

PROJECT MANAGEMENT METHODOLOGY APPLIED TO A RESEARCH AND  
RECOMMENDATION STUDY: UNDERSTANDING WORKPLACE ACCIDENTS INVOLVING  
EQUIPMENT “BLIND SPOTS”

By

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## **Abstract**

Nearly 25 percent of work vehicle-related deaths take place while the vehicle is moving in reverse. The total cost to employers in 2000 was \$60 billion, with two-thirds of the accidents taking place on-the-job. Due to the high number of vehicle blind spot accidents that take place each year, it is critical to ensure current technology is being utilized to prevent future accidents. (“Guidelines for employers to reduce motor vehicle crashes,” 2006)

While the Occupational Safety and Health Administration (OSHA) investigates industrial fatalities, too little information is gathered into general categories to effectively understand the overall effectiveness of U.S. regulations, and if current technology may reduce blind spot incident and accident rates in the workplace.

To improve safety performance in the workplace, it is essential to understand the underlying causes of accidents. Researching white papers and gaining an understanding of patterns and contributing factors, recommendations can be made to help improve workplace safety.

Data collected from a custom-made questionnaire deployed within the Municipality of Anchorage and Matanuska-Susitna Borough provided insight to many jobsites within the area, in addition to thoughts and considerations of working-class individuals regarding company policy, laws, regulations, technology use and potential, and equipment blind spots.

### **Keywords**

Blind Spots

Construction Equipment

Backing Safety

Warning and Alert Technology

Vehicle-Related Fatalities

# **Project Management Methodology Applied to a Research and Recommendation Study: Understanding Workplace Accidents Involving Equipment “Blind Spots”**

## **Introduction and Problem Statement**

Driving in the United States transformed from a luxury to a necessity both for personal use and employment duties. When the automobile first appeared on American roads, pedestrians and horse-drawn wagons outnumbered them. “If a pedestrian strode into a street and maybe a wagon wheel ran over their foot, the law would be on their side . . . judges would say pedestrians belonged there, and if you’re operating a heavy dangerous vehicle, it’s your fault,” explains Peter Norton, a historian of technology at the University of Virginia (Hsu, 2012).

Since the creation of automobiles, operators and pedestrians have battled for ownership of the roads in America. The automobile industry even created the term “jaywalking” as a psychological campaign tool to discourage pedestrians from walking on roadways. (Hsu, 2012) The amount of effort required to safely operate a piece of equipment or vehicle intimidates many people, as many car manufacturers in the United States continue to produce heavier vehicles. The average car in 1987 weighed 3,221 pounds, while the average car in 2010 weighs just over 4,000 pounds (Tuttle, 2012).

The Occupational Safety and Health Administration (OSHA) states motor vehicle crashes cost employers \$60 billion annually. These losses are generally from medical care costs, legal expenses, property damages, and lost productivity. The average cost for an accident is \$16,500. If the accident takes place on-the-job and results in an injury or death, costs range from \$74,000 to greater than \$500,000 respectively (“Guidelines for Employers to Reduce Motor Vehicle Crashes,” 2006).

Vehicle or equipment blind spots pose a serious threat to the public as well as companies large or small who are reliant on vehicles or equipment. Limited information can be found to date explaining the true costs of blind spots and what corrective measures can be taken to effectively reduce the likelihood of an incident taking place involving a blind spot.

It is important to understand that vehicle and equipment blind spots exist and are likely to exist well into the distant future. This research and recommendation study is intended to be used as a general guide to better understand where blind spots exist, what has been done to reduce incident rates, and what technology exists.

### **Purpose of Project**

The purpose of this study is to provide a review of workplace accidents/accidents resulting from equipment blind spots and identify technologies and methods to reduce blind spot accidents. Topics to be addressed include blind spots of workplace equipment, frequency and severity of equipment blind spot, workplace accidents, employer costs of accidents, laws, recommendations, and current technology used in reducing workplace accidents involving equipment blind spots.

## **Background and Significance**

The Department of Transportation's Federal Highway Commission Traffic Volume Trends report estimated vehicle travel on all roads and streets was approximately 5.7 billion miles for July 2016, up 2.0% compared to July 2015 ("Federal Highway Administration", 2016). In 2000, 88% of the driving age population held a driver's license, up from an estimated 57% in 1950, representing an increase of 128 million drivers over a 50-year period ("Licensed Drivers - Our Nation's Highways - 2000," n.d.). Backing vehicles and equipment present a serious occupational hazard if not properly addressed. The Bureau of Labor Statistics found that, between 2003 and 2010, 443 struck-by fatalities occurred with 143 fatalities involving a vehicle or equipment backing up ("Prevent Backover", 2015). Furthermore, according to the National Safety Council, one out of four vehicle accidents involve poor backing techniques, resulting in approximately 500 deaths and 15,000 injuries per year.

In the United States, concern over the frequency and extent of industrial accidents and health hazards in the workplace led to the creation of the Occupational Health and Safety Act of 1970. This act established specific health and safety requirements for nearly all industries within the United States. The Occupational Health and Safety Administration (OSHA) was created subsequently in 1971. The Occupational Safety and Health Administration, an agency of the United States Department of Labor, requires all employers to maintain a record of illnesses, injuries, and fatalities. This federal agency ensures employee safety and health in the United States by working with employers and employees ("Occupational Safety and Health Administration," 2015).

In addition to OSHA, the National Institute for Occupational Safety and Health (NIOSH) was created as a non-governing body to research and develop industry recommendations. The Fatality Assessment and Control Evaluation (FACE) is a program within NIOSH developed for investigation of and tracking of fatalities to understand root causes for the fatality and provide recommendations for prevention.

The Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFIO) is another government agency which works towards providing comprehensive information pertaining to fatal work injuries. Each year, the CFIO produces a report of fatalities occurring in the workplace from the preceding year. Health and safety professionals, analysts, and researchers extensively use data from this report to help understand and ultimately prevent fatal work injuries from occurring.

The Census of Fatal Occupational Injuries, Fatality Assessment and Control Evaluation, Occupational Safety and Health Administration, National Highway Traffic Administration, and many other public and private entities all provide insight and clarity to accidents and trends occurring in the workplace.

## **Assumptions**

Following are assumptions of this study:

1. The information collected is sound and accurate.
2. The definition for blind spot is similar in white pages.
3. Accidents reported involving equipment are not considered accident, not premeditated.
4. Questionnaire respondents are accurate and honest.

## **Acronym List**

BLS: Bureau of Labor Statistics

CFIO: Census of Fatal Occupational Injuries

FACE: Fatality Assessment and Control Evaluation

NETS: Network of Employers for Traffic Safety

NHTSA: National Highway Traffic Safety Administration

NIOSH: National Institute for Occupational Safety and Health

OSHA: Occupational Safety and Health Administration

SIMS: Safety Information on Management System



## **Literature Review**

### **Introduction**

The purpose of this study is to provide a review of workplace accidents resulting from equipment blind spots and identify technologies and methods to reduce blind spot accidents. Topics to be discussed in this chapter include blind spots, frequency of blind spot accidents in the workplace, Severity of blind spots in the workplace, employer costs from blind spot accidents, governmental efforts to address blind spots, OSHA recommendations, NIOSH recommendations, current technology used to reduce blind spots, effectiveness of U.S. Laws and regulations, proven methods for reducing blind spot accidents, case studies examining technology to reduce blind spots, hierarchy of controls applied to addressing blind spots.

### **Blind Spots**

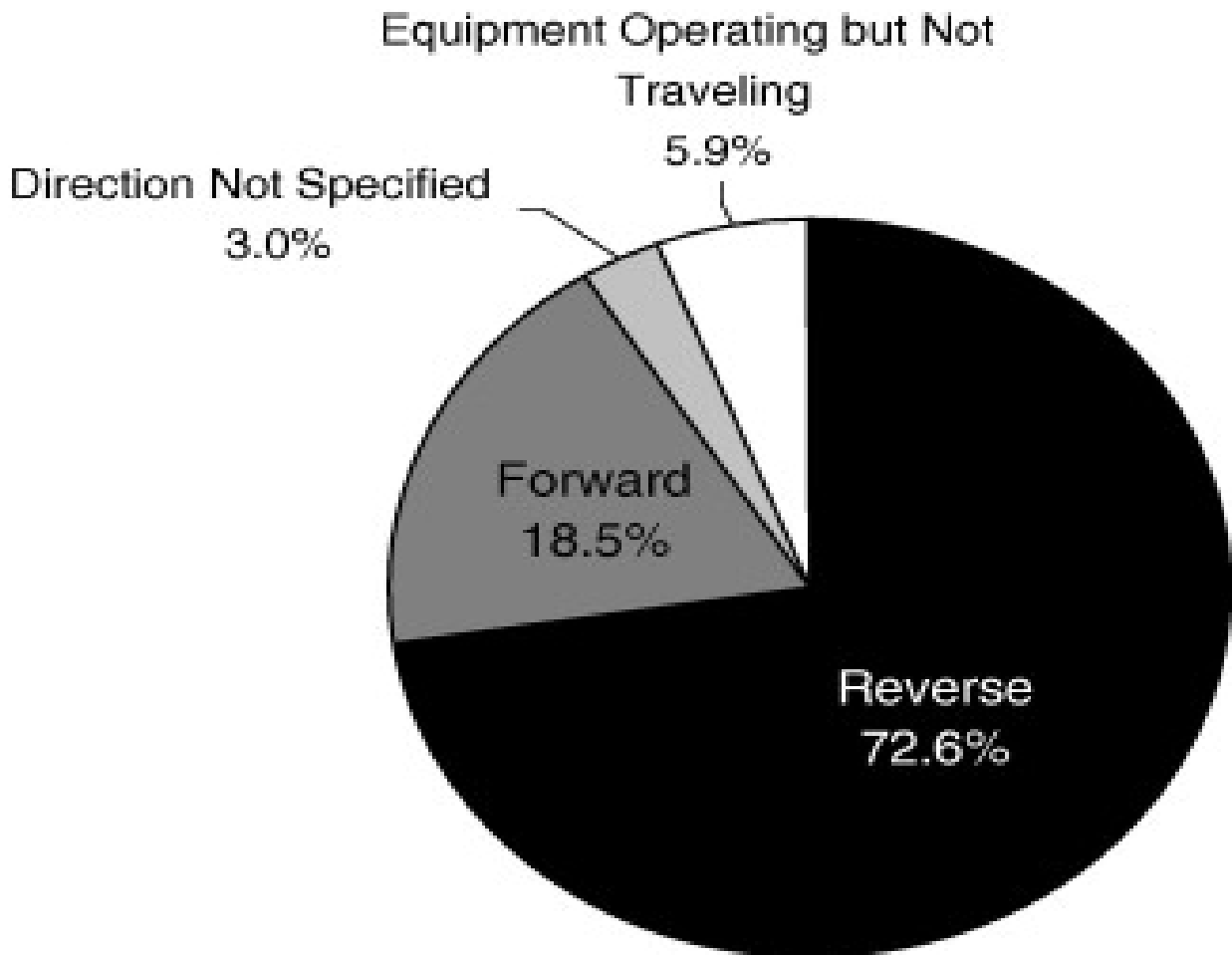
The term blind spot (or blind area) is used to describe an area around the equipment whereas it cannot be directly observed by the operator while at the controls, thus minimizing his or her ability to safely operate equipment, potentially resulting in an incident or accident. Each vehicle model and equipment model has its own unique blind spots. Construction equipment is typically large and has a fully-enclosed or partially-enclosed cab. These characteristics typically increase the size of blind spots and reduce visibility.

Research performed by Jimmie Hinze and Jochen Teizer examined data between 1990 and 2007 and concluded the most commonly involved piece of equipment in visibility-related fatalities involved dump trucks. Dump trucks ride relatively high off the ground with a material transportation bed. Due to the bed design and size, this creates a large “blind spot” for the operator. The operator must rely on rear-view mirrors that only provide a limited field-of-view. Objects located directly behind and close to the rear of the dump truck are not visible to the operator when moving in reverse. There is limited research in the field of measuring blind spots, thus far, most methods to correct blind spots is done by intuition and making assumptions as to where there are blind spots present on a given piece of equipment (Teizer, Allread, & Mantripragada, 2010).

### **Frequency of Blind Spots Accidents in the Workplace**

Blind spots can be found in nearly every industry, although mining, agriculture, and construction industries routinely have a high number of fatalities because of the constantly changing work environment. Workers and equipment on a construction site are commonly in close proximity in restricted spaces (Hinze & Teizer, 2011). Approximately 25% of construction worker deaths are the result of collisions, rollovers, struck-by accidents, and a variety of other equipment-related accidents (Hinze & Teizer, 2011).

Research conducted by Jimmie Hinze and Jochen Teizer examined data from OSHA from 1990 to 2007 showed 594 of the 659 visibility-related fatality cases involved equipment or vehicles. The direction of travel of the equipment is particularly important when evaluating visibility-related fatalities. As shown in Exhibit 1, equipment moving in reverse represented 72.6 percent of the equipment-related accidents, while 18.5 percent of the instances involved equipment traveling forward (Hinze & Teizer, 2011). The remaining 8.9 percent of visibility-related fatalities involved data which either didn't provide direction or the vehicle was not traveling during time of incident.



**Exhibit 1: Nature of Equipment Movement at the Time of Accident Occurrence. Note: Retrieved from <http://www.sciencedirect.com/science/article/pii/S0925753511000099>**

Consumer Reports examined vehicles to determine the closest distance at which a 28-inch tall traffic cone could be detected behind a wheel from the operator's available view. Operator heights were 61 inches and 68 inches. The Consumer Reports data shows several patterns between rear visibility and

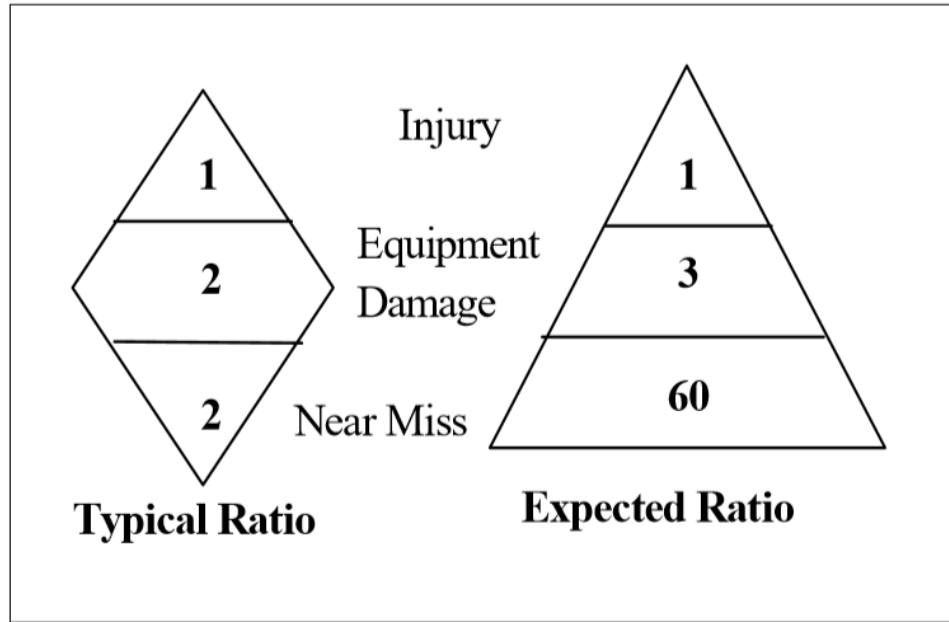
height, as the taller operator’s average blind spot length was 14 feet in comparison to 23 feet for the shorter operator (“The Danger of Blind Zones - Vehicle Blind Spots,” 2014).

The Consumer Reports also examined blind spot area by vehicle type. The Consumer Report data shown in Exhibit 2 determined the longest blind spots were found for pickup trucks, followed by minivans and sport utility vehicles. Sedans had a blind spot average 2 feet smaller than the blind spot of an SUV. It should be noted some sedans were found to have worse rear visibility than some SUVs during the study (“The Danger of Blind Zones - Vehicle Blind Spots,” 2014).

Car Type	Average Driver	Short Driver
Small Sedans	12 ft.	24 ft.
Midsized Sedans	13 ft.	22 ft.
Large Sedans	13 ft.	23 ft.
Wagons/hatchbacks	9 ft.	15 ft.
Small SUVs	13 ft.	22 ft.
Midsized SUVs	18 ft.	28 ft.
Large SUVs	19 ft.	31 ft.
Minivans	15 ft.	26 ft.
Pickups	24 ft.	35 ft.
Sporty Cars	13 ft.	21 ft.

**Exhibit 2: The Danger of Blind Zones | Vehicle Blind Spots - Consumer Reports. Note: Retrieved from <http://consumerreports.org/cro/2012/03/the-danger-of-blind-zones/index.html>**

A study performed by Frank Bird on the accident ratio conducted by Frank Bird explains that for every major injury in workplace, there are 10 minor injuries, 30 accidents involving equipment damage and 600 near-misses. Although most experts disagree with such a large number for near-misses, a simplified accident ratio has been accepted. The simplified accident diamond ratio of 1:2:2 shown in Exhibit 3. Analysis of the accident experience of the typical organization shows that there are two equipment-related accidents and two near-misses (Borg, 2002).



**Exhibit 3: The Simplified Accident Diamond Ratio Note: Retrieved from <http://signalsafety.ca/files/Predictive-Safety-Near-Miss-Hazard-Reporting.pfd>**

### **Severity of Blind Spot Accidents in the Workplace**

The Census of Fatal Occupational Injuries (CFIO) published safety statistics in 2009 explaining the construction industry accounts for approximately 21 percent of all occupational fatalities in 2007. Although “the 2007 fatality rate remains the lowest fatal work injury rate ever recorded by the fatality statistics,” accident causation and other safety statistics within the past decade show high numbers of fatality rates for accidents involving heavy equipment striking personnel (Teizer, Allread, & Mantripragada, 2010).

Between 1992 and 1998 the CFIO reported 465 vehicle related construction fatalities. Of that 465, 318 of those fatalities involved workers-on-foot. The Bureau of Labor Statistics report published around the same time reported that 51percent of the fatalities occurred when a vehicle was in reverse; blind spots were considered to be the main factor. Although near-misses are seldom reported, these typically occur more often. At the time of this report, the CFIO reported the overall fatality work injuries in 2014 increased for the first time since 2008. Fatal work injuries due to roadway accidents were 5percent higher than the previous year.

### **Employer Costs from Blind Spot Ancients**

Blind spot awareness continues to gain momentum within the workplace, with a goal to prevent all injuries from occurring. Between 1979 and 1989, medical, legal and insurance costs for jobsite accidents went from an estimated \$8.9 billion annually to \$17.2 billion annually (Hinze & Teizer 2011).

Approximately 25 percent of construction worker deaths are a result of collisions, rollovers or struck-by accidents (Hinze & Teizer 2011). According to OSHA, motor vehicle crashes cost employers approximately \$60 billion annually. These losses are generally from medical care costs, legal expenses, property damages, and lost productivity. The average cost for an accident is \$16,500. If the accident takes place on-the-job and results in an injury or death, costs can range from \$74,000 to greater than \$500,000 respectively.

### **Governmental Efforts Addressing Blind Spots**

The bill, the Cameron Gulbransen Kids Transportation Safety Act of 2007 was signed into law on February 28<sup>th</sup>, 2008 by President George W. Bush. The bill was named after two-year-old Cameron Gulbransen, who was inadvertently backed over by a Sport Utility Vehicle (SUV) due to the large blind spot associated with the vehicle (“The Danger of Blind Zones - Vehicle Blind Spots,” 2014).

The Cameron Gulbransen Kids Transportation Act identified three of the most serious causes of preventable injuries and fatalities to young children: getting caught between an automatically closing window, placing a vehicle’s transmission into gear without having to depress the brake, resulting in an uncontrolled runaway vehicle, and accidental injury due to a vehicle striking a child due to vehicle blind spots. This required the federal Secretary of Transportation to issue backup collision safety regulations within three years and require full compliance within four years (“The Danger of Blind Zones - Vehicle Blind Spots,” 2014).

The Code of Federal Regulations 29 CFR 1926.601(b)(4), 29 CFR 1926.602(a)(9)(ii), and 29 CFR 1926.952(a)(3) provides standards for workplace vehicles and equipment, although OSHA does not specifically require alarms for powered industrial equipment such as forklifts. OSHA 29 CFR 1910.178(q)(6), does, however, prohibit employers from removing safety devices if the equipment was equipped from the manufacturer.

In 2007 the 110<sup>th</sup> Congress required the National Highway Traffic Safety Administration (NHTSA) to begin collecting and maintaining information regarding injuries and fatalities for crashes that occur off the public traffic ways. To comply with this directive, NHTSA developed a virtual data collection system to provide information regarding injuries and fatalities that occur to people in non-traffic crashes and non-crash accidents. As a result of the data collected, in March of 2014, the U.S. Department of Transportation finalized a set of federal standards which will require all new vehicles under 10,000 pounds to have backup cameras by mid-2018.

OSHA has specific regulations regarding the use of machinery when engaged in reverse. OSHA regulations, specifically Title 29 CFR 1926.601(b)(4), state:

“No employer shall use any motor vehicle equipment having an obstructed view to the rear unless:

The vehicle has a reverse signal alarm audible above the surrounding noise level or:

The vehicle is backed up only when an observer signals that it is safe to do so.’’

Construction safety found in 29 CFR 1926 subpart O exists to protect workers and equipment operators from collisions. In this subpart, regulation 1926.601(b)(4-4ii) discusses the necessity for a clear rearview. However, this can be bypassed with the use of a reverse horn or use of signaler. 1926.601(b)(5) discusses the need for a crack-free window with clear view. Under 1926.602(a)(8)(i), it explains the ability of the brake and/or fender system of earth-moving equipment when permitted through written consent by the manufacturer, per 1926.602(c)(1)(ii) (Teizer, Allread, & Mantripragada, 2010).

### **OSHA Recommendations**

The Occupational Safety and Health Administration (OSHA) recommends the following procedures to help prevent blind spot accidents:

- Ensure that spotters and drivers agree on hand signals before backing up.
- Instruct spotters to always maintain visual contact with the driver while the vehicle is backing.
- Instruct drivers to stop backing immediately if they lose sight of the spotter.
- Not give spotters additional duties while they are acting as spotters.
- Instruct spotters not to use personal mobile phones, personal headphones, or other items which could pose a distraction during spotting activities.
- Provide spotters with high-visibility clothing, especially during night operations.
- Provide and require safety tailgate meetings regularly to emphasize the seriousness of the hazard and to keep employee awareness up.
- Have all personnel on the job site wearing reflective vests that adhere to the ANSI/ISEA 107-1999, American National Standard for High-Visibility Safety Apparel standard.
- Coordinate job schedules to ensure only essential workers will be in the areas where equipment is operating.
- Pre-plan where storage areas are to be.
- Coordinate job conditions, such as haul roads.
- Establish control points to limit access by the public to the job site.
- Ensure compliance with OSHA standards for vehicle and equipment backing

### **NIOSH Recommendations**

The National Institute for Occupational Safety and Health (NIOSH) recommends the following procedures to help prevent blind spot accidents:

- Create and enforce an operating procedure that addresses how to work safely and lists best practices to follow when working near vehicles and other equipment.

- Establish safety procedures for working at night with backing equipment.
- Ensure high-visibility apparel is worn.
- Take precautions. Use equipment that creates minimal blind spots or has proximity warning devices.
- Design the worksites to minimize or eliminate the need for backing vehicles and equipment before work begins.
- Hire a competent person to supervise worksites involving backing vehicles and equipment.
- Be sure drivers know not to back up equipment unless they are under the direction of a spotter.
- Use barrels, barricades, cones or reflective devices to guide vehicles and equipment away from workers.
- Post signs informing workers where it is safe to walk.

### **Current Technology Deployed to Reduce Accidents**

A variety of technologies exist which have the potential to aid in the detection of objects directly behind, and to the sides of the equipment. The two most common technologies are sensor-based and visual-based systems, although GPS-based proximity warning systems, and ultra-wide band technology are gaining in popularity as technology becomes more affordable. Advances in manufacturing technology combined with increased awareness of blind spots have improved equipment and automobile mirrors significantly since the first automobile.

#### **Cameras**

A backup camera is a type of video camera produced specifically for installation in vehicles and equipment. This camera is appropriately mounted on the rear of the vehicle and free from visual obstructions. The purpose of the camera is to assist the operator in backing up and to alleviate the blind spot. A navigation screen is mounted near the operator in the cab of the vehicle or equipment.

The consumer cost for a new truck to be equipped with a camera was estimated at \$325 in a Notice of Proposed Rulemaking (“Preliminary Cost Benefit,” 2006). Latest estimate by NHTSA claims that a full system, including a camera and an in-dash display for 2018 model year vehicles will cost between \$132 to \$142 (Nelson, 2014).

#### **Proximity Detection Systems**

Radar, ultrasonic, and electromagnetic technologies are three types of proximity detection systems designed to alert the operator of the presence of obstacles within close proximity to the vehicle. The most common technology for proximity detection systems is ultrasonic systems. These sensors are typically placed in the front and/or rear bumper. Sensors emit acoustic pulses with a control unit

measuring the intervals between each reflected pulse and then calculating the distance to the identified object.

A study conducted by the National Highway Traffic Safety Administration (NHTSA) estimated the cost of four ultrasonic sensors and the necessary hardware, and installation for a vehicle is approximately \$41 to install. The same study estimated the installation of radar sensors ranged from \$41 - \$100. Both estimates based on dollar rates in 2006 (“Preliminary Cost Benefit,” 2006).

#### Tag-based Proximity Warning Systems

Tag-based proximity warning systems use active radio-frequency identification (RFID) technology to detect objects or individuals by an immediate audible and/or visual warning to the operator of the equipment. Tag detectors or readers are installed on vehicles or equipment. Two-way communication between the reader and the tag allows alarms to be generated at the tag also. This technology provides a wide-range of features depending on the manufacturer. Common features include: visual and audible alarm systems, adjustable detection zones, data logging, 360-degree coverage, and unique proximity detection to inform operators what or who is within proximity of the equipment.

#### Ultra-wideband Technology

Ultra-wideband technology uses nanosecond radar signal pulses to produce an instantaneous bandwidth waveform (Ruff, 2007). The circuitry system consists of a low-noise amplifier, broadband tunnel detector, and digital signal processing. A transmitter emits nanosecond radar pulses from the transmitting antenna while the receiver antenna picks up both the transmitted pulse and the reflected pulses generated from the surrounding area. The signal processor performs calculations and converts the data into a precise measurement of distance to obstacles detected. (Ruff, 2007)

#### GPS-Based Proximity Warning

GPS-based proximity warning systems use differential GPS receivers and radios to accurately identify and locate vehicles and equipment in real time. Information is then transmitted and displayed to equipment operators through visible and audible warning systems. Locations of stationary objects could be identified in a database and transmitted to equipment operators warning them of their proximity to the stationary object (Sullivan, 2012).

Mirrors are not the most effective means for increasing operators’ visual range. However, when supplemental mirrors are applied, operators believe the mirrors have the potential to reduce backing and blind-side crashes (Zeyher, n.d.). Often referred to as “blind spot mirrors” these mirrors add a high distortion, wide field-of-view mirror to the outside corner of the factory mirror. These mirrors come in different shapes and sizes depending on the manufacturer, although the concept of increasing the field-of-view remains.



## **Effectiveness of US Laws and Regulations**

As stated in many research reports, OSHA regulations have helped at reducing fatalities and injuries from occurring. The Occupational Safety and Health Administration (OSHA) sets forth minimum guidelines to protect those working (Teizer, Allread, & Mantripragada, 2010). In the four decades since the creation of the Occupational Safety and Health Act (OSH Act) was signed into law, workplace deaths and reported occupational injuries have dropped by more than 60 percent (“Injury and Illness Prevention Programs,” 2012).

OSHA examined programs in eight states where the state had either required an injury and illness program or provided incentives through its workers’ compensation programs. The success of these state programs lowered accidents by nine percent to more than 60 percent. Below are states showing the greatest improvements:

- From 1973 until 2005 Alaska had an injury and illness plan requirement. Five years after implementation, Alaska’s injuries and illnesses reduced by 17.4 percent.
- California required an injury and illness prevention plan in 1991. Five years later, injuries and illnesses reported were down 19 percent.
- Colorado allowed companies to adopt basic injury and illness prevention plan components in return for lower workers’ compensation premiums. Cumulative annual reduction in accidents was 23 percent.
- Hawaii required injury and illness prevention plans starting in 1985, resulting in a net accident reduction of 20.7 percent.
- Massachusetts companies received a workers’ compensation premium credit for enrolling in a risk reduction program. Companies participating in the program showed a 20.8 percent improvement in their loss ratios.
- North Dakota has a program for companies who have a risk management program under its workers’ compensation program. Workers’ compensation premiums received a five percent discount, resulting in a 38 percent reduction of serious injuries over a four- year period.
- Texas had a program from 1991 to 2005 which identified the most hazardous workplaces. Companies were required to participate in injury and illness prevention programs. From 1991 to 1995, employers reduced injuries and illnesses by 63 percent each year.
- Washington required companies to establish injury and illness prevention programs starting in 1973. Five years after implementation, company net decrease in injuries and illnesses was 9.4 percent.

## **Proven Methods of Reducing Blind Spot Accidents**

The Construction Industry Institute reported “the better safety records occurred when site-specific safety plans were prepared for the projects” (Hinze, 2001). Therefore it can be assumed that better planning in the beginning will result in a safer work environment. Organizations addressing backing accidents are more effective when the top management commitment and active employee participation is present. If possible, policy should include avoiding backing entirely, by positioning the vehicle in such a manner so the need for backing is eliminated or significantly reduced is preferred.

## **Internal Traffic Control Plans**

An Internal Traffic Control Plan (ITCP) is a method to safely and effectively coordinate worksites involving worker, work vehicle, and equipment movements in the activity area. The use of ITCP helps protect workers on foot because workers on foot often work in close proximity to large vehicles and equipment. ITCP also help reduce risks for vehicles and equipment by identifying hazardous locations and safe travel routes on the worksites.

## **Workplace Driver Safety Programs**

In a joint effort by the Network of Employers Traffic Safety (NETS), NHTSA, and OSHA, guidelines for a safety program have been established to reduce motor vehicle related deaths and injuries in the workplace. Development and enforcement of Safe Driving Programs have been extremely effective in reducing motor vehicle related deaths and injuries. Outlined below are a few examples of success stories from [www.osha.gov](http://www.osha.gov).

### **Nationwide Insurance of Columbus, Ohio**

Nationwide is a large insurance and financial service companies in the United States, operating a large private motor fleet. Nationwide implemented Network of Employers for Traffic Safety (NETS) 10-step program in 1998. Since implementation of the program, the organization’s preventable crashes decreased by 53 percent, despite an increase of 19 percent in miles driven. The organization’s total motor vehicle costs decreased by 40 percent.

### **Charter Communications, Michigan**

Charter Communications is a cable service provider to Michigan residents. Charter employees drive approximately 1.5 million miles per month with a fleet of over 650 vehicles. Charter Communications then worked with Michigan NETS to establish a corporate seatbelt program. Seatbelt-used rates went up 74 percent with a decrease in motor vehicle crashes by 30 percent. Two years after implementation, the company reached 94 percent seat belt use.

## Pike Industries of Barre, Vermont

Pike Industries, an asphalt and paving company, has approximately 250 employees operating a 280-vehicle fleet. Pike Industries implemented a safety program requiring all new drivers to receive classroom training and to be assigned a mentor. Workers' compensation claims for vehicle-related accidents dropped from a high of 73 percent of total losses to 2 percent between 2001 to 2003.

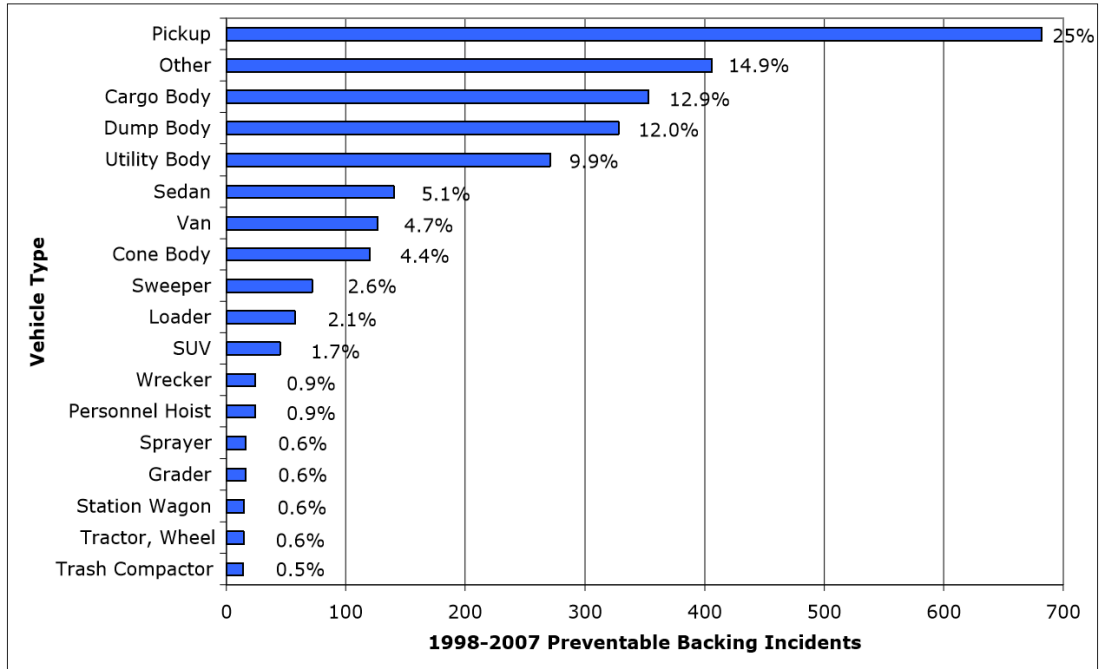
## Case Studies

### California Department of Transportation (Caltrans)

The Traffic Safety Center at the University of California-Berkley found that 93.2 percent of the State of California Department of Transportation workplace motor vehicle backing crashes were preventable by the driver according to internal California Department of Transportation, or Caltrans' data. From 1998 to 2007, backing crashes represented 30 percent of preventable crashes in Caltrans' fleet, resulting in \$5.45 million in vehicle repairs along (Cooper, Duffy, Ragland, & Shor, 2009).

The most common vehicle involved in preventable backing crashes in the Caltrans fleet is the pickup truck. Backing crashes involving pickup trucks represented nearly 25 percent of preventable backing crashes. The data used was not normalized, as there are more pickup trucks than other types of vehicles in the fleet, but it provides an area of focus for safety improvement. The study reports that if Caltrans were to address backing crashes for pickup trucks (sedans, vans, SUVs, station wagon included), then approximately 37 percent of backing crashes could be eliminated as shown in Exhibit 4.

Two potentially powerful tools for eliminating accidents were the enhancement of Caltrans' Safety Information on Management System (SIMS) database to allow a better understanding of the scope and magnitude of the problem, and management action to support a strong safety culture. Literature review performed determined the most effective form for backing accident prevention is the integration of multiple technologies including back-up alarms, radar, and video in order to effectively reduce backing accidents (Cooper, Duffy, Ragland, & Shor, 2009).



**Exhibit 4: 1998-2007 Preventable Backing Incidents Note: Retrieved from [http://trforum.org/downloads/2009\\_52](http://trforum.org/downloads/2009_52)**

Washington State Department of Transportation

The Spokane Research Laboratory of the National Institute for Occupational Safety and Health, in cooperation with the Washington State Department of Transportation evaluated several methods for reducing blind spot accidents. The main effort of this research was to evaluate devices that assist equipment operators in monitoring blind areas around equipment and to prevent collisions with workers or objects. Tests were conducted on Washington State Department of Transportation sanding vehicles and dump trucks during the winter months, as well as utility trucks in the summer months. Conditions and equipment would simulate real-world conditions on equipment used by the state department.

To narrow the list of technologies to be evaluated, systems were used based on their ability to properly function through rain and snow, to handle the tough environment of highway construction, and to meet minimum standards regarding mounting position and detection range. In all, the three systems tested were: Preco’s standard Preview Radar system, Sonar Safety System’s Hingsight 20/20 sonar system, and Intec Video System’s Car Vision Camera System (Ruff, “Evaluation of Devices to Prevent Construction Equipment Backing Incidents”). General observations based on the tested collision warning and camera systems included:

- Highway construction zones are typically crowded and sensor based systems would often alarm, resulting in operator’s lack of trust in system.

- Alarm functions of sensor based systems provide a warning to operator and are considered a more provide a more comprehensive method of monitoring. While camera systems are a more passive technology, much like mirrors.
- Using two systems in combination allowed for operator to refer to camera system when sensor-based system provided an alarm.
- Most trucks used in construction also pull trailers. Most sensor-based systems would sense the trailer and produce an alarm.
- Cameras worked well during warmer months, but would quickly build up snow, ice, or road grime in winter months and require constant cleaning of the lens.
- Most camera and sensor systems are engineered for automobiles and on-road trucking.

### **Hierarchy of Controls**

The most effective method for hazard control is to physically eliminate the hazard completely. Over the past few years the automobile and heavy equipment industries have made significant progress in reducing blind spots. The Cameron Gubransen Kids Transportation Act of 2007 passed to help eliminate backing-related accidents with the use of backup cameras and sensor based systems designed to alert drivers of obstacles in the automobile's blind spots.

Substituting the hazard is the second most effective hazard control. Substituting the hazard is an effective measure to reducing employee exposure. Vehicles and equipment are often capital-intensive and therefore used for many years. While substitution is effective, it is often a cost disadvantage to employers.

The third most effective method for controlling the hazard is engineering controls. Engineering controls do not remove the hazard, but does use engineering practices to isolate the hazard from the employee. Engineering controls are typically expensive and time-consuming.

The fourth most effective means for controlling the hazard is with administrative controls. Administrative controls do not remove hazards, but utilize policies and procedures to prevent employee exposure to the hazard. Administrative controls typically consist of company policies, operating procedures, health and safety plans, signage, and safety-related employee training.

The least effective means for controlling the hazard is the use of personal protective equipment. Personal protective equipment including gloves, hardhats, safety glasses, safety footwear, and high-visibility clothing are required in many jobsites. High-visibility clothing is the best form of personal protective equipment to prevent an incident involving a worker-on-foot, and a vehicle or piece of equipment in the workplace.

### **Summary**

The above literature review concludes that blind spots within the workplace continue to exist and unfortunately cause injury and even death. Since the creation of OSHA in 1970 workplace injuries and

deaths involving equipment have been declining according to data provided by government agencies. Advances in technology have led to many manufacturers of heavy equipment and automobiles to install systems to help aid operators identify obstacles in blind spots.

Organizations are becoming more aware of the costs related to accidents involving blind spots and implementing policies and procedures. There was no singular solution to preventing injuries from occurring due to blind spots. By taking a multifaceted approach utilizing recommendations from OSHA and NIOSH, creating company policies and procedures appropriate for work performed, safe-driver training, company enforcement, and active employee involvement accidents can be eliminated or significantly reduced.

## **Methodology**

### **Introduction**

The purpose of this study is to provide a review of workplace accidents resulting from equipment blind spots and identify technologies and methods to reduce blind spot accidents. While the Occupational Safety and Health Administration (OSHA) investigates industrial fatalities, too little information is gathered into a small number of general categories to effectively understand the overall effectiveness of U.S. regulations, and if current technology could help reduce incident or accident rates in the workplace involving blind spots. To better understand conditions in the workplace, 30 questionnaires containing 15 questions were distributed throughout Anchorage and the Matanuska-Susitna Borough. The purpose of the questionnaires was to identify key areas of interest for this research and to better understand if U.S. regulations, company policies and procedures, and technology could reduce accidents involving blind spots. The questionnaire is located in Appendix A.

### **Instrumentation**

- Questionnaire survey
- Microsoft Excel

### **Data Collection Procedures**

Between August 6<sup>th</sup> to September 1<sup>st</sup> the author distributed a questionnaire containing 15 questions. Questionnaires were distributed to employees working in construction, oil and gas, environmental, local and state government. Information collected did not contain any personal information or information that could easily identify the respondent's employer, but rather focused on worksite conditions, company policies, procedures, requirements and technology. The questionnaire was initially developed with the intention of limiting the time required to answer the questions. By only providing a 'yes' or 'no' for possible answers, the quality of the data proved to be limited. Starting on September 10<sup>th</sup>, 2016 the author distributed the same 30 questionnaires to the same respondents over a two-week period. This updated questionnaire used a graphic rating scale, also known

as a continuous rating scale. This provided respondents an opportunity to answer the questions with greater detail.

### **Data Analysis Procedures**

The author reviewed results from the questionnaire and developed visual graphics to represent the findings using Microsoft Excel. Results from an earlier questionnaire provided limited value for the study. A refined questionnaire was redeployed. Results from the refined questionnaire provided the author with assurances for the topics researched.

### **Limitations**

1. Limitations of the sample size. The sample size was limited to 30 respondents.
2. Limitations of diversity from the sample size. The geographic location was limited to the Anchorage area and the Matanuska-Susitna Borough.

### **Summary**

Questionnaires were distributed to a limited sample size of 30. The respondents were all within the Anchorage area, and the Matanuska-Susitna Borough. Respondents had a wide range of educational and technical backgrounds as well as the industries they worked in. Initial questionnaire developed did not provide the author with valuable data, therefore the rating mechanism was modified and deployed to the same respondents.

## **Results**

### **Introduction**

The purpose of this study is to provide a review of workplace accidents resulting from equipment blind spots and identify technologies and methods to reduce blind spot accidents. Questionnaire results were used to help understand overall understanding of workplace environment with regards to technology, policy, and procedures.

### **Questionnaire Results**

Listed below are results from the questionnaire. A continuous rating scale was used where a one (1) was considered the lowest possible score and a ten (10) was the highest possible score. If the respondent did not feel the question was applicable or he/she was unable to answer the question, then N/A was applied.

1. Please rate your employer driving policy.
  - Median score of 8.0
  - Average score of 6.8

- All 30 respondents answered this question.
2. Please rate the safe guards used at jobsites used to keep employees from vehicle-related accidents. This may include barriers, signage, company policy, or traffic control plans.
    - Median score of 7.50
    - Average score of 7.3
    - 100 % of respondents answered this question
  3. Please rate current technology used in the workplace is enough to help prevent blind spot accidents involving equipment.
    - Median score of 7.0
    - Average score of 6.2
    - 66.6 % of respondents answered this question
  4. Would you consider your company to be an early adopter for technology in the workplace?
    - Median score of 2.0
    - Average score of 3.5
    - 100 % of respondents answered this question
  5. Do you think cameras for heavy equipment could help prevent equipment-related accidents? If yes, please rate the potential effectiveness of cameras.
    - Median score of 9.5
    - Average score of 8.7
    - 100 % of respondents answered this question
  6. Does your company require the use of a spotter when backing up vehicles or equipment? If yes, please rate the effectiveness of using a spotter in preventing accidents.
    - Median score of 10.0
    - Average score of 9.0
    - 100 % of respondents answered this question
  7. How would you rate the effectiveness of OSHA and other governing bodies?



- Median score of 7.0
  - Average score of 6.2
  - 100 % of respondents answered this question
8. How would you rate the effectiveness of backup cameras?
- Median score of 1.0
  - Average score of 4.3
  - 100 % of respondents answered this question
9. Does your company support a safe working environment? If yes, please rate the level of support.
- Median score of 9.0
  - Average score of 9.0
  - 100 % of respondents answered this question
10. How would you rate the blind spots of the equipment you are operating?
- Median score of 5.0
  - Average score of 5.2
  - 100 % of respondents answered this question
11. Do you think the use of technology is going to make the workplace safer or more of a distraction?
- Median score of 10.0
  - Average score of 8.8
  - 100 % of respondents answered this question
12. Does any of the equipment on the jobsite have backup cameras or sensors to help detect obstacles in equipment blind spots?
- Median score of 2.0
  - Average score of 4.2
  - 100 % of respondents answered this question
13. Does the use of audible alarms used on equipment when backing up provide a sufficient alert to employees on foot? Please rate the effectiveness of the audible alert.

- Median score of 8.0
- Average score of 7.7
- 83.3 % of respondents answered this question

14. Can you rate management's commitment to understanding and preventing future accidents?

- Median score of 9.0
- Average score of 7.3
- 100 % of respondents answered this question

15. Does the company you work for provide or require training related to safe driving? If yes, can you rate the overall effectiveness?

- Median score of 9.0
- Average score of 7.6
- 100 % of respondents answered this question

All questions answered:

- Median score of 8.0
- Average score of 6.7

Results from the revised questionnaire provided the author with additional insight to conditions of many jobsites in multiple industries. Below are questions or concerns voiced by the respondents during informal conversations:

- Our company doesn't have a program or policy about driving or backing up. Do we really need one when we only have eight employees?
- The organization takes driving very seriously. Yearly driving training programs are required by all employees regardless if they drive for work.
- The heavy equipment used on many if not all our sites are older models and do not have any systems to help the operator when backing up. It would be great to them [sensor-based and/or visual-based systems] on the equipment.
- Several trucks have them [visual-based systems] for backing up to trailers. They are aftermarket units and they make backing up much easier when they aren't dirty.
- Do insurance premiums go down if our vehicles and equipment were to have these systems [sensor-based and/or visual-based systems] installed?

- We have a lot of laborers working in areas considered to be blind spots. We haven't had an incident take place that I am aware of, but I know of several close calls. It would be interesting to know how many close calls it takes before someone is injured.

### **Summary**

Data from the redeployment of the questionnaires provided the author with guidance and assurance that the topics discussed in this research and recommendation study were aligned and topics discussed were relevant. Interestingly, conversations with the questionnaire respondents led into the respondents asking the author questions. The author did not document all the conversations, but did make note of several statements and questions asked by the respondents. These statements and questions made by the respondents of which the author considered worth noting in the results section.

## **Recommendations and Conclusion**

### **Recommendations**

Based on literature reviews and results from the questionnaire deployed, the following recommendations should be minimum considerations to reduce the likelihood of accidents involving vehicle or equipment blind spots in the workplace.

- Ensure vehicles and equipment are compliant with OSHA regulations. OSHA has set minimum standards for vehicles and mobile equipment when traveling in reverse.
- Utilize government agencies, private organizations and nonprofit organizations which focus on driving safety. Information is readily available on many websites at little or no cost.
- Provide training to employees to help raise awareness of blind spots and promotes a positive safety culture. Studies have shown when employees are provided training, accidents and near-misses are reduced.
- Install sensor-based and visual-based systems to vehicles and equipment that don't come with these systems. Advances in technology over the past decade have made it easier than ever to install new systems. Other technology such as tag-based proximity warning systems and GPS-based proximity warning systems provide an additional layer of protection.
- Consider blind spots when choosing vehicles and equipment. Each piece of equipment has its own unique set of blind spots. The operator of the equipment should be familiar with the equipment and have identified all blind spots prior to work.
- Use site-specific health and safety plans, standard operating procedures, and internal traffic control plans to allow for consistent communication to employees. Each job site is unique and requires special consideration.

- Always wear hard hats, safety glasses, and protective footwear on jobsites. Personal protective equipment is the last line of defense for employees. The use of high visibility clothing does provide easier identification, but is rendered useless in blind spot situations.
- Conduct post-accident investigations to provide valuable information to all interested parties. While this is a reactive recommendation, the information collected may improve workplace safety by identifying potential gaps in company policies and procedures.

## **Conclusion**

Accidents involving blind spots account for a large number of injuries and fatalities in the workplace. Equipment blind spots are identified to be the cause of poor visibility for the operator. Blind spots can be found in nearly every industry and account for a significant number of injuries and fatalities in the workplace. Legislative efforts to reduce blind spot accidents have been successful by requiring automobile manufacturers to install sensor and visual-based systems intended to alert drivers of obstacles or humans in the vehicles blind spots.

Many government agencies and not-for-profit organizations are dedicated to informing the public of safe driving techniques by providing examples of policies, procedures, and guidelines to be shared and implemented.

The data results from the questionnaire proved to be useful when performing literature reviews and determining topics to be discussed in this study. Questionnaire respondents overwhelmingly felt the use of technology is, and will continue to make the workplace safer when applied to helping identify and eliminate accidents caused by blind spots.

## **Further Research Recommended**

- Data collection and analysis of organizations utilizing sensor-based systems and visual-based systems to determine effectiveness of the systems.
- Cost analysis of sensor-based and visual-based systems to determine savings potential.
- Data collection of direct and indirect costs associated with accidents resulting from equipment blind spots.
- Data collection and analysis of organizational safety performance record in relation to level of management participation.
- Cost savings analysis for insurance premiums for organizations with sensor-based or visual-based systems installed on equipment.

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## Appendix A

### Blank Questionnaire

Please rate the following questions as accurately as possible. A one is the lowest possible rating, while a 10 is the best highest rating. If the question is not applicable, please circle N/A.

1. Please rate your employer driving policy.

1	2	3	4	5	6	7	8	9	10	N/A
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2. Please rate the safe guards used at jobsites used to keep employees from vehicle-related accidents. This may include barriers, signage, company policy, or traffic control plans.

1	2	3	4	5	6	7	8	9	10	N/A
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3. Please rate current technology used in the workplace is enough to help prevent blind spot accidents involving equipment.

1	2	3	4	5	6	7	8	9	10	N/A
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4. Would you consider your company to be an early adopter for technology in the workplace?

1	2	3	4	5	6	7	8	9	10	N/A
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5. Do you think cameras for heavy equipment could help prevent equipment-related accidents? If yes, please rate the potential effectiveness of cameras.

1	2	3	4	5	6	7	8	9	10	N/A
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6. Does your company require the use of a spotter when backing up vehicles or equipment? If yes, please rate the effectiveness of using a spotter in preventing accidents.

1	2	3	4	5	6	7	8	9	10	N/A
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7. How would you rate the effectiveness of OSHA and other governing bodies?

1	2	3	4	5	6	7	8	9	10	N/A
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**Appendix A (Cont.)**

**Blank Questionnaire**

8. How would you rate the effectiveness of backup cameras?

1	2	3	4	5	6	7	8	9	10	N/A
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9. Does your company support a safe working environment? If yes, please rate the level of support.

1	2	3	4	5	6	7	8	9	10	N/A
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10. How would you rate the blind spots of the equipment you are operating?

1	2	3	4	5	6	7	8	9	10	N/A
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11. Do you think the use of technology is going to make the workplace safer or more of a distraction?

1	2	3	4	5	6	7	8	9	10	N/A
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12. Does any of the equipment on the jobsite have backup cameras or sensors to help detect obstacles in equipment blind spots?

1	2	3	4	5	6	7	8	9	10	N/A
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13. Does the use of audible alarms used on equipment when backing up provide a sufficient alert to employees on foot? Please rate the effectiveness of the audible alert.

1	2	3	4	5	6	7	8	9	10	N/A
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14. Can you rate management's commitment to understanding and preventing future accidents?

1	2	3	4	5	6	7	8	9	10	N/A
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15. Does the company you work for provide or require training related to safe driving? If yes, can you rate the overall effectiveness?

1	2	3	4	5	6	7	8	9	10	N/A
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**Appendix B**  
**Questionnaire Results**

Question #	ID 1	ID 2	ID 3	ID 4	ID 5	ID 6	ID 7	ID 8	ID 9	ID 10	ID 11	ID 12	ID 13	ID 14	ID 15	ID 16	ID 17	ID 18	ID 19	ID 20	ID 21	ID 22	ID 23	ID 24	ID 25	ID 26	ID 27	ID 28	ID 29	ID 30			
1	8	1	9	9	9	7	1	5	10	10	3	8	9	10	10	9	2	7	9	10	9	2	6	9	8	1	10	5	6	2	Question 1 Average	6.8	
2	7	5	9	7	10	7	9	6	9	10	5	8	7	10	9	8	6	7	9	10	9	6	3	10	8	3	10	3	6	2	Question 2 Average	7.3	
3	N/A	N/A	N/A	N/A	8	5	10	N/A	10	10	N/A	1	N/A	9	8	2	2	N/A	3	9	7	7	4	9	8	2	4	N/A	5	N/A	Question 3 Average	6.2	
4	1	1	1	1	8	1	9	1	8	10	1	1	1	5	9	2	2	1	3	1	1	6	3	2	8	5	4	1	1	6	Question 4 Average	3.5	
5	9	10	10	10	9	9	8	10	10	10	9	9	9	10	10	10	10	8	10	10	8	5	10	10	8	7	10	5	6	1	Questions 5 Average	8.7	
6	10	10	10	9	9	9	10	9	10	10	10	10	10	10	9	10	10	9	10	10	8	9	2	10	8	9	9	10	10	2	Question 6 Average	9.0	
7	7	6	8	3	7	8	8	1	9	5	7	6	7	8	9	8	7	6	5	8	10	5	2	10	3	5	9	3	4	1	Question 7 Average	6.2	
8	1	1	1	9	10	10	1	3	1	1	1	1	1	1	10	9	10	8	9	10	8	1	1	1	8	7	1	1	1	1	Question 8 Average	4.3	
9	8	9	10	10	10	10	7	6	10	10	8	9	9	8	10	9	10	8	10	10	9	9	9	8	8	10	10	8	10	8	Question 9 Average	9.0	
10	2	4	5	9	10	7	8	8	1	8	7	7	1	1	1	3	5	3	10	10	9	5	2	2	6	5	10	1	3	3	Question 10 Average	5.2	
11	10	10	10	9	10	10	10	10	10	10	10	10	10	10	8	8	10	8	9	10	12	7	4	9	8	8	10	6	6	2	Question 11 Average	8.8	
12	1	1	1	1	1	7	1	1	10	8	8	9	6	8	10	1	1	1	1	1	1	7	4	9	1	6	10	2	5	2	Question 12 Average	4.2	
13	1	9	N/A	N/A	10	7	7	9	10	N/A	10	10	5	10	10	8	N/A	8	10	10	9	5	5	N/A	8	8	10	1	7	5	Question 13 Average	7.7	
14	1	1	1	10	8	8	10	10	10	8	10	10	10	8	9	1	1	1	10	9	10	7	1	9	10	8	10	10	9	10	Question 14 Average	7.3	
15	10	10	10	10	10	10	10	10	10	7	8	10	10	9	9	2	2	5	5	5	5	10	7	4	9	5	6	10	6	5	5	Question 15 Average	7.6
Respondent Average	5.4	5.6	6.5	7.5	8.6	7.7	7.3	6.4	8.5	8.4	6.9	7.3	6.8	7.8	8.7	6.0	5.6	5.7	7.5	8.2	8.0	5.9	4.0	7.6	7.0	6.0	8.5	4.4	5.6	3.6	All questions averaged	6.8	
Respondent Median	7.0	5.5	9.0	9.0	9.0	8.0	8.0	7.0	10.0	10.0	8.0	9.0	8.0	9.0	9.0	8.0	5.5	7.0	9.0	10.0	9.0	6.0	4.0	9.0	8.0	6.0	10.0	4.0	6.0	2.0			