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ROLLOUT OF A DIGITAL COMPREHENSIVE SAFETY MANAGEMENT SYSTEM  
IN A LARGE PUBLIC AGENCY: A CASE STUDY WITH KENTUCKY  
TRANSPORTATION CABINET

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THESIS

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A thesis submitted in partial fulfillment of the  
requirements for the degree of Master of Science in  
Civil Engineering in the College of Engineering  
at the University of Kentucky

By

Salena Pham

Lexington, Kentucky

Director: Dr. Gabriel B. Dadi, Professor of Civil Engineering

Lexington, Kentucky

2023

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## ABSTRACT OF THESIS

### ROLLOUT OF A DIGITAL COMPREHENSIVE SAFETY MANAGEMENT SYSTEM IN A LARGE PUBLIC AGENCY: A CASE STUDY WITH KENTUCKY TRANSPORTATION CABINET

It's understood that construction is extremely dangerous and highway construction has an added risk that comes from the presence of traffic. Many steps and prevention measures can be taken to reduce the risks to workers' safety in highway work zones. Kentucky Transportation Cabinet (KYTC) realized they had room for improvement and wanted to have a database that would allow for analysis of the common causes of incidents. The new software KYTC wanted to implement is called Origami Risk. Origami Risk is a cloud-based safety management system (SMS) software that offers a huge range of customizable risk management, RMIS, environmental health & safety, and data analytics tools in a single platform that is accessible via web browser and mobile app. To better understand how to implement a SMS in a public agency a literature review was done to review other Department of Transportation's implementation process and what they learned from the experience. Researchers also held focus groups with KYTC to understand the expectations and concerns of the employees who will be using or administering the SMS. All this information was collected and distributed to KYTC to assist with developing an effective implementation process for a new digital comprehensive SMS.

**KEYWORDS:** Safety Management System, Highway Maintenance, Department of Transportation, Implementation

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Salena Pham

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11/16/2023

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Date

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## CHAPTER 1. BACKGROUND

### 1.1 Introduction

Most of the research done on work zone safety focuses on traffic accidents involving motorists (Mohan and Zech, 2005). There is limited research done on a department of transportation workers' safety. However, it is understood that construction is extremely dangerous and highway construction has an added risk that comes from the presence of traffic. The research usually gives statistics on the accidents occurring in work zones and some leading causes. An analysis of 240 accidents over 5 years involving New York State Department of Transportation highway and bridge construction project workers resulting in hospital or fatal injuries showed that construction accidents accounted for 80% of all serious injuries and almost 60% of all fatalities (Bryden and Andrew, 1999). Also, traffic accidents account for 22% of serious worker injuries and 43% of all fatalities in the 240 accidents. Tools and equipment were a reoccurring factor contributing to 50% of the serious workers' injuries and 20% of all fatalities. While falls accounted for 25% of all serious construction injuries (Bryden and Andrew, 1999).

Another analysis of New York State Department of Transportation work zone accidents involving 36 fatalities and 3,055 serious injuries from 1990 to 2001 concluded that most of the accidents fall into one of five identified accident types. The five accident types are struck/pinned by large equipment, trip or fall (elevated), contact with electrical or gas utility, struck-by moving/falling load, and crane/lift device failure. These five work area accident types were the cause of 96% of the fatal accidents, accounted for almost 63% of the hospital-level injury accidents, and almost 91% of the total costs. The total cost of construction work area accidents is \$133.8 million (Mohan and Zech, 2005).

The study also examined accidents involving motorists and construction workers calling them traffic accidents. This has appeared in previous studies showing that workers struck by motorist accounts for about 50% of the vehicle-related fatalities among highway workers (Mohan and Zech, 2005). The analysis of the traffic accidents showed that the accidents fell into one of the five accident types. The five traffic accident types are workspace intrusion, worker struck by a vehicle inside the workspace, flagger struck by a vehicle, worker struck by a vehicle entering/exiting the workspace, and construction equipment struck by a vehicle inside the workspace. These five traffic accidents account for 86% of fatal traffic accidents, almost 70% of hospital-level injury and minor injury accidents, and 79.4% of the total costs. The total cost of traffic accidents is \$45.4 million (Mohan and Zech, 2005).

Many steps and prevention measures can be taken to reduce the risks to workers' safety in highway work zones. Some of the preliminary measures focus on the regulations and recommendations of OSHA and the Manual in Uniform Traffic Control created by the Federal Highway Administration (Pratt et al., 2001). The Manual on Uniform Traffic Control Devices (MUTCD) provides guidance on training, personal protective equipment, speed reduction, barriers, and lighting in highway construction. The manual ensures that the design and setup of highway work zones are uniform. While OSHA 29



CFR\*1926, Subpart O explains the use of vehicles and equipment within an off-highway job. Subpart G addresses flagging, signs, signals, and barricades (Pratt et al., 2001).

A workshop held by the National Institute for Occupational Safety and Health (NIOSH) discussed safety concerns for workers on foot, safe operations of construction vehicles within work zones, and special safety issues like night work in highway work zones. These topics were discussed among individuals in government, labor, industry, academia, and state departments of transportation (DOTs) (Pratt et al., 2001). Their knowledge and experiences were combined with the NIOSH analysis of literature on highway safety, and worker fatalities data in the highway and street construction industry. With the workshop data and the literature research done, the NIOSH created a list of injury prevention measures that can be reviewed by multiple stakeholders to decide what interventions would pertain to them the most.

This is exactly what the Kentucky Transportation Cabinet (KYTC) did after looking at their data and their current incident report process. KYTC realized they had room for improvement and wanted to have a database that would allow for analysis of the common causes. The analysis would identify areas that could better reduce the risk. This initiative came from KYTC wanting to improve their safety culture and become more digitalized. This case study is one of many partnerships between KYTC and the University of Kentucky Civil Engineering Department with the intent of improving the safety of KYTC employees.

KYTC has recently focused on near-miss reporting and was using a web-based reporting tool. The study on near-miss pointed out some issues with the web-based reporting tool. KYTC employees were not aware of the web-based reporting tool for near-miss and didn't know how to access it. In the study, it was determined that a KYTC employee's use of the near-miss web-based reporting tool is dependent upon their awareness of the web-based tool's existence (Atkins, 2022). The researchers also explain how other departments of transportation have implemented online forms and tools to make reporting easy and convenient while acting as a secure database to store information and analyze trends. Researchers also noted that paper-based reporting turnaround time took longer due to the fact the report had to be handed off by multiple people before arriving at the proper desk. Also, paper forms were often "lost" in the process and resulted in no corrective action. KYTC saw room for improvement and saw the benefits of digitalization. Digitalization like online reporting can save time and money. Online reporting as stated before stores the information instantly and allows for analysis. The analysis of KYTC data would allow them to make informed corrective action across the entire state with statistics to back it up. KYTC saw the benefit of having a database of information that could be analyzed and invested into an SMS.

The Kentucky Transportation Cabinet then reached out to the University of Kentucky Civil Engineering Department to conduct literature research and provide assistance on how to implement a new software and process into a public state organization. The new software the Kentucky Transportation Cabinet wanted to implement is called Origami Risk. Origami Risk is a cloud-based safety management system (SMS) software that offers a huge range of customizable risk management, RMIS, Environmental health &

safety, and data analytics tools in a single platform that is accessible via web browser and mobile app.

## 1.2 Problem Statement

It is understood that construction is extremely dangerous and highway construction has an added risk that comes from the presence of traffic. There is limited literature on the use of safety management systems in the department of transportation for maintenance worker safety. The literature usually focuses on the main causes of motorist incidents and comes up with preventative measures. KYTC is focused on improving worker safety by analyzing incident claims involving maintenance workers to create preventative measures. The digital safety management system would be an upgrade from the paper process of incident reporting. The change can be taken negatively but if effectively implemented can show promising results, like saving money, effectively communicating issues, and improving safety performance across the state.

## 1.3 Objectives

This study's primary objective was to support the early implementation of a comprehensive digital safety management system in KYTC's maintenance crews and draw conclusions from the data collected. This involved addressing concerns from maintenance crews and evaluating literature to provide guidance to effectively transition to a new digital safety management system.

## CHAPTER 2. LITERATURE REVIEW

### 2.1 Safety Management System used by DOTs for Traffic Safety

Academic publications exist on safety management systems (SMS) used in different industries, but few publications exist on safety management systems in departments of transportation (DOTs). SMS used in DOTs usually involves motorist safety on roads. In 1993, a safety management system was created by the Virginia Department of Transportation. The system focused on five major areas:

1. Coordinating and integrating safety efforts more fully;
2. Identifying hazardous highway safety problems and establishing priorities to correct them;
3. Ensuring early consideration of safety in all transportation projects;
4. Identifying safety needs of special groups in planning and design; and
5. Routinely maintaining and upgrading safety hardware.

There was also a similar system sponsored by the Federal Highway Administration (FHWA) and the Indiana Department of Highways. With similar areas of focus on statewide traffic safety-related data. The Iowa Department of Transportation has an online system that allows users to access the available traffic records and safety reports in Iowa. Iowa's system provides six different categories of traffic- and safety-related reports and summaries: crash, roadway, driver, vehicle, Injury Surveillance System (ISS)/Bureau of Emergency and Trauma Services (ETS), and citation/adjudication (Khattak and Iranitalab, 2016). A few other states have similar safety systems to assess crash data like South Carolina, Maine, and Michigan (Souleyrette, 2011).

### 2.2 Safety Management System used by DOTs for Worker Safety

This study used a safety management system for worker safety. It involved an online survey questionnaire that was sent out by email to members of the AASHTO COM and NAATSHO. It was used to better understand the current use of SMS in DOTs (National Academies of Sciences, Engineering, and Medicine, 2022). There were 41 fully completed responses from 41 state DOTs. Out of the 41 responses, 27 DOTs have or have had an SMS, and 14 DOTs didn't have any SMS experience. 9 DOTs who did not reply. When asked what information was collected, 100% of the DOTs collected data on incident occurrence, 65% collected data on incident investigations, 42% collected data on near misses, 39% collected data on training records, 23% collected data on Toolbox Tasks/Pre-Job Briefings, 23% collected training guides, 23% collected policy manuals, 23% collected other write-in data, and 19% collected data on behavior observations.

Regardless of whether it was an in-house developed system, a commercial system, or no system at all, most of the data entry was through a web-based portal (70%), 41% collected data on paper and manually entered it into an electronic system, 30% entered data through an Excel spreadsheet or similar software, 30% collected data through a scanned in paper converted to a pdf, 19% entered data through a mobile application, and 11% collected data on paper (National Academies of Sciences, Engineering, and Medicine, 2022).

Once the data is collected, the information can be distributed to multiple people to keep for their records, to self-address, to provide corrective actions, or to not be used for any action. Using the data from the SMS overall helped improve documentation efforts, improve health and safety business efficiencies, improve health and safety performance while reducing associated costs, and improve organizational relationships. Common aspects that were noted by DOTs that were needed for the implementation of an SMS were written policies and procedures. The written policies and procedures helped guide data entry and reporting. While also assigning responsibility to individuals to manage and interpret the data. Another aspect is close organizational relationships, the relationships showed commitment to safety in leadership, which motivated field crews. The decision to make occupational safety a separate division and not grouped with human resources or another department was noted as important by the DOTs.

Cybersecurity was a concern for any web-based system as well as accessibility of the system through the state DOT's intranet or lack of internet access for field crew. Another challenge the DOTs faced was changing the workflow of how safety was managed. It had pushback due to the lack of confidence in the new system due to the possibility of inaccuracy in the data. After the data was processed came another challenge of needing more administrative efforts for data entry and reviewing the analyzed data to better understand the safety trends. The cost was only noted as a challenge by DOT who didn't currently have a SMS. The 41 DOTs who responded knew it was a significant investment but did not see cost as a challenge. Especially when deciding to develop an in-house system or to purchase a commercial system that fits their needs.

From the 41 DOTs that responded, five were selected for more in-depth analysis. The five DOTs were asked to participate in web interviews to collect more information on their SMS processes and strategies. These state DOTs were chosen because of their survey responses. The survey responses describe their experiences with SMSs that could be a guide for other DOTs. The five DOTs chosen for the case examples were Connecticut, Nevada, Tennessee, Texas, and Virginia. The rubric used to select the five DOTs for more in-depth analysis is they currently have an implemented SMS, have more than 3 years of experience with their SMS, and use their SMS for reporting and tracking.

The web interviews were semi-structured with the same base question for each state but could have personalized details to describe each state's SMS experience. Each state was asked seven questions (National Academies of Sciences, Engineering, and Medicine, 2022):

- “Describe the decision-making process (how? when? and why?) to acquire/develop a safety management system (SMS).”
- “Describe your agency’s organizational structure to manage maintenance worker safety (i.e., what division is responsible, what staffing resources exist, what responsibilities exist).”
- “How is your SMS deployed, used, and managed?”
- “Describe the SMS’s features, functionality, benefits, and mechanisms used.”
- “What policies and procedures do you have pertaining to the SMS? Are they in official policy manuals?”
- “What would you estimate as the costs associated with acquiring, maintaining, and managing your SMS (rough estimates are sufficient)?”
- “What suggestions do you have as lessons learned or best practices related to the use and implementation of safety management systems?”

The summary of the experiences from these five state DOTs and their SMS varied. Connecticut Department of Transportation (Connecticut DOT) decided to use a SMS to improve their worker safety data and to get better analysis from the information. This required the Connecticut DOT to decide to switch to a new digital SMS from their previous paper-based SMS. The problem with the paper-based SMS was the statistical analysis of the data was general and couldn’t give in-depth information on the areas of concern. The digital SMS used by the Connecticut DOT is a cloud-based commercial safety database system.

The SMS was customizable and could be configured to the DOT’s needs. The system has many features like collecting safety data, accidents, injury management, and medical monitoring. The system could analyze the data to track trends and give statistical insight. The other features offered by the SMS were occupational health and safety like training and industry hygiene for the DOT employees. A challenge of the SMS was access. Some features of the SMS were only accessible through the intranet. This restricts the employees’ abilities, which is why Connecticut DOT is looking for a solution. A benefits analysis has not been conducted by the Connecticut DOT. The benefits stated have highlighted the new perspective on safety data. The DOT can make better-informed decisions to help the workers, but no analysis has been done to quantify the return on investment or reduce injury rates/worker compensation. Looking back the Connecticut DOT would put more effort and resources into figuring out the “how to” and “how long” details of the SMS implementation (National Academies of Sciences, Engineering, and Medicine, 2022). This was gradually done due to limited resources. The importance of getting everyone to support the system required the DOT to be able to train the crew, managers, supervisors, and superintendents to roll out the system.

The Nevada Department of Transportation (Nevada DOT) has an in-house developed SMS that was created and updated with the influence of OSHA programs. The main intention was to build a stronger safety culture. The Nevada DOT has a predefined workflow that happens when an incident occurs using their SMS. When an incident occurs, the employee is trained to inform their supervisor and to complete a report with all the details. Once that report is uploaded an investigation starts that involves a meeting

with district safety officers or district engineers to address the issues. The SMS has many modules that can monitor crash investigations, worker compensation claims, training, and trends. The benefits of this SMS can be seen by comparing the injury data from 2011 to the data from 2020. In 2011, there were 145 reported injuries, but in 2020 there were only 55 reported injuries (National Academies of Sciences, Engineering, and Medicine, 2022). In 2019, there were 75 reported injuries. It can be assumed that COVID-19 affected the data from 2020. Another benefit was the reduced cost per claim in worker compensation. The cost per claim in 2011 was \$18,000 and was reduced to \$7,800 (pre-COVID-19). Overall, the Nevada DOT has seen a savings of \$300,000 per quarter in worker compensation claims because of their SMS.

When asked about SMS implementation suggestions and lessons learned the Nevada DOT used this as a moment to reflect on how their efforts have been successful and by keeping the system in-house with in-house training. They have been able to avoid the cost of third-party providers and can have a hands-on approach to what is being done in their state DOT's SMS. They also state the importance of having leadership support to roll out the system successfully.

Tennessee Department of Transportation's (Tennessee DOT) decision to use a SMS was due to several traumatic events. In 2016, the DOT experienced three fatalities which was the moment Tennessee DOT knew they needed to create a stronger safety culture and a safer work environment so this wouldn't happen again. They started by developing a team of a safety director and assistant director to review the written programs and safety data. In 2017, they began reaching out to other DOTs and talking with field crew to get their opinion on what was needed in a SMS. After gathering the information from other DOTs and their field crew, Tennessee DOT developed an in-house SMS. It started from paper property damage and injury reports to worker compensation data from a third-party administrator. It all got shared through Microsoft SharePoint to make reporting easier and was a database for reported data.

The transition to a digital system changed how the DOT communicated and helped them make better-informed decisions when it came to safety. Also, having a full-time data analyst helped point out their safety trends. The SharePoint allows the DOT to effectively communicate information to employees in every county. An example described is "Safety Mondays," where the crews are shown a safety-related video in all 95 county maintenance shops or construction offices. The Tennessee DOT SMS is a Tableau Software. Some features of the software included a dashboard tool that can provide a visual report of the data and trend analysis. Another benefit was the SMS cut the DOT estimated worker compensation and property damage cost by approximately \$1 million in 2019 (National Academies of Sciences, Engineering, and Medicine, 2022). Looking back the Tennessee DOT realized that a SMS was needed, but the culture around safety played a huge part in its success. Establishing a strong safety culture through their internal campaign called "Work 4 Us" helped gain the commitment of the crew members to work safer. They point out the fact that building trust between leadership, management, and crew members is a key component of safety.

Texas Department of Transportation's (Texas DOT) SMS was originally a system used for collecting basic information on worker compensation and vehicle accident claims. The system then developed into a Microsoft Access database system that could store the data and track claims. The big initiative to have a fully function safety management system came after they adopted the Safety Mission Zero approach of having no employee fatalities. Texas DOT realized they needed a more comprehensive digital SMS to help them reach this goal. Texas DOT's SMS is a commercial safety system that was customized to fit their DOT needs. The system is combined with Tableau software to create a dashboard for viewing. The SMS used by Texas DOT manages and tracks injury and incident reports, claims, vehicle incidents, and employee safety and health. The SMS is accessed through Texas DOT's intranet and has access to the Texas DOT's personnel database. The benefit of the SMS and Texas DOT's personnel database being integrated is it saves time and reduces input errors when creating reports (National Academies of Sciences, Engineering, and Medicine, 2022). Error-free reports are a priority because of Texas DOT controlled workflows. Every report is sent to multiple people to either investigate, develop a solution, or decide on compensation. Before the investigation can be closed, the incident report must be reviewed to determine the root cause and ensure a corrective action is assigned.

Some benefits of Texas DOT SMS are their attention to detail and customization with the vendor allows them to add and create modules to fit their needs specifically. The new module can then be offered to other DOTs that are looking at inquiring a SMS or want to add new features to their current system. Another benefit is the decrease in fatalities. Texas DOT has an average of one employee fatality per year but in the past three years, there has been zero employee fatality. Looking back the Texas DOT understood the severity of adopting such a comprehensive system. The DOT knew it was an investment that required a lot of informed decisions. They determined their needs and made sure to shop around for a system that offered everything they needed and could be customized to fit their current and future plans.

Virginia Department of Transportation (Virginia DOT) leadership in the safety division decided to develop a SMS to better understand their safety data. Before this Virginia DOT would collect paper reports, but then they decided to use a Microsoft Excel spreadsheet. The reports are reviewed by the district safety manager and are passed on to the assistant director in the central office safety division for additional review. Virginia DOT worker compensation is run by a third-party provider but by connecting their SharePoint system, they can provide an automatic paperless process. The Virginia DOT's SMS is a Microsoft SharePoint Platform with a predefined workflow that collects data through Microsoft InfoPath Forms. This is done for vehicular and equipment crashes or incidents, incident investigations, occupational health, civility training, and programs in the workplace. Another example of this is the Integrated Solutions program, this program allows the purchase of PPE, chemicals, and oil with the approval of the safety division (National Academies of Sciences, Engineering, and Medicine, 2022).

For training purposes, Virginia DOT uses a learning management system called Virginia DOT University. The training on the learning management system is created by

the DOT, but they have plans to create classes for equipment certifications. The Virginia DOT safety division also has plans to create a near-miss reporting and data collection through a geographic information system. All these individual systems collaborate to create monthly or quarterly safety report analyses to see if safety is improving or worsening. Virginia DOT didn't provide any quantity benefits, but the SMS was seen as an opportunity for the DOT to grow and have a stronger safety culture and safer work environment. They did this through a SMS and looking back they knew it would take trial and error and required lots of feedback. The Virginia DOT just kept communicating, collaborating, and improving to make things work.

### 2.3 Safety Management System in Other Industries

Center for Aviation Safety Research at Parks College of Engineering, Aviation, and Technology, Saint Louis University created a study showing the benefits of SMS implementation and the costs of developing a SMS program as well as costs associated with incidents and accidents. They used a macro-to-micro level of analysis to prove the benefits of safety programs. The macro level of the study involved three major air carrier accidents that all resulted in damage to the airplane and the loss of life in two of them. The macro level analysis of the accidents showed that the parent companies involved stock prices dropped when measured at one, three, six, and twelve months after the accident. The study states this can show a correlation between the accidents and losses of stocks (Lercel et al., 2011). The stock value and net worth of an airline can decrease as much as 25% after an airline accident. Which can represent a loss of \$328,000,000 in capital for US Airways (Airbus, 2008). An accident could leave an airline in bankruptcy if they are unable to recover.

For a mid-level analysis, the researchers investigated three organizations to see how safety interventions can impact an organization's finances, which could lead to macro-level effects. The three organizations were chosen because there is a lack of literature on the financial benefits of safety management systems in the aviation industry. These organizations were also picked because the industries have safety reputations to uphold due to potential safety-related accidents. The three organizations are a local construction firm and two healthcare product manufacturers.

The construction firm was McCarthy Building Companies, Inc., the 10<sup>th</sup> largest general contractor in the United States with \$3.5 billion in annual revenue. They started a safety system in 1997 that had broader safety culture concepts and system management policies and procedures (Evans et al, 2010). McCarthy Building Companies, Inc. invested \$2.3 million which covered the cost of the software and hardware for their new system. The results showed that in twelve years there was a 92% decrease in lost time and recordable incident rates. There was also a reduction of worker compensation insurance losses from \$3 million in 1997 to approximately \$240,000 in 2009. This was an example chosen by the researchers to show that a safety program can prevent unfortunate events, reduce risks, and save money.



The next two examples from healthcare providers show how an incident can cause penalties, lawsuits, loss of consumer confidence, and risk of bankruptcy because of safety/quality-related incidents. Which could have been avoided with the implementation of a safety management system. Baxter International Inc. was a leader in the healthcare industry in the production and marketing of medical equipment. This came to an end in 2006 when Baxter entered a consent decree with the Food and Drug Administration (FDA). The FDA recalled the infusion pumps manufactured by Baxter and required the company to refund the customer or send out replacement pumps. The recall showed a cost totaling close to \$600 million as reported by the FDA (“F.D.A. Orders”, 2010).

The next healthcare example involves KV Pharmaceutical stopping shipments of their drugs in tablet form and recalling a production lot of painkiller Hydromorphone HCl 2 mg tablets. These tablets were recalled because they were oversized (Anonymous, 2009). KV faced class action lawsuits, had to fire the company’s Chief Executive Officer, and laid off 1,020 of its employees. In 2009, KV reported revenue of \$312.3 million, which is down 46% from \$577.6 million in 2008. In 2010, KV was forced to pay \$26.7 million in fines and restitution, which caused an additional layoff of 289 employees (Doyle, 2010).

The financial losses made it hard for KV Pharmaceutical to continue with business as usual. Which caused KV to hire a law firm that specializes in bankruptcies and restructuring. One of the conclusions made is these unfortunate events were caused by a safety and quality lapse in the company’s process and could have been avoided if the company had controls and systems in place (Lercel et al., 2010). The company’s stock also dropped following the unfortunate events. The companies knew their responsibilities as healthcare providers because consumers and investors don’t like safety-related issues. The researchers point out that in the 21<sup>st</sup> century, there is a certain level of perfection that is expected. This level of perfection can be achieved with a safety program that prevents and reduces risks.

The micro-level analysis of this study involves examples from aviation organizations and brings in the cost involved with having and not having a SMS. The first example involves an aircraft manufacturer releasing a mandatory service bulletin that required the locking mechanism on the main door to be performed. A new paint job was also scheduled at the same time as the mandatory service. The paint job required the door to be closed which was an issue. The door was currently in the middle of being serviced. The electrical harness and connector were not reconnected before putting the door back on. Which caused the electrical harness and connector to get caught in the hinge area. This caused damage to the door, electrical harness, and connector. Also, time was wasted like production and engineering hours, lead time on parts, and now more schedule delays.

The manager completed incident reports and told the proper people, but this happened three more times before the issue was identified. These four incidents cost the company \$108,000. The Maintenance, Repair, and Overhaul (MRO) organization did not have a process or system in place to effectively communicate the hazard. Once the hazard was identified, the maintenance team worked to find a solution to eliminate the hazard.

The team came up with a solution after 16 hours and with an average compensation of \$65 per hour. The total cost of the solution was \$1040 (Lercel et al., 2011).

Another example of an unfortunate event was when a flight crew was performing pre-departure cockpit checks and discovered a switch on a flight management system control panel was broken. The switch lever was broken meaning the aircraft could not dispatch. This was bad because the aircraft owner and business associates were on the aircraft waiting to depart. This was the second aircraft that the switch was found broken. The cost of replacing the switch and renting another aircraft totaled to \$18,000 with this incident. The company did an investigation and noticed the problem was previously reported. The flight crew people were stepping over the center instrument and kicking the switch.

The company then did a phone survey and noticed that 13 out of 23 aircraft or 56% also had a broken switch. The employee interview also showed that most employees were aware of this hazard, but the company didn't have a reporting system to distribute information effectively and provide corrective action. The company's Quality Control and Engineering personnel developed a solution with the help of the aircraft manufacturer. The time spent developing the solution cost \$1200. The parts and labor to replace the switch were \$2300 per aircraft. Overall, the two incidents cost \$19,775, but the cost to eliminate the hazard for the two aircraft is \$5800 (Lercel et al., 2011).

These are examples of situations where a safety management system can make all the difference. With the construction firm, McCarthy Building Companies, Inc. McCarthy had a 92% decrease in lost time and recordable incident rates. Also, a reduction of worker compensation insurance losses from \$3 million in 1997 to approximately \$240,000 in 2009. Investing in a safety management system can make a work environment safer and run more efficiently. The examples from the healthcare providers show how the lack of a safety management system can cause safety and quality lapses in a company's process (Lercel et al., 2011). Every incident caused by a safety and quality lapse can cause penalties, lawsuits, loss of consumer confidence, and risk of bankruptcy because of safety/quality related incidents. In the 21<sup>st</sup> century, there is a level of perfection that is expected by consumers and investors.

The aviation examples at the micro-level were used to show the cost of incidents with and without a safety management system. The examples showed that the recurring incidents cost the company a substantial amount of money. This could have been avoided if there was an effective way of communicating this issue while allowing a corrective action or solution to be developed. The examples show how the time and money needed to develop the solution is a fraction of the time and money caused by the recurring incidents.

## CHAPTER 3. METHODOLOGY

### 3.1 DECA Readiness Assessment Plan

After the initial meeting with the Kentucky Transportation Cabinet (KYTC), the research team had a better scope of the project and what their concerns were with their new safety management system (SMS). The safety management system that was purchased is Origami Risk, but it was renamed BOOTS (Boosting Occupational Outcomes in Transportation Safety) for KYTC's use. The research team first created a BOOTS readiness assessment plan with information provided from web interviews with the KYTC Secretary Office of Safety and from KYTC presentations from the 2021 and 2022 NAATSHO Conference. The purpose of the readiness assessment plan was to provide a breakdown of the research team's vision moving forward with BOOTS implementation.

The research team wanted to provide KYTC with a clear and concise plan. The readiness assessment plan contained four sections: Define, Establish, Communicate, and Answer (DECA). The Define section shown in Figure 3.1 represents the "define the solution" objective of the readiness assessment plan. This section had basic information like who, what, where, why, and when of the BOOTS implementation. This required research on what was possible with the Origami Risk system. The first step was to figure out how customizable the system was and how to analyze the data from the system. The Establish section shown in Figure 3.2 was used to "Establish KPIs or Key Performance Indicators". The research team developed a list of leading and lagging indicators for crews, superintendents, district safety coordinators, and KYTC State Highway Engineers (SHE). The Establish section also introduced the plan of conducting a focus group session. The Communicate section shown in Figure 3.3 was the strategy for "how to" effectively share BOOTS implementation with the employees of KYTC. The last section of the readiness assessment plan is Answer. The Answer section shown in Figure 3.4 was a reminder to provide a space for feedback and questions. This was meant to be used for the BOOTS focus group sessions that would later be held.

## Define the Solution

### Origami Risk

#### ➤ Why...

- Improving the safety culture across KYTC
- Become a “Performance-based, data-driven” organization
- Tie lagging & leading indicators together
- Move from paper-centric to data-centric
- Automate data collection & integration
- Support digital transformation vision of KYTC

#### ➤ What...

- Web-based Safety Management System through Origami Risk
  - Incident Reporting, Notification, Workflow, Investigation, and Follow through
  - Job and Process/Equipment Management on Jobsites
  - Employee Hazard Exposure Management Tools and Assessment
  - Interconnect across all functions for reporting, analysis, workflow, & consistency

#### ➤ Where...

- Throughout the crews, districts, and executive levels of the Kentucky Transportation Cabinet

#### ➤ When...

| Task Name                                       | Start Date | End Date |
|---|------------|----------|
| KYTC Origami Implementation                     | 06/09/22   | 07/10/23 |
| KYTC Project Launch                             | 06/09/22   | 07/07/22 |
| Setup Origami Database                          | 06/21/22   | 06/23/22 |
| Configure Users / Security / SSO                | 06/22/22   | 04/14/23 |
| Convert Historical Data                         | 06/22/22   | 02/02/23 |
| Convert Risk Master Data for Ongoing Processing | 06/13/22   | 02/17/23 |
| Risk System Configuration                       | 06/22/22   | 05/12/23 |
| EHS System Configuration                        | 11/07/22   | 04/21/23 |
| Configure Interfaces                            | 09/26/22   | 04/21/23 |
| Configure Reports & Dashboards                  | 04/03/22   | 05/01/23 |
| Prepare for Go Live                             | 02/14/23   | 06/22/23 |
| Go Live   | 07/10/23   | 07/10/23 |
| Post GO LIVE Punchlist                          | 07/10/23   | 07/24/23 |

#### ➤ Who...

- *Is leading*
  - Secretary’s Office Of Safety (Tony Courtwright)
  - SMS Champion (Jon Lam)
- *Benefits or is impacted*
  - Secretary’s Office Of Safety (Tony Courtwright)
  - SMS Champion (Jon Lam)
  - Area Administrators
  - District Safety Coordinators
  - Maintenance Superintendents and Crews

Figure 3.1 Define Section in Readiness Assessment Plan

**Establish KPIs**

Identify a list of KPIs (metrics) and connect KPIs to different stakeholders

Conduct a focus group session with Crews, Superintendents, and District Safety Coordinator in one district per administrator responsibility to review and identify KPIs and particular concerns. In addition, conduct a focus group session with representatives from the State Highway Engineers (SHE) Office of KYTC. In the tables below, some conceptual ideas for KPIs are presented for each stakeholder group. The focus groups will add, refine, and delete KPIs as they see fit.

**Crews**

| Leading Indicators            | Lagging Indicators         |
|-------------------------------|----------------------------|
| Time for data entry           | Time for request follow-up |
| Number of access times        | More frequent JRAs         |
| Confidence in confidentiality |                            |

**Superintendents**

| Leading Indicators            | Lagging Indicators         |
|-------------------------------|----------------------------|
| Time for data entry           | Time for request follow-up |
| Number of access times        | More frequent JRAs         |
| Confidence in confidentiality |                            |

**District Safety Coordinators**

| Leading Indicators                         | Lagging Indicators                              |
|--|---|
| Time for data entry                        | Incident response time                          |
| Number of access times                     | More frequent PPE inspection                    |
| Number of paper forms/submissions received | More frequent jobsite and facility observations |
|  | Percent of suggestions with follow-up actions   |

**KYTC SHE Office**

| Leading Indicators                         | Lagging Indicators                            |
|--|---|
| Safety more frequently discussed           | Incident response time                        |
| Employee willingness to report             | Better OSHA annual reporting and analysis     |
| Worker’s Compensation amounts              | Percent of suggestions with follow-up actions |
| Number of paper forms/submissions received | OSHA statistics                               |

Figure 3.2 Establish Section in Readiness Assessment Plan

- Communicate**
- Communicate the plan to different stakeholders via different means to ensure buy-in
    - Adapt and adjust communication efforts according to the audience
  - Keep change messages simple and regular
  - Continuously reinforce the role of Origami in the forward success/mission of KYTC
  - Communicate plan/schedule/timeline -> incremental changes
  - Incorporate KPIs into communicated messages
  - Communicate key benefits
  - Make it visual – see provided one-page Communication Plan Template

Figure 3.3 Communicate Section in Readiness Assessment Plan

- Answer**
- KYTC to have a mechanism to answer questions and concerns
    - Make sure KYTC employees are heard

Figure 3.4 Answer Section in Readiness Assessment Plan

### 3.2 Focus Group

When deciding what districts to conduct the focus groups the research team acquired the help of the KYTC Secretary Office of Safety. KYTC after deliberating decided to conduct focus groups in District Five and District Twelve. District Five provides services to an eight-county area, including Bullitt, Franklin, Henry, Jefferson, Oldham, Shelby, Spencer, and Trimble Counties. The focus group met in Louisville, KY which is in Jefferson County. District Twelve provides services to a seven-county area, including Floyd, Johnson, Knott, Lawrence, Letcher, Martin, and Pike Counties. The second focus group met in Pikeville, KY which is in Pike County. These districts were chosen because KYTC wanted to get feedback from a range of employees. These two districts both have their unique safety hazards due to their population and location. This would allow KYTC to hear from employees working in more populated urban environments as well as less dense rural environments. Something that was also considered is these districts were perceived to have either a more active or less active safety program compared to other districts. The focus groups met in the maintenance barns of the districts. The focus groups were going to be an hour. The number of attendees was ideally no more than 15 people. This included 7-10 maintenance crew, 2-3 superintendents, 1-2 transportation engineer supervisor, 1 safety coordinator, and 1 chief district engineer. The agenda for the focus groups:

- Introductions (5 minutes)
- Microsoft PowerPoint: Introduction of the Safety Management System (15 minutes)
- Questions (5 minutes)
- Feedback on anticipated use (20 minutes)
- Feedback on branding (10 minutes)
- Closing and timeline (5 minutes)

From the DECA assessment plan, the research team knew how to effectively communicate information about BOOTS in a short amount of time and decided on a Microsoft PowerPoint presentation. The Microsoft PowerPoint presentation went through multiple revisions to address the correct audience without communicating too much information or too much “behind the scenes” information that could overwhelm them. The Microsoft PowerPoint presentation can be found in Appendix 1. An outline of the Microsoft PowerPoint presentation:

- Introduction of Safety Management System
- Our Solution
- What can it do?
- Project Phases and Elements
  - Focus Area 1: Incident Reporting and Response
  - Focus Area 2: Process Management
  - Focus Area 3: Hazard Exposure Management
- Foundation of System
- “How to” Access the System
- Incident and Near-Miss Reporting Process
- Individual Capabilities in SMS
- Specific Data Type Access per User
- Questions
- Feedback & Timeline

The Microsoft PowerPoint brief introduced the shared problems in KYTC followed by the introduction of the new safety management system. The new safety management system was presented to be the solution to KYTC’s problems by showcasing the abilities of the new system. The project was divided into three phases and elements. For the foundation of the system, a visual was shown of what happens to data that is input into the BOOTS (Origami Risk Database). A “how to” was also provided for accessing the SMS, with directions from a desktop or a mobile device app. Another visual used showed the pre-defined workflow of what happens when an incident or near-miss is reported. The next Microsoft PowerPoint slides are tables with information to show what each user can do or see in the system. Then there was a slide asking if there were any questions. Finally, at the end of the presentation feedback was collected on ways to motivate users

and any suggestions for branding. The feedback and questions collected were sent to KYTC for review.

### 3.3 BOOTS Training

The next step is to assist with training. KYTC collaborated with a team from Origami Risk to learn how to use the system and to create a user-friendly dashboard. The KYTC Secretary Office of Safety then created a user manual with screenshots of the BOOTS reporting system to give “step-by-step” directions. In addition to the manual, voice-over videos were created to guide users through the different modules and sections of the SMS. The research team assisted by reviewing the videos and providing feedback on the quality, duration, and “step-by-step” instructions. The objective was to make sure the videos were clear enough for any employee with little to no computer knowledge could follow along. The research team also wanted to ensure the videos were concise enough that if a crew member needed help in the field, the video could assist the crew in real-time with the SMS. KYTC has plans to introduce a new module with a new training video every few weeks to give everyone time to get acclimatized to the new SMS.

4. Fill out all forms with all of the information that is available. The fields denotated with red asterisks are required to complete report.
  - a. For all Incident addresses please enter a specific address if available, however, if not use the incident description to provide a street name, intersection, mile marker, or use the lookup address button. **For the reported by only fill out your first and last name.**

5. Next you will select which type of incident occurred, Employee injury, state property damage, private property damage, or non-KYTC employee injury:

**Please select all incident types associated with this incident:**

- Employee Injury or Illness
- State Vehicle and Equipment Damage (no private property involved)
- Private Property Damage (could involve a state vehicle)
- Injury to non-KYTC employee

Figure 3.5 Snippet from BOOTS User Manual



| User Training Resource Contents |   |
|---------------------------------|---|
| Topic #                         | Subject   |
| 0                               | RMIS 1.1 / 1.2 - Incident & Safety Opportunity Reporting, Notifications |
| 1                               | RMIS 2.1/2.2 Workers Comp Admin & RMSC Data                             |
| 2                               | RMIS 1.3/1.4 - Supervisor & Safety Investigation                        |
| 3                               | EHS 1.1 - Safety Observations/Audits                                    |
| 4                               | RMIS 2.3 Property Damage Admin  |
| 5                               | RMIS 1.5 - Root Cause Analysis  |
| 6                               | EHS 1.2 - Asset Tools & Certification Tracking                          |
| 7                               | EHS 2.1/2.2 - JHA & SDS Access, Job Safety Briefings                    |
| 8                               | EHS 2.3 - Work Permits process  |
| 9                               | EHS 3 Medical, exposure records, etc. (LATER)                           |

Figure 3.6 Voice-Over Training Video Topics

After going live and a few weeks of collecting data. Another web meeting was scheduled for a recap and to review progress. KYTC had informed the team of their trial and error with customizing the dashboard to show data that could be beneficial to them. The research team was then asked to assist with data analysis. The challenge KYTC had to figure out was how to interpret the data to assist in corrective action decisions. The first round of data analysis required us to find the easiest way to export data from BOOTS software. The research team did this by working with the KYTC Resource Management Analyst to develop a solution. The most versatile solution to data capture was Microsoft Excel Sheets. The data was then exported to Microsoft to go through early data analysis.

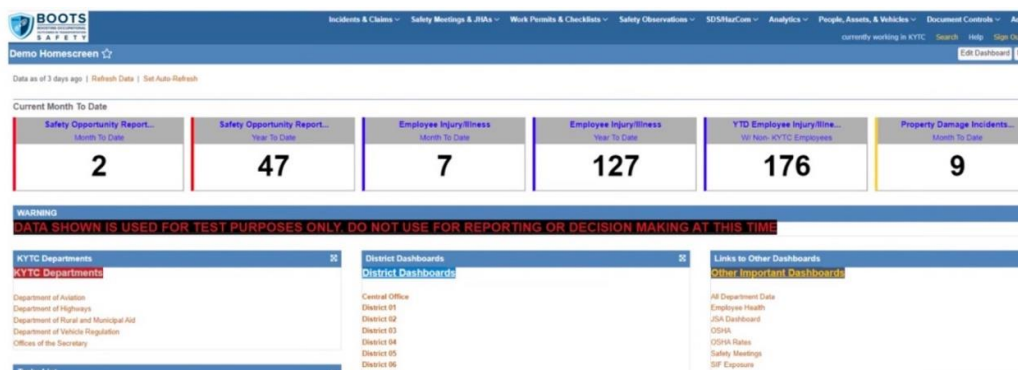


Figure 3.7 BOOTS Training Dashboard

## CHAPTER 4. RESULTS AND DISCUSSION

### 4.1 Focus Group Concerns

When reviewing the questions collected from the focus groups there were similarities. The concerns expressed were then grouped into three categories: connectivity, training, and logistics. The concerns involving connectivity were about the internet service in the field especially in more rural areas. Another concern mentioned was the maintenance barns are known to have weak Wi-Fi strength. The questions asked specifically were “What tasks can be done offline?” “What tasks need a connection to be done?”. This led to concerns about how the safety management system (SMS) would be accessed. There was some pushback on the use of personal devices since field crews are not given work devices or cell phones. It was also brought up that each maintenance barn is provided with one iPad. This makes it difficult for multiple task-based job briefings and equipment inspections to be done at the same time. The suggestion from the focus group was to have more iPads provided with cellular data that would have the SMS link or QR code readily available for the crews. The concerns of internet connection also brought up the conversation of whether it was okay to share the responsibility of reporting with someone with a good internet connection if the employee in the field is not able to. This continued into the logistic concerns.

The logistic concerns were questions on how reporting would work in the system. The first few questions were “Can a report be started by an individual and then assigned to another to complete?” “Can one be started, saved, and finished later by the same individual who is not a licensed user?” “Can reports be modified to add information as new info comes in (i.e., police reports)?”. The focus groups also wanted to know where the notifications would come from and what would they be about. They wanted to know if there would be notifications that serve as reminders for training, PPE, safety checks, vehicle maintenance, equipment inspections or maintenance, and job briefings. Another logistic concern was verifying signatures to confirm and verify the participants in a job briefing.

The other concerns from the focus group were questions and comments on the training aspect of the rollout for the SMS. The focus group wanted to know what kind of training would be provided due to the learning curve of a digital comprehensive SMS from the previous paper-based system. The focus group also communicated that they “would benefit from hands-on training and the ability to submit dummy reports to build confidence in reporting”. To build their confidence with the new system they also said they would like a checklist to know what information is needed to create a report and alert them if any information is missing.

The minutes from the focus group can be found in Appendix 2. The feedback from the focus group gave the KYTC Secretary Office of Safety an idea of how their employees felt about the new SMS. It allows them to plan their rollout to meet their employee’s needs. Internet service is an important aspect to the successful

implementation of the SMS. This is something that can be worked on with the internet service provider. The initial pushback of the use of personal devices is understandable. However, due to limited resources, a solution has not yet been developed, but it is noted by executive leadership. The concerns about internet service and devices show the desire to work together and to use this system. These are productive thoughts by the crew to ensure minimal issues with the SMS on their end. Once the crew has more experience using the SMS. This concern can be reopened to see if more devices would improve the use and accuracy of the data in the SMS.

The logistic concerns are good questions, but the crew can not edit or modify the report once submitted. The BOOTS software has a limited number of licensed users. Licensed users can edit and modify reports. Any information that isn't initially collected by the crew can be added, but only by administration. In the beginning, this could require more collaboration from the administration to edit reports. However, KYTC has hired a resource management analyst to oversee the SMS who could share some of the responsibility. These logistic concerns can also be better resolved in phase two of the project where the focus is to have more accurate data. In phase two of the SMS project, the focus is on the rollout of process management. The concern about verifying signatures for attendance can also be addressed when the focus shifts to job safety briefings and vehicle/equipment inspections in phase two. The question of notifications serving as reminders for training, PPE, safety checks, vehicle maintenance, equipment inspections or maintenance, and job briefings can also be addressed when the module is revealed. The software can be customized to meet KYTC's needs.

From the feedback gathered from the focus groups KYTC Secretary Office of Safety saw a need for visual training. The visual training came in two forms. A user manual was created with step-by-step instructions to show employees what information was needed in a report. The SMS also has required questions that are marked with an asterisk to alert employees of missing information in the report. To help with training the KYTC Secretary Office of Safety created voice-over videos to give their employees some guidance on the new system. The research team was asked to view the videos and to give feedback on them. Overall, the videos were very informative, but it was suggested the videos be broken up into shorter individual topics. It was also mentioned that there is a need for an assessment after every video to ensure that each employee has viewed the training videos and understands the topic. The research team also expressed concerns about how the video is filmed mirroring a desktop view and on a mobile device it could look different and cause difficulties. For example, the drop-down boxes with options for causes and injury codes were very long and could be hard to read on a mobile device and there could be human error when selecting.

## 4.2 Boots Results

Once BOOTS went live and data started coming in. KYTC reached back out to the University of Kentucky Civil Engineering Department to assist with basic analysis of the data. In the first couple of months of going live, KYTC had inserted previous incident claims, safety opportunity reports, and worker compensation claims. The research team

used the go-live date of July 10<sup>th</sup>, 2023, as a marker to compare the previous process to the new process with the safety management system. The idea was to show the effect the new SMS had on KYTC employees thus far. To show the effect he claims from September 2022 and September 2023 were compared as a case study. This data from 2022 was manually input by KYTC employees when configuring the new SMS, BOOTS. The comparison of the data is shown below.

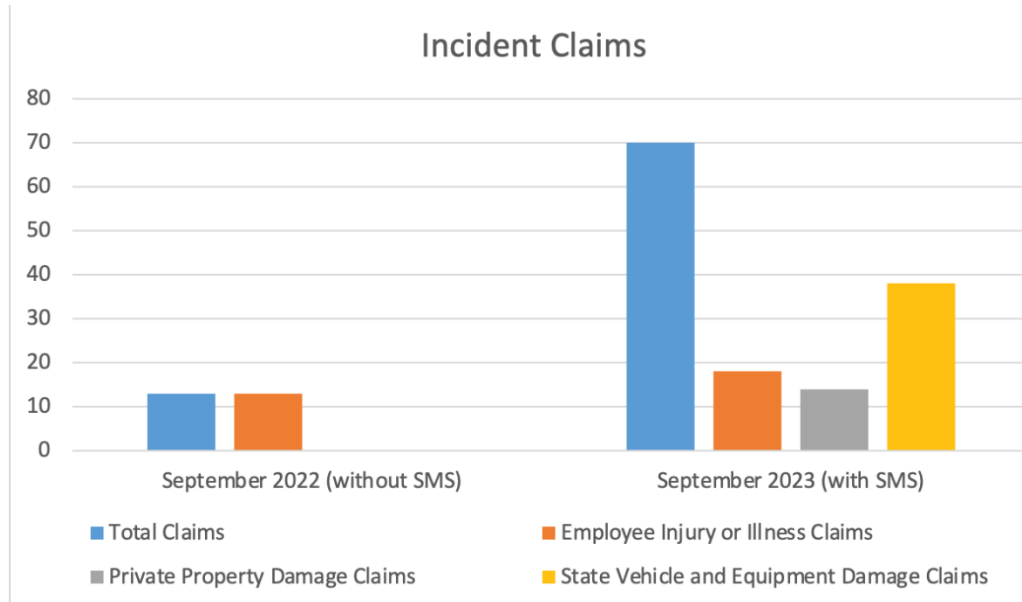


Figure 4.1 Incident Claims Results

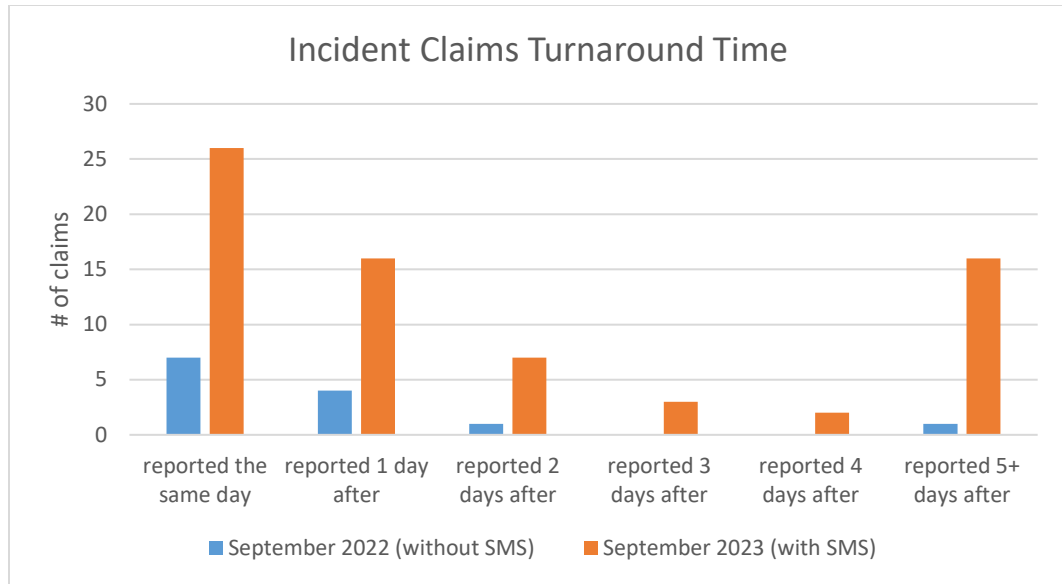


Figure 4.2 Incident Claims Turnaround Time Results

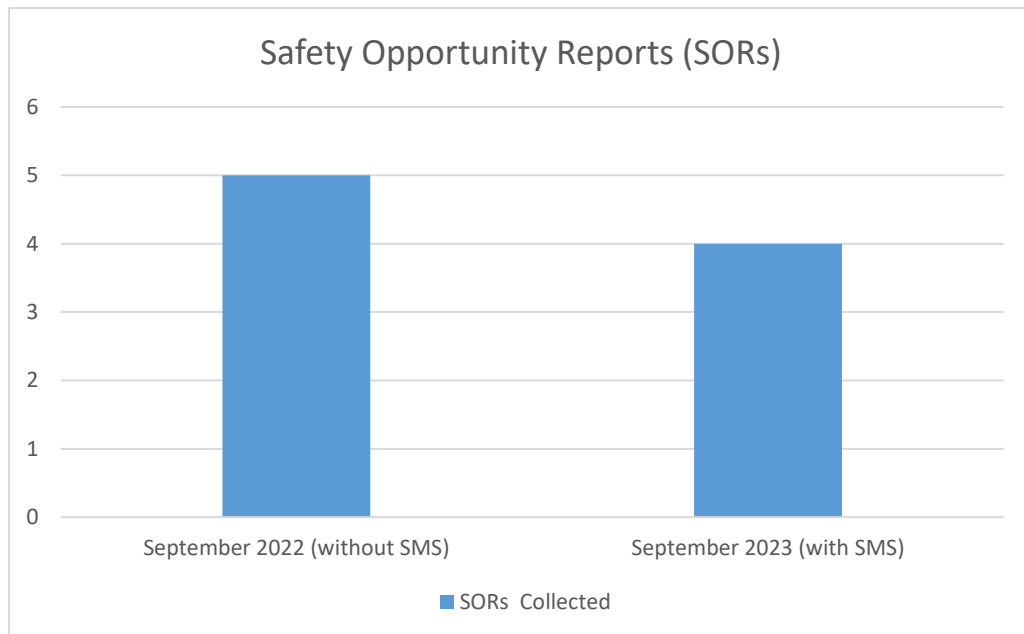


Figure 4.3 Safety Opportunity Reports Results

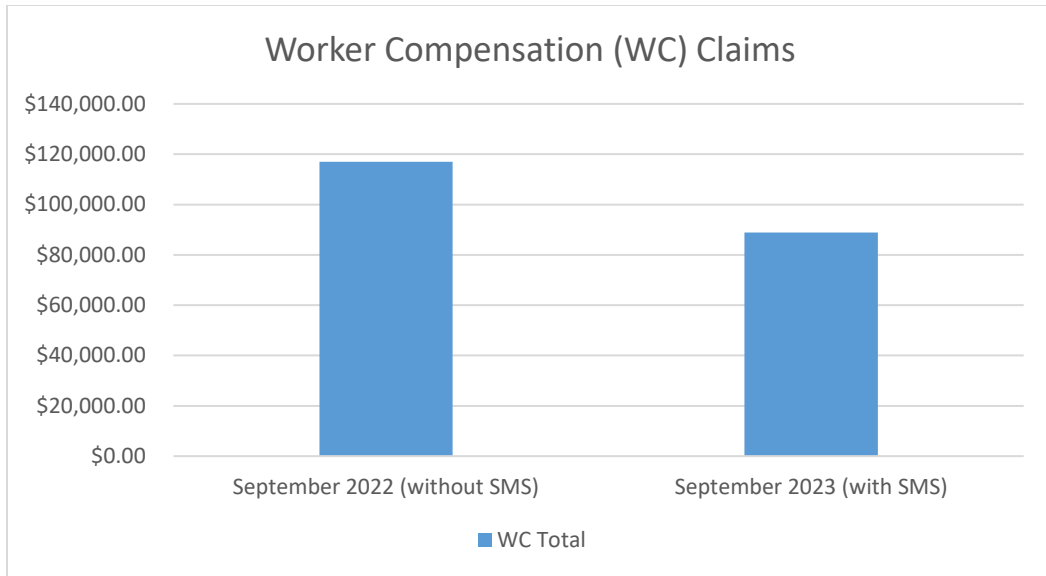


Figure 4.4 Worker Compensation Claims Total Results

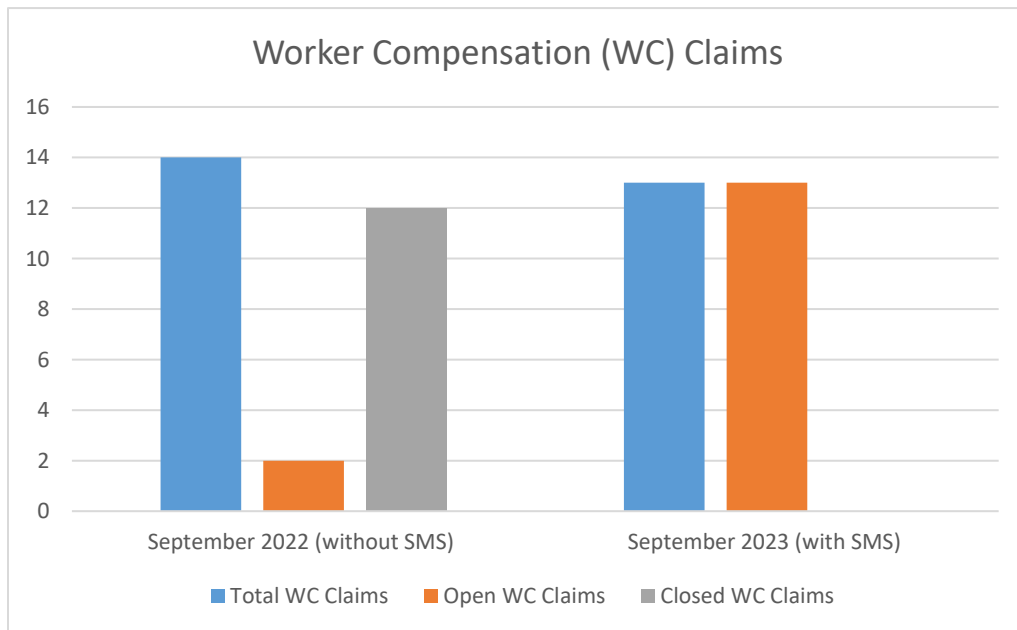


Figure 4.5 Worker Compensation Claims Results

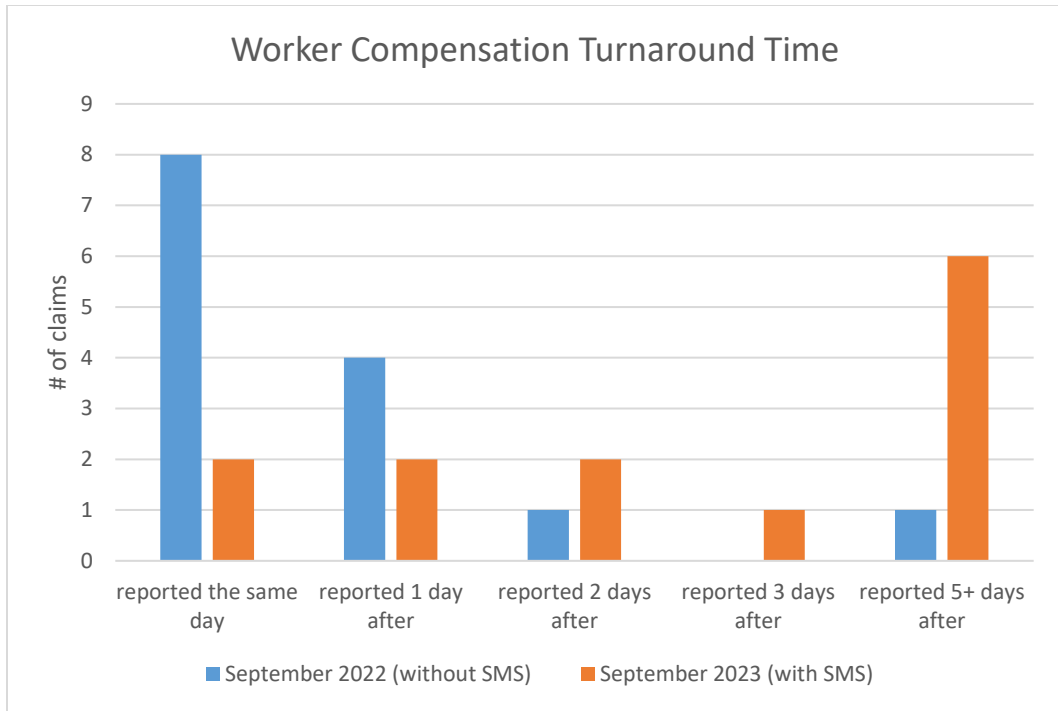


Figure 4.6 Worker Compensation Claims Turnaround Time Results

### 4.3 Incident Data Analysis

From the historical data given to us by KYTC for incident claims in 2022. The research team isolated the incidents from September 2022 that were reported without a SMS. In September 2022, there were 13 total reports, and they were all classified as employee injury or illness. In September 2023, there was a record of 70 total incident claims reported in the SMS. The breakdown showed 18 employee injuries or illnesses, 14 private property damage, and 38 state vehicle and equipment damage (no private property involved). This is approximately five times more incident claims in a year. With the incident claims given the only claims that can be compared are the employee injury or illness incidents; in September 2022 there were 13 claims and 18 claims in September 2023. These numbers are similar, but KYTC’s goal with the new system is to improve their employee’s safety.

The system can help develop data to show what conditions incidents are most likely to happen in. This allows the KYTC Secretary Office of Safety to evaluate their current work conditions and improve. The claims being stored in a database can provide details on the root cause of the incident. The data is the support and proof they need to develop informed corrective actions to prevent these incidents from happening again. The root cause could be the location, weather, time of day, equipment, or residents. It would give KYTC insight into who, what, where, and why it happened. How this information is obtained with the SMS is important to consider. With the SMS, concerns about handwriting and translation of forms can be prevented due to its digital properties. Overall, this is beneficial to the well-being of KYTC employees and KYTC stakeholders.

**Report a New Incident**

**Reporter Details**

**i** If entering this report for an incident involving another person, use the involved employee name in the "Reported By" field.  
Do not use your name unless you were involved.

Reported by:

Reported By Phone Number:  ext.

Reported By Email:

Reported By Title:

**General Incident Details**

Incident Date:

Incident Time:

Describe what happened:

Equipment, Materials, Chemicals Employee Using:

Were safeguards or safety equipment provided?  Yes  No

Were safeguards or safety equipment used?  Yes  No

**Address of Incident**

Incident Street1:

Incident Street2:

Incident City:

Incident County:

Incident State:

Incident Postal:

Incident Location Description:

Did the incident occur in a signed Traffic Control work zone?  Yes  No

Figure 4.7 BOOTS Incident Claim Reports

Another aspect that is critical in incident claims is when was it reported and when the incident occurred. When comparing incident claim data from September 2022 and September 2023 the research team reviewed turnaround time for this process. In September 2022, 54% were reported the day the incident occurred. This compared to 37% in September 2023 is subjective due to the addition of incidents involving property damage. Occupational Safety and Health Administration (OSHA) has a requirement that employers must report work-related fatalities within 8 hours. OSHA also requires the report of any inpatient hospitalization, amputation, or eye loss that occurs within 24 hours of a work-related incident. However, employers are not required to report it if the incident is from a motor vehicle accident on a public street or highway. Employers are required to report if it occurs in a construction work zone. The Kentucky Personnel Cabinet has a requirement that the first report of injury or illness must be completed within three working days after injury. The importance of a short turnaround time ensures more accurate reports. The short turnaround time gives employees a greater chance of remembering details and accurately describing the incident. When reviewing all incident claims in September 2023, 74% were reported within three days. This would help during the investigation process of determining the root cause and corrective action.

#### 4.4 KYTC Safety Opportunity Reports Analysis

The SMS is also a place where KYTC employees can take pride in maintaining a safe work environment. Investing in a new SMS was the first step, but in the system,



KYTC provides an outlet for employees to anonymously submit safety opportunity reports (SORs). In September 2022, there were 5 SORs and in September 2023 there were also 5 SORs collected. However, one of the five reports in September 2023 was an error duplicate report. Safety opportunity reports are essentially near misses or safety suggestions that are observed by employees. SORs are a way for employees to contribute and have a voice in their work environment. When reviewing the SORs, the research team considered how reliable, appropriate, and actionable they are. Before the new SMS, BOOTS rollout on July 10<sup>th</sup>, 2023, SORs were recorded on paper then they transitioned to recording them on a third-party reporting website.

In September 2022, two out of five reports were about building safety. One of the reports stated a bullet was found on the floor in a Division of Motor Vehicle Licensing office. The report shared that there was no concern or incident, and they were just sharing the information. The report shared information that could be a concern and appropriately explained that it was an informative report, and no one was in danger. However, there are no precautions that can be taken. The second report stated that two main exit doors were broken and had caution tape on them for some time. This shows a concern for building safety and blocked exits. The report tells us the location of the doors which helps the reliability of the report. A picture of the specific unsafe condition in the report could have given more information on the situation. This concern is appropriate and actionable due to the knowledge of emergency exit route regulations. The report is an opportunity to correct and improve the building safety.

The other three reports were concerns about state vehicles and equipment. They were suggestions for improving safety in general. The topics discussed were a jagged edge in a truck bed and suggestions for equipment that would make a job safer. Maintaining safe state vehicles is a way to keep employees safe. The concern was brought up to a supervisor and the action that could be taken is to schedule maintenance work on the truck bed. The reports that suggested equipment attached links that provided additional information on the equipment. This is appropriate as the field crew is using the current equipment and has first-hand knowledge of the hazards. This is actionable because it can be brought up to leadership to consider.

In September 2023, there were five SORs reported in the SMS. One of the reports was an error duplicate report. The duplicate report stated an employee stepped off a trailer and missed the step. The employee does not provide any other information on the conditions leading up to this near miss. Any information like what kind of trailer, time of day, weather, location, etc. can be helpful information. The additional details could help KYTC with determining the appropriate action. Another report that could have used more detail explained an employee climbed four feet on a truck bed to fuel a slope mower. The employee doesn't include details on who, what, where, and why this happened. The first step would be to talk to a supervisor about possible solutions.

Another report was about a snake coming out of the ground. This is not preventable but can be a discussion with employees on animal hazards in a work environment. The last report described an experience of an employee traveling through a

work zone where there was only one sign on both ends with a flagger ahead and both flaggers were not standing in a lit-up work area. The report also says no state employee was overseeing the work being performed. The employee does state that proper PPE was worn but was still concerned due to the heavily traveled roadway. With the given location and date, the information can be reviewed to determine the conditions. This will provide insight into what can be improved in work zone safety measures.

Figure 4.8 BOOTS Safety Opportunity Reports

Overall, once the process transitioned for SORs from a website to an app. The average number of reports was similar. The quality of the reports was also comparable. The new SMS can now collect a database of SORs to see if a concern is brought up frequently and where it occurs. This information can be beneficial to KYTC in limiting the number of near misses and creating safer work environments.

#### 4.5 KYTC Worker Compensation Data Analysis

When analyzing worker compensation data, the research team focused on the data in September 2022 and September 2023. Due to personnel data concerns, the focus was on the amount of money paid, the number of claims, and the turnaround time for the claims. For September 2022, there was a reported \$116,942.49 in worker compensation across 14 claims with 2 claims still open. In September 2022, 57% of the claims were reported the same day, 29% were reported the day after, 7% were reported 2 days after, and 7% were reported 5 days after. The research team compared this to September 2023 data where there was a reported \$88,938.46 across 13 claims and all 13 claims were still open. In September 2023, 15% were reported the same day, 15% were reported a day after, 15% reported 2 days after, 8% reported 3 days after, and 46% reported 5 or more

days after. When reviewing the data, you can see a difference of \$28,004.03 and a similar number of total claims.

The biggest difference is the turnaround time when the incident occurred and when it was reported. This could be explained by the change in process. The system is new and the employees in all departments of KYTC are learning to use it. The lack of confidence in using the new system previously mentioned in the focus groups could be the reason an employee pushed back from filing a claim. In 2022, the worker compensation claims process was done on paper and involved employees coming in person to fill out the form. The process was familiar to everyone, and everyone knew what to expect. This process was tedious but required the employee to be more punctual to get the claim started. The new SMS, BOOTS system can be accessed anywhere through a mobile device which can lead to employees procrastinating. The assumption that it can wait can have a negative effect on the accuracy of the data. The Kentucky Personnel Cabinet has a requirement that the first report of injury or illness must be completed within three working days after injury. The same understanding of short turnaround time applies to incident and worker compensation claims.

**WORKERS COMPENSATION – FIRST REPORT OF INJURY OR ILLNESS**

|   |                                   |   |  |  |
|---|-----------------------------------|---|--|--|
| EMPLOYER (NAME & ADDRESS INCL ZIP)<br>Kentucky Transportation Cabinet<br>Department of Highways, District   |                                   | CARRIER/ADMINISTRATOR CLAIM NUMBER<br>n/a   | OSHA LOG NUMBER<br>OSHA #  | REPORT PURPOSE CODE<br>n/a   |
|   |                                   | JURISDICTION<br>n/a   | JURISDICTION CLAIM NUMBER  |  |
|   |                                   | INSURED REPORT NUMBER   |  |  |
|   |                                   | EMPLOYER'S LOCATION ADDRESS (IF DIFFERENT)<br>Kentucky Transportation Cabinet-Division of Workers' Compensation |  | DISTRICT/AREA #  |
| INDUSTRY CODE   | EMPLOYER FEIN                     |   |  | PHONE #  |
| <b>CARRIER/CLAIMS ADMINISTRATOR</b>   |                                   |   |  |  |
| CARRIER (NAME, ADDRESS, & PHONE #)<br>Risk Management Services Company  |                                   | POLICY PERIOD<br>TO   | CLAIMS ADMINISTRATOR (NAME, ADDRESS & PHONE NO)<br>Risk Management Services Company  |  |
|   |                                   | CHECK IF APPROPRIATE<br><input checked="" type="checkbox"/> SELF INSURANCE                                      |  |  |
| CARRIER FEIN<br>n/a   | POLICY/SELF-INSURED NUMBER<br>n/a | ADMINISTRATOR FEIN  |  |  |
| AGENT NAME & CODE NUMBER<br>n/a   |                                   |   |  |  |
| <b>EMPLOYEE/WAGE</b>  |                                   |   |  |  |
| NAME (LAST, FIRST, MIDDLE)  |                                   | DATE OF BIRTH   | SOCIAL SECURITY NUMBER   | DATE HIRED   |
| ADDRESS (INCL ZIP)  |                                   | SEX<br><input type="checkbox"/> MALE<br><input type="checkbox"/> FEMALE<br><input type="checkbox"/> UNKNOWN     | MARITAL STATUS<br><input type="checkbox"/> UNMARRIED<br><input type="checkbox"/> SEPARATED<br><input type="checkbox"/> MARRIED<br><input type="checkbox"/> UNKNOWN | OCCUPATION/JOB TITLE   |
| PHONE   | # OF DEPENDENTS                   |   |  | EMPLOYMENT STATUS  |
|   |                                   |   |  | NCCI CLASS CODE<br>n/a   |
| RATE PER:<br>PER: <input type="checkbox"/> DAY<br>WEEK: <input type="checkbox"/> MONTH<br>OTHER: <input type="checkbox"/>   | DAYS WORKED/WEEK                  | FULL PAY FOR DAY OF INJURY?<br>DID SALARY CONTINUE?   |  | <input type="checkbox"/> YES<br><input type="checkbox"/> NO  |
| <b>OCCURRENCE/TREATMENT</b>   |                                   |   |  |  |
| TIME EMPLOYER BEGAN WORK:<br><input type="checkbox"/> AM<br><input type="checkbox"/> PM   | DATE OF INJURY/ILLNESS            | TIME OF OCCURRENCE<br>( ) CANNOT BE DETERMINED  | AM<br>PM   | LAST WORK DATE   |
| CONTACT NAME/PHONE NUMBER   |                                   | TYPE OF INJURY/ILLNESS  |  | PART OF BODY AFFECTED  |
| DID INJURY/ILLNESS EXPOSURE OCCUR ON EMPLOYER'S PREMISES?<br><input type="checkbox"/> YES <input type="checkbox"/> NO   |                                   | TYPE OF INJURY/ILLNESS CODE   |  | PART OF BODY AFFECTED CODE   |
| DEPARTMENT OR LOCATION WHERE ACCIDENT OR ILLNESS EXPOSURE OCCURRED  |                                   | ALL EQUIPMENT, MATERIALS, OR CHEMICALS EMPLOYEE WAS USING WHEN ACCIDENT OR ILLNESS EXPOSURE OCCURRED            |  |  |
| SPECIFIC ACTIVITY THE EMPLOYEE WAS ENGAGED IN WHEN THE ACCIDENT OR ILLNESS EXPOSURE OCCURRED  |                                   | WORK PROCESS THE EMPLOYEE WAS ENGAGED IN WHEN ACCIDENT OR ILLNESS EXPOSURE OCCURRED                             |  |  |
| HOW INJURY OR ILLNESS/PERSONAL HEALTH CONDITION OCCURRED: DESCRIBE THE SEQUENCE OF EVENTS AND INCLUDE ANY OBJECTS OR SUBSTANCES THAT DIRECTLY INJURED THE EMPLOYEE OR MADE THE EMPLOYEE ILL |                                   |   |  |  |
|   |                                   |   |  | CAUSE OF INJURY CODE<br>n/a  |
| DATE RETURNED TO WORK   | IF FATAL, GIVE DATE OF DEATH      | WERE SAFEGUARDS OR SAFETY EQUIPMENT PROVIDED?<br>WERE THEY USED?  |  | <input type="checkbox"/> YES <input type="checkbox"/> NO   |
| PHYSICIAN/HEALTH CARE PROVIDER (NAME & ADDRESS)   |                                   | HOSPITAL OR OFF SITE TREATMENT (NAME & ADDRESS)   |  | INITIAL TREATMENT<br><input type="checkbox"/> NO MEDICAL TREATMENT<br><input type="checkbox"/> MINOR BY EMPLOYER<br><input type="checkbox"/> MINOR CLINIC/HOSP<br><input type="checkbox"/> EMERGENCY CARE<br><input type="checkbox"/> HOSPITALIZED > 24 HOURS<br><input type="checkbox"/> FUTURE MAJOR MEDICAL/LOST TIME ANTICIPATED |
| <b>OTHER</b> KYTC Equipment <input type="checkbox"/> Auto to 3/4 Ton <input type="checkbox"/> 1 Ton or Greater <input type="checkbox"/> Equipment <input type="checkbox"/> None             |                                   |   |  |  |
| WITNESSES (NAME & PHONE #)  |                                   |   |  |  |
| DATE ADMINISTRATOR NOTIFIED   | DATE PREPARED                     | PREPARER'S NAME & TITLE   |  | PHONE NUMBER   |

FORM IA-1(r 1-1-02)      SEE BACK FOR IMPORTANT INFORMATION      ©IAIABC 2002

Figure 4.9 Sample of First Report of Injury or Illness

## CHAPTER 5. CONCLUSIONS

Change in an organization is not easy. It requires work behind the scenes to prepare the employees involved. This is something KYTC knew when they decided to implement a new safety management system (SMS) called BOOTS. The investment in an SMS was an opportunity to grow and to create a safer work environment with data to show it. KYTC reached out to the University of Kentucky Civil Engineering Department for assistance on early implementation of the SMS. The research team first developed a readiness assessment plan to strategize an approach for the rollout of BOOTS. This established the research team's understanding of the software, key performance indicators for different stakeholders, and a plan for how to communicate and get feedback from it. The research team wanted to consider all the parties involved by holding focus groups with attendance from employees with different job titles and locations. The focus group's purpose was to gather insight from the employees before the rollout to make sure their concerns were addressed. The focus group's purpose was also to inform the employees on the capabilities of the BOOTS system and what's to come in the different phases of the project.

This communicated the plans for the organization and promoted support for the implementation of the SMS. The feedback from the focus group was collected and used in the implementation. An example is when concerns about training for the SMS were brought up. KYTC took the feedback and created training that targeted the field crews who would be reporting. The focus groups asked for visual training. KYTC provided step-by-step instructions on how to navigate the SMS software and how to submit a report. The training came in two forms: voice-over videos and a user manual. The goal of the training was for them to be clear and concise to be readily available for field crews to use side by side with the system to encourage successful implementation of the SMS.

Once the system went live KYTC reached back out asking for assistance with early data analysis. Due to the system only being live for a few months, KYTC was still in its trial-and-error phase with customizing the system. They wanted to take the first step and reflect if their previous assumptions before the rollout were correct. By capturing the data, the research team was able to compare the incident claims, safety opportunity reports, and worker compensation before and after the implementation of the SMS. The analysis involved reports from September 2022 and September 2023. The research team noticed there were 5x more incident claims reported with the SMS. The research team predicts that there weren't more employees getting hurt in September 2023. There were just more injuries reported in September 2023 than in September 2022. The SMS gave employees a convenient way to report an incident. The SMS also provided KYTC with a database for private property damage and state vehicle and equipment damage data. The amount of safety opportunity reports remains constant due to the recent transition away from a paper-based process. The change from a website to an SMS submission of the SORs did not discourage employees.

A brief analysis was done on worker compensation claims to review the amount of compensation and number of claims filed. This analysis was limited due to a lack of personnel data. A part of the worker compensation analysis is an analysis of the

employee involved. KYTC explained they have a responsibility to protect the privacy of their employees, but this was an obstacle in the data analysis. Without knowledge of the employee's personnel file like relationship status, number of dependents, hire date, education, part-time or full-time status, etc. no conclusions could have been made in connection.

Due to the nature of the new system, the predefined workflow for the incident and worker compensation investigations had to be adapted. Another limitation was the missing link from an incident claim to a worker compensation claim. Their predefined workflow was shifted and in early data analysis, this limited the review because the research team didn't have the whole story. The research team would either find the incident claim where an employee was injured but no worker compensation claim was electronically linked or vice versa. Eventually, it was determined that the information was manually inserted to link the two claims. Once this is explored there could be conclusions from the data. Future work on this topic can include an annual review to highlight possible benefits and limitations of an SMS in a public agency. A review could identify district performance and reporting consistency. A benefit assessment can show a return on investment or quantify safer work conditions. A review could also provide KYTC with limitations that can become new objectives for maintaining a digital comprehensive SMS. Also, an additional focus group or satisfactory survey still needs to be done to determine if everyone's expectations were met to encourage continuous support in the system.

## APPENDICES

### APPENDIX 1. Focus Group Presentation

Introducing

## Safety Management System



### Today's Agenda

- Introductions (5 minutes)
- Introduction of the Safety Management System (15 minutes)
- Questions (5 minutes)
- Feedback on anticipated use (25 minutes)
- Feedback on branding (5 minutes)
- Closing and timeline (5 minutes)

## Introductions








- Name
- Position

## Introduction of the Safety Management System





## Our Solution: SMS

-  Web-based Safety Management System
-  Accessible via Mobile Phone, Tablet or PC
-  Effective sharing of information and tasks
-  Single source for common safety resources, tasks, and data
-  Capture photos and videos on the fly-right from mobile app- to add clarity
-  Easy sign in with no login or passwords to remember
-  All data is stored in one place.

### What can it do?

Empower employees across KYTC to easily and efficiently report injuries, illnesses, vehicle and property damage, and safety issues.

Ease burden of routine safety tasks such as jobsite, facility and equipment checks

Provide information needed to learn from incidents and close calls

Eliminate paper and outdated processes to drive efficiency

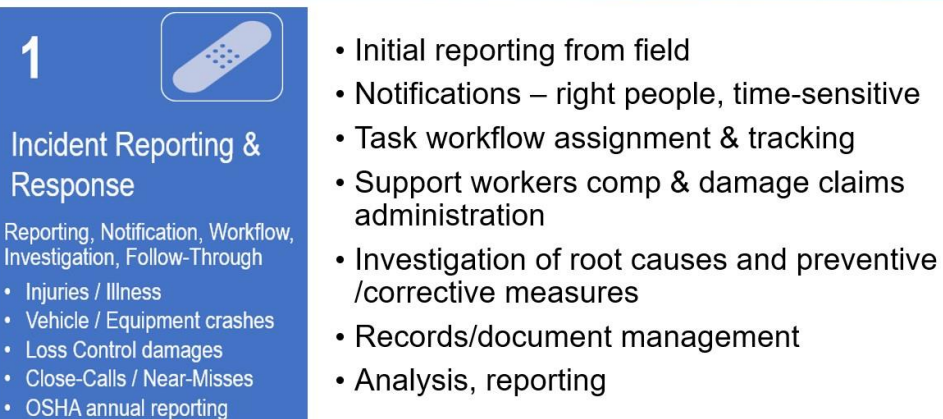
Provides tools for supervisors and their teams to positively impact their own safety and health .

Drives a proactive safety culture by identifying workplace hazards and reducing exposures

## Project Phases & Elements



## Focus Area 1



## Focus Area 2

2



### Process Management

Job & Process focused

- Job Safety Briefings
- Task and Job Risk Assessments
- Work Permitting
- Jobsite / Facility observations
- Vehicle /Equipment pre-op inspections

- Increase availability of resources
- Improve access to processes & tools
- More accurate data
- Real-time work permitting
- Data to allow evaluation of processes
- Objective, consistent performance measures

## Focus Area 3

3



### Hazard Exposure Management

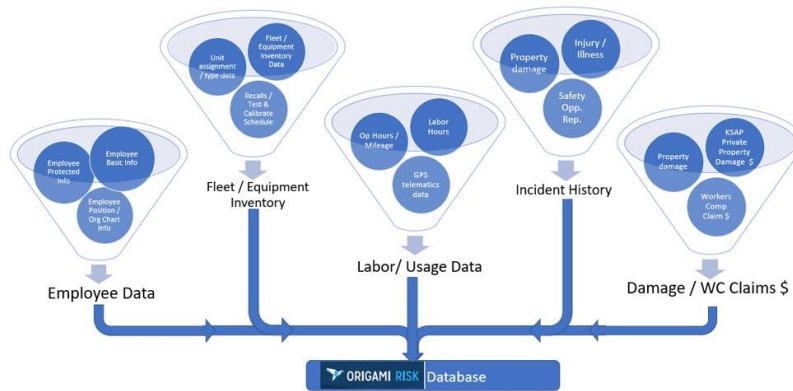
Employee exposure focus

- Equipment /PPE testing & inspection tracking
- Exposure assessment & monitoring tools
- HazChem inventory / SDS
- Medical surveillance tracking

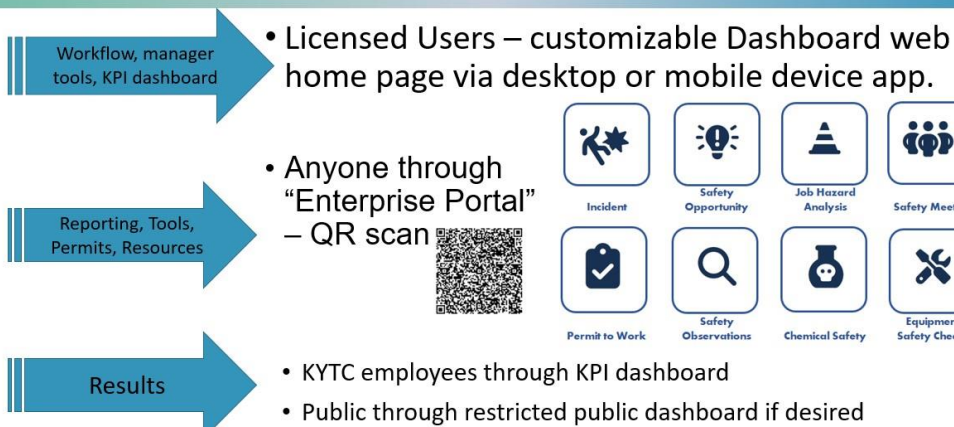
- Critical testing/inspection compliance
- Single point for managing employee exposure records & surveillance
- 24/7 access to SDS files
- Employee certification/licensure tracking

# Foundation of System

## Information Sources



## Access



# Incident Reporting

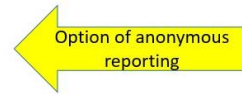
## Basic Incident Reporting Process



- Single resource
- Clear process
- Notifications
- Task assignments
- Sharing data / documents
- Accountability & tracking
- Measure / analyze
- Report (OSHA & management)

- *Prevention of incidents*

## Basic Near-Miss Reporting Process



| Capability   | System Admin.                      | Workers Comp Coord. District Safety                                  | SOS Exec. Dir, Safety Admin.   | Legal, State Risk, Division of Equipment                             | Managers   | Non- Licensed Enterprise Portal User                         |
|--|------------------------------------|--|--|--|--|--|
| mapping, user security, reports, incidents, tasks, forms                                   | Yes                                | No   | No   | No   | No   | No   |
| SSO accessible with configurable Origami home screen                                       | Yes                                | Yes  | Yes  | Yes  | Yes  | No   |
| Can be assigned actions within an existing record  | Yes, In task list                  | In task list   | in task list   | In task list   | In task list   | By "Grant Access" link-specific record and time frame        |
| Create "Grant access" for specific records   | Yes                                | Yes  | Yes  | Yes  | Yes  | No   |
| Assign/monitor task completion or status   | Yes, In task system                | Yes, In task system  | Yes, In task system  | Yes, In task system  | Yes, In task system  | Not real time. Can be notified of status                     |
| Obtain reports<br>1. Can configure new<br>2. Can edit existing<br>3. Can execute pre-built | 1,2,3                              | 3, and receive reports specific to their role or organizational unit | 3, and receive reports specific to their role or organizational unit | 3, and receive reports specific to their role or organizational unit | 3, and receive reports specific to their role or organizational unit | Receive reports through email as attached file               |
| Initiate new records   | Yes                                | Yes  | Yes  | Yes  | Yes  | Yes, To defined types through Enterprise-Wide Portal         |
| Access Existing records  | On-demand, subject to restrictions | On-demand, subject to restrictions                                   | On-demand, subject to restrictions                                   | On-demand, subject to restrictions                                   | On-demand, subject to restrictions                                   | Specific access for defined time through "Grant Access" link |
| Location/Cost Center restriction   | District                           | None- all KYTC   | None- all KYTC   | None- all KYTC   | Managed cost centers   | None   |

| Specific Data Type Access  | System Admin. | Workers Comp Coord. District Safety | SOS Exec. Dir, Safety Admin. | Legal, State Risk, Division of Equipment | Managers | Non- Licensed Enterprise Portal User |
|--|---------------|-------------------------------------|------------------------------|--|----------|--------------------------------------|
| Employee Data-Basic  | Full          | Edit                                | Edit                         | View                                     | View     | None                                 |
| Employee data - sensitive / protected  | Full          | Edit                                | Edit                         | None                                     | None     | None                                 |
| Employee incident days away, restricted, transferred                                     | Full          | Edit                                | Edit                         | View                                     | View     | None                                 |
| Incident employee medical treatment  | Full          | Edit                                | Edit                         | View                                     | View     | None                                 |
| Incident workers comp financials   | Full          | View                                | View                         | View                                     | View     | None                                 |
| Safety / RCA investigation reports   | Full          | Edit                                | Edit                         | View                                     | View     | None                                 |
| Supervisor investigation tool  | Full          | View                                | View                         | View                                     | Edit     | None                                 |
| Incident (injury or prop damage) claim / matter #, recovery \$, claim \$, status updates | Full          | View                                | View                         | Edit                                     | View     | None                                 |



## Questions?

Anything we can clarify before asking for feedback

Feedback on Motivating Use

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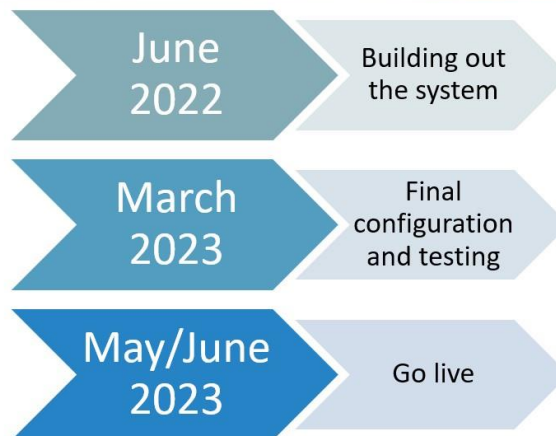
Feedback on Barriers to Use

---

## Branding

SPARK – Safety Performance and Reporting Kit

## Timeline







Anything else you'd like KYTC to know?

[gabe.dadi@uky.edu](mailto:gabe.dadi@uky.edu); 859-257-5416

## APPENDIX 2. Focus Group Minutes

### **District 5 Focus Group Minutes:**

#### Introductions (5 minutes)

#### Introduction of the Safety Management System (15 minutes)

#### Questions (5 minutes)

#### Feedback on anticipated use (25 minutes)

- HT employee: Would they need to fill out the workers comp claim and print and bring to doctor's office? DSC reminded employee that only claim number is needed, don't need the form.
- **Would benefit greatly from a clear definition of a near miss and examples of boundaries (i.e. what is a near miss? What is NOT a near miss)**
- **Would like to have the QR code or access to the system readily available. Suggested having cards with QR code like the Safety Opportunity Reporting Tool. Noted having links on intranet site and can save link once accessed from the QR code.**
- **Noted concerns with connectivity. What tasks can be done offline? What tasks need a connection to be done? Significant concerns voiced with wifi strength in maintenance barns.**
- Liked the idea of automatic push notifications in workflows.
- Reinforced that the system needs to be mobile friendly and user friendly. Similar to car insurance (i.e., State Farm) apps that make accident image capture and reporting clear, simple, and easy.
- **Would really benefit from access to more iPads with a cellular package.**
- **Would benefit from hands on-training and the ability to submit dummy reports to build confidence in reporting.**
- TES: Consider having special access for 1 person in barn for standard reporting. Concern from others on adding those responsibilities to an individual with the lack of staff.
- **Can a report be started by an individual and then assigned to another to complete? Can one be started, saved, and finished later by the same individual that is not a licensed user?**
- **Could someone in the field with poor cell coverage or other issues call someone else to start a report?**
- Consider automated phone reporting system where a number is called, and standard questions are asked to start the report then a link sent to upload photos/videos.
- **Are task-based job briefings included and readily accessible in the system? Same for equipment inspection walkarounds**

- **Several significant concerns on having hardware and connections to participate. Pushback on using personal devices. How would equipment inspections be done efficiently with a single iPad in the barn? Suggestion to complete a paper equipment inspection and take a picture with an iPad.**
- If work is repeated for multiple days, is there a job briefing needing for each day? Could one be done that covers multiple days?
- **Have a checklist and make clear what information is needed to complete a report. Have it alert people to what's missing.**
- **Can reports be modified to add information as new info comes in (i.e., police reports)**
- **How will this rollout? Since D12 and D5 are focus groups, will we be the first to use it or will it go statewide?**

#### Feedback on branding (5 minutes)

- Seemed to like Safety Performance and Reporting Kit (SPARK). Like the idea of naming, it something for quick and easy reference. SPARKY!

#### Closing and timeline (5 minutes)

- Thanked attendees and presented a timeline for rollout.

### **District 12 Focus Group Minutes:**

#### Introductions (5 minutes)

- Intro:
  - Electronic Safety Reporting System from 3<sup>rd</sup> party provider

#### Introduction of the Safety Management System (15 minutes)

- PPT
  - Moving safety reporting from paper to electronic system
  - Help us be more proactive v reactive
  - Web based, via phone/tablet/PC, single source of safety data, can use photo/video
  - Immediately notify safety coordinator and workman's comp
  - More efficient analysis and reporting – real time
  - PPE/Hazardous material
  - Not called ORIGAMI
  - Will all be pulled into 1 safety management system
  - Improved workflow- incident and near miss reporting- report, notifications immediately sent, que supervisor for investigation, workman's comp, damage/equipment repair/clean up
  - Different levels of access/responsibility within the system depending on position and job title

- Do not currently have a good way of tracking: workflow, safety issues, near misses
- Started in Texas
- Too reactionary, not nearly proactive enough in current system
- Do not want to take more time away from work for administrative duties

Questions (5 minutes)

- Question on:
  - Scenario with Tim- wind damage, work permit, list of PPE, job briefing, THEN go do your job, will not have to fill out 14 pages of paperwork
  - **Verifying- signatures**
  - **Notifications on app**
  - **Notifications for trainings, gloves, PPE, safety checks, vehicle serviced, equipment tracking, AED**

Feedback on anticipated use (25 minutes)

- Motivate to Use:
  - User Guides
  - Training Sessions
  - Less paperwork
  - Auto-populate personal information
  - Help us think through everything we need prior to going to jobs
  - Seat belt report for supervisors
  - SDS sheets for chemicals/hazardous waste – will not have to go back to facility to find book and look up protocols
  - Real time awareness to all techs
- Barriers to Use:
  - Connectivity
  - Job Changes after they get their job briefings
  - Learning curve
  - **Change is hard- Need in-person training sessions- test reports**
  - Verifying Signatures

Feedback on branding (5 minutes)

- Safety Performance and Reporting Kit (SPARK) – no one cares what you call it

Closing and timeline (5 minutes)

- Thanked attendees and presented a timeline for rollout
  - Rollout projected date: May-June 2023
  - Rollout will not be all at once: District v Job Title
  - Email Dr. Dadi with all your comments and concerns

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## VITA

Salena Pham

1. Education:
  - a) University of Kentucky-Bachelor of Science in Civil Engineering (May 2022)
  - b) University of Kentucky-Master of Science in Civil Engineering (In Progress, Expected December 2023)
  
2. Professional Positions:
  - a) Graduate Research Assistant-University of Kentucky (May 2022-December 2023)
  
3. Scholastic and Professional Honors:
  - a) 2022 Outstanding Senior in Civil Engineering Award
  - b) KY-WV Louis Stokes Alliances for Minority Participation Scholar
  - c) C. Michael Garver Scholarship Recipient
  - d) Ford Blue Oval STEM Scholarship Recipient