions like what formula they use to calculate ROI and what ROI value is used as the break-even point.

3. **Request time-related details.** This means asking the period of time over which the ROI is expected to take place and if additional investments are required throughout that time to bring about the advertised ROI.

4. **Request cost-related details.** This means asking questions about the specific costs being used for the calculation, such as direct versus indirect incident costs.

5. **Get context.** This means asking for more information about the general environment in

which the ROI calculations took place, like if the ROI data are based on a specific study or pilot project, to determine how realistic it is to expect similar results for a specific carrier and its unique operations.

6. **Request data and testimonials.** For large purchases where the ROI being advertised is critical for budgeting purposes, it might make sense to dig a lot deeper and request specific data from the supplier and perhaps independently check with other users to verify the supplier's advertised figures.

7. **Ask about management and maintenance requirements.** Remember, many types of STEs require active management by carrier staff to be effective, and some will require ongoing maintenance costs to maintain their efficacy. ROI data that only considers implementation costs doesn't provide an accurate picture of the total costs associated with the technology if the technology will require additional investments in the form of staff or third-party contracted support to be effective.

The above list is just a suggested guideline on things to consider when presented with ROI data, especially when the ROI data is coming from a supplier interested in selling a product or service. Sometimes, just a few well-thought-out questions are all that are needed to flush out the details necessary to make a good purchasing decision.

An ROI Calculator Exercise (and Table 2)

It was difficult to identify evidence related to the return on investment (ROI) for safety technology elements (STE) and safety management practices (SMP) that carrier management could use to make specific predictions for their own companies. Studies and grey literature sources discussing ROI also often presented data more related to efficacy as ROI data, like collision rate reductions. Nevertheless, the evidence presented in **Table 1** and the rest of the chapter on efficacy, the information presented in this section, and data from the interviews suggest that, overall, carriers can expect positive ROIs for investments made in STEs as long as they are also managing them and any related data appropriately.

This section will now present and discuss two sources of ROI data. The first is a specific example from one of the interviews. Then, we will discuss the Federal Motor Carrier Safety Administration's (FMCSA's) ROI calculator and present and discuss our results from an exercise we did specifically for this resource.

ROI Source 1: An Interviewee's Reported ROI

One interviewee was able to provide a very specific ROI result for a pilot project testing technology meant to alert drivers to obstacles along the right side of their vehicles, like pedestrians and other vehicles. The pilot project was for a small number of the vehicles in a specific division of this >1,000 power unit carrier. It was designed in such a way that the results for the STE-equipped vehicles is comparable against the larger population of vehicles doing the same work without the STEs, allowing them to collect efficacy and ROI data for this pilot project to help determine if they will implement the technology in more of their vehicles.

They reported that this ongoing pilot project was so-far delivering close to a 160% ROI (but they use 100% as their break-even point, so this would be a 60% ROI using the ROI calculation method presented at the start of this chapter). This is for the technology currently providing 20-22% frequency and 18% cost severity reductions for right lane change and right turn collisions for the pilot vehicles at around the 12-18 month point in the pilot project. They expect to achieve 160% ROI at around 25% efficacies, and these results are promising enough that they intend to begin equipping new vehicles with the STEs in the pilot project to eventually have their entire fleet thusly equipped.

These ROI and efficacy data are certainly encouraging. More details would still be needed, though, to be able to say with confidence if another carrier could expect to see the same results. The main takeaway for the purposes of this resource is this: carriers are reporting both safety benefits and financial benefits to investing in STEs alongside robust SMPs, meaning that other carriers not as far down the safety technology road should make these types of investments a high management priority.

ROI Source 2: FMCSA's/VTTI's ROI Calculator

The US Federal Motor Carrier Safety Administration (FMCSA) has a free, online tool that allows for the calculation of ROIs for multiple STEs. This tool was developed with the assistance of Virginia Tech Transportation Institute (VTTI), and this is the reference and URL for the tool as of the time of this book's writing:

Federal Motor Carrier Safety Administration. (n.d.). Tech-Celerate Now ROI calculator. *U.S. Department of Transportation. Accessed March 7th, 2025, from https://www.fmcsa.dot.gov/tech-celerate-now/tech-celerate-now-roi-calculator*

The specific STEs the FMCSA/VTTI ROI calculator includes are:

- Automatic emergency braking (AEB)
- Adaptive cruise control (ACC)
- Forward collision warning (FCW)
- Lane departure warning (LDW)
- Blind spot monitoring (BSM)
- Lane keep assist (LKA)
- Lane centering assist (LCA)
- Adaptive steering
- Road-facing cameras
- Driver-facing cameras
- Camera-based mirror system

The rest of this section will use the above-referenced ROI calculator to systematically present the ROI results for each of the above STEs. We will use a made-up company, Sample Carrier Inc., with standardized data for this carrier so that the type of carrier being used in the following ROI calculations is transparent and standardized.

Case Study: Introducing "Sample Carrier Inc." for ROI Calculations

To illustrate ROI calculations for safety technologies, we created a fictitious trucking company, Sample Carrier Inc., a 50-power unit tractor-trailer long-haul carrier that does cross-border general freight hauling between Canada and the US. Here are some additional details about this made-up carrier that are necessary to use the FMCSA/VTTI tool:

- Annual fleet IFTA mileage: 7,500,000 km (4,660,000 miles); 150,000 km per truck (93,000 miles per truck)
    - This is a required entry for the FMCSA/VTTI ROI calculator.
- Cost of capital: 7%
    - Cost of capital refers to the minimum required return on an investment to cover the costs related to funding operations, like interest payments on financed equipment. This is a required entry for the FMCSA/VTTI

ROI calculator.

- Out-of-pocket crash costs: $80,000 per crash (in US dollars)
    - This is a general figure used for demonstration purposes. Collision costs will vary greatly from incident to incident. This figure would be an average cost for the specific types of collisions that we hope the STEs being trialed will help mitigate. This is a required entry for the FMCSA/VTTI ROI calculator.

Sample Carrier Inc. Will be used as the test carrier for all of the ROI estimates presented and discussed below, all of which came from the FMCSA/VTTI ROI calculator.

Case Study: ROI Calculator Results for Sample Carrier Inc.'s Separate Implementation of Each Available STE

Using the FMCSA/VTTI ROI calculator referenced above, the details for the fictitious carrier Sample Carrier Inc. above, and the additional details for how the ROI calculator was configured for this exercise below, we used the ROI calculator to report its results for each individual STE it had to offer. This would mimic one of the ways a carrier could use the ROI calculator to assess the potential financial implications for the various STEs for their operations.

In addition to the information provided above for Sample Carrier Inc., there are other data entry fields in the FMCSA/VTTI ROI calculator that either have to be filled in by the user or set to a default setting. For simplicity, all default settings were left alone as follows:

- The calculator's estimated price per unit was used for each cost per unit;

- Annual fees or subscription costs per unit were set to $0 for each STE;

- We selected "Yes" to whether we would provide training to drivers on how the STE works and if we would provide coaching, and the default hourly pay rates for drivers ($19.30 per hour) and managers ($29.00) were used;

- We entered 50 for the number of vehicles on which the STE would be installed and used 4,660,000 miles for the total annual IFTA miles field;

- We selected "Industry Average Crash Rates" for the Crash Data part of the calculator instead of creating fictitious numbers for Sample Carrier Inc., and;

- Crash prevention and severity effectiveness were left at the default setting of 70%.

The results of assessing each STE separately in the ROI calculator are presented in **Table 2** below. All dollar values are in US dollars.

Table 2 - ROI Results from FMCSA/VTTI ROI Calculator for Sample Carrier Inc.

Safety Technology Element (STE)	Estimated Price per STE Unit ($)	Return On Investment (%)	Pay Period (years)	Net Present Value ($)
Automatic Emergency Braking (AEB)	613.00	100	1	709,335.20
Adaptive Cruise Control (ACC)	575.00	100	1	711,301.44
Forward Collision Warnings	1,163.00	100	1	680,876.50

(FCW)				
Lane Departure Warnings (LDW)	1,883.00	100	1	643,621.48
Blind Spot Monitoring (BSM)	713.00	100	1	704,160.89
Lane Keep Assist (LKA)	1,964.00	100	1	639,430.29
Lane Centering Assist (LCA)	1,100.00	100	1	684,136.32
Adaptive Steering	1,681.00	100	1	654,073.58
Road-Facing Cameras	522.00	100	1	714,043.83
Driver-Facing Cameras	467.00	100	1	716,889.70
Camera-Based Mirror System	2,047.00	100	1	635,135.61

-

To further test aspects of the FMCSA/VTTI ROI calculator, we selected one STE (AEB) and ran the calculator again using all the same information as above except for the estimated price per STE unit which we altered to see what impact it would have on the results. Here is what we found:

- Further decreasing the per STE unit cost did not increase ROI nor decrease the payback period, but it did slightly increase net present value.
    - For example, decreasing the AEB per-unit price to $10.00 (an unrealistically low number) resulted in an ROI of 100%, a payback period of 1 year, and a net present value of $740,536.29.
- Further increasing the per STE unit cost eventually affected ROI (decreased), payback period (increased), and net present value (decreased).
    - For example, increasing the AEB per-unit price to $5,000.00 resulted in an ROI of 54.94%, a payback period of 2 years, and a net present value of

$482,338.26.

Case Study: Discussion

The FMCSA/VTTI ROI calculator is a relatively easy to use free online tool that does allow for users to play around with financial information for multiple STEs fairly quickly. However, it still requires a decent understanding of carrier business practices and financial metrics. Carriers interested in using it themselves should try to use the inputs that are the most specific to their operations as possible while also understanding that the outputs from this calculator are still estimates meant to help carriers attain a more holistic understanding of STE financial performance that includes active driver training and coaching.

The ROI percentages and payback periods did not change from 100% and 1 year, respectively, for each of the calculator's STEs when simulating complete fleet implementation for Sample Carrier Inc., but net present value did change. Furthermore, the above results from modifying AEB unit price in the ROI calculator suggests an ROI of 100% and payback period of 1 year are the best-possible results and that net present value is the more useful indicator of financial performance of the STE over the default 5-year timeframe. Given the assumptions we put in place to simplify this exercise, net present value is an important financial performance metric when using this ROI calculator to better understand the longer-term financial performance of an individual STE. So, carriers using this calculator should look at 100% ROI and a 1-year payback period as the best-case scenario and further assess net present values for more insights into long-term financial performance.

This calculator provides many opportunities for customization including different STE pricing models, training, and coaching. It also allows for the user to assess different combinations of STEs (i.e., it can be run with any combination of the above STEs it includes, not just one at a time). Also, the percentages used for collision prevention and severity effectiveness (i.e., efficacies) are adjustable, allowing the user of the calculator to modify efficacy for each time they use the calculator based on their own experience or information from other sources, like the efficacy data we have presented in **Table 1** of this resource in the chapter on efficacy. What this all means is that the results above we present for this ROI calculator are, by no means, representative of the financial performance for the STEs it represents for all type of operations. For example, a carrier could use the calculator to assess financial performance for an STE they want to implement in only a small sample of their fleet, or they may want to adjust the default settings of the various data entry fields of the calculator based on their own internal collision data.

Finally, let's discuss the efficacy customization. The calculator allows the user to change the predicted efficacy for each STE or combination of STEs. More specifically, it allows for efficacy to be expressed both in terms of collision prevention and collision severity reduction, using 70% for each as the default. From this resource's section on efficacy (see **Table 1**), though, we know that that safety management and technology efficacy can be measured in many more ways. Efficacy is often reported qualitatively (i.e., researchers and industry experts stating they believe they are effective based on their deep understanding of the topic), or it's reported quantitatively (i.e., with numerical data like percentage of incident frequency reduction) with great variety both in terms of the metrics being used and the estimates for the same metrics between different sources. Determining appropriate efficacies for the FMCSA/VTTI ROI calculator is, therefore, something that requires either a good understanding of applicable research results or access to STE-specific efficacy data from internal operations or another trusted source. For example, a carrier that trials one of the STEs included in the ROI calculator on only a sample number of their fleet vehicles could potentially calculate their own percentages for collision frequency and severity reductions themselves for this sample of their fleet. Then, they could use their calculated figures in the ROI calculator to estimate the financial performance of expanding the STE to the rest of their fleet.

Final Case Study Takeaways

One key takeaway for STE and SMP ROI is that trying to determine an accurate estimate for a specific carrier is a challenging thing to do. Indeed, the carriers interviewed as part of the writing of this resource could rarely report a specific ROI figure with confidence: only the example mentioned at the start of this section was provided, and all other data provided by interviewees were related to efficacy, not ROI. However, these carriers also all expressed trust in that safety technology with intelligent and complimentary safety management best practices does have a positive ROI while also commenting on how a positive ROI isn't necessarily a requirement for them to invest in safety technology. Instead, ROI was more useful in deciding between similarly performing technologies of the same type and for demonstrating that, overall, modern fleet STEs and SMPs are good for business and safety.

Specific to the FMCSA/VTTI ROI calculator, STEs appear to generally perform well, financially speaking, as evidence by the positive ROI and payback period results in **Table 2** for the Sample Carrier Inc. case study we used. Each STE is estimated to pay for itself in relatively short order when fully implemented in a fleet using the default efficacy and collision data settings in the calculator. This should be interpreted as strong evidence that any STE investment of the types offered in the calculator should generally not end up being a major cost centre for carriers and may even end up generating additional revenue, although measuring this with certainty is difficult given all of the complexities involved in ROI calculations and different variables in unique fleet operations. In other words, the FMCSA/VTTI ROI calculator shows that trucking-specific regulators and researchers have enough evidence for the efficacy and potential financial benefits of advanced carrier STEs that they can openly encourage individual carriers to explore making related investments based on expected financial as well as safety-specific benefits at the individual company level.

Carriers using any type of ROI calculator need to also understand that these tools provide estimates to help reduce money-related resistance to investing in safety technology. They do not guarantee specific results for specific carriers. Carriers investing in STEs and SMPs must still accept a degree of uncertainty and be sure that their investments are feasible given their current budgets and operational realities.

Using Efficacy to Estimate ROI (and Table 3)

This final section of the return on investment (ROI) chapter is about the relationship between efficacy and ROI, and also about how carriers can use efficacy data to help them make better estimates in terms of ROI. As we've seen so far in this resource, data on efficacy for safety technology elements (STEs) and safety management practices (SMPs) are more common than data on ROI, and efficacy metrics are typically directly related to safety performance whereas ROI metrics are not always as directly related. Therefore, carriers can expect to have to more information about efficacy for any given STE/SMP than will be available for ROI. This means it's important, then, to understand the relationship between these two concepts to see how efficacy data may be used to gain insights into financial performance.

The more a carrier knows about its own safety performance the better. All carriers should be tracking costs associated with incidents, training, equipment, etc., and carriers should also have enough data - both quantitative and qualitative - to understand their major concerns from a safety performance perspective. If not, then it's important to get a handle on this sort of information as it will otherwise not be possible to measure the efficacy and/or ROI of any safety investment with much confidence.

So, let's move forward in this discussion assuming that the carriers we're discussing have basic data and cost tracking systems in place and can look up internal information on things like incident rates and costs. The higher the quality of this internal information, the more accurate a carrier can make predictions in terms of what safety investments are likely to bring about the most significant positive change - and what the initial and ongoing costs may be, along with any potential returns.

The main argument for this last ROI section is this: carrier-specific variables are going to have a much bigger impact on accurate ROI predictions than industry-wide estimates. Therefore, to make the best possible ROI estimates, carriers should apply industry efficacy data to their own costs and business model to evaluate the ROI of any STE (or combination of STEs) instead of relying on ROI claims that use data from other carriers/the broader industry. Then, as long as they have a system in place to manage their own data, they can figure out their own efficacy and ROI data for STEs they implement into their operations by tracking pre- and post-implementation performance.

We'll now present some general steps carriers can take to use their own data and industry/research/supplier-provided efficacy data to do their own ROI estimations.

Estimating ROI from Efficacy Data

The **first step** a carrier needs to take is establish baseline data for its own operations. This should include metrics related to safety performance and incident costs. Here are some examples:

- Annual overall collision rates, like collisions per cumulative fleet distance travelled, collisions per unit of revenue, collisions per driver, etc.

- Frequencies for different types of collisions, like rear-ending collisions, single-vehicle collisions, road departures, etc.

- Average collision severity by collision type (typically measured in dollars)

- Injury rates per number of drivers/workers (like injuries per 100 drivers for large carriers)

- Rates of unsafe driving behaviours, like convictions (i.e., tickets) per number of drivers or distance travelled

- Collision cost data, like immediate costs per collision type

- Scores from audits, such as scores from electing to do an annual compliance audit, or the scores from annual audits of the carrier's OHSMS if it has a safety certification like an Alberta Certificate of Recognition (COR)

- Driver and/or staff engagement survey results

- Driver and other staff turnover

- Existing safety metrics from regulators, like the data in an Alberta Carrier Profile and/or a carrier's USDOT safety scores

These above metrics and the system that tracks them will then serve as a foundation for all future safety investments. Carriers with this sort of data on hand can trial individual STEs and/or SMPs throughout their entire operations or by starting with a smaller pilot project and then actually be able to do their own assessments of efficacy and ROI through properly designed pre- and post-implementation studies.

The **second step** is then to use the above information to identify the safety-related strengths and weaknesses of the company. The carrier should be able to identify the top issues it faces. This might be a particular type of collision, like more rear-ending collisions are taking place compared to all other collision types. Or, it might be that a specific time of year sees the highest rates and severities for collisions and other incidents. Regardless, the carrier can use its own data to identify its greatest risks.

The **third step** is to then identify the specific STE, SMP, or perhaps STE/SMP combination that's best suited for addressing the above identified top problems. If a carrier's most frequent and severe collision type is rear-ending collisions in urban settings then applicable STEs should be chosen, like AEB and FCW systems with active driver coaching instead of camera-based mirror systems. This step should result in the carrier creating a short list of STEs/SMPs that are best suited for the issues at hand.

The **fourth step** is then to find validated efficacy data for the above identified STEs/SMPs. This may be by searching primary literature like peer-reviewed academic journals, or it could be by searching grey literature which includes government reports, industry articles, and resources like this one (see the different efficacy sections, **Table 1**, and the Methods section for more information on these types of sources and on conducting such literature searches). Another potential efficacy data source is from other companies if the carrier has suitable and trustworthy contacts in its professional network.

The **fifth step** is to then use the above identified efficacy information in conjunction with the carrier's own data from the first step to then calculate ROI estimates. Recall from earlier in this chapter the formula for ROI:

ROI = [[[Net Benefit from Investment] - [Cost of Investment]] / [Cost of Investment]] x 100%

We only need to know the net benefit from the investment and the cost of the investment to figure out ROI. Here is how we can now use carrier and efficacy data to figure out these two variables:

- Net benefit from investment:
    - This is how much additional money the carrier is "making" (which would typically be money saved by incident cost reductions for safety-related

ROIs) by investing in the specific STEs and SMPs identified to address a specific problem.

    - It's important to note that this is the overall benefit to the carrier, which means figuring out how the investment made the carrier more money and minus any potential costs it might have incurred for the carrier (except for the cost of the investment itself as per below).

- Cost of investment:

    - This is how much money the carrier had to pay for the investment. If the carrier was installing a type of STE in each vehicle and expanding an aspect of its safety management program to support it, the cost of investment would be how much the carrier had to pay upfront to buy the STE and then the ongoing costs associated with it which would include other costs like any subscriptions, financing, maintenance, and the salaries of the additional staff hired to assist in the management of this new STE.

Both the net benefit and cost of the investment will generally change over time when it comes to safety management investments. This is because, as time goes on, the safety investment will continue to provide value through reduced incidents, thereby increasing its dollar value with time. Then, any ongoing costs for the investment (like subscriptions, financing payments, maintenance fees, human resources, etc.) will also be increasing with time. Depending on the rates at which these could both be increasing, it may be the case that we get very different ROI information when calculated at different points in time, like one month versus one year post-implementation.

Time also has to be considered in the calculations. Be sure to calculate ROI using numbers that are from the same period of time.

Another Exercise: Sample Carrier Inc.'s ROI Predictions

Let's go back to the fictitious company Sample Carrier Inc. that was used in the last section in this chapter on the FMCSA/VTTI ROI calculator and go through an ROI calculation exercise using the steps laid out above. Remember that Sample Carrier Inc. is a 50-power unit carrier based in Canada that primarily does cross-border Canada-US general freight hauling.

Sample Carrier Inc. has improved its internal record keeping and data management. As a result, its management have the following data:

- Annual collision rate: 20 collisions per year of various types
- Annual collision types:
  - 10 rear-end collisions (where a Sample truck rear-ended another vehicle), which represent 50% of all collisions
  - 5 lane-departure collisions, which represents 25% of all collisions
  - 5 collisions that Sample's management puts in their "Other" category, representing the final 25% of all their annual collisions

Based on the above data from the previous year, Sample's management decides to put a plan together to specifically try to reduce rear-end collisions. They then determined the financial costs associated with these collisions:

- Annual immediate pre-insurance adjustment collision costs per rear-end collision: $50,000
- Total annual immediate pre-insurance adjustment collision costs for rear-end and lane departure collisions:
    - [10 x $50,000 for rear-end collisions] = $500,000 per year

Less directly, Sample's management has determined these collisions are also contributing to increasing driver turnover. They also contribute to the ongoing worsening of their Canadian and American government fleet safety scores, which is further contributing to rising insurance costs each year in addition to the increased insurance costs from the collision claims themselves.

At this point, Sample's management now knows that rear-end collisions represent $500,000 in annual immediate costs and that there are other, indirect costs resulting from these collisions. They then do their own research for potential STEs and SMPs to help them address this issue along with data on their efficacies:

- STEs:
  - Automatic emergency braking (AEB): Predicted to reduce rear-end collision occurrences by 41% based on Sample Carrier's type of operations.
  - Forward collision warning (FCW): Works with AEB systems to help improve driver response time, further assisting in reducing rear-end collision occurrences by helping drivers remove themselves from such situations before the AEB system has to intervene. When paired with the above AEB system, it further reduces rear-end collision occurrences by 21%.
- SMPs:
  - Proactive driver coaching program using telematics data on rear-end collision leading indicators (speeding, following distance, and hard-braking)

to create monthly coaching plans specific to each driver identified as high-risk for having a preventable rear-end collision. An insurance industry report claims this approach to coaching reduces at-fault rear-end collision occurrences by 15%.

Note: The total for efficacy percentages above would be 41% + 21% + 15% = 77%. However, it shouldn't be assumed they can be added together because the studies Sample finds present these numbers separately. Therefore, it would be reasonable to assume there is some overlap in efficacy between these three safety interventions, so Sample decides to use 60% as their estimated efficacy for this combination of STEs and SMP for reducing their annual occurrences of rear-end collisions, a reasonable approach given the information they have at hand.

Sample's management then gets information on how much it will cost to implement the above STEs and SMP into their operations:

- They find a retrofitter who can install an AEB system on each of their trucks for $3,500 per vehicle. The AEB system includes FCW features, so there is no additional cost for the

FCW. There are no anticipated significant ongoing maintenance or subscription costs, so Sample's management decides not to include such estimates in their ROI calculations.

    - With 50 trucks, the upfront implementation cost will be 50 x $3,500 = $175,000. This is a one-time, first-year cost.

- Since Sample already uses an ELD system that has telematics and data analysis features they just haven't taken advantage of yet, there is no equipment or software costs for the driver coaching plan. However, they predict increased involvement of their safety manager in providing this coaching and have to adjust office staffing accordingly by expanding a part-time administrative position into a full-time position to take on some of the safety manager's administrative duties to free them up for coaching. They estimate this new cost at $1,000 per driver per year across the entire fleet, deciding this figure will account for initial training for all drivers and then ongoing coaching for 50% of the company's drivers annually.

- With a maximum of 50 drivers at any time, the annual costs specific to driver training and coaching for their rear-end collision mitigation plan is 50 x $1,000 = $50,000. This is an ongoing annual cost.

Let's recap: Sample Carrier spends $500,000 annually on immediate costs for the average of 10 rear-end collisions it experiences each year. It's proposed STE+SMP safety plan for reducing the annual number of these collisions is expected to reduce their occurrences by 60% per year. This means they expect to have 60% fewer rear-end collisions, which would be 60% x 10 = 6 fewer rear-end collisions per year. Since each collision represents $50,000 in immediate costs, the estimated annual savings on rear-end collisions is 6 x $50,000 = $300,000 per year.

Sample Carrier Inc.'s management then wanted to estimate the ROI for their rear-end collision safety plan for both the first and second years separately to better understand short-term and longer-term costs. The ROI formula is:

ROI = [[[Net Benefit from Investment] - [Cost of Investment]] / [Cost of Investment]] x 100%

They start with year 1. First, they need to determine the Net Benefit from Investment and Cost of Investment. Here is what they determined:

- Year 1:
    - Net benefit from investment: $300,000
        - This is the amount calculated above for the savings they expect for a full year using 60% efficacy for rear-end collision occurrence reduction.
    - Cost of investment: $225,000
        - This is the sum of the cost of installing the STEs ($175,000) and the one year's worth of driver training and coaching costs ($50,000).

Using these figures, here is the year 1 ROI calculation:

- ROI = [[[Net Benefit from Investment] - [Cost of Investment]] / [Cost of Investment]] x 100%
- ROI = [[$300,000 - $225,000] / [$225,000]] x 100%
- ROI = 33%

Sample's management then proceeds to estimate the ROI year 2:

- Year 2:
    - Net benefit from investment: $300,000
        - This is the amount calculated above for the savings they expect for a full year using 60% efficacy for rear-end collision occurrence reduction.

Why this is the same for years 1 and 2: *A fair question here would be why doesn't Sample Carrier see a 60% reduction on the results from the first year's improvements? In other words, why are we* *still using 60% of the initial 10 collisions instead of 60% of the remaining 4 collisions from year 1? The reason why is that our calculations are assuming Sample Carrier's activities, power unit count, annual mileage, driver turnover, and other impactful factors are remaining the same for each year. The AEB+FCW+training+coaching plan is continuing to work on the same carrier with the same general risks present. Sample Carrier would have to take further safety-related actions to further reduce rear-end collisions, like additional training or finding even more effective AEB and FCW systems.*

    - Cost of investment: $50,000

        - Since the STEs were fully paid for in year 1, the $50,000 cost for ongoing driver training and coaching remains the only cost related to this safety intervention for year 2.

- ROI = [[[Net Benefit from Investment] - [Cost of Investment]] / [Cost of Investment]] x 100%

    - ROI = [[$300,000 - $50,000] /

[$50,000]] x 100%

- ROI = 500%

At this point, Sample Carrier's management has finished estimating year 1 and year 2 ROIs for their investment in STEs and SMP enhancements to reduce rear-end collisions. **Table 3** below summarizes the results.

Table 3 - ROI Summary for Sample Carrier Inc. Rear-End Collision Mitigation Plan

Year of Post-Safety Investment	Net Benefit of Investment	Cost of Investment	ROI
Year 1	$300,000	$225,000	33%
Year 2	$300,000	$50,000	500%

Exercise Discussion

The above exercise using the made-up company Sample Carrier Inc. outlines how a carrier may go about using data on efficacy and their own internal safety data to estimate their own ROI, including doing so over multiple years. In the end, we saw how a specific plan to pair STEs and SMPs to address an issue of negative safety performance in the carrier could not only provide a way to significantly reduce the frequencies of rear-end collisions for Sample Carrier, but we also saw how ROI changes with time. In the above example, Sample would see a positive ROI for year 1 even after completely paying for the STE implementation and first-year staff costs for this specific plan. Then, ROI increased dramatically for year 2 due to the fact the STE implementation costs are only a year 1 expense.

We tried to create an exercise that was reasonable while simple enough to demonstrate how a carrier can use efficacy and their own data to make more accurate ROI estimations for their operations. However, we made some assumptions that we'll now discuss to highlight limitations of the exercise and to encourage carriers and safety professionals reading this resource to consider additional factors when doing this sort of work themselves (or interpreting efficacy and ROI data from other sources).

First, we're assuming that Sample Carrier's operations and safety performance stay consistent year over year. Number of power units, overall distance driven, risk exposure, driver turnover: these are all things that could (and likely would) change from one year to the next. Remember how we said Sample's management considered driver turnover to be indirectly associated with their safety performance? Well, it could be that case that Sample would see short-term increases in driver turnover as drivers exit the organization due to being identified as high risk or on their own accord due to not liking the changes. Changes in driver turnover would impact overall financial performance, but we did not get into that level of detail.

Second, we did year 2's calculations using the same information for year 1 minus the upfront STE implementation costs. In reality, though, a carrier may generate enough data over the first year of such a safety investment project that it has better estimates for STE efficacy and SMP costs based on its actual performance. Therefore, the better a carrier can collect and analyze its own data, the better it can estimate ongoing ROI and many other metrics associated with safety and financial performance.

Section Conclusion: Efficacy- and Carrier-Informed ROI is More Informative

The main takeaway from this section is the importance of understanding how carrier-specific data and efficacy data from reliable sources can be used to estimate ROI with greater accuracy. The second main takeaway is that the general process for estimating ROI outlined above can be a useful way to do a deep dive into carrier-specific operations and safety performance to not only estimate ROI but better understand the various factors that impact safety and financial performance.

All in all, ROI is useful for understanding the costs associated with safety management and investments in safety. It's also complicated and difficult to estimate with precision. This, along with the data from the interviews, suggests that carriers can use ROI to help them understand safety-related costs and the potential benefits or additional costs associated with specific STEs and SMPs. However, ROI is not the same as efficacy, and STEs and SMPs should be evaluated primarily based on their efficacy. This is because ROI is often just an estimate unless a very robust and detailed system has been used to calculate it whereas efficacy data are directly related to how effective any STE/SMP is at improving safety performance.

Chapter Nine – Moving Beyond Compliance

This chapter turns to the subject of how carriers can move from being focused mostly – or completely – on compliance to the world of proactive safety management. After a discussion around compliance versus proactivity and other important language, we'll present strategies for carriers at different stages of safety management evolution to move beyond compliance.

Compliance versus Proactive Safety Management

This chapter starts with us addressing this question: What do we mean when we say "compliance"?

"Compliance", for the purpose of this chapter and the aspect of the industry it addresses, means to follow every detail of every applicable safety regulation. Compliance, more generally, can also mean to adhere to any set of rules, like the rules associated with a voluntary occupational health and safety (OHS) management system (OHSMS) standard like an Albertan COR or SECOR; however, we' referring to the compliance-with-regulation use of the term compliance for this chapter. So, a compliant carrier is one that is following and doing all of the things required of it by safety-related regulation. A non-compliant carrier would be one that isn't, and it could be non-compliant in a minor way by perhaps missing a few details, or it could be majorly non-compliant by operating as a trucking company without a safety program at all (or any other example of gross non-compliance).

"Proactive safety management" and "proactivity", for all of this resource, refers to activities related to addressing safety-related deficiencies and improving safety performance for the inherent benefit in such activities. In other words, a proactively safe carrier is one that has an OHSMS in place that meets compliance requirements but goes further for the purpose of improving safety outcomes, like reducing collisions and injuries, even when there is no immediate legal requirement to do so. Proactivity in safety management is a safety management approach where things are done for the sake of the human, social, ethical, financial, and also legal benefits they provide to the organization. Also, approach to safety management still values compliance, but it sees compliance as a minimum requirement and doesn't wait for laws to require actions to improve safety - it actively seeks out such opportunities.

Think of proactive safety management like we would strategic business management. Businesses are managed for the purpose of being successful. Business leaders aren't strategic because the law says they have to be. They are strategic because they want their organization to succeed and grow. In other words, they're motivated by success. Proactive safety management is philosophically similar: the proactive safety leader wants safety performance to improve because they want to see how successful an organization can be at achieving its mission without causing harm to anyone and, perhaps, even enhancing the lives of those who work for it. So, when we use language like "moving beyond compliance" in this chapter, we're talking about carriers shifting from a compliance-based mindset (i.e., I only have to so what the law says I do) to a proactivity mindset (i.e., I'll do what the law says, but I'm actually concerned about improving safety system outcomes, not passing compliance audits).

Moving beyond compliance is important. It's what this chapter is all about. In short, safety regulations are well-intentioned rules meant to protect people from the actions of carriers, both in private facilities and on public roadways. However, they can't reasonably be expected to prescribe the best possible approaches to safety management for all individual types of companies. Instead, they generally provide a basic level of safety for all carriers. Furthermore, regulations take time to update, and new solutions for safety management like many of the STEs and SMPs mentioned in this resource aren't specifically addressed in regulations. Therefore, a compliance-only approach to safety means that such a carrier is missing out on a massive aspect of safety management and is failing to use the tools available today to further improve their safety performance.

Another main difference between compliance and proactivity is strategy. Strategy, as we use the word, refers to the things people and organization do to attempt to affect future outcomes based on the information they have on hand today. Strategic business leaders build plans meant to do things like improve both short- and long-term growth in response to market data. Proactive safety management leaders do the same by trying to get the best possible data available today to make decisions and plans that will bring about improved short- and long-term safety performance. If a safety professional/carrier is only concerned with complying with the law, though, then no strategy is needed: the law (perhaps alongside interpretive material) tells us what to do, and we just have to then allocate the necessary resources to make it happen. Being proactive, though, requires us to be strategic, and we need more than what's contained in the regulations to develop solid safety management strategies.

Driver files serve as a useful example of the differences between compliance and proactivity. These files are required by both Canadian and American carriers (including Canadian carriers that operate in the US), and they require carriers to maintain specific documentation for all of their drivers like driver abstracts, training records, records of tickets and collisions, and other similar documentation.

If we're only concerned with compliance, then safety management stops once we have driver files containing everything needed in each driver's file as per the applicable regulation makes us compliant. However, a compliance-only approach to driver files doesn't require us to ask ourselves questions like why we're collecting the documentation in the first place. Carriers with a proactive safety culture would have compliant driver files because they still value compliance, but they would go further and attempt to use the information within the files for safety performance improvement. For example, driver files contain driver-specific information related to incidents and collisions, and these data are useful in designing strategy around improving safety performance.

A Theoretical Aside

All compliance means is following a set of rules. Compliance is all that would be needed if the perfect set of safety rules existed in legislation that included the necessary details by company type to solve all safety problems and promote continuous improvement. If such regulations did indeed exist, then compliance alone would be all that we'd have to do. Proactivity would essentially become a compliance requirement, but there would be enough information in the regulations themselves that safety professionals wouldn't have to develop strategies; everything they need would be laid out clearly for them in the regulations, and they would need only follow the rules as a checklist to bring about the ideal safety culture with associated positive performance outcomes.

Some safety regulations are more prescriptive than others, and some do encourage strategy and critical thinking. Generally speaking, OHS legislation in Canada requires companies to identify hazards in their operations that could harm people and then take action to reduce the risk these hazards pose. This is a fairly nonprescriptive approach to regulation as it outlines a general process but requires employers to do the work of assessing and controlling hazards. Transportation-specific legislation, commonly (and somewhat informally) referred to in Canada as NSC regulations, are typically more prescriptive and require specific actions to address previously identified hazards. The HOS rules are like that: they prescribe maximum work and driving times and minimum rest times for drivers to reduce the risk of fatigue-related collisions taking place. This forms a basic, mandatory safety net upon which carriers are free to take further action to address fatigue hazards more specific to their operations.

All these regulations are generally well-intentioned in that their purpose is to produce safer public highways. When a hazard is well-understood, like how tired drivers pose a threat to public safety, prescriptive rules make sense, like how the HOS rules provide a basic fatigue-related safety net. Hazards are often not well known, though, especially as industries change and new processes are introduced. Employers doing the work are the ones in the best position to understand potential hazards, so it would not be realistic for those writing the regulations to provide a list of all hazards and prescribe specific controls. So, less-prescriptive regulations requiring employer-led hazard assessments are also useful because they require activities that should result in specific actions applicable to the employer.

This is all to say that regulations can't reasonably be expected to have all of the answers to improving safety performance. If they did, theoretically speaking, all anyone would have to do is follow the regulations. In other words, compliance and proactivity would essentially become one and the same as the benefits of proactive safety management would be baked into the regulations with the necessary detail to be actionable for all types of organizations. Indeed, some regulations are much more encouraging of proactivity than others when they require companies to build systems and critically examine their operations. Furthermore, regulations that are not like this and simply say specific things must be done are still valuable when the action they prescribe is effective.

So, compliance and proactivity are not at odds, and we're not criticizing safety regulations. Both matter. What we are doing is encouraging carriers and safety professionals to consider the meanings of these terms to see how they both fit within an OHSMS.

Strategies for Moving Beyond Compliance

How does a carrier move beyond compliance into proactivity? Is it even possible for every type of carrier to make this move? These are logical questions now that we have discussed compliance, proactive safety management, presented ideas on doing carrier self-assessments, and argued that compliance alone, while important, isn't good enough for optimal safety performance. This following and final section in this chapter will explore strategies for making this safety management transition.

We'll first discuss basic concepts carriers will have to understand when setting the stage to move beyond compliance.

Understanding the Basics: Initial safety management activities involve first understanding what safety regulations actually apply to the organization. For carriers, this will vary based on their specific operations. A carrier that operates solely within Alberta and hauls only non-dangerous goods general freight will have Alberta's OHS regulations (i.e., the Alberta *Occupational Health and Safety Act* and its regulations) and the provincial-level NSC regulations (i.e., the Alberta *Traffic Safety Act* and corresponding commercial vehicle regulations) to follow. However, if they expand into hauling dangerous goods, then they will also have dangerous goods regulations to follow. If they start hauling in more than one province, they will have to change to the federal-level NSC regulations and, potentially, the federal OHS regulations. If they want to operate in the US, they will have the FMCSRs and other USDOT regulations to follow. So, the specific safety regulations that a carrier must follow are based on its type and area of operations, and this must be understood by the carrier with certainty.

Once compliance is under control, a carrier then needs to have a reasonably good level of knowledge on the elective safety technology elements (STEs) and safety management practices (SMPs) that exist as potential solutions to their safety problems.

This knowledge is critical as, without it, a carrier won't have any tools beyond the regulations to assist them in building a proactive safety culture.

While carriers are learning about STEs and SMPs, they should also be learning about proactive safety management and strategy. As described in earlier sections in this chapter, strategic thinking is a core component of proactive safety management. The type of skills and thinking involved in compliance-centric safety are different than those in proactivity-centric safety, so carriers will also have to ensure they have the right internal skillsets to support moving beyond compliance.

Carrier Self-Awareness: In addition to the concepts introduced above, a carrier needs to be self-aware with regards to the degree to which their safety culture is compliance-centric versus proactivity-centric in order to develop effective strategies for moving their safety management beyond compliance. While there are endless ways we can categorize carriers based on different attributes, we have created the following five categories for the purpose of tailoring compliance-to-proactivity strategies to carriers of these different types:

1. The Non-Compliance Carrier

2. The Reactive, Compliance-Focused, and Content Carrier

3. The Reactive, Compliance-Focused, and Discontent Carrier

4. The Somewhat Proactive Carrier

5. The Proactive, Advanced Carrier

These five categories differ from each other based on attributes related to their respective safety cultures. More specifically, degree of compliance, willingness and/or interest in change, and degree of proactivity are the main differentiators. The sections below present strategies for each type of carrier to 1) assist carriers in understanding where they are right now in terms of safety culture and 2) help them identify appropriate activities for their safety and general management folks to do to support a transition into proactive safety management.

Note: This is meant as a guide. There are many other ways carriers can be categorized, such as in terms of size, revenue, area of operations, etc. We chose to focus on attributes related to safety management and safety culture as these are more directly related to the ability and willingness of a carrier to make changes to support proactivity.

If you don't find your company matches well with any of the following categories, don't worry. Feel free to pick strategies from any category if they feel right. Additionally, safety management is complicated work, so be sure to reach out for external assistance like AMTA for help in applying the strategies presented below - or anything else in this resource.

Strategies for Carrier Type 1: The Non-Compliant Carrier

Description: This is a carrier that is not compliant with the safety regulations that apply to it. It is aware that it has compliance issues, and getting compliant is the primary goal of all safety management activities (i.e., safety isn't strategic, it's focused on figuring out what laws to follow and then making sure they're following them).

Carriers that mostly fall into this category have to focus on compliance. They could certainly benefit from proactive safety interventions including investing in STEs and SMPs; however, they lack the safety management systems and structure to be able to do this in an effective way. Therefore, they need to get the basics figured out first, and that includes ensuring they are aware of the legislation and more specific regulations that apply to them and, then, take the necessary action to become compliant with them.

Specific activities carriers in this category can do to become compliant and begin their journey to proactive safety management include:

- Deal with any immediate compliance concerns, such as paying tickets and responding to notices from government regulators.

- Contact their local trucking safety association to see what rules likely apply to their operations and to build a professional network.

- Conduct compliance audits to identify where, specifically, they're noncompliant.

- If becoming compliant means investing in STEs/SMPs (like how federally regulated carriers in Canada must use ELDs), reach out to an impartial third party like a trucking association to help pick technology that will not only solve their immediate compliance concerns but also have the capabilities to help them move towards proactivity.

- Ensure there is someone in place who is directly responsible for safety management. Depending on the carrier's size, this may be a dedicated position or become part of the duties of another role, but it's important that there is someone who is in place to actually do this work. This person needs to be competent, too, so it may be advisable to work with a safety consultant or to provide their chosen internal person with appropriate training.

Strategies for Carrier Type 2: The Reactive, Compliance-Focused, and Content Carrier

Description: This is a carrier that is aware of their compliance requirements and has systems in place to meet them. Safety performance problems, like collisions and injuries, are dealt with as they come up and the activities that take place in response to such incidents are focused on ensuring all related compliance requirements are being met. The safety culture is one that views compliance as the goal, and management and staff generally do not see this as a problem. However, this doesn't mean they are happy with their safety performance: they just struggle to see past compliance and don't see how investments in safety and being proactive are going to help them.

Obviously, some people within this type of carrier want to see improvement or else the carrier would otherwise not be seeking to change anything. However, “content” refers to general attitudes within the carrier’s safety culture where people are happy with the state of things and don’t see the need for safety to be much more than managing compliance with regulations. Carriers of this type need motivation to move past stagnation; in other words, there is no desire to do more than the minimum in terms of safety. Much of the work a carrier in this category needs to do revolves around changing attitudes and developing systems, like data management and analysis systems, to be able to better understand their safety performance.

Specific activities carriers in this category can do to move beyond compliance include:

- Make the business case to management that a shift is needed in how the company views safety and that this shift should include investments in STEs and SMPs based on expert advice and trusted resources. This should include demonstrating the cost of doing nothing in safety management by reviewing evidence related to ROI and efficacy for STEs and SMPs.

- Identify people within the organization who are onboard with making the change to proactive safety management and get their support in arguing that proactive approaches to safety can help address safety performance issues.

- Develop a data management system that organizes and tracks safety performance, including metrics directly related to compliance, and work on identifying trends and areas of greatest concern.

- Solicit feedback from drivers and other staff on perceived safety issues in an anonymous manner.

- Contact trucking safety associations to learn more about what companies are doing in terms of safety management and to build a professional network.

Strategies for Carrier Type 3: The Reactive, Compliance-Focused, and Discontent Carrier

Description: This is a carrier that is aware of their compliance requirements and has systems in place to meet them. Safety performance problems, like collisions and injuries, are dealt with as they come up and the activities that take place in response to such incidents are focused on ensuring all related compliance requirements are being met. The safety culture is one that views compliance as the goal. However, there are enough staff and/or individuals within management that consider this to be a poor approach to safety management, and there is genuine interest in improving safety performance beyond compliance requirements.

Carriers in this category will be doing safety-related things that look very similar to Carrier Type 2. The difference, though, is that these types of carriers are well-aware that their current approaches to safety management could be better, and they also accept the benefits of proactively investing in safety but perhaps don't know where to start. Since there is already an acceptance of the need for change, strategies for moving such a carrier beyond compliance don't have to focus on buy-in.

Specific activities carriers in this category can do to move beyond compliance include:

- Develop a data management system that organizes and tracks safety performance, including metrics directly related to compliance, and work on identifying trends and areas of greatest concern.

- Identify one of the biggest problems, from a safety performance perspective, the carrier faces and develop a plan to invest in STEs/SMPs to address it in a controlled, measured manner. When doing so, ensure the safety program is adequately staffed so that having people do this work does not mean that systems managing compliance begin to fail.

- Solicit feedback from drivers and other staff on perceived safety issues in an anonymous manner.

- Contact trucking safety associations to learn more about what companies are doing in terms of safety management and to build a professional network.

- Set internal safety performance goals that reinforce proactivity, such as improving over their own past performance.

- Make a safety investment plan specific to the main safety problems the carrier faces that prioritizes highest impact for the cost, like beginning to use telematics data from their ELD provider in conjunction with driver-specific training and coaching to address the worst unsafe behaviours taking place. Ideally, this will be a way to see results quickly which is encouraging and can motivate further, similar work.

Strategies for Carrier Type 4: The Somewhat Proactive Carrier

Description: This is a carrier that considers proactivity to be a cornerstone in effective safety management. They have systems in place to manage their compliance. They also have systems that are serving them beyond compliance purposes, and they have invested in safety by bringing in STEs and/or SMPs purely to further improve their safety performance against their current and past results using metrics that are appropriate for this purpose. However, they have areas of concern where they do not know how to proceed to make additional improvements. Aspects of their safety culture are still compliance-focused, too, even though they overall have made considerable progress from compliance to proactivity.

Carriers of this type should be focusing on fine-tuning and refining their current activities since they have already moved away from a compliance-centric approach to safety management and have elements of proactive safety management in place. No massive changes in mindset and safety management approaches are likely needed. Instead, carriers of this type can look at their data and past and present successes and failures to implement increasingly targeted plans at an appropriate pace so as to not overwhelm staff and detract from existing systems.

Specific activities carriers in this category can do to move further beyond compliance include:

- Reach out to carriers that are safety leaders in their industry niche to see what they're doing to find further safety performance improvements.

- Connect with their local trucking safety association for guidance and to develop a professional network of proactive carriers that can serve as role models.

- Look at current STE and SMP data to do their own ROI and efficacy calculations to identify aspects of their current safety management activities that may be underperforming.

- Without getting rid of lagging indicators, identify and track leading indicators to further shift safety management towards prevention.

- Look into administrative processes related to safety to see if there are ways to make them more efficient; while this isn't a strategy to directly improve safety performance, freeing up staff and driver time can allow for more efforts to be put towards activities that do directly impact safety performance.

Strategies for Carrier Type 5: The Proactive, Advanced Carrier

Description: This is a carrier that considers proactivity to be a cornerstone in effective safety management. They have systems in place to manage their compliance. They also have systems that are serving them beyond compliance purposes, and they have invested in safety by bringing in STEs and/or SMPs purely to further improve their safety performance against their current and past results using metrics that are appropriate for this purpose. There are no safety performance issues that are not being addressed, and their safety performance is, in general, better than comparable industry average (although they likely still have some safety issues they are actively working to address as safety performance is characterized by ongoing improvements). This type of carrier has systems in place to routinely evaluate itself and current STEs/SMPs in the industry as part of their ever-evolving strategies related to continual safety improvement. Finally, they are fleet safety leaders: they set trends and evaluate new safety solutions more than they follow behind what other carriers are doing, at least in some aspects of their OHSMS.

Basically, continuous improvement is the strategy here. Carriers in this category should keep doing what doing and not lose momentum lest they become complacent and lose their status as a safety leader. This carrier is the type that could be a candidate for brand-new technology, like partnering with associations/universities/suppliers to actually push the envelope in terms of safety performance. It can also be very challenging for carriers of this type to find the right expertise to further make improvements as most safety professionals work with less advanced carriers. Therefore, they may need to look at nontraditional sources of expertise like universities, thought leaders in specific spaces, researchers, and specialized safety consultants from time to time to ensure they continue to receive external feedback on their safety management activities.

Specific activities carriers in this category can do to maintain their position as an industry safety leader include:

- Reach out to carriers that are safety leaders in their industry niche to see what they're doing to find further safety performance improvements.

- Connect with their local trucking safety association as a source of information on new industry developments and to develop a professional network of proactive carriers that can serve as near-peer role models.

- Get involved in the STE/SMP supplier and research communities to see if there are ways new technology and safety practices can be trialed within their operations (potentially at a reduced cost, too).

- Pilot emerging and promising technology for direct and indirect safety improvements.

- If resources allow it, establish positions related to research, development, and ongoing improvement. For example, this could be creating a team of safety staff who are dedicated to scanning literature and connecting with the broader safety research community to make sure the carrier is always exploring ways to do better (or a scaled-down version of this more suitable for their size as a company).

- Market their safety culture to attract and retain the safest drivers and customers.

Chapter Conclusion

Regardless of how a carrier might be categorized based on the above carrier types, all carriers have at least this much in common: they all have room to improve in terms of safety performance. Compliance only allows a carrier to make safety improvements as far as the regulations direct them to. Beyond that, it's up to the carrier to become aware of its safety-related strengths and weaknesses, take ownership over its culture, and then implement strategies to drive further improvements. The strategies presented above provide some starting points for carriers at different places in this journey.

Chapter Ten – Conclusions

This resource has presented a detailed list of safety technology elements (STEs) and safety management practices (SMPs) applicable to carriers. We've discussed what some large carriers are already doing in terms of proactive safety management, presented an analysis of STE and SMP efficacies, provided information and examples on return on investment (ROI) for carriers looking to invest in safety technologies, and proposed strategies for carriers at different stages of safety program management development to move beyond compliance to further improving their safety performance. Let's turn now to the initial questions laid out in the introduction:

1. **What does the current landscape look like with regards to STE and SMP options available for Alberta-based and other North American carriers?**

Carriers have many, many options for both STEs and SMPs to help them both comply with safety regulations and to work towards continual safety performance improvements. Many of these options are meant to reduce collision frequencies and severities, but many also address other aspects of a carrier's safety management system.

STEs related to fleet safety management also change quickly. Many of the STEs we've discussed weren't available on the market just a few short years ago. Carriers can expect continually innovation in safety technology. This means STEs today will perform differently - better, most likely - as time goes on, and there will almost certainly be completely new STEs introduced in the short-term future that weren't available for inclusion in this book.

What this all means is that carriers should use resources like this one to develop their staff's knowledge around STEs and SMPs. Safety management needs to include an ongoing practice of self-education to keep current on developments in terms of technology, best practices, and regulatory updates.

2. **Does it make sense for carriers to invest in STEs and SMPs to improve their safety performance? In other words, are these fleet safety management tools effective, and is there any chance of receiving a positive return on such investments?**

In short, yes to all of these questions. There is considerable evidence supporting the efficacies of STEs and SMPs and, while it's harder to specifically assess, positive ROIs are likely to be seen by carriers that make strategic investments in safety technologies and management practices.

Possibly the most important takeaway for carriers here, though, is to understand that their investments in STEs and SMPs need to be appropriate for their operations. Efficacy and ROI data from other sources is useful, but it should not be expected that a carrier will see the same results themselves due to the great complexity that exists within a fleet environment. The strategies and suggested practices laid out in the previous chapters can help carriers develop their own practices for vetting information and deciding how best to make safety-related investments.

3. **How can industry associations like AMTA position themselves to serve their members and other industry parties in the world of rapidly evolving technology and safety management practices?**

AMTA, nearly 90 years old at the time this resource was written, has seen tremendous change in the trucking and busing industries in Alberta and the rest of the world since its founding. We're no stranger to change and challenge, and we continue to take steps to remain current on safety management developments to better be able to advise our members. This resource is just one such example, and AMTA will continue to share our knowledge and what we learn with our industry.

We continue to learn and contribute to safety management developments for carriers. Our non-government, non-carrier position in the industry and interest in seeing carriers safely thrive means we're a unique resource for carriers who, by engaging with us, can benefit from the work we do and participate in the larger safety and transportation community.

What now?

There has never been a time with more readily available safety management solutions to help carriers make safety-related improvements in their operations. Today's STEs and SMPs won't stay the same, though, as they constantly evolve. Therefore, while we've offered a solid knowledge foundation on these topics in this book, it should never be assumed that professional development in this area is ever complete.

This resource offers insights and systems more insulated from obsolescence that carriers can use to help themselves. These include:

- How to do literature searches to self-educate on STEs and SMPs.
- How to understand STE/SMP efficacy and how it differs from ROI.
- How ROI works and how to estimate it for a specific carrier's operations.
- Based on a self-assessment of a carrier's safety culture, how best to move forward in investing in STEs and SMPs to improve safety performance beyond what's possible through regulatory compliance alone.

As more and more solutions are made available to help carriers operate more safely, those that take advantage of such solutions will see safety performance improvements. Based on what we've learned about efficacy, ROI, and the actual practices of various large carriers, those doing this work will also likely become more competitive. The safety gap between carriers that strive for continual improvement and those that remain satisfied with minimum compliance (or even lower standards) will grow, and it can be expected that those not working to improve their safety performance will see increased negative attention from regulators, customers, and the public. So, while not all carriers need to take the same approaches as those that lead in the safety management space, it is nevertheless important to develop a safety culture that is constantly seeking out ways to improve.

-

Carriers don't need to do this work alone.

AMTA is available to help.

AMTA Alberta Motor Transport Association