Construction Project Administration and Management for Mitigating Work Zone Crashes and Fatalities: An Integrated Risk Management Model

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16. Abstract

The goal of this research is to mitigate the risk of highway accidents (crashes) and fatalities in work zones. The approach of this research has been to address the mitigation of work zone crashes through the creation of a formal risk management model to be utilized during the construction management and administration of highway projects for all stages of the project life-cycle. The result of these efforts is realized through the design of an integrated risk management model. A standard risk management model has three components: risk identification, risk analysis, and risk response. The risks are identified by the factors that contribute to work zone crashes. The risk analysis involves understanding the tendency of a hazard to influence the frequency or severity of a loss, and the risk response relates to the appropriate countermeasures to the factors that contribute to work zone crashes. The number of hazards and mitigation strategies corresponding to work zone crashes can be substantial.

The intent of this research is to develop a formalized risk management plan to identify potential hazards on plans, designs, or jobsites and to cue a risk response to the hazards. Mitigation strategies may take the form of a mitigation "method" (alert motorist, assist worker/motorist, control motorist, inform motorist, and protect worker/motorist).

The results of this research will be a formal step-by-step methodology to be utilized by managers and decision makers. Each stage of the project life-cycle (or Project Development Process) will provide a checklist of hazards and mitigation strategies. This research will also provide a qualitative method to assess the likelihood and severity of a hazard or multiple hazards on a roadway work zone.

This research is intended to provide a holistic approach to risk management that is to be integrated into the existing corporate structure and not to be considered a standalone program. This integrated approach will allow a formalized procedure to be utilized by any member of an organization during all phases of the construction project life-cycle.

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INTRODUCTION

1.1 Introduction

In the United States, over 900 people die every year in automobile crashes in highway work zones (Iowa DOT 2008a). In addition, 40,000 motorists involved in highway work zone crashes suffer from injuries, and 52,000 are involved in property damage only crashes (Mohan 2002). It is in the interest of the traveling public, designers, department of transportation agencies, and contractors to explore methods to reduce these tragic statistics. The goal of this research is to develop a new, integrated approach to risk mitigation of highway crashes and fatalities in transportation construction work zones. This goal is primarily achieved through the development of a formal integrated risk management model to be utilized during the construction management and administration of highway projects for all stages of the project life-cycle, from planning through construction. Within the integrated risk management program, validation and application of the model is accomplished by focusing on the three components of the standard risk management model: risk identification, risk analysis, and risk response (Smith 1999). The risks are generally identified by recognizing the factors that contribute to work zone crashes. The risk analysis involves understanding the probability of a hazard influencing the frequency or severity of a loss, and the risk response relates to the deployment of appropriate countermeasures to attenuate the factors that contribute to work zone crashes. The number of hazards and mitigation strategies can be substantial.

The results of this research will be an integrated risk mitigation model that defines a formal step-by-step process to be utilized by managers and decision makers. At each stage of the project life-cycle (or project development process), the model suggests a checklist of hazards and mitigation strategies to be considered. After developing the integrated risk model, research validates the identification, analysis, and response components through a quasi-quantitative method to assess the likelihood and severity that a hazard or multiple hazards could pose on a roadway work zone.

1.2 Background

In Iowa, there are on average 6.5 deaths per year, 136 injury crashes, and 224 property damage only crashes, totaling an average of 366 work zone crashes per year. Ninety percent of Iowa work zone fatalities are motorists (Iowa DOT 2008a). Past research has addressed the primary factors that contribute to work zone crashes involving injuries or fatalities, and the mitigation strategies have focused on physical measures taken during construction. Some of the identified factors include speed, inattentive driving, following distance, aggressive driving, and large trucks (Iowa DOT 1999; Dissanayake and Lu 2002; Chambless 2002; Roadway Safety Foundation 2007; Hausman 2007). The leading types or causes of work zone accidents are rear-end collisions, workers struck by motorists, workers struck by construction equipment (mostly when backing up), and motorist collisions with large trucks (Garber 2002; Hausman 2007; Pratt 2001; Pigman 1990). In addition, the times in which work zone accidents are most likely to occur are nighttime (dark), Fridays, evenings of weekends (after bar time), summer months, and in periods of heavier traffic (Hausman 2007; Pigman 1990; Pratt 2001).

Typical initiatives to reduce the number of fatalities and injuries are usually physical in nature (i.e., barricades, signage) and are put in place in the actual work zone during construction (Pratt 2001; Richards 1986; Hargroves 1981; Bushman 2005). However, physical traffic calming measures have not always proven to be effective when not followed by enforcement (Arnold 2003; Pratt 2001; Richards and Dudek 1986; Huebschman et al. 2003). Therefore, it may prove more effective and efficient to use innovative contracting and project administration to address work zone safety in the planning, design, and preconstruction phases of the project.

1.3 Problem Statement

Work zone accidents can be classified as (1) accidents that occur in the work zone and that are caused by and affect only the parties in the contract, such as construction workers, department of transportation (DOT) personnel, consultants, etc., and (2) accidents that occur because of the interaction between the traveling public and participants in the construction process. Therefore, two groups of parties are generally impacted by work zone accidents: the project workers on site and the traveling public. Workers are affected by both the jobsite conditions and the effect of interactions with passing motorists. The traveling public is also affected by jobsite conditions and other construction-related conditions, as well as other travelers in the work zone. This research focuses on the interaction of the traveling public, workers, and work zone conditions (merging patterns, signage, construction equipment, truck traffic, barricades, lighting, speed, congestions, etc.). Previous research will prove valuable in identifying mitigation strategies and providing additional resources to reduce the number of injuries and fatalities in work zones. However, the focus of this research is to develop and implement an accident mitigation program to manage the existing strategies in order to provide the greatest benefit to the traveling public, the contractor, and transportation agencies.

Taken strictly from a need basis, all parties involved in the construction project can benefit from the implementation of an accident mitigation program. This program will take the form of a formal risk management program that will specifically address the needs at the construction project administration and management level. The benefits to developing a formal risk management model are vast; however, the following is an abbreviated list of some of the motivations for developing an integrated risk management program:

- Save lives
- Decrease injuries
- Reduce property damage
- Moderate risk of liability
- Lower insurance premiums for contractors
- Reduce costs associated with claims/litigation
- Decrease project delays
- Reduce traffic delays (social/economic)
- Curtail knee-jerk reactions (overcompensation)
- Provide proper allocation of resources based on likelihood and cost of risk

Some of the additional potential benefits to developing and implementing an accident mitigation program at the construction project administration and management level will likely come in the form of improvements to innovation and technology as it relates to work zone safety.

There are several topics that are beyond the scope of this research project. Jobsite accidents that are not directly related to the interaction with the traveling public will not be included in this research. These are the types of jobsite-related accidents that may occur whether or not the work is conducted in the vicinity of the traveling public. Some examples include workers on foot struck by construction vehicles or equipment, falls, equipment roll-overs or collisions, etc. In essence, any jobsite safety concern that would typically be addressed by company safety policy and Occupational Safety and Health Administration (OSHA) regulations will not be included in this research. However, developing a mitigation program for jobsite safety will be recommended for future research. Therefore, from this point forward, this report will concentrate on the mitigation of work zone "crashes" because the term "crash" implies an interaction between the traveling public, the workers, and the work zone conditions.

1.3.1 Current Standard of Practice

Examination of the current state of practice within the industry, as exemplified by the Iowa Department of Transportation (Iowa DOT), indicates the primary utilization of the *Manual on Uniform Traffic Control Devices* (MUTCD) at the design level. The general concept is that a project is designed as needed based on project requirements, whereupon the Iowa DOT's Office of Design Methods develops a traffic control plan (TCP) based on input gathered from a variety of sources, such as the Regional Planning Affiliation (RPA), Metropolitan Planning Organization (MPO), Transportation Improvement Program (TIP), and the Iowa County Engineers Association Service Bureau (ICEASB). In general, the TCPs closely follow the MUTCD specifications. The TCPs are presented in the project plans along with any anticipated traffic events (civic and social events and holidays). By following established standards, the current state of practice appears to take an approach of mitigation of liability as opposed to mitigation of traffic crashes and fatalities. This approach operates under the assumption that if a plan is created and followed according to professional standards, there is less chance of a lawsuit being filed, even if the plan is inadequate. However, if a plan was created but not followed, even if the implemented measures are better than the plan, the likelihood of a lawsuit is increased. The philosophy behind the use of standardized TCPs generated from a group of standards detailed in the MUTCD is that standardization minimizes confusion for the traveling public. The accepted belief is that when unique traffic control measures or designs are implemented, drivers are more likely to become confused. Therefore, it is the intent of this research to develop a program that delves deeper into work zone conditions and traffic control by analyzing the factors that contribute to work zone crashes and fatalities. These factors will further be categorized into components in order to provide structure to the program.

1.4 Research Objectives

This research explores mitigating work zone fatalities and accidents through construction project administration and management. The objective of such mitigation strategies is to address work

zone safety risks before construction starts. Essentially a “Loss Control Program” (Dorfman 2005) may be implemented in the form of a risk management model. Considering the five components of crash mitigation discussed in the subsequent sections, it is apparent that the best party to manage the risk may or may not be part of the construction phase of the project. The party that can best manage the risk may be a stakeholder in any of the stages of the construction project life-cycle (i.e., planning and programming, design, letting, and construction). The objective of this research is to explore strategies for mitigating work zone fatalities and accidents before construction starts through project administration and management. Therefore, this research will create a formal risk management model to be utilized during the construction management and administration of highway projects in order to mitigate work zone accidents and fatalities for all stages of the project life-cycle.

This research emphasizes the mitigation of transportation work zone crashes and fatalities; however, this project has been developed in such a way that the model presented can serve as a framework or template for managing risks pertaining to all types of construction projects. This research is intended to provide a holistic approach to risk management that is to be integrated into the existing corporate structure and not as a standalone program. This integrated approach will allow a formalized procedure to be utilized by any member of an organization during all phases of the project life-cycle. Risk management is one of the many functional requirements for the project management and administration of construction projects (Fisk 2006). This research develops a formalized process to manage risks during all phases of the project life-cycle; therefore, the framework was created using best practices from all industries that utilize risk management functions. This allows managers to utilize this framework for all risks that are associated with construction projects, regardless of the risk classification. While useful in all areas of construction, the risk management process formalized in this research will be examined with in-depth focus on the life safety issue of mitigating work zone crashes and fatalities and on the creation of a formal risk management process that is unique to highway construction projects.

Using the framework and the step-by-step process developed in this project, project managers and administrators can integrate this model into their existing management structure, allowing stakeholders to manage multiple risks within the project, regardless of risk classification (i.e., social risks, political, life safety, economic, scheduling). The purpose of this framework is to implement a risk management strategy as early as possible in the project life-cycle in order to better manage risk through effective decision making and identification of stakeholders best suited to manage those risks.

The standard risk management model (identify, assess, respond) includes four responses to risk: (1) accept, (2) transfer, (3) avoid, or (4) reduce (mitigate). The primary risk associated with work zones as applied to this research is vehicle crashes in the vicinity of the project site defined by the limits of the work zone area. The appropriate response to the risk of a work zone crash is to reduce or mitigate either the frequency or severity of such crashes because work zone crashes cannot be completely avoided or responsibly accepted and are extremely difficult to transfer to another party. Risk mitigation strategies are created by determining the contributing factors (hazards) of work zone crashes, assessing the risks associated with the factors, and responding to the risk by implementing appropriate countermeasures (work zone management strategies) to the contributing factors. Ultimately, this research will be used to do the following:

- Determine when and how to use various work zone management strategies
- Effectively identify and quantify risks
- Mitigate risks utilizing the existing strategies

This research is not intended to establish new strategies but is meant to stimulate innovation and promote the use of technology in response to the efforts of the risk management program. The end result of this research is the creation of a loss control program in the form of an integrated risk management model. This integrated risk management program will provide a formal step-by-step process that will be used to identify, assess, and respond to risks by providing checklists and brainstorming cues that will assist the risk management team across all stages of the project life-cycle of any highway construction project.

LITERATURE REVIEW

2.1 Literature Review

The policies and actions of the project management and administrators associated with a highway project will greatly impact the safety outcomes of the project. This research focuses on the project management and administrative functions involved in transportation projects. Therefore, this research utilizes the literature review as a method to define the process by which transportation design and construction projects are managed. The approach of this chapter is to create a baseline for understanding the terms required to fully create and implement a formal risk management program for all stages of the project life-cycle, followed by a review of past research in the area of risk management in projects involving work zone safety in order to establish the point of departure for this project. Although this research is primarily concerned with the mitigation of work zone accidents and fatalities, the goal of the research was to keep the format of risk management in general terms so that agencies and individuals can use the proposed risk management model to manage multiple project risks. Therefore, the literature review is utilized to create a risk management model by defining concepts in terms that apply to the design and construction industry as a whole and not exclusively to highway projects. The validation and application of the model presented in this project is based exclusively on input from highway sector professionals and highway crash data and is therefore applicable specifically to that industry. Once the framework has been developed for an integrated risk management program, the desired risk category may be explored within the existing risk management structure. This will allow researchers and practitioners to focus on the standard risk management model without recreating the structure needed to integrate the risk management model into an existing management structure.

The integrated risk management model can be understood by considering the research target shown in Figure 1. The outer ring of the target shows project management and administration, which represents the overall existing corporate structure. The framework of the management and administration functions spans the entire project life-cycle. Thus, the project phases represent the next inner circle of the research target. The project life-cycle is defined in the research target in order to acknowledge required tasks and subsequently, the risks that can be identified within those activities. In addition, each stage or phase of the project life-cycle includes stakeholders who may or may not be unique to that particular project stage. Parties that are best suited to manage the risks within a particular phase should be part of the risk management team. The next circle on the research target is the integrated risk management program. This research program serves as the framework for a formal step-by-step process that will assist the risk management team with the implementation of the program with the purpose of ensuring continuity and a standard approach to risk management within a corporate structure. This will allow stakeholders at all levels of management to follow the same procedures that may improve the level of objectivity provided by the risk management approach. The integrated risk management program encompasses the elements of the existing standard risk management model, as shown in Figure 1, and focuses on identification, assessment, and response to various risks. Note that the outer circles of the research target may be applied to any project-related risks during any phase of the project life-cycle; however, the innermost circle, or “bull’s eye,” represents a specific risk classification. For this research, the “bull’s eye” is the risk of work zone crashes on roadways.

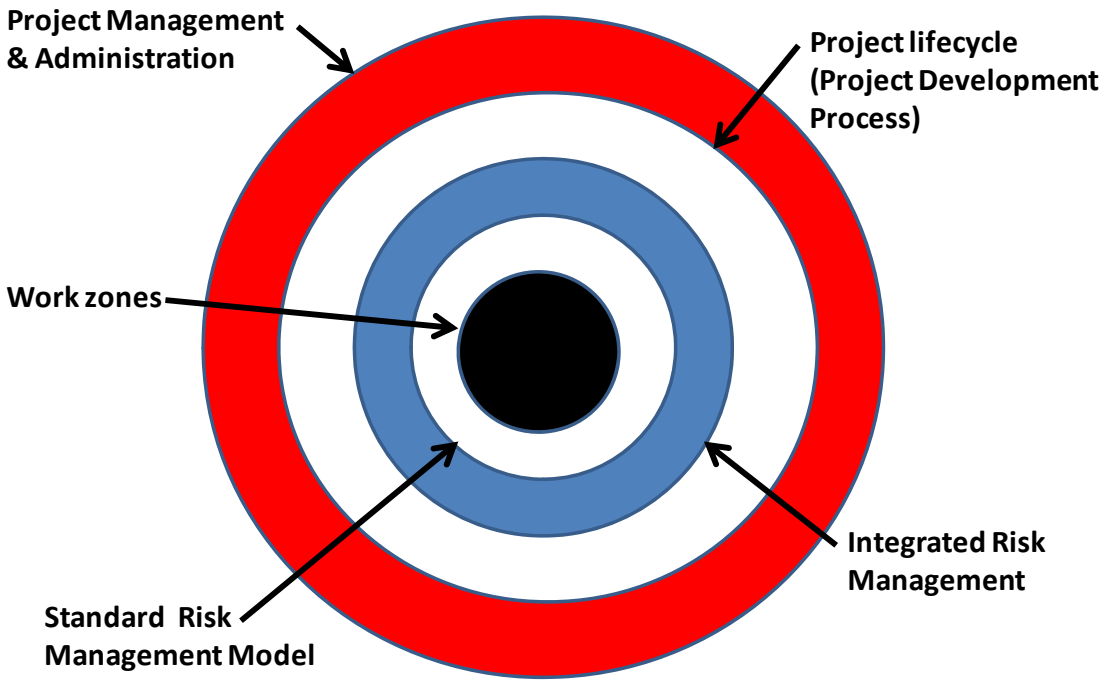

Figure 1. Research target: integrated risk management model for highway work zone projects

The following sections will be focused on developing the outer rings of the research target. However, in order to provide an in-depth analysis into the use of the risk management model, it will be applied to address the specific risks associated with the mitigation of work zones crashes and fatalities.

The concepts explored in this literature review focus on the following areas, starting with a global perspective and narrowing to the specific topic of this research:

- Project management and administration
- Project life-cycle
- Project development process (highway construction)
- Risk/risk management

The literature review lays the framework from which the integrated risk management model was created. The review takes several individual aspects of project management and administration and distills them into a comprehensive system to be utilized for a specific purpose of accident mitigation of roadway work zones.

2.2 Midwest Transportation Consortium (MTC) Research Definitions

For the purposes of research related to risk management in construction work zones, project management extends across all phases of the project life-cycle. Therefore, the basic

responsibilities and tasks of the project management team will encompass all areas of each of the phases of the project life-cycle. *Project management*, then, refers to the tasks and responsibilities required for project coordination and integration and not necessarily to the specific personnel or individuals performing the tasks. The purpose of identifying the project management tasks and responsibilities is to provide a baseline for which the panel experts (focus group) will identify stakeholders and from which to specifically document the current state of the practice of risk management in each phase of the project life-cycle.

During the construction phase, the construction project management and construction project administration is delineated by the managerial and administrative tasks and responsibilities as well as the individuals performing the function. During the construction phase, the construction project manager is considered to represent the contractor on the project, while the construction project administrator represents the owner. Each is responsible for the contract compliance by its respective party to the contract (CSI 2005). For this research, the term *construction project administrator* refers to all aspects of construction administration as it applies to the parties of the contract.

2.3 Project Development Process (Highway Construction)

The construction project life-cycle is a generic process that describes the activities associated with the planning, design, procurement, and construction of a specific constructed facility. The intent of this section is to specifically identify the stages of a construction project life-cycle as it applies to the planning, design, and construction of highway and roadway projects. However, as with the description of the "generic" construction project life-cycles, where many organizations (such as Construction Specifications Institute [CSI] or Design Build Institute of America [DBIA]) and authors use differing terminology to describe the project phases, the state highway agencies also vary in their descriptions from state to state. The Iowa DOT defines this process as the project delivery process (PDP). The term *project development* is "a series of processes (e.g., planning, programming, design, and construction) that convert highway transportation needs into a completed facility that satisfies the need" (Anderson and Blaschke 2004). The Federal Highway Administration (FHWA) describes PDP in two phases: planning and project development (FHWA 2001). The planning process focuses on planning and programming. Long-range plans are based on transportation needs and short-term plans are focused on specific projects.

National Cooperative Highway Research Program (NCHRP) Synthesis 331states that one of the goals of the state highway agencies (SHAs) is to maintain, upgrade, and improve the highway systems within the state (Anderson 2004). NCHRP Synthesis 331 further states that SHAs must identify and prioritize transportation needs and then address the needs with the implementation of individual projects (Anderson 2004). Therefore, lists of needs and potential projects are created. The cost associated with the proposed project is required to effectively translate the need into a viable project. When a funding agreement (by various entities) has been executed, the project is "programmed" and authorized for further development (Iowa DOT 2008c). According to NCHRP Synthesis 331, authorized projects move through advanced planning and preliminary design, including environmental clearance, to the final design. When the right-of-way is

acquired, the project goes through the letting phase. The project is awarded (if it meets the bidding requirements) and the construction process begins.

In the absence of documentation that fully describes the activities involved in each stage of the Iowa DOT's specific project delivery method in the application of federal aid to roadway projects, interviews with DOT personnel and an adaptation of a modified version of the PDP as described by Anderson (2004) are used to describe the stages of the project development process. Anderson (2004) terms these phases as planning, programming, advanced planning/preliminary design, final design, letting, award, and construction. Because the Iowa DOT describes "programming" as an event that authorizes the project to proceed to the following stages (Iowa DOT 2008c), this project modifies the PDP of Anderson (2004) as follows: the initial stage of the PDP for this research combines *planning* and *programming*. The second stage of the PDP is *preliminary design*. The third stage is *final design*. The fourth stage combines *letting* and *award*, and the final stage of the PDP is *construction*. Figure 2 graphically displays these stages of the PDP.

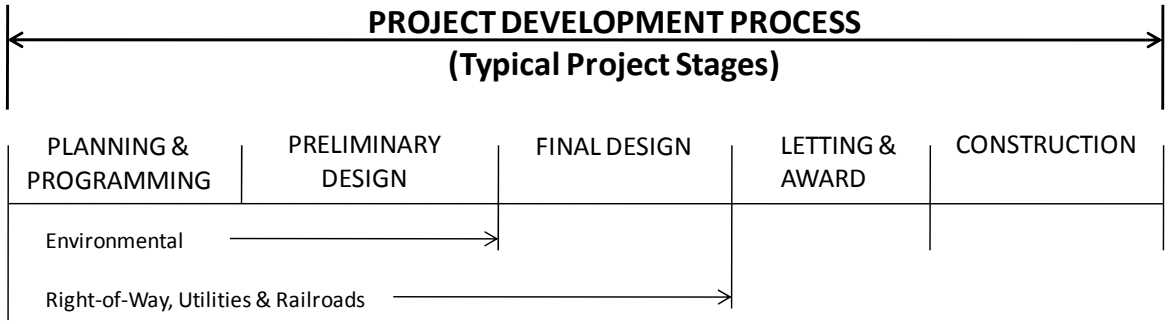

Figure 2. Typical stages of the PDP

Understanding each of these stages is critical in determining the activities that have the greatest impact on identifying hazards and mitigating accidents and fatalities in work zones during each phase as it applies to the construction of transportation facilities.

2.4 Unique Contribution of this Research

This section will detail several studies similar to the research presented in this project. Specifically, studies using an integrated risk management approach across all project development phases and studies examining work zone-related risks will be reviewed. This research expands on the qualitative assessment of risks utilizing a two-dimensional risk matrix and a comprehensive full life-cycle risk program. Through the broad scope of these previous literatures, this research will draw out relevant findings, consolidate the findings, and build on their strengths. The section closes with a statement of the unique contribution of this research project.

Several important tools have been developed for use in the management of risks related to the transportation industry. The NCHRP Report 574, *Guidance for Cost Estimation and*

Management for Highway Projects during Planning, Programming, and Preconstruction, is one such tool (Anderson, Molenar, and Schexnayder 2007). The intent of this review is not to discuss the specifics of this report but to give a general outline of the concepts behind the report. NCHRP Report 547 is used to serve as a guide to prevent cost escalation through the life of the project from planning through preconstruction. This tool can be utilized at the organization level, program level, and the project level. Even though it is not explicitly viewed as a risk management program, it does integrate the need to identify, assess/analyze, and respond to risks associated with cost escalations during the project development. Essentially, this report identifies situations or conditions that would minimize the likelihood of a cost overrun. This is accomplished through a detailed assessment of each phase of the project development and the development of a guide to be followed by the management team. The purpose is to provide a method to increase the accuracy and decrease the variability of project and cost estimates. NCHRP Report 547 is similar to this research project in that it delves into the activities associated with each phase of the project development process for roadway projects: planning, programming and preliminary design, final design, advertise and bid, and construction phase. It emphasizes the need to identify and mitigate potential problems early on in the project and follow up on each potential problem during each successive project phase. It recognizes the need for project management functions and develops the understanding that risk management is a subset of project management. The NCHRP project created a number of "strategies" to be implemented throughout all phases of the project development, including management, scope and schedule, off-prism, risk, delivery and procurement, document quality, estimate quality, and integrity strategies.

The NCHRP 574 research differs from the present research by way of the risk management program implementation. The NCHRP project produced a guidebook for persons involved in highway projects in order to show best practices for cost control as related to each specific phase of the project life-cycle. This research will move beyond these best practices to emphasize the importance of an overall project management structure in order to integrate a risk management program. This research has chosen to focus on the integrated risk management approach, while the creation of a project management program will be left for future research. NCHRP 574 has stressed the need for a strong project management team to fully implement the prevention of cost escalation; however, the present research has developed the framework for the implementation of an integrated risk management program and has developed tools and techniques from which to identify, assess, and treat potential risks associated with vehicle crashes and fatalities in roadway work zones.

An additional resource that has approached the topic of risk management in highway projects is NCHRP 8-60. The main objective of NCHRP 8-60 was to develop a comprehensive guidebook on risk-related analysis tools and management practices for estimating and controlling transportation costs. The purpose of NCHRP 8-60 is to provide an approach to selecting tools and practices that support a systematic approach to risk management, is applicable to all project phases, and is applicable to all projects. It is essentially a "how to" manual for risk analysis and management practices. The essence of NCHRP 8-60 is cost control and cost estimation; however, the system of managing the risk has important implications for the work of this research project. The NCHRP report accomplished its objectives by determining the current state of the practice through the use of a literature review and recent and ongoing research results,

along with federal requirements and guidance and the current risk management practices related to cost estimation and control; the report recognizes the aspects of risk management as being risk identification, risk assessment (qualitative and quantitative), and risk response. NCHRP 8-60 chronicled eight case studies from California Department of Transportation (Caltrans), Washington State Department of Transportation (WSDOT), the U.S. Department of Energy Office of Environmental Management (DOE-EM), New York Metropolitan Transportation Authority (NY MTA), Ohio Department of Transportation (ODOT), and others. The results of the case studies were provided through a description of the risk management process; the method of identifying, analyzing, and responding to risks; and the method of risk monitoring and control for each of the case studies.

The research identified in this section describes the need to develop risk management models for the management of risks for transportation projects. The research that looked at risk from an integrated life-cycle perspective focused on specific risks such as cost, quality, and time. None of the research on integrated risk management looked specifically at project life-cycle risks associated with roadway work zones. This section also described research that investigated project management tools for the identification, assessment, and allocation of risks. Several of the tools that were identified have been utilized in the development of this research project during the risk identification and mitigation phases of this research. The present MTC research project has developed and enhanced prior integrated risk management models by incorporating tools and methods from a business perspective, specifically the insurance and finance industries. In addition to life-cycle risk analysis, this section acknowledges a qualitative method developed by Shen (1997) to assess and rank highway project risk based on a risk significance index, although this report does not go into the specific details of Shen's research. However, Shen's (1997) method would serve well to assess hazards that cannot be assessed by use of quantitative data. This will be a recommendation for future research. Finally, this section acknowledges the research conducted by Yong Bai (2007) at the University of Kansas that specifically predicts the probability of work zone fatalities and injuries using binary logistic regression methods with a set of predictors that have been used to evaluate the effectiveness of temporary traffic control methods. The approach to the research presented in this report is similar to the approach used by Bai (2007) in that it utilizes a state crash database to compile descriptive statistics of queried data. While Bai (2007) looked primarily at two severity levels (fatal and injury), the research presented in this report investigated all severity levels (fatal, major injury, minor injury, possible injury, and property damage only), as compiled in the Iowa statewide crash database. This research also develops a unique method of assessing the likelihood and severity of vehicle crashes utilizing a two-dimensional risk matrix based on work zone vehicle crash data.

METHODOLOGY

3.1 Methodology

The research objectives described earlier require a multifaceted research approach entailing the use of construction management and administration functions for the purpose of risk management for all stages of a project life-cycle. This research is focused, in particular, on the mitigation of highway work zone crashes and fatalities. The framework for an integrated risk management program will be developed in the following sections of this report through the use of various sources obtained during the literature review. This section focuses on the methodologies used to develop, validate, and apply the model specifically to risks associated with work zone crashes and fatalities. Several methodologies will be applied in the model development and in its validation and application. With the exception of the risk assessment portion of this research, the methodology for this project is primarily qualitative. This was accomplished through the use of focus groups, surveys, personal interviews, and content analysis

Although crash mitigation planning for work zones is not specifically a public relations problem, this topic favors the applied research approach because it examines specific, practical issues (Wimmer and Dominick 2006). An integrated risk management approach uses stakeholder assessment and is similarly structured to a typical public relations research program, in that consequences of actions are primary targets of interest, and the opinions of a cross section of individuals are desired. Strategic research, as applied to public relations, is used to develop campaigns or programs to be used in deciding program goals and how to achieve such goals (Broom 1990). The bulk of the research performed will be modeled after public relations research.

A leading public relations text presents a four-step model for the research process: (1) define the public relations problem, (2) plan public relations program, (3) implement the public relations programs through actions and communications, and (4) evaluate the program (Cultlip and Broom 1994). It is the intent of this research to create a program that meets these requirements. The research problem was defined in the introduction of this report and utilizes crash statistics to emphasize the need to develop a strategy that implements a holistic approach to risks associated with highway work zones. It was during the initial stages of this research that the most logical strategy to mitigate risks associated with highway work zones was determined to be an integrated risk management program that could be implemented through existing management structures.

3.2 Research Objectives

The objective of this research is to develop a formal risk management model and to validate its usefulness for application in mitigation of work zone hazards. In order to accomplish this research objective, the preferred methodology favors a combination of qualitative research and analytic assessment that follows a path of content analysis, a focus group, surveys, and database analysis. The results of this research revolve around the implementation of the standard risk management model for each phase of the project life-cycle: risk identification, risk assessment, and risk response (treatment). To best explore how the standard risk model will work in real-life

application, the research plan for this project was conducted in a similar three phase process: (1) the model development phase, (2) the model validation phase, and (3) the model application phase (see Figure 3). The following section (Model Development) will develop the integrated risk management model. The results of this work will validate and detail the application of this model.

The model development phase of this research was exclusively qualitative. Through a detailed literature review and content analysis of existing research and literature on the subject of risk management, particularly in the area of highway work zone safety, a program for implementing integrated risk management within an organization was developed. The results of this phase also provided checklists and identification cues and techniques for the identification of work zone hazards throughout the phases of a highway project. Brainstorming cues for use by project stakeholders were developed by performing qualitative assessments of the results of the content analysis of papers and articles. This research led to the identification of five factors of work zone crashes and three primary causes of work zone crashes.

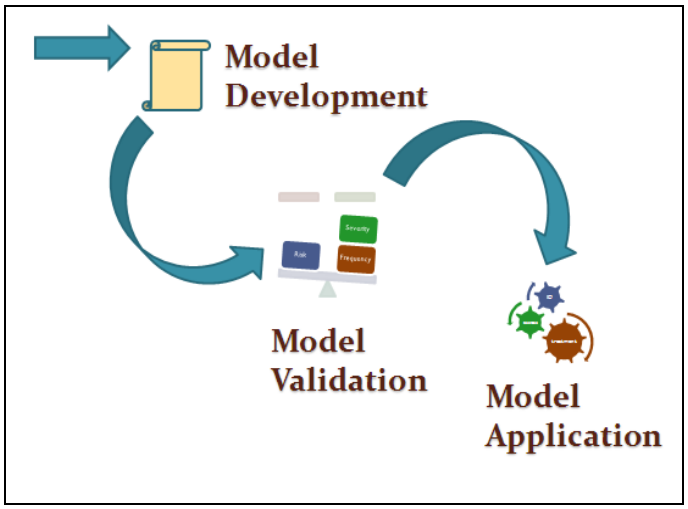

Figure 3. Research methodology

The model validation phase of this research involved qualitative assessments and an analytic quasi-quantitative assessment of work zone hazards. A risk assessment approach was chosen as opposed to a purely quantitative approach of risk due to the subjective nature of evaluating risks that have a high degree of uncertainty. This phase involved the implementation of a focus group of industry professionals to validate and to build upon the lists of hazard and associated project phases, as identified in the analysis of past research. A survey instrument was employed to further validate the conclusions of the focus group. This research then assessed the frequency and severity of crashes based on the hazards, as identified and validated. This was accomplished by developing an assessment strategy based on the analysis of statewide crash data provided by the Iowa DOT. The essence of this approach was derived from the research conducted by Yong Bai (2007). The product of this assessment is a risk matrix that provides a quasi-quantitative understanding of the severity and frequency that a work zone hazard has on the risk of vehicle crashes.

The model application phase involved the application of the standard risk model through the use of the checklists, brainstorming cues, and the risk matrix tool in the identification and assessment of work zone hazards. These tools can be applied in much the same manner as conducted in the research for this report in a real-world scenario. In this research, the ultimate response to the potential risk of a vehicle crash in a work zone is mitigation (reduction). The identification of work zone hazards and the assessment and assignment of a risk score to each identified hazard aids in the prioritization of hazards requiring mitigation. A risk score is based on a combination of the relative frequency and relative severity of a hazard. A hazard with a high risk score or a high frequency or severity ranking requires a prioritized treatment (response) strategy. This was accomplished by responding to the hazard in the same way that the standard risk management model responds to risk: accept, reduce, transfer, or avoid. These responses were developed through the creation of hazard mitigation strategies for each phase of the project life-cycle. This was accomplished through the development of checklists generated from a focus group, surveys, and content analysis. During the content analysis, the mitigating source was identified in order to ascertain the phase of the project in which the mitigation strategy could be implemented; this concept is a contribution of this research to the risk management methodology for the mitigation of work zone crashes and fatalities.

RISK MANAGEMENT MODEL DEVELOPMENT

4.1 Introduction

This section will develop an Integrated Risk Management Program to be recommended for implementation by organizations and agencies that engage in construction activities. The concept of this program is generic but has been organized in such a way to give preference to the transportation industry and organizations that implement and administer transportation projects. An integrated approach to risk management suggests that there are multiple specialty groups, multiple levels of management, and multiple project phases that need to be bridged within the risk management model. In doing so, large/complex organizations or partnerships of multiple organizations will largely benefit from the formation of such a risk management program. However, the emphasis of this program is on communication and teamwork; therefore, regardless of the size or complexity of the organization, the following template for integrated risk management may be utilized and adapted by any organization interested in managing project risks.

Section 2 discussed in detail the project life-cycle for the general construction industry and the project development process typically utilized by state highway agencies. The model developed in this section will highlight the development of an integrated risk management approach (see Figure 4) that is intended to provide risk management expertise to a specific task or project phase while meeting the needs of the organization and providing and sharing information with stakeholders in different functional areas and project phases.

Contained within this section is the combination of best practices and recommendations that have been published by noted authors and organizations from the United States, the United Kingdom, and Canada. A comprehensive review and compilation of prior research and published procedures has resulted in the organization and development of a step-by-step process for agencies and organizations to develop and integrate a formal risk management approach into their existing management structure with minimal disruption to the organization. The key to the success of implementation of this program within an organization is dependent on the commitment from and involvement of senior levels of management. The flow of this section and the integrated risk management model will start at the corporate or senior level and continue through the development of organizational policy. It will then proceed to the selection of a risk management “champion.” This section will describe the characteristics of the risk management authority and will provide best practices for assigning the appropriate risk management responsibility primarily at the project level but also at the organizational level, depending on the needs of the organization. This model will then describe the need to include or develop the project definition. In most cases, the project definition is developed in the planning and programming stages; however, the project objectives and consideration are required for the management of risks identified in all phases of the project life-cycle. The project definition will provide the risk management team with information needed to control various project risks. This model will then apply the three-step standard model to each of the project phases. This process will involve the selection and implementation of a risk management team from a list of stakeholders for each project phase who are identified prior to applying the principles of the

standard risk management model. All information from each project phase is then documented, compiled, and shared at the senior management level. The information gathered from previous project phases is to be utilized to assist risk management teams in subsequent project phases. All information gathered during the application of the standard risk management model will be recorded and documented in a risk log or risk register. Finally, the risk management program will be evaluated and improvements to the program will be recommended.

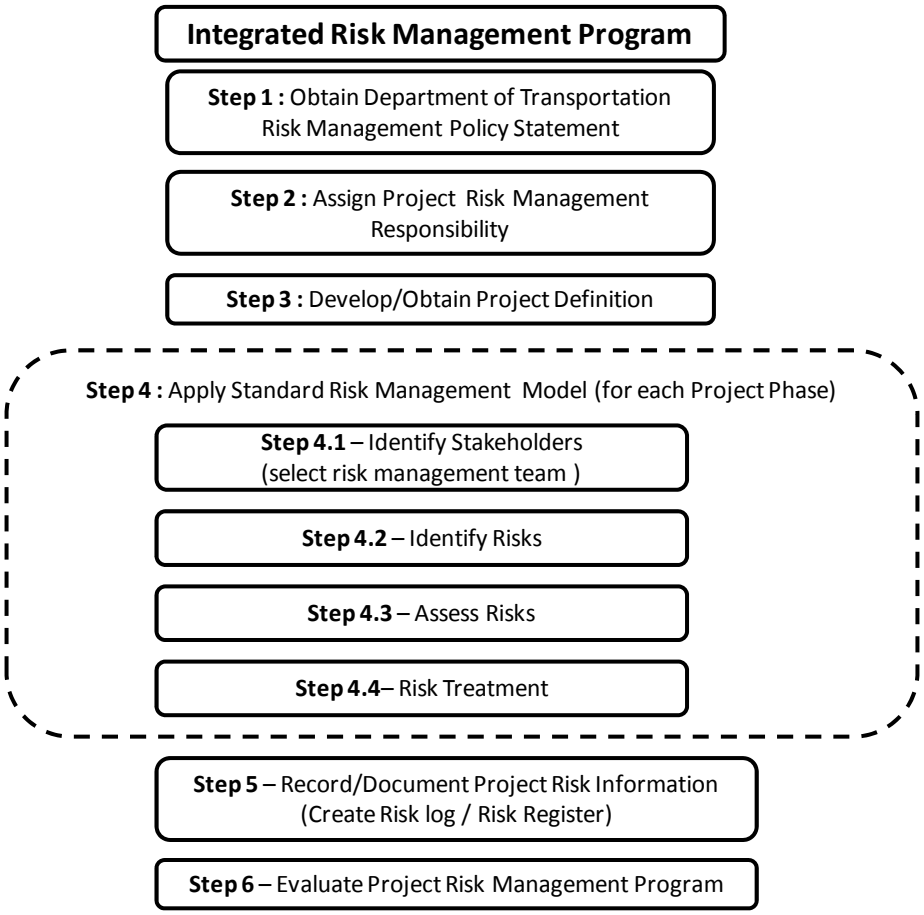

Figure 4. Basic model of the proposed integrated risk management program

The proposed template detailed in this section supplies the framework that must be in place within an organization in order to apply the integrated risk management program and processes. The model developed in this section details the required steps that must be undertaken in such an endeavor: obtaining a risk management policy statement, assigning risk management responsibility, developing a project definition, applying the standard risk model (identify risks, assess risks, treat risks), documenting project risk information, and evaluating the program. The remainder of this report will focus on the validation and application of the process through a detailed examination of the standard risk model step (Step 4) of the process.

RESULTS

5.1 Introduction

The purpose of this section is to utilize the methods described in the risk management model development process (Section 4) to identify, assess, and respond to specific risks, in particular the risk of vehicle crashes and fatalities in roadway work zones. Essentially, the scope of this research is to create a list of work zone hazards that can be identified during each stage of the project development process for a typical roadway project. Ultimately, the results of this section will provide a list of identified hazards for each stage of the project development process, develop a method to assess hazards utilizing crash data provided by the Iowa DOT, and provide a list of possible mitigation strategies for each of the identified hazards that may be implemented in each phase of the project development process. The results of this section are not intended to represent a specific roadway project; the intent is to utilize the standard risk management model for a typical highway project. In addition, this project and the processes and methodologies used focus on a single risk: vehicle crashes involving the traveling public in a work zone environment. Numerous other risks (e.g., work site safety not involving the traveling public, financial losses) may be associated with transportation projects and can be managed in the same manner; however, management of those risks remains outside the scope of this research. Thus, the following results utilize processes to identify hazards that increase the frequency and severity of vehicle crashes involving the traveling public in roadway construction work zones.

5.2.1 Focus Group Objectives: Risk Identification during Each Project Phase

This section was developed in order to identify the project phase in which a work zone hazard can first be identified, assessed, and treated. This was accomplished through the use of a focus group and was validated by an Internet survey. Prior to conducting the focus group discussion, a preliminary template was created for each project phase that identified activities performed in each phase, a tentative list of stakeholders or participants in each phase, a partial list of hazards that can be identified in each phase (this utilized the results of the content analysis), and a partial list (checklist/prompt list) of mitigation strategies for each phase. A group of industry experts was selected to participate in the focus group discussion that was lead by the primary investigator of this research. The focus group was given the following objectives:

1. Create the framework for an integrated risk management model
2. Identify activities, tasks, and considerations associated with each stage of a typical project
3. Identify stakeholders for each stage of a typical project
4. Create a checklist of potential hazards/risks (related to work zone accidents) that are typically associated with each stage of the project
5. Create a list of possible strategies to manage each of the identified hazards/risks for each stage of the construction project life-cycle

Appendix A shows the results of the expert panel discussion for each phase of the project development process. The results of the expert panel were compiled and developed into a survey

format that required respondents to agree or disagree with the statements pertaining to hazard identification during each stage of the project development process (planning and programming, design, letting and award, and construction). The online survey was intended to support the findings of the expert panel by asking a larger number of experts to state their opinions regarding the results of the expert panel discussions. Respondents were asked to identify their area of expertise, and the online survey directed them to the portion of the survey that represented each respondent's specialty area. Respondents were allowed to participate in only the portion of the survey that coincided with their area of expertise.

The information gathered during the literature review was instrumental in detailing the activities associated with each phase of the project life-cycle or project development process. This allowed the focus group discussion to concentrate on the hazards associated with each phase while limiting discussion to the activities associated with each project phase and to the stakeholders for each phase. Detailed information on project phases, activities, and stakeholders is provided in Section 2.

5.2.2 Focus Group Findings: State of the Practice and "Best Practices"

The findings from the focus group discussion have been provided in a narrative format for each project phase. The purpose of this format is to provide a state-of-the-practice overview for the current project development process, which resembles that of an "informal" risk management process. This will allow for the transformation of an "informal" program into a "formal" risk management process. In this section, the results of the focus group will be provided in terms of a narrative of the state of the practice for each project phase, the identification of the probable hazards associated with each project phase, and the mitigation strategies that may be implemented during each project phase.

The results from the focus group discussion facilitated the development of a list of hazards that are introduced to the project in specific project phases. In other words, some risks that are manifested in construction work zones are actually created or exacerbated by decisions made in the planning, design, or procurement phases. The focus group results also identified best practices for risk management and mitigation, which were then used to construct the survey instrument to validate and confirm the hazards noted by the expert panel. Once validated by the survey results, the findings served as the foundation for the development of the project hazards checklist. In addition, the hazards identified by the focus group participants were correlated with fields on the crash data reports to produce quantifiable measures for the frequency and severity of crashes associated with specific hazards. The quantitative analysis of crash data served as further validation of the expert panel findings.

The following section details the focus group findings as associated with each phase of the project development process, as defined by state highway agencies. While the primary focus of the group was in the identification of project phase-specific activities, hazards associated with each phase, and state of the practice mitigating strategies, future areas in need of research or innovation were also discussed.

5.2.2.1 Planning and Programming Phase

The activities of the planning and programming stage can be combined in an attempt to simplify the identification of hazards and the associated mitigating strategies. According to the expert panel focus group, the planning and programming stage can involve a full corridor approach or can be associated with smaller scale projects. The intent is to use this phase to identify potential hazards, regardless of the size and complexity of the project. Therefore, this stage is primarily focused on what to do with the existing traffic and the additional traffic associated with lane and road closures. Ultimately, this phase consists of go or no-go decisions. The decisions made in this phase will have a significant impact on the hazards associated with future project phases.

The focus group emphasized that during the planning and programming phase, decisions about traffic flow and traffic density are taken into consideration; these decisions are impacted by the size of the project, the volume of traffic, and local access needs. Therefore, traffic decisions depend on region and location of the roadway project. Traffic volume studies are performed in this phase in order to determine how many lanes of traffic must remain open to traffic during construction for the given situation.

During this phase, decisions are made as to whether or not to "build under traffic." This pertains to road construction and bridge construction/replacement that may require the need for contractors to work within traffic flow. The alternatives to building under traffic include providing a detour on site or providing an alternate route (detour) off site. The consensus of the focus group participants was that workers benefit most from a work area that is completely closed to traffic.

During the concept phase (planning and programming), decisions are made that may have an effect on local businesses and employers. It is in this stage that the external requirements are determined. Requirements posed by external entities such as the Highways for Life Program and the needs of local businesses may necessitate the need to accelerate the construction schedule. At this stage, planners should try to identify to the best of their capabilities how local needs will affect traffic. Adjustments to the construction schedule may be required based on these findings. This means that the contractor may be forbidden from working during certain events or is forced to perform on an alternative schedule (night construction, etc.). This may pose certain hazards for the work zone. For instance, when ramps are closed, access is limited, or when contractors are required to work at night, workers and the traveling public are placed at a greater risk of vehicle crashes. Therefore, for high-volume, high-speed projects, 23CFR630 Subpart J "Work Zone Safety and Mobility" is often utilized by stakeholders as a current state of practice when building under traffic.

Focus group participants felt that there is a need for a more formal process of addressing work zone safety and mobility when building under traffic. This research project provides such a formal process through the design and implementation of an integrated risk management process. Ultimately, decisions made during the concept phase (planning and programming) about traffic routes will eventually affect the safety of workers and the traveling public. When considering a bridge construction project, the first decision made by planners is whether or not to build under

traffic. This decision may require designers to phase construction that may force the traveling public into head-to-head traffic. However, in some cases, an option may be present that will allow designers to shut down the roadway in order to complete the construction project without traffic interruptions. Other decisions made in this phase may also affect safety. For instance, in order to minimize the length of the work zone, decisions may be made to keep the roadway open to traffic by allowing work to be completed in segments and opening each segment up to traffic before merging traffic down again in the next work area. This is discussed later in this section.

In addition to decisions about building under traffic, decisions as to material type such as portland cement concrete (PCC) pavement or asphalt cement concrete (ACC) pavement are also made. These decisions are not necessarily made in terms of managing construction risks (accessibility, duration, etc.); however, implementing the material selection process into the risk management model allows decision makers the ability to control the project duration, which takes the exposure of work zone hazards to the traveling public into consideration. The type of material, such as PCC or ACC overlays or full-depth replacement, is generally influenced by economics; however, material selection also affects traffic safety. When an overlay is effective in terms of strength and durability and it also reduces the construction duration, it can be considered a mitigating strategy.

The focus group panel identified additional traffic generation that comes from events, holidays, and seasonal travel/road use as a potential hazard during the planning phase. The Office of Traffic and Safety at the Iowa DOT has identified that the season/month of year and the time of day impacts traffic safety and the probability of crashes. To mitigate this hazard, the contractor may be forbidden from working during certain events or may be required to perform work on an alternative schedule (night construction, etc.). Typically, this needs be written into the contract during the final design and is re-introduced during letting to ensure that the contractor schedule is in agreement with specifications that recognize specific dates.

The members of the focus group felt that locating merge points in the construction project have a significant importance in the planning, design, and construction phases. It was the opinion of the participants of the expert panel that merge points in locations between work areas can pose significant traffic difficulties. For instance, in cases where a work zone is located some distance from the next work zone, experts debated the wisdom of opening up all lanes to traffic between the zones because of the difficulty of re-channelizing traffic into the second zone. Some experts felt that it would be easier to keep the motorists channelized for a longer period. This is an interesting debate, as researchers and authors have suggested that long stretches of work zone that do not appear to have any construction activity tend to become a hazard for motorists.

In the case of the construction of overhead structures and blasting, it was the view of the expert panel that it is desirable to completely close the work zone area to the traveling public through the use of detours and closures. However, in some cases, construction phasing must be designed for demolition work when building under traffic. This is especially true for bridge demolition projects when the route may need to be closed for a specific duration (evenings). An example of this type of phasing was the 2008 24th Street bridge replacement project in Council Bluffs, Iowa.

Many of these decisions are typically made early in the project, specifically in the planning and programming stage.

During the panel discussion about the planning and programming phase, speed limit in the work zone was identified as a hazard for all project phases. However, since speed is a policy issue, there is a need to retain flexibility throughout the project specifications in order to allow for adjustments for special conditions in the work zone. Another hazard that has recently received additional interest is the work zone hazard associated with oversized/permitted loads. These oversized loads have complicated the existing designs of work zones. For Iowa roadways, longer trailer assemblies hauling wind turbine components have become a difficulty in some work zones. The identified mitigation strategy in this case is to specify alternate routes for these permitted loads.

Contractor involvement and innovative contracting have been identified as potential mitigation strategies for work zone safety. The focus group expressed concern that, in general, the construction division is not as "involved" on larger projects as they are on smaller Iowa DOT projects. Also, a contractor selection process that includes past safety performance and the inclusion of a project management personnel that is responsible for work zone safety issues were identified as mitigation strategies.

The focus group also discussed intelligent transportation systems (ITS) as a mitigation strategy for work zone safety. This is accomplished by establishing an integrated work zone that addresses existing traffic conditions on a real-time basis with the work zone traffic control design.

5.2.2.2 Design Phase

During the focus group discussion, the preliminary design, design development, and the final design phases were discussed separately. However, this narrative will combine the results of the expert panel in order to emphasize that many tasks and hazards may be identified throughout the design process, and it may prove to be more beneficial to include all hazards pertaining to the design phase into one section. As mentioned in the literature review, the bulk of the traffic control design and specifications pertaining to the work zone is typically conducted in the final design stage; however, it would prove beneficial if many of these hazards and mitigation strategies could be identified throughout the design phase, especially earlier in the design phase.

The preliminary design phase concentrates on the constructed facility. However, initial constructability is also evaluated in this phase. Depending on the size and complexity of the project and the scope of work, an engineer may or may not be assigned or dedicated to a particular project; as such, the decision-making typically done in this phase may be of limited scope. The focus group of industry experts emphasized that one must be sure to recognize that the project development process is evolutionary, which means that decisions made upstream will affect actions downstream and should be re-evaluated at each project phase. The challenge to this paradigm is that design details need to be made based on earlier decisions from the planning and programming phases, and this can pose certain design challenges. This justifies the need for a

risk management program that operates throughout the various project phases to minimize such discrepancies.

During the final design phase, the final details of the constructed facility are formalized. In this phase, the alternate routes and detours are evaluated in greater detail. It makes sense that the traffic control plans are established once the permanent structure is in its final design stage. This means that the general alignment of the permanent structure has been determined and only temporary traffic measures need to be analyzed and designed.

Members of the expert panel emphasized that the process of risk management needs to look at risk throughout the whole project life-cycle. For instance, a decision made early in a project about the use of an alternate route may not, in fact, turn out to be the best route. In a case such as this, mitigating strategies should be available to allow for compensating for subsequent decision making based on new information. In addition, decisions relating to traffic flow have typically been made after the general arrangement of the construction project has been determined, but focus group participants felt that traffic flow issues need to be addressed earlier in the planning process. Also related to traffic flow are concerns about the direction, location, and flow of construction vehicle traffic. A risk management process that is incorporated into the entire project life-cycle will address the probable location and flow of construction materials being brought to the site prior to awarding the project to a contractor. Also, being aware of hazards and mitigating strategies throughout the project life-cycle will limit the number of instances where DOT personnel will be required to adjust and mitigate an in situ traffic problem.

The focus group identified *interaction points*—locations where construction traffic joins the proximity of regular traffic—as work zone hazards. The identification of the interaction points with the traveling public and pedestrians tend to take place in the design phase but should also be considered in the concept phase. Designers and decision makers need to determine when and where these points come together. Designers must also consider Americans with Disabilities Act (ADA) requirements at these locations. With contractor involvement, designers can make design decisions that effectively integrate the contractor's probable work plan. According to an industry expert, "sometimes you restrict construction work to a specific area to limit contractor exposure and use flaggers to keep pedestrians in line." Although the actual mitigation of the interaction points hazard may occur at the construction phase, it needs to be addressed in the design phase.

Several mitigation strategies were identified as associated with the design phase:

Contractor Involvement and Constructability. During the focus group discussion, contractor involvement and constructability reviews were identified as mitigation strategies for work zone hazards. During this process, the contractor responsibilities were also discussed. Contractors need to be involved when considering the constructability of the sequence of work; they need to be involved in an overall project safety responsibility program, and they need a voice in determining what construction allowances are available to ensure that the contractor is given enough time to complete the project. Also, the contractor needs to be involved in understanding and developing the communication needs within the construction team. Some special considerations that the contractor needs to be aware of during the design process include

locations of construction traffic staging areas, locations of borrow pits, and contractor access points. Often, these issues are under the contractor's influence and need to be considered in the overall project process. As part of the bidding process, it may be desirable to specify that the contractor have a safety person on staff for the project, that there is an early and continuous communication plan in place, and that there is a framework for reporting unsafe actions or near misses. In general, the contractor selected for a project should be aware that safety is everyone's job and general responsibility.

Design Details/ Size and Complexity of Project. One issue that expert panelists discussed was the practice of using generalized standard details on projects without consideration for project specifics, such as size and complexity. In fact, the question was raised, "Do smaller projects have a higher percentage of work zone crashes?" It is understood by the expert panel that in terms of roadway design, the general policy is to use standards even though it may not make sense for a given project geometry and topography. This could lead to unnecessary hazards in the project construction. Therefore, a mitigating strategy is to start looking at design projects differently on an individual basis, with less emphasis on standardized details.

An area that the focus group participants felt needed more specifications in order to mitigate work zone hazards was in specifying a "safe" height for drop-offs in pavement milling jobs when building under traffic conditions.

Falling Debris. For more complex projects, the sequencing and phasing of traffic required to mitigate falling debris in projects involving overhead structures can be noted in the concept phase but can also be re-assessed in each of the following stages, particularly in the design phase.

Driver Confusion/Unfamiliarity/Skills. During the focus group, a detailed discussion was engaged about mitigation strategies that could be used to limit driver confusion. In general, an accepted mitigation strategy involves channelizing the motorists in such a way that there is no choice or thought required by the motorist as to which route to take. The belief among the focus group participants was that the less reading for the driver, the better. Making the traffic barriers and markings move the traffic without effort from the driver is considered a good practice. Driver/operator unfamiliarity with the work zone needs to be considered a hazard that can cause motorists to become confused, leading to potential crashes. The focus group participants felt that project-specific awareness initiatives could mitigate against driver unfamiliarity. A current mitigation strategy to bring about project awareness involves work zone initiatives programmed a year or so out to begin educating the public and providing press releases that are given to local press venues following the letting process.

During the discussion, "driver skills" was identified as a work zone hazard that could be identified during all phases of the project. The expert panelists felt that, as a whole, driver training processes have been losing ground and that programs focused on such efforts have failed. More innovation in driver training, especially concerning the work zone environment, is needed.

Traffic Control. The panel participants also discussed the need for continuity of traffic control when there is a multiple prime in general proximity. Many times, traffic control is applicable to the needs of the contractor who has originally designed and placed the traffic control; however, this traffic control may or may not be in concert with the needs and objectives of the other contractors. Therefore, more general oversight is needed in order to ensure continuity of the traffic control. One way to mitigate against this hazard is to work out solutions in contract language or by bid items for changes to traffic control.

A consensus of the focus group participants revealed that during the design phase, risks arising from inadequate traffic control can be best mitigated by the following: pavement marking design, construction traffic considerations (involving early contractor involvement), consideration of an out-of-distance program (targeting a specific hauler or trucking company with information or incentives concerning avoiding or restricting their use of the area under construction) to reduce traffic from carriers, specifications for signage, traffic control, enforcement, specifications for flagger training, and adjustable speed limit specifications. In addition to specifications and designs, the focus group discussed the need to identify potential hazards/problems associated with alternate routes and detours from the perspective of as many qualified individuals as possible by actually driving the routes.

The focus group also identified the type of contract as a possible mitigation strategy. For instance, an itemized bid versus a lump sum contract may be utilized in order to administer adequate and relevant work zone traffic control. Since it is difficult to incentivize and penalize for work zone safety, a possible mitigation strategy against inadequate traffic control is for the DOTs to make the process easier for contractors to make changes to the standard design once the contract has been awarded. Flexibility provided in the contract will allow innovation to be applied rapidly.

The panel identified the lack of positive protection for workers within the work zone as a potential hazard. Therefore, the industry professionals from the focus group identified the following as possible mitigation strategies: specify the ingress and egress of work area, specify law enforcement, specify separate pay items for traffic safety, and specify high-visibility apparel for all stakeholders. Many of these strategies are required on federally funded projects, but the mitigation strategies should be required for all projects based on the risk assessment.

5.2.2.3 Letting and Award Phase

Outside of incomplete plans and the general lack of contractor safety training, the focus group expressed particular concern over the contract period to ensure that the construction start date and the contract start date coincide so that the work zone is not set up a long time before construction actually begins, as this could result in hazards from confused or inattentive drivers. In addition, from the perspective of the focus group, roadway projects typically lack adequate overall project management. Currently, in situations where there is more than one concurrent project in the same general proximity, the resident engineer typically retains project responsibility. It was the view of the focus group participants that contractor fines and sanctions for non-compliance to safety requirements and infractions would serve as mitigation strategies

for contractor safety violations. In was the belief of focus group participants that in most cases, the low bid contracting method does not incentivize contractors for safety.

Other concerns come in the form of contractor selection. The focus group felt that contractors should be prequalified based on safety records and that they should be evaluated based on their safety performance on past projects. Since traffic control is essentially the contractor's responsibility, the expert panel felt that in order to ensure that the contractor is proactive, a mitigation strategy would involve issuing fines for inadequate traffic control. The focus group also felt that there should be increased levels of sanctions for safety infringements. They felt that the contractor needs to have more ownership for on-site safety and surveillance. In the case where construction is spread over more than one construction season, the focus group participants felt that there must be provisions for interim phase coordination for signage during project transitions.

5.2.2.4 Construction Phase

Ultimately, everything identified as a potential hazard in the earlier project phases will be realized during the construction phase. This is especially true if the hazard was identified but not explicitly mitigated at an earlier phase.

Some specific issues and mitigating strategies encountered in the construction phase include

Driver Skills. During the discussion, the topic of driver characteristics came into play. It was noted that although driver characteristics are an important aspect of risk management hazard identification, there is very little that can be done to mitigate the problem. According to the focus group, many initiatives have been employed to shape driver characteristics, but in general, driver skills and knowledge have worsened over the years due to a decreased ability to understand English, increased cell phone usage, and increased poor attitude. Driver education programs have been removed from the public school systems, thereby allowing less opportunity to educate younger drivers. The current situation for license renewal requires a fee and a vision check; little is done to create a positive method to educate existing drivers. This is one area where innovative strategies could be designed and implemented to mitigate this particular hazard.

Signage. Several mitigation strategies were suggested by the focus group participants to deal with hazards involving inadequate signage. One strategy involves the removal of signs that are not credible or simply do not apply to the situation. If work zone signs are posted and there is no activity, to the motorist, the sign is not credible and ultimately becomes a hazard. The focus group emphasized the use of multiple devices to get the attention of motorists. It was felt that limiting the number of signs that must be read by a motorist by employing a simple changeable message targeted directly at the motorist may be most effective. This simple message could be effectively followed up with channelizing devices (jersey barriers, flashing arrows, etc.). Other important hazard mitigation strategies involve ensuring that signs are clean and serviceable and ensuring that tapers follow the updated MUTCD. Another suggested mitigation strategy includes alerting the motorist early, prior to the point in which a decision must be made. It was suggested that this is best accomplished with a changeable message sign (CMS) that is effective in

providing the most up-to-date pertinent information. The CMS should be followed with flashing arrows. Simplicity was stressed by the participants, as too many traffic devices could serve as an additional hazard by confusing motorists.

Visibility. To ensure that visibility is not an issue in the construction phase, focus group participants suggested that portable light sets be positioned in such a way to minimize glare and blinding of motorists and that visibility of workers is ensured by enforcing the wearing of high-visibility apparel, as specified in contracts.

Work Zone Length. A mitigation strategy that was suggested for reducing hazards associated with congestion in the work zone is the concept of lane rentals by the contractor. In order to prevent contractors from utilizing more roadway than is absolutely necessary, it was recommended that contractors pay for lane rentals per unit of road taken from the travel lanes. This will reduce congestion in the travel lane, thereby reducing the hazard associated with traffic congestion.

5.2.3 Survey Results

An online survey was created using the results of the focus group discussion. The hazards identified during the focus group were tabulated, as shown in Appendix A. The hazards identified during the content analysis and by the focus group participants were placed according to the project phases in which they were likely to be relevant and addressable, according to the interpretations of the individuals involved in the process. The purpose of the survey was to validate the findings of the expert panel and to ensure that the interpretations of the researcher were in general agreement with the views of industry professionals.

Essentially, 39 hazards were identified throughout the process. Ten hazards were identified during the planning and programming phase, 26 hazards were identified during the design phase, 15 hazards were identified during the letting and award phase, and 30 hazards were identified during the construction phase. The compilation of the results from the survey validation process is presented in table format in Appendix B and displays the 39 hazards, the respective assessment number, and the project phase with which the hazard should be identified. A marker was chosen to signify the project phase in which the identified hazard would originate. The results of the survey are reported in such a way as to show the level of agreement from the survey respondents. For instance, if all respondents agreed with placing an identified hazard in a particular project phase, that hazard would be represented by a large filled circle. If more than 50% agreed, the hazard would be represented by a circular marker with a small dot in the center. If less than 50% agreed, the hazard would be represented by an empty circle. Write-in responses are represented by an empty circle with a dashed outline. If none of the respondents agreed, no mark would have been utilized; however, there were no hazards that had 100% disagreement. It is, however, noteworthy that 16 of the hazards had 100% agreement in at least one project phase. Also, respondents for six of the hazards had 50% or more disagreement in at least one project phase. And one hazard (#28 poor driver skills) had 80% disagreement (20% agreement) in one project phase. This is likely because practitioners feel that “poor driver skills” should be identified somewhere outside of the project development process.

5.3 Assessment of Crash Data

In the following sections, the 39 hazards are evaluated to determine the ability to assess the frequency and severity that a hazard may pose on the risk of work zone crashes and fatalities. Of the 39 hazards, 22 were deemed to be closely represented by fields within the statewide crash database that was created from a compilation of accident reports prepared by investigating officers. A later section will detail the research approach and findings of the assessment of these hazards. Following a discussion of the assessment of these risks, attention will return to the mitigation of the risks associated with each hazard. The results of the expert panel, as described in the previous section, highlight the mitigation strategies that may be implemented in each project phase. Later, this section formalizes the results from the content analysis and develops a method of identifying mitigation strategies based on the stakeholder's ability to manage the risk and the project phase that may provide the most effective method to implement the mitigation strategy.

In the following section, the identified hazards from the focus group study and the survey were integrated, assessed, and quantified using data from the Iowa statewide crash database. The Iowa crash database was queried to list data pertaining to work zones crashes, as documented on the investigating officer's report. The integration of this information provides a methodology that can be utilized to employ actual crash data in providing a quasi-quantitative assessment of each hazard as identified in the previous section of this research.

In order to obtain descriptive statistics to describe the overall occurrence and severity of Iowa work zone crashes, a query was created to gather data for all severity levels of crashes from the year 2001 to 2008, as provided in the Iowa DOT Saver Crash Data from the Office of Traffic and Safety. The data from 2008 was preliminary and may not be fully inclusive of all crash data for that year but was included in this research because partial data concerning crashes most likely represents a level of randomness required for a representative data set.

As shown in Table 1, 5,405 crashes occurred in work zones from 2001 to October 2008, as indicated in the data extracted from the statewide crash database. The severity of each crash is as reported on the Iowa DOT "Investigating Officer's Report of Motor Vehicle Accident" (see Appendix C). This table shows the total number of crashes for each severity level: fatal, major injury, minor injury, possible/unknown injury, and property damage only. The data show that 1% of all of the total crashes resulted in fatalities, approximately 4% of all crashes were serious injury crashes, 11% were minor injury crashes, 19% were possible or unknown injury crashes, and approximately 65% were property damage only crashes (see Figure 5).

Table 1. Iowa statewide work zone crash statistics: total number of crashes (2001–2008*)

Year	No. of Fatal Crashes	No. of Serious Injury Crashes	No. of Minor Injury Crashes	No. of Possible/ Unknown Injury Crashes	No. of Property Damage Only Crashes	Total Crashes
2001	8	9	44	74	222	357
2002	6	21	77	110	331	545
2003	6	25	75	143	515	764
2004	7	34	72	151	588	852
2005	7	31	98	176	527	839
2006	1	26	88	161	464	740
2007	5	28	56	111	439	639
2008*	7	27	69	135	431	669
Total	47	201	579	1061	3517	5405

*data from 2008 is preliminary and may not be all-inclusive

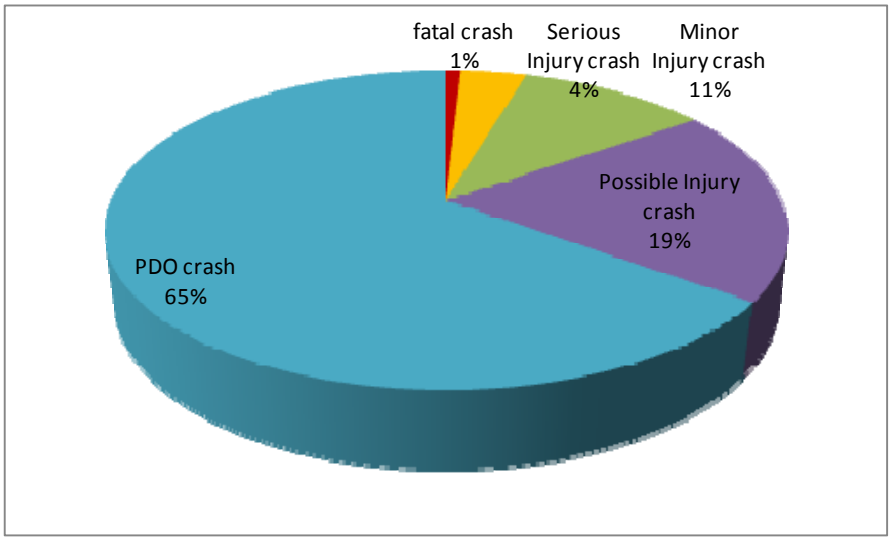

Figure 5. Statewide work zone crash severity distribution: total crashes (2001–2008)

This research analyzes data that include the total number of vehicles involved in each of the crash severity levels. The purpose for including the total number of vehicles involved in a crash is to capture the characteristics of all participants in the crash event and to fully capture the characteristics and trends relating to crashes. When multiple vehicles are involved in a crash, the aggregate of the characteristics of each vehicle/driver may determine the severity of the crash. Crash severity level is determined by the most severe outcome for the crash-wide event, as indicated by the severity field (denoted by "CSEVERITY" in the database).

Table 2 shows that a total of 10,369 vehicles were involved in work zone crashes from 2001 to October 2008. A comparison of Table 1 and Table 2 reveals that, on average, approximately two vehicles (10,369 vehicles / 5,405 crashes = 1.9 veh./crash) were involved in each crash. This

shows that each vehicle provides at least some contribution to the frequency and/or severity of every crash. The remainder of this section will focus only on the total number of vehicles involved in every type of crash. This will provide a larger data set to analyze and will provide more value in ascertaining the extent to which each identified hazard contributes to the frequency or severity of vehicle crashes in work zones.

Table 2. Iowa statewide work zone crash statistics: total vehicles involved in crashes (2001–2008*)

Year	No. Vehicles involved in Fatal Crashes	No. Vehicles involved in Serious Injury Crashes	No. Vehicles involved in Minor Injury Crashes	No. Vehicles involved in Possible/ Unknown Injury Crashes	No. Vehicles involved in Property Damage Only Crashes	Total No. of vehicles involved in Crashes
2001	23	18	96	157	416	710
2002	17	52	174	250	663	1156
2003	9	39	130	294	988	1460
2004	11	68	150	306	1141	1676
2005	11	52	178	347	988	1586
2006	2	46	166	308	908	1430
2007	7	46	88	210	795	1146
2008	13	47	119	263	763	1205
Total	93	368	1101	2135	6672	10369
%	0.90	3.55	10.62	20.59	64.35	

*data from 2008 is preliminary and may not be all inclusive

Figure 6 reveals that the work zone crash severity distribution of the total vehicles involved in crashes is very similar to the severity distribution of the total crashes. Of the total vehicles involved in work zone crashes, 1% were fatal crashes, 3% were major injury crashes, 11% were minor injury crashes, 21% were possible/unknown injury crashes, and 64% were property damage only crashes. Notably, a combination of fatal and serious injury crashes make up nearly 4% of all vehicles involved in crashes.

Ultimately, it is the severity distribution of all vehicle crashes that will be utilized to determine the relative severity of each of the identified work zone hazards; therefore, since the severity distribution of the total number of crashes was nearly the same as the severity distribution of the total number of vehicles involved in crashes, assessing the hazards using the data for all vehicles involved in each crash provided the greatest amount of sensitivity to the characteristics of the factors that impact the frequency or severity of work zone crashes.

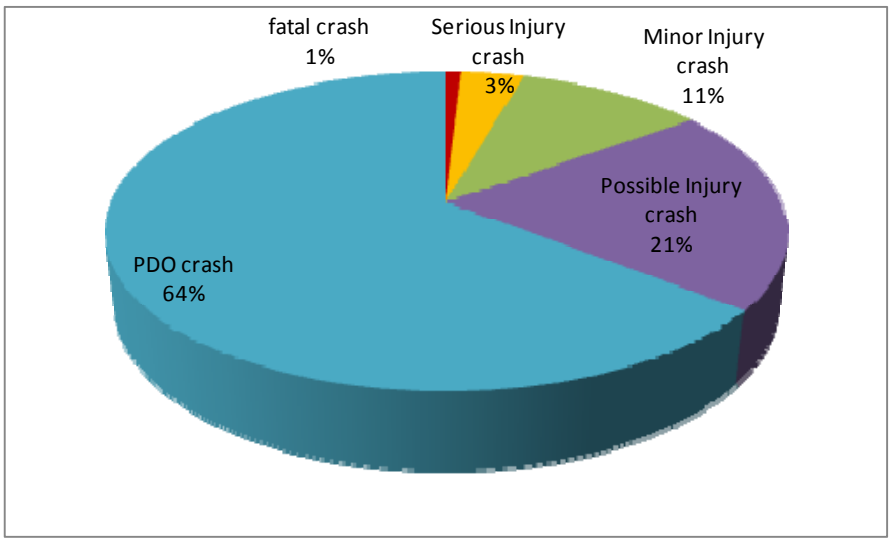

Figure 6. Statewide work zone crash severity distribution: total vehicles involved in crashes (2001–2008)

5.3.1 Selection of Hazard Assessment Metrics

Considerable effort was undertaken in correlating the risk assessment of the identified work zone hazards to the collection of relevant crash data in order to provide the most applicable representation of the hazard as it pertains to the many coded entries on the investigating officer's report. Appendix C provides a copy of Form 433033 from the Iowa DOT "Investigating Officer's Report of Motor Vehicle Accident" utilized by the responding officer. It is this report and the accompanying codes and description of driver characteristics, vehicle characteristics, road characteristics, operating environment, and work zone condition, as described in the previous section, that provided the basis for assimilating the data. Unfortunately, the report is formatted to accommodate the investigating officer and not necessarily the transportation researcher; therefore, the factors that influence the crash are not explicitly listed on the report form. Therefore, great care was taken in order to extract the most applicable data field variables that can most closely represent the underlying concern of the identified hazard. This process was shown to be the most exhaustive component of the risk analysis process. Some researcher judgment was required to align an identified hazard to the available data variables of the crash report. However, the intent of this research is to develop a methodology that can be utilized to formalize the risk management of work zone crashes and fatalities with the understanding that the nature of risk management depends on the ability to standardize the approach to managing risk. Therefore, the decision-making process must take into account the limitations of the data, while at the same time providing a reasonable correlation between the identified hazard and the data variable(s).

As discussed in the previous section, upon listing potential risks or hazards during the risk identification process, the risk should be classified or grouped in order to aid the analysis and risk response functions. During the analysis of work zone hazards, it was determined that there are essentially five groups or factors that influence the rate and severity of work zone crashes: driver characteristics, vehicle characteristics, road characteristics, operating environment, and

work zone condition. Through the use of these factors or group classifications, several of the fields on the investigating officer's report were grouped for the purpose of correlating the correct factor grouping of identified hazards with the appropriate field in the accident report. The field names and values for the database are provided in Appendix D. Table 3 displays the grouping of these data fields.

Table 3. Grouping of data fields from accident report data for work zone crashes

Grouping /Factor	Data Field – (crash data)	Field Description
Driver characteristic	DCONTCIRC1 & DCONTCIRC2	Contributing Circumstance - Driver
	DL_STATE	Driver's License State
	SEQEVENTS1	Sequence of Event 1st Event
Road characteristic	RCONTCIRC	Contributing Circumstance - Roadway
	ROADTYPE	Type of Roadway Junction/Feature
Vehicle characteristic	CARGOBODY	Cargo Body Type
	VCONFIG	Vehicle Configuration
Operating environment	WEATHER1 & WEATHER2	Weather Conditions
	LIGHT	Light Conditions
	VISIONOBS	Vision Obscurement
	NM_ACTION	Non-Motorist Action
	TIME	Time of Crash
	DAY	Day of week
	MONTH	Month
Work zone condition	WZ_TYPE	Work Zone Type
	WZ_LOC	Location
	TRAFCONT	Traffic Controls
	SPEEDLIMIT	Posted Speed Limit

For some of the identified hazards, the data fields were combined in order to properly categorize the risk. For instance, "construction vehicle traffic" was identified as a work zone hazard by the focus group/survey instruments. However, in the crash reports, data were grouped by both roadway condition and vehicle type. Therefore, in the query, only when the conditions "construction work zone" and "cargo body vehicle" (since construction vehicles are identified by the cargo body) were both met was the assumption made that the hazard of "construction vehicle traffic" was present. The data field for the cargo body was combined with the data field for the roadway contributing circumstance with the value corresponding to work zones. For example, vehicles with construction-type cargo bodies involved in crashes that have been reported as work zone-related, roadway-contributing circumstances infers that the combination of these two fields will yield a condition for assessing construction vehicle traffic. For this research, only the data

fields for construction vehicle traffic were combined to represent a specific condition; all other hazards were represented by only one data field.

In some cases, it was necessary to represent a hazard that has been grouped in one classification by a data field that has been grouped in a different classification. For instance, “traffic congestion and delay” was identified as a work zone hazard, according to the focus group/survey instruments; however, under the classification “operating environment” on the crash report, there is no entry for traffic congestion. Therefore, it is assumed that evasive action (presumably from stop-and-go traffic) best represented the conditions of the hazard. However, evasive action is classified as a “driver characteristic” on the crash report and not “operating environment.” This research qualifies that engineering judgment must be implemented in cases where the crash report may not explicitly represent identified hazards. The concept of the research is to develop the best approach to assessing hazards. Hazards assessed within the confines of objectivity based on basic assumptions are preferred to qualitative assessment based on “best guess.”

5.3.2 Database Queries and Data Analysis

The data for this research were provided by the Iowa DOT in the form of statewide crash data from the years 2001 through October 2008. The work zone data were compiled by Dr. Michael Pawlovich of the Iowa DOT from a larger statewide database. The data compiled by Dr. Pawlovich include only crashes from work zones and were pulled from a database of all types of crashes occurring statewide. This data were provided in the form of a database file, or .dbf. Microsoft Access was utilized to design queries that extracted data from the database from specific data fields, as provided on the motor vehicle accident report. In all, over 2,400 queries were designed to extract data from the 2001 through 2008 database files. For each query, specific fields were identified and parameters were specified based on the desired output. The general requirements for each query were crash severity, vehicle number (the number given to each vehicle crash-wide), and the field(s) of interest that best represent(s) the identified hazard.

Queries were performed to count the number of crashes in the eight-year period for each of the five crash severity levels (fatal, major injury, minor injury, possible/unknown injury, and property damage only) that correspond to the data field that best represents the identified work zone hazard. This process allowed for the assignment of a risk score to each of the queried hazards.

5.4 Risk Assessment

The risk assessment tool created from this work is intended to provide a quasi-quantitative guide to risk assessments based on quantitative data provided from a statewide crash database. In the previous section, the statewide crash database was queried in order to provide descriptive statistics of crashes that possessed characteristics similar to the hazards identified in the first part of this section. The purpose of the descriptive statistics was to evaluate the severity and frequency of vehicle crashes with specific characteristics. In this section, the severity and frequency of those crashes will be normalized against all statewide work zone crashes in order to

get a relative comparison of crash severity and frequency that a particular hazard poses on a work zone.

The tool that was chosen to best apply to a qualitative assessment of work zone hazards is the risk matrix (see Figure 7). The risk matrix is a two-dimensional representation of crash frequency and severity, with specific characteristics (hazards) that are associated with the crash.

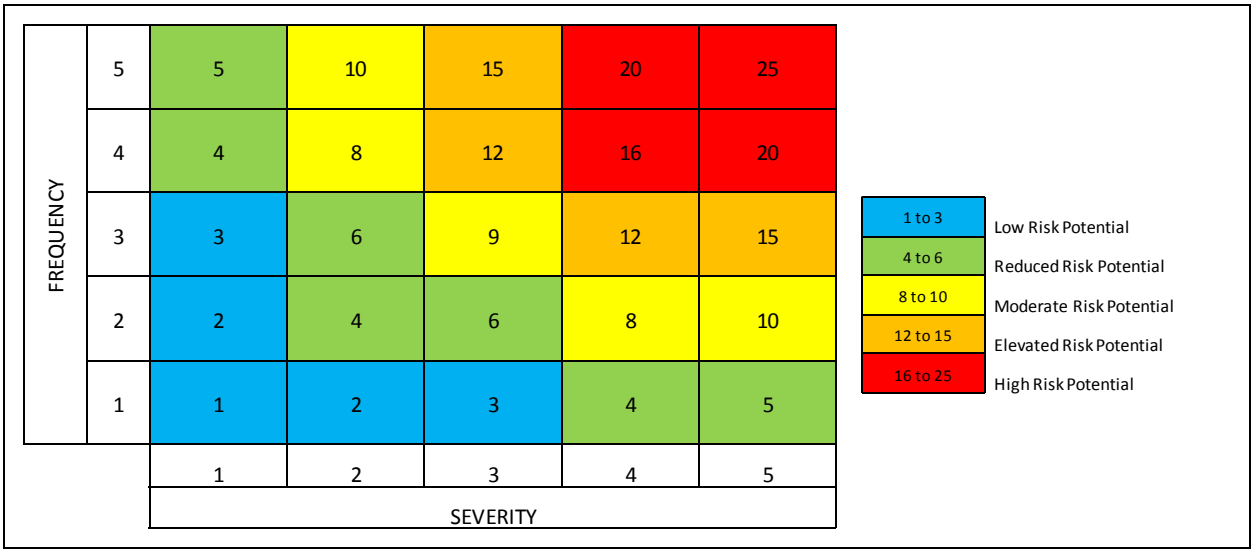

Figure 7. Risk assessment matrix

This section will develop a process that converts the crash frequency and severity to characteristics that best reflect the identified hazards in the first phase of this research in order to rank the relative importance of each work zone hazard. In the subsequent sections, the frequency and severity of the crashes will be normalized in order to ascertain the relative severity distribution of each hazard with respect to the severity distribution of all work zone crashes. This is accomplished through formulating an average crash severity ratio and then ranking that ratio on a scale from 1 to 5, as shown on the horizontal axis of the risk assessment matrix. The relative frequency of the vehicle crashes with characteristics that best reflect each identified hazard was developed by dividing the total number of crashes that best represent that hazard by the sum of all statewide work zone crashes included in this study from the crash database. The relative frequency was then plotted on a scale from 1 to 5, as shown on the vertical axis of the risk assessment matrix.

5.4.1 Assessment Matrix Conclusions

The results displayed in the tables included in Appendix E should be used in conjunction with the two-dimensional matrix in Figure 7 above. For the frequency and severity rankings, any risk that was assessed as a 5 was color-coded red in order to provide a “red flag” for the risk management team. Also, since the “typical” crash is assigned a three in both severity and frequency, it was determined that a combined risk score of nine is considered a moderate risk. This means that risk scores greater than nine are considered a higher risk, and anything lower

than nine is a lower risk. The risk matrix displays a band through the middle and assigns a moderate risk category to risk scores between eight and ten. Therefore, for this research, any risk score greater than ten has been highlighted in order to bring attention to the associated hazard. In the risk score column of the tables in Appendix E, the cell containing the risk score has been filled if the score was greater than ten.

Six hazards have been assessed with a severity score of 5 (none of the hazards scored a 5 in frequency). Listed are the six hazards receiving a 5 for a severity score:

- Dark conditions/roadway not lighted
- Poor driver skills (aggressive driving)
- Poor visibility of workers
- Railroads
- Posted speed through the work zone (65 mph)
- Traffic speed and speeding (exceeded authorized speed)

However, 16 hazards were identified as having a combined risk score greater than ten:

- Driver/operator unfamiliarity
- Inadequate/confusing traffic control (no controls present)
- Lane closures
- Lane shift/crossover (head to head)
- Commercial trucks
- Dark conditions/roadway not lighted
- Poor driver skills (operator error)
- Points of merge
- Posted speed through the work zone (65 mph zone and 50–60 mph zone)
- High-risk traffic (Wednesdays, Thursdays, and Fridays)
- Seasonal road use (June, July, and September)

According to the logic and methodology of this research, these hazards should be determined to have priority when mitigating work zone hazards.

This section utilized the methods described in the risk management model development process (Section 4) to identify, assess, and respond to specific risks, in particular, the risk of vehicle crashes and fatalities in roadway work zones. The results of this section provided a list of identified hazards for each stage of the project development process, developed a method to assess hazards utilizing crash data provided by the Iowa DOT, and provided a list of possible mitigation strategies, which is included in Appendix F, for each of the identified hazards that may be implemented in each phase of the project development process. Of the 39 hazards that were identified, 22 were assessed and quantified using data from the Iowa statewide crash database for work zones. A combined risk score was determined by multiplying the severity ranking and the frequency ranking on the two-dimensional risk matrix. The section concluded with the identification and listing of mitigation strategies for all phases of the project

development process. The results have chronicled the existing state of the practice of crash mitigation that will serve as the first step in establishing a formal risk management program.

CONCLUSIONS

6.1 Introduction

The goal of this research was to develop a method with which to mitigate work zone crashes and fatalities. This was accomplished through the creation of a formal risk management model that can be utilized during the construction management and administration of highway projects for all stages of the project life-cycle. This effort resulted in the development of an integrated risk management model, as discussed in Section 4. This research consequently focuses on the standard risk management model for the identification, assessment, and response (treatment) of hazards that may increase either the frequency or severity of a vehicle crash in a work zone. The results of this research are presented by the three components of the standard risk management model. The first phase of this research was the identification of risks, the second phase was the assessment of risks, and the third phase was the identification of possible mitigation strategies. The tasks of the first and third phases were accomplished through the use of a comprehensive literature review, content analysis of papers and articles, a focus group discussion, and Internet surveys for identifying work zone hazards and mitigation strategies. The tasks of the second phase were accomplished through the analysis of work zone crash database information and the development of a unique tool that allows for a qualitative assessment of hazards using quantitative data.

The following sections will discuss the findings of the three phases of this research, make observations and recommendations based on these findings, and discuss future research goals pertaining to work zone crash mitigation and the management of construction industry risks.

6.2 Risk Potential

The following section will discuss the results of the survey that was conducted during the identification of hazards phase and its comparison to the results of the database analysis. In order to prioritize the mitigation of potential hazards, the concept of “risk potential” must be explored. During the hazards assessment phase, a two-dimensional risk matrix approach was developed in order to ascertain the relative frequency and severity of a specific work zone hazard (see Figure 7). The risk matrix assigns a risk score to each hazard based on the product of the relative severity and relative frequency of a hazard. In Appendix E, assessed hazards are assigned a severity rank, a frequency rank, and a risk score. Any risk/hazard that was given a rank of 5 in severity or frequency was color coded in red to signify the need for an urgent response. Also, a hazard that received a risk score of 12 or greater was color-coded in orange or red to signify the need for an urgent or immediate response, respectively. All other hazards were not color-coded. However, it should be noted that any hazard that received a risk score between 8 and 10 poses a moderate risk and should be given considerable attention when managing risks. Also, for this research, any hazard that received a ranking of 5 in either frequency or severity suggests a high severity or high frequency that would also pose a moderate risk of work zone crashes.

The following sections provide a breakdown of the risk potential of a hazard.

6.2.1 High Risk Potential

According to the precepts of this research, any hazard that received a risk score of 16 or greater is in need of immediate risk attention. These hazards pose the greatest risk of vehicle crashes and fatalities in the work zone. Immediate attention must be made by all stakeholders during all phases of the project development process.

6.2.2 Elevated Risk Potential

For this research, any hazard that received a risk score between 12 and 15 is in need of urgent risk attention. These hazards pose an elevated risk of vehicle crashes and fatalities in highway work zones. Urgent attention must be made by all stakeholders during all phases of the project development process.

6.2.3 Moderate Risk Potential

Any hazard that was given a ranking of 5 in either severity or frequency according to this research is considered a moderate risk, and further attention should be given. All hazards that received a risk score between an 8 and a 10 should also be considered a moderate risk because the numerical combination of severity and frequency suggests that the hazard possesses a risk of a vehicle crash that is of the same distribution of all work zone crashes. Since the goal of this research is to reduce (mitigate) accidents and fatalities in work zones, any hazard that has been assessed between an 8 and a 10 must receive priority attention by all stakeholders during all phases of the project development.

6.2.4 Reduced Risk Potential

For this research, any hazard that received a risk score between 4 and 6 is in need of some risk attention. These hazards pose a risk of vehicle crashes and fatalities in highway work zones. However, the risk potential is slightly less than a “typical” hazard. Reasonable attention must be made by all stakeholders during all phases of the project development process.

6.2.5 Low Risk Potential

There really is no acceptable level when it comes to the risk of vehicle crashes; however, when evaluating hazards on a relative scale, some of them carry a lower risk potential on the scale of hazards. Therefore, for this research, any hazard that received a risk score of 3 or lower poses a lower risk of vehicle crashes and fatalities in highway work zones than a “typical” hazard. Reasonable attention must be made by all stakeholders during all phases of the project development process.

6.3 Findings

This section will deal specifically with the findings of the hazard identification phase and the findings of the risk assessment phase of this research. The risk response phase of this research compiled a consolidated list of mitigation strategies for each hazard during each phase of the project development process. Therefore, risk managers are presented with the opportunity to select from among the listed mitigation strategies or they may use other innovative methods to create a new strategy. For this reason, no further discussion is made about the possible treatment of risks associated with work zone crashes and fatalities.

During the first phase of this research, 39 primary hazards where identified as having the potential to increase either the likelihood or severity of a vehicle crash in a roadway work zone. Of these hazards, 22 were found to correlate with data fields in the statewide crash database and were evaluated using 56 assessments of the database (54 of these assessments yielded usable output). The findings of the assessment phase revealed that 3 of the identified hazards had risk scores of 16; 13 had risk scores between 12 and 15; 21 had risk scores between 8 and 10; 13 had risk score between 4 and 6; and 4 had risk scores lower than 4. The following is a discussion of these findings.

6.3.1 Hazards of High Risk Potential

From the assessment portion of this research, it was found that three hazards were identified with risk scores of 16 (there were no hazards with a score greater than 16): (1) #9 driver/operator unfamiliarity (out-of-state driver's license), (2) #10 seasonal road use—June, and (3) #10 seasonal road use—September. These hazards are shown in Table 4.

Table 4. Hazards with high risk potential

Hazards with High Risk Potential	Risk Score
#9) Driver/operator unfamiliarity (out-of-state driver's license)	16
#10) Seasonal road use—June	16
#10) seasonal road use—September	16

6.3.2 Hazards of Elevated Risk Potential

From the assessment portion of this research, it was found that 13 hazards obtained a risk score between 12 and 15: (1) #9 inadequate/confusing traffic control (no controls present), (2) #10 seasonal road use—July, (3) #12 high-risk traffic—Wednesday, (4) #12 high-risk traffic—Thursday, (5) #12 high-risk traffic—Friday, (6) #17 lane closures, (7) #17 lane shift/crossover, (8) #18 commercial trucks, (9) #24 roadway not lighted, (10) #28 poor driver skills (operator error), (11) #34 the points of merge, (12) #35 the posted speed (65 mph), and (13) #35 the posted speed (55–60 mph). These hazards are shown in Table 5.

Table 5. Hazards with elevated risk potential

Hazards with Elevated Risk Potential	Risk Score
#9) Inadequate/confusing traffic control (no controls present)	12
#10) Seasonal road use—July	12
#12) High-risk traffic—Wednesday	12
#12) High-risk traffic—Thursday	12
#12) High-risk traffic—Friday	12
#17) Lane closures	12
#17) Lane shift/crossover (head-to-head)	12
#18) Commercial trucks	12
#24) Hours of dark; roadway not lighted	15
#28) Poor driver skills (operator error)	12
#34) The points of merge	12
#35) The posted speed (65 mph)	15
#35) The posted speed (55–60 mph)	12

6.3.3 Hazards of Moderate Risk Potential

From the perspective of this research, a hazard that has a risk score between 8 and 10 is considered to have a moderate risk potential. Additionally, hazards that have a high rank of 5 in either the severity or frequency calculation are considered to pose a moderate risk. From the assessment portion of this research, it was found that no hazard obtained a relative frequency rank of 5; however, seven obtained a severity rank of 5. Two of these hazards were identified earlier as having an elevated risk potential: (1) #24 lack of visibility/glare/lighting (dark roadway not lighted) and (2) #31 the posted speed through the work zone (65 mph). The five remaining hazards with a severity score of 5 are: (1) #4 construction vehicle traffic—flatbed, (2) #28 poor driver skills (aggressive driving), (3) #29 poor visibility of workers (workers involved in crash), (4) #31 railroads, and (5) #39 traffic speed and speeding. These hazards are shown in Table 6.

Table 6. Hazards with moderate risk potential due to high severity ranking

Hazards with Moderate Risk Potential due to Severity Rank of 5	Risk Score
#4) Construction vehicle traffic—flatbed	10
#28) Poor driver skills (aggressive driving)	10
#29) Poor visibility of workers (workers involved in crash)	5
#31) Railroads	5
#39) Traffic speed and speeding	10

All but one of the five hazards was in general agreement in terms of the focus group, the survey respondents, and the database analysis. The four hazards that were in general agreement are: (1) #4 construction vehicle traffic—flatbed, (2) #29 poor visibility of workers (workers involved in crash), (3) #31 railroads, and (4) #39 traffic speed and speeding. Therefore, only the hazard that

is in general disagreement— #28 poor driver skills (aggressive driving)—will be discussed. As mentioned earlier, there is some disagreement between the focus group, the survey respondents, and the database analysis for the hazard of "poor driver skills." This may be the case because many construction industry professionals see driving skills as an area generally out of their immediate influence. However, just as the case with "operator error," "aggressive driving" has been shown to have a relatively high average severity ratio of 2.8; this ranked a 5 in terms of severity and has a risk score of 10, both of which make "poor driver skills (aggressive driving)" a moderate risk. In any case, more emphasis must be placed on innovative methods to mitigate "operator error." As mentioned earlier, some mitigation strategies are presented in the results section of this work; however, work zone safety will greatly benefit from future research in this area.

6.5 Future Research

As a follow-up to the results of this research project, it is suggested that the following be considered as recommendations for further research in the area of construction project life-cycle analysis and risk management:

1. More queries and data mining on the list of 39 hazards of this research using the approach of this research. For instance, time of day, principal driving holidays, etc. should be assessed.
2. Build on the methodologies described in this research to conduct multivariate risk assessments to determine the effect on frequency and severity when multiple hazards contribute to a work zone crash.
3. Expand the scope of this research by reviewing a sampling of actual accident reports for crash characteristics and information not available in the crash database.
4. As also recommended by the University of Kansas (Bai 2007), extend this study to include DOT crash data from various other states.
5. Evaluate hazards that could not be assessed by using the database by utilizing the approach suggested by Shen and Gan (2003), which uses survey responses to qualitatively assess uncertainty in construction projects. This recommendation is consistent with future research needs discussed by Zou (2006).
6. Conduct research to develop a holistic risk management model to investigate all other transportation-related risks to which agencies, departments, and organizations are exposed.
7. Expand the scope of this project by conducting research on the work zone jobsite that addresses jobsite safety risks not related to the traveling public.
8. Expand the nature of this research for the implementation and evaluation of a risk management program by the Iowa DOT.
9. Develop an automated method to manage work zone vehicle crash risks based on the automated method of assessing scheduling risks presented by Schatterman (2008), which utilizes a database created and maintained using the methods and results of this research.
10. Test the generalizability of the integrated model by utilizing the tools, methods, and approach of this research to create a formal integrated risk management model for general construction and mining operations by assessing and evaluating the accident

reports and databases maintained by OSHA and the Mine Safety and Health Administration (MSHA).

11. Conduct research as to the state of the practice for SHAs in terms of life-cycle or the project development process of highway/roadway projects. This will facilitate the development of a project management function that would thereby implement a formal risk management program. Without an existing project management program, it is nearly impossible to adopt an integrated risk management program.
12. Develop a case study approach to apply, document, and assess the integrated risk management program inside an organization and on a project-specific basis.
13. From the results of this research more attention and innovation needs to be addressed in the following areas:

    a. Creating adjustments to the investigating officer's crash report that explicitly documents the hazards and factors associated with work zone crashes.
    b. Development of a near-miss reporting structure that can gather incident data from the view point of a bystander, potential victim of a crash, and the individual who nearly caused a crash.
    c. Development of an accident/near-miss log that is maintained by the project management team.
    d. Development of innovative methods to conduct driver training. This should be an ongoing process that takes into account driver skill development and maturity. This could possibly be incorporated as an extension of the current driver's license renewal process.

6.6 Section Summary

Section 4 of this work contains a framework of an integrated risk management model. This model is intended for the seamless integration into an existing management system. In order to fully integrate a risk management program into an organization, a full project management program must already be in place where the next logical step is to integrate a risk management ideology. The essence of a risk management program is the standard risk management model, as described in sections 2 and 4, where the impetus is risk identification, risk assessment, and risk response (treatment). The results section of this report contains information pertaining to the identification, assessment, and possible mitigation strategies for work zone hazards. Not all hazards are easily quantifiable by the use of database analysis. More research needs to be conducted qualitatively to assess hazards that possess a degree of uncertainty.

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APPENDIX A. FOCUS GROUP WORKSHEET/RESULTS

STAGE 4-A: RISK MANAGEMENT CHECKLIST – PLANNING & PROGRAMMING PHASE

PLANNING & PROGRAMMING	PRELIMINARY DESIGN	FINAL DESIGN	LETTING & AWARD	CONSTRUCTION

	What are the planning activities associated with each project phase?	Who should be part of the risk management team for each project phase? (Stakeholders)		What are the potential hazards associated with each planning activity? (check list)		What are some mitigation strategies for these hazards?
Major Activities:	**Activity Considerations**	**Stakeholders**		**Potential Hazards**	**FACTORS**	**Mitigation Strategies**
Planning	Determine Purpose and Needs • Existing conditions • Future requirements • Time (Urgency) • Schedule • Safety needs • Type of Project o Bridge replacement o Full depth pavement replacement o Asphalt overlays • Merge Points • Lane Capacity Improvement or Requirement Studies • Feasibility study • Route study • Corridor study • Subarea study • Major Investment Study (MIS) • Value Engineering study Environmental Considerations • Environmental documentation Interagency Coordination	➢ Department of Transportation ➢ Systems planning ➢ District Engineer (lead PMT) ➢ OLE ➢ Traffic & Safety ➢ ROW ➢ Bridge ➢ Elected Officials ➢ Consultants ➢ Contractors and construction managers ➢ Zoning authorities/local jurisdictions ➢ Transportation authorities ➢ MPO/RPA ➢ Health and Safety Authorities ➢ Local Business owners ➢ Architect/Engineer ➢ Financial & legal advisors ➢ Property Owners ➢ Commuters ➢ Third Party ➢ Law Enforcement ➢ Emergency Response ➢ Media ➢ Schools ➢ Railroad ➢ Utilities ➢ Large Employers (large traffic generators)	1A-DC	➢ Build/Rebuild under traffic	➢ WORKZONE CONDITION	➢ Control Risk during subsequent phases • Design phase (construction phasing for demo work,etc.) • Construction phase
			2A-DC	➢ Falling Debris/material • Overhead structures repair/replacement • Blasting	➢ WORKZONE CONDITION	➢ Detours (off site) ➢ Road Closures ➢ Lane Closures ➢ Control Risk during subsequent phases • Construction phase (scheduling)
			10A	➢ Traffic Congestion & Delay through workzone	➢ OPERATING ENVIRONMENT	➢ Detours (& Alternate Routes) • Off site • On site ➢ Road Closures ➢ Lane Closures ➢ Shoulder shift ➢ Accelerated Project Completion Scheduling (to limit exposure of traveling public)
			3A-DLC	➢ Extra traffic volume through workzone • Construction traffic • Events • Holidays • Seasonal traffic/road use	➢ OPERATING ENVIRONMENT	➢ Control Risk during subsequent phases • Design phase (alignment, geometry, etc.) • Final Design (schedule, standard specs, etc.) • Letting & Award phase (construction schedule) • Construction phase (Construction Scheduling)
			4A-DC	➢ Detour/Head-to-Head traffic shift/Shoulder Shift • Condition of roadway • Extra traffic volume	➢ ROAD CHARACTERISTICS • Road condition • Road geometry • Road type	➢ Recon/drive detour to identify potential problems ➢ Upgrade route prior to letting (if possible) ➢ Control Risk during subsequent phases • Design phase (road geometry/condition) • Construction phase (flaggers, pace vehicles, law enforcement)
			5A-D C	➢ Posted Speed Through WorkZone	➢ WORKZONE CONDITION	➢ Policy Change ➢ Control Risk during subsequent phases • Design phase • Construction phase
			6A-DC	➢ Points of Merge	➢ WORKZONE CONDITION	➢ Control Risk during subsequent phases • Design phase • Construction phase

	What are the planning activities associated with each project phase?	Who should be part of the risk management team for each project phase? (Stakeholders)		What are the potential hazards associated with each planning activity? (check list)		What are some mitigation strategies for these hazards?
Major Activities:	**Activity Considerations**	**Stakeholders**		**Potential Hazards**	**FACTORS**	**Mitigation Strategies**
			7A-DC	➢ Accelerated project completion • Overexposure of workers • Inclement weather construction • External construction completion date requirement (harvest, overlay cure, etc.)	WORKZONE CONDITION OPERATING ENVIRONMENT	➢ Material Selection to minimize construction duration • PCC/ACC, etc. • Full Depth vs. Overlay ➢ Control Risk during subsequent phases • Design phase • Construction phase
			8A-D C	➢ Railroads, Pedestrian Paths/travel routes & Trail Crossings	➢ OPERATING ENVIRONMENT	➢ Integration with Third Parties (coordination) • ITS – Integrating Strategies (Intelligent Transportation Systems) ➢ Control Risk during subsequent phases • Final design phase (TCP's, etc.) • Construction phase(flaggers)
Programming	Selecting & Prioritizing projects Environmental Determination Schematic Development Public Hearings ROW plan Project Funding	➢ Department of Transportation ➢ Program management	9A-DC	➢ Increased number of commercial trucks on existing routes or alternate routes	➢ VEHICLE CHARACTERISTICS	➢ Out of distant payment (pay carriers to stay off routes)

STAGE 4-C: RISK MANAGEMENT CHECKLIST – FINAL DESIGN PHASE

PLANNING & PROGRAMMING	PRELIMINARY DESIGN	FINAL DESIGN	LETTING & AWARD	CONSTRUCTION

	What are the planning activities associated with each project phase?	Who should be part of the risk management team for each project phase? (Stakeholders)		What are the potential hazards associated with each planning activity? (check list)		What are some mitigation strategies for these hazards?
Major Activities:	**Activity Considerations**	**Stakeholders**		**Potential Hazards**	**FACTORS**	**Mitigation Strategies**
Final Design	➢ Final Design • Pavement and bridge design • Traffic control plans • Utility drawings • Hydraulic studies/drainage design ➢ Establish final ROW need ➢ ROW acquisition ➢ Calculation of bid quantities ➢ Cost estimates ➢ Special provisions ➢ Reviews Traffic Control: ➢ Sequence of construction • Work zone speed • Temporary illumination • Preliminary staging plan • Buffer distances ➢ Detour /road closure plan • Temporary pavement • Improvements to alternate routes • Traffic control layout • Merge point details • Intersections (line of sight) • Signs and pavement marking • Pedestrians and Bike plans ➢ Contract Provisions • Accelerated construction • Restrictions (workhour,	➢ Owner/owner agent ➢ Architect/Engineer ➢ Estimators ➢ Contractors and construction managers ➢ Product representatives ➢ Law enforcement ➢ Consultants ➢ Design consultants coordination	0C-C	➢ Driver confusion • Too many decisions (especially at higher speeds) • Driver/operator unfamiliarity • Inadequate/confusing traffic control	➢ WORKZONE CONDITION	➢ Traffic control plan (standards modified to situation) ➢ ➢ Maintain Positive Control - Signage (get signs made up ahead of time) • detour • temporary barrier rails (channelizing) • minimize posted signage (less is more) • use CMS, but minimally before entering area • flashing arrows ➢ Education/Information for unfamiliar drivers ➢ Media (radio/TV), website, advanced warning signs) ➢ Visualization in 3D (information prior to driving in work zones) used in Council Bluffs ➢ Manage Risk During Construction Phase
			1C-C	➢ Multiple Prime in general proximity • Discontinuous workzone signage • Discontinuous traffic control	➢ WORKZONE CONDITION	➢ Contracting and Project Management - Continuity of Traffic Control
			2C-C	➢ Road Characteristics through workzone • Roadway classifications • Narrow bridges • Narrower shoulders • Intersections • Fore slopes • Blind spots • Line of sight obstructions • Limited visibility due to topography	➢ ROAD CHARACTERISTICS	➢ Re-design – modify standard design when appropriate ➢ Standards ➢ Adjustments to standard documents ➢ Engineering & design (widen, remove, modify) ➢ Traffic control devices ➢ Inform Motorist (signs, media, etc.) ➢ Staging (TRAFFIC STAGING???) ➢ Manage Risk During Construction Phase
			3C-LC	➢ Traffic Speed & Speeding • excess traffic speed • limited stopping distance	➢ DRIVER CHARACTERISTICS	➢ Temporary signals ➢ Project Specified Design Speed (advisory speed) – written in specs ➢ Lane narrowing & barriers (design) ➢ Speed cameras (written in specs) ➢ Enforcement details in specifications ➢ Policy enforcement ➢ Manage Risk During Subsequent Phases • Letting • construction

	What are the planning activities associated with each project phase?	Who should be part of the risk management team for each project phase? (Stakeholders)		What are the potential hazards associated with each planning activity? (check list)		What are some mitigation strategies for these hazards?
Major Activities:	**Activity Considerations**	**Stakeholders**		**Potential Hazards**	**FACTORS**	**Mitigation Strategies**
	access, lane closures) • Safety		4C-LC	➢ Lack of flexibility in traffic control (lack of incentive for change to traffic control)	➢ WORKZONE CONDITION	➢ Bid Items for traffic control adjustments ➢ Assign bid items for traffic control ➢ Assign responsibility – bid items ➢ Manage Risk during Subsequent Phases • Letting • construction Traffic Control Plans 90% standard 10% Project Specific Goals
			5C-LC	➢ Inadequate capacity/geometry & Confusing layout (increased demand on alternate routes; increased demand on alternate routes) • Detours • Road Closures • Lane Closures o Moving (markings, shoulder repair) o Stationary	➢ WORKZONE CONDITION	➢ Upgrade conditions/geometry ➢ Traffic control plans (signs, barriers, etc) ➢ Manage Risk during construction phase • Media outlets/education/information/closure dates
			7C-C	➢ Inadequate buffer distance	➢ WORKZONE CONDITION	➢ Design adequate buffer space ➢ Manage Risk During Construction Phase
			7C-C	➢ Poor visibility of workers	➢ WORKZONE CONDITION	➢ Bid Items for worker safety training ➢ Project Specification for high visibility worker apparel
			➢	➢ Construction vehicle traffic	➢ WORKZONE CONDITION	➢ Develop schematic Internal Traffic Control Plans (early contractor involvement) ➢ Specify Ingress/egress points ➢ Manage Risk During Construction Phase
			➢	➢ Jobsite Congestion & traffic • Traffic congestion (local traffic) • Traffic delays	➢ WORKZONE CONDITION	➢ Constructability Reviews and Sequencing for concept of work (reverse schedule construction) ➢ Schedule and allowance incentives & workday constraints
			➢		➢	➢
			9C-C	➢ Lack of positive control of traffic	➢ WORKZONE CONDITION	➢ Contracting language & constraints (training, flaggers, barricades, signs/signals, traffic control, etc.) ➢ Manage During Construction Phase
			10C-C	➢ Lack of Visibility/glare/lighting	➢ OPERATING ENVIRONMENT	➢ Specify/Design Glare Screen ➢ Specify/Design Lighting ➢ Specify/design reflectors ➢ Manage During Construction Phase
			11C-C	➢ Driver / Operator Inattention	➢ DRIVER CHARACTERISTICS	➢ Design/specify rumble strips ➢ Taper Designs follow up-to-date MUTCD (reflective) ➢ Specify high visibility worker apparel ➢ Specify CB Radio message in vicinity of transition

	What are the planning activities associated with each project phase?	Who should be part of the risk management team for each project phase? (Stakeholders)		What are the potential hazards associated with each planning activity? (check list)		What are some mitigation strategies for these hazards?
Major Activities:	**Activity Considerations**	**Stakeholders**		**Potential Hazards**	**FACTORS**	**Mitigation Strategies**
						area ➢ Manage Risk During Construction Phase
			12C	➢ Poor Driver Skills	➢ DRIVER CHARACTERISTICS	➢ Education/training/testing ➢ Initiate smart workzone initiatives at letting
			13C	➢ Previous Paint lines (Confusion)	➢ WORKZONE CONDITION	Specify effective removal techniques (sandblasting is preferred but causes other environmental issues)
				➢ Inclement weather	➢ OPERATING ENVIRONMENT	➢ Awareness initiatives, speed control, driver training ➢ Reflectorized barriers, rails, etc. ➢ High visibility worker apparel
				➢ Non-Standard Detour route	➢	ADJUST STANDARDS IF NECESSARY TO FIT ACTUAL SITUATION
			1A-DC	➢ Build/Rebuild under traffic	➢ WORKZONE CONDITION	➢ Determine construction phasing for demo work,etc. ➢ Control Risk during subsequent phases • Construction phase
			2A-DC	➢ Falling Debris/material • Overhead structures repair/replacement • Blasting	➢ WORKZONE CONDITION	➢ Construction Phasing ➢ Construction Schedule ➢ Traffic Control Plans ➢ Control Risk during subsequent phases • Construction phase (contractor mitigation)
			(3A-DC) 6C-LC	➢ Extra Traffic Volume through workzone • Construction traffic • Events • Holidays • Seasonal traffic/road use	➢ OPERATING ENVIRONMENT	➢ Design phase (alignment, geometry, etc.) ➢ Final Design (schedule, standard specs, etc.) ➢ Planning Calendar as part of Bid Documents • Special events • Harvest season completions • Visualization in 3D ➢ Manage/Control Risk during subsequent phases • Letting & Award phase (construction schedule) • Construction phase (Construction Scheduling)
			4A-DC	➢ Detour/Head-to-Head shift/Shoulder Shift • Condition of roadway • Extra traffic volume	➢ ROAD CHARACTERISTICS • Road condition • Road geometry • Road type	➢ Upgrade route prior to letting (if possible) ➢ Re-design road geometry/condition ➢ Control Risk during subsequent phases • Construction phase (flaggers, pace vehicles, law enforcement)
			5A-D C	➢ Posted Speed Through WorkZone	➢ WORKZONE CONDITION	➢ Traffic Control Plans and designs to reduce speed ➢ Control Risk during subsequent phases • Construction phase

	What are the planning activities associated with each project phase?	Who should be part of the risk management team for each project phase? (Stakeholders)		What are the potential hazards associated with each planning activity? (check list)		What are some mitigation strategies for these hazards?
Major Activities:	**Activity Considerations**	**Stakeholders**		**Potential Hazards**	**FACTORS**	**Mitigation Strategies**
			6A-DC	➢ Points of Merge	➢ WORKZONE CONDITION	➢ Design points of merge for traffic & construction requirements ➢ Control Risk during subsequent phases • Construction phase
			7A-DC	➢ Accelerated project completion • Overexposure of workers • Inclement weather construction • External construction completion date requirement (harvest, overlay cure, etc.)	WORKZONE CONDITION OPERATING ENVIRONMENT	➢ Awareness initiatives, speed control, driver training ➢ Reflectorized barriers, rails, etc. ➢ High visibility worker apparel ➢ Control Risk during subsequent phases • Construction phase
			8A-D C	➢ Railroads, Pedestrian Paths & Trail Crossings	➢ OPERATING ENVIRONMENT	➢ Local Jurisdiction agreement and 3rd Party (railroad, etc.) ➢ Design for Pedestrian protection (no standards yet – assign to contractors) ➢ Integrate into the Design of Traffic Control Plans, etc. ➢ Integration with Third Parties • ITS – Integrating Strategies (Intelligent Transportation Systems) ➢ Control Risk during subsequent phases • Construction phase(flaggers)
			9A-DC	➢ Increased number of commercial vehicles (trucks) on existing routes	➢ VEHICLE CHARACTERISTICS	➢ Out of distant payment (pay carriers to stay off routes)
					➢	•
				➢	➢	➢
				➢	➢	➢

STAGE 4-D: RISK MANAGEMENT CHECKLIST – LETTING AND AWARD PHASE

PLANNING & PROGRAMMING	PRELIMINARY DESIGN	FINAL DESIGN	LETTING & AWARD	CONSTRUCTION

	What are the planning activities associated with each project phase?	Who should be part of the risk management team for each project phase? (Stakeholders)		What are the potential hazards associated with each planning activity? (check list)		What are some mitigation strategies for these hazards?
Major Activities:	**Activity Considerations**	**Stakeholders**		**Potential Hazards**	**Contributing Hazards**	**Mitigation Strategies**

LETTING & AWARD
 	
(Procurement)
	Commonly known as the procurement stage:
	• Owner makes the proposed construction documents available to prospective contractors
	• Project Information
	  • Distribution of info
	  • Control of info
	• Contractor qualifications
	  • Experience
	  • Special training and certifications
	• Contractor determines price
	  • Visit site
	  • Assemble price
	  • Calculate
	  • Present
	• Competitive Bidding
	• Contract Negotiations
		➢ Owner/owner agent
		➢ Architect/Engineer
		➢ Prospective Contractors
		➢ Prospective subcontractors
			1D	➢ Missing information (documentation of risk assessment)
				➢ Incomplete plans (TCP's)
				➢ Incomplete bid requirements (safety, etc.)
					➢	➢ Bid item identification
						➢ Pre-bid meetings & communications

			2D	➢ Inadequate Contractor safety training ➢	➢	➢ Contractor Management addressing safety ➢ Minimum site visits by safety director

			3D	➢ Contractor Complacency
				➢
					➢	➢ Contractor fines and sanctions
						  • (lack of PM)
						  • Fines for traffic control

			4D	➢ Workzone area laid out long before construction begins	➢	➢ Contract period is set to reflect actual construction (this prevents contractors from setting out workzone to satisfy contract but waits for construction to start)
			5D	➢ Lack of contractor project management (directed toward safety)	➢	

			6D	➢ Contractor selection	➢	➢ Worker training requirements
						➢ Contractor prequalification using safety record
						  • Evaluation on past project
						  • Insurance rate factor

			7D	➢ Final Schedule not part of contract (project duration)	➢	➢ Schedule and sequencing as condition of contract (meetings & requirements)
			8D	➢ Lack of accident/near-miss reporting structure	➢	➢ Bid item for on-site traffic technician ➢ Bid Item for On-site surveillance
			9D	➢ Non-credible/non-current signs during interim season	➢	➢ Interim phase coordination- season to season signage during project transitions

			1C-LC	➢ Multiple Prime in general proximity
				  • Discontinuous workzone signage
				  • Discontinuous traffic control
					➢	➢ Packaging of lettings to ensure continuity of workzone signage and project management responsibility

			3C-LC	➢ Traffic Speed & Speeding
				  • excess traffic speed
				  • limited stopping distance
					➢ DRIVER CHARACTERISTICS	➢ Policy enforcement
						➢ Manage Risk During Subsequent Phases
						  • construction

			4C-LC	➢ Lack of flexibility in traffic control (lack of incentive for change to traffic control)	➢ WORKZONE CONDITION	➢ Bid Items for traffic control adjustments ➢ Assign bid items for traffic control ➢ Assign responsibility – bid items ➢ Manage Risk during Subsequent Phases • construction

STAGE 4-D: RISK MANAGEMENT CHECKLIST – LETTING AND AWARD PHASE

PLANNING & PROGRAMMING	PRELIMINARY DESIGN	FINAL DESIGN	LETTING & AWARD	CONSTRUCTION

	What are the planning activities associated with each project phase?	Who should be part of the risk management team for each project phase? (Stakeholders)		What are the potential hazards associated with each planning activity? (check list)		What are some mitigation strategies for these hazards?
Major Activities:	**Activity Considerations**	**Stakeholders**		**Potential Hazards**	**Contributing Hazards**	**Mitigation Strategies**
			3A-DLC	➢ Extra traffic volume • Construction traffic • Events • Holidays • Seasonal traffic/road use	➢ OPERATING ENVIRONMENT	➢ Pre-bid meeting to discuss construction schedule ➢ Control Risk during subsequent phases • Construction phase (Construction Scheduling)
			12C	➢ Poor Driver Skills	➢ DRIVER CHARACTERISTICS	➢ Education/training/testing ➢ Initiate smart workzone initiatives at letting
			6C-LC (4A-DC)	➢ Extra Traffic Volume	➢ OPERATING ENVIRONMENT	➢ Contractor Schedule to consider Planning Calendar (special events, harvest season, etc) • Minimize construction operations • No major activities • Minimize excess traffic ➢ Manage Risk during subsequent phases (construction)
			➢		➢	➢
			➢		➢	➢

STAGE 4-E: RISK MANAGEMENT CHECKLIST – CONSTRUCTION PHASE

PLANNING & PROGRAMMING	PRELIMINARY DESIGN	FINAL DESIGN	LETTING & AWARD	CONSTRUCTION

CONSTRUCTION	What are the planning activities associated with each project phase?	Who should be part of the risk management team for each project phase? (Stakeholders)		What are the potential hazards associated with each planning activity? (check list)		What are some mitigation strategies for these hazards?
Major Activities:	**Activity Considerations**	**Stakeholders**		**Potential Hazards**	**FACTORS**	**Mitigation Strategies**

Execution of work required by contract documents	Team effort working toward delivering completed facility ready for its intended use:
	• Contractor's activities
	  • Planning
	  • Scheduling
	  • Mobilization (Equip)
	  • Material purchasing
	  • Fabrication of components
	  • construction
	• Construction Categories
	  • Contract Administration
	  • Contractor Project Management
	• Contractor responsibility
	  • Supervision
	  • Implement/enforce safety rules
	  • Schedule and coordinate deliveries and work
	  • Provided submittals
	• Communication
	  • Meetings
	• Project Closeout
		➢ Owner/owner agent
		➢ Architect/Engineer
		➢ Consultants
		➢ Testing agencies
		➢ Contractors
		➢ Subcontractors
		➢ Authorities having Jurisdiction (AHJ's)
		➢ Product representatives
			➢	➢ Inadequate Internal Traffic Control Plans (ITCPs)	➢	➢ Develop ITCP specifically for the anticipated traffic and operating procedures

				➢ High Risk traffic • Friday • Evenings – (bar time) • Rush Hour Traffic	➢	➢ Event Calendar Updates (District) ➢ Coordination meetings ➢ Law Enforcement
			➢	➢ Jobsite Congestion & traffic • Traffic congestion (local traffic) • Traffic delays	➢ WORKZONE CONDITION	➢ Implement sSequencing for concept of work ➢ Schedule and allowance incentives & workday constraints ➢ Permitting for overweight (less truck traffic with larger loads)- annual permits for truckers (to reduce # trucks in workzone) ➢ Ground guides (on site) to prevent motorists from entering worksite ➢ Use of ground guides to manage on site construction traffic (particularly large trucks)
			➢	➢ Non-credible signs	➢	➢ Remove non-credible signs (follow up with enforcement) ➢ Signage and traffic control reviews (credibility)
			➢	➢ Length of workzone (too long)	➢	➢ Lane Rental Specs
			➢	➢ Dirty / non-serviceable signs/reflectors, etc.	➢	➢ Clean & Maintain signs, reflectors, etc. (sign maintenance and safety compliance)
			➢	➢	➢	➢
			0C-LC	➢ Driver confusion • Too many decisions (especially at higher speeds) • Driver/operator unfamiliarity • Inadequate/confusing traffic control	➢ WORKZONE CONDITION	➢ Early warning (multiple simultaneous methods) place in sufficient distance ahead of decision area ➢ CMS ➢ Flashing arrow ➢ Taper (updated MUTCD) ➢ Increase use of reflectorized arrow, signs, painting, etc. ➢ Information OUTLETS • Resident Engineer office • 511 (cell phones) • IA.org (internet) ➢ Media outlet for project information • Lane Closures • Traffic information • Alternate routes • Detours
			1C-C	➢ Multiple Prime in general proximity • Discontinuous workzone signage • Discontinuous traffic control	➢ WORKZONE CONDITION	➢ Contracting and Project Management responsibility ➢ Continuity of Traffic Control devices & signs

CONSTRUCTION	What are the planning activities associated with each project phase?	Who should be part of the risk management team for each project phase? (Stakeholders)		What are the potential hazards associated with each planning activity? (check list)		What are some mitigation strategies for these hazards?
Major Activities:	**Activity Considerations**	**Stakeholders**		**Potential Hazards**	**FACTORS**	**Mitigation Strategies**
			2C-C	➢ Road Characteristics through workzone • Roadway classifications • Narrow bridges • Narrower shoulders • Intersections • Fore slopes • Blind spots • Line of sight obstructions • Limited visibility due to topography	➢ ROAD CHARACTERISTICS	➢ Inform Motorist (signs, etc.) ➢ Employ Traffic control devices ➢ Erect Signs ➢ Staging (TRAFFIC STAGING???) ➢ Field modify when appropriate (with approval) ➢ Manage Risk During Construction Phase
			3C-LC	➢ Traffic Speed & Speeding • excess traffic speed • limited stopping distance	➢ DRIVER CHARACTERISTICS	➢ Temporary signals ➢ Project Specified Design Speed ➢ Lane narrowing ➢ Speed cameras ➢ Law Enforcement posted at critical timeframes (may cause other problems)
			4C-LC	➢ Lack of flexibility in traffic control (lack of incentive for change to traffic control)	➢ WORKZONE CONDITION	➢ Bid Items for traffic control adjustments ➢ Assign bid items for traffic control ➢ Assign responsibility – bid items
			5C-LC	➢ Inadequate capacity/geometry & Confusing layout (increased demand on alternate routes; increased demand on alternate routes) • Detours • Road Closures • Lane Closures o Moving (markings, shoulder repair) o Stationary	➢ WORKZONE CONDITION	➢ Field Upgrade conditions/geometry ➢ Employ Traffic control plans (signs, barriers, etc) ➢ Media outlets • Education • Information • closure dates
				•	➢	➢
			7C-C	➢ Inadequate buffer distance	➢ WORKZONE CONDITION	➢ Maintain / ensure adequate buffer space ➢ Worker training ➢ Slow traffic (positive control)-law enforcement ➢ barriers
			7C-C	➢ Poor visibility of workers	➢ WORKZONE CONDITION	➢ Bid Items for worker safety training ➢ Project Specification for high visibility worker apparel
			➢	➢ Construction vehicle routes	➢ WORKZONE CONDITION	➢ Implement Internal Construction Traffic Control Plans ➢ Employ & Enforce Ingress/egress points
			9C-C	➢ Lack of positive control of traffic	➢ WORKZONE CONDITION	➢ training ➢ flaggers ➢ barricades ➢ signs/signals ➢ traffic control
			10C-C	➢ Lack of Visibility/glare/lighting	➢ OPERATING ENVIRONMENT	➢ workzone smart initiative ➢ Driver training/testing, etc.

CONSTRUCTION	What are the planning activities associated with each project phase?	Who should be part of the risk management team for each project phase? (Stakeholders)		What are the potential hazards associated with each planning activity? (check list)		What are some mitigation strategies for these hazards?
Major Activities:	**Activity Considerations**	**Stakeholders**		**Potential Hazards**	**FACTORS**	**Mitigation Strategies**
						➢ Install Glare Screen ➢ Install Barriers ➢ Install Lighting ➢ Temporary lighting ➢ Lighting placement - Ensure proper placement of portable light units to prevent blinding and glare for motorists
			11C-C	➢ Driver/operator inattention	➢	➢ Taper designs follow up-to-date MUTCD (reflective) ➢ Ensure high visibility worker apparel ➢ Portable rumble strips ➢ Announcement on CB radios in transition area
			12C	➢ Poor Driver Skills • Speed • Stopping distance • Inclement weather	➢ DRIVER CHARACTERISTICS	➢ Education/training/testing ➢ Initiate smart workzone initiatives at letting ➢ Driver training, driver information, awareness initiatives
			13C	➢ Previous Paint lines (Confusion)	➢ WORKZONE CONDITION	➢ Remove previous paint lines (sandblast works best but has environmental consequences)
			1A-DC	➢ Build/Rebuild under traffic	➢ WORKZONE CONDITION	➢ Control Risk during subsequent phases • Design phase (construction phasing for demo work,etc.) • Construction phase
			2A-DC	➢ Falling Debris/material • Overhead structures repair/replacement • Blasting	➢ WORKZONE CONDITION	➢ Construction scheduling
			3A-DC 6C-LC	➢ Extra Traffic Volume through workzone • Construction traffic • Events • Holidays • Seasonal traffic/road use	➢ OPERATING ENVIRONMENT	➢ Restricted construction activities based on Planning Calendar as part of Bid Documents • Special events • Harvest season completions • Event calendar (district) • Coordination meetings ➢ Visualization in 3D ➢ Construction Scheduling
			4A-DC	➢ Detour/Head-to-Head shift/Shoulder Shift • Condition of roadway • Extra traffic volume	➢ ROAD CHARACTERISTICS • Road condition • Road geometry • Road type	➢ flaggers ➢ pace vehicles ➢ law enforcement
			5A-D C	➢ Posted Speed Through WorkZone	➢ WORKZONE CONDITION	➢ law enforcement
			6A-DC	➢ Points of Merge	➢ WORKZONE CONDITION	➢ Monitor and adjust as required(flexibility provided in contract documents)
			7A-DC	➢ Accelerated project completion • Overexposure of workers • Inclement weather construction • External construction completion date requirement (harvest, overlay cure, etc.)	WORKZONE CONDITION OPERATING ENVIRONMENT	➢ Taper designs follow up-to-date MUTCD (reflective) ➢ Ensure high visibility worker apparel ➢ Portable rumble strips ➢ education/training/testing ➢ Initiate smart workzone initiatives at letting ➢ Driver training, driver information, awareness initiatives

CONSTRUCTION	What are the planning activities associated with each project phase?	Who should be part of the risk management team for each project phase? (Stakeholders)		What are the potential hazards associated with each planning activity? (check list)		What are some mitigation strategies for these hazards?
Major Activities:	**Activity Considerations**	**Stakeholders**		**Potential Hazards**	**FACTORS**	**Mitigation Strategies**
			8A-D C	➢ Railroads, Pedestrian Paths & Trail Crossings	➢ OPERATING ENVIRONMENT	➢ Integration with Third Parties ➢ ITS – Monitoring ITS Effectiveness (deployment monitoring) ➢ flaggers
			9A-DC	➢ Increased number of commercial trucks on existing routes or alternate routes	➢ VEHICLE CHARACTERISTICS	➢ Out of distant payment (pay carriers to stay off routes)

Table B.1. Consolidated work zone hazards by project phase: hazards # 1 through #12 listed alphabetically

	Identified Hazard	Assess #s	PROJECT PHASE			
			Planning & Programming	Design	Letting & Award	Construction
1	a contract that does not include a final schedule showing project duration and event planning				○	
2	accelerated project completion requirements (i.e., overexposure of workers; inclement weather construction; external construction completion date requirement –harvest, overlay cure time, etc.)		● 50	● 60		● 56
3	build/rebuild under traffic (work on shoulder; intermittent or moving work)	1,2	● 100	● 100		● 56
4	construction vehicle traffic (dump trucks, flatbed, concrete mixer)	3,4,5	◌	● 75		● 90
5	contractor complacency				○	
6	contractor selection process				○	
7	dirty/non-serviceable signs/reflectors, etc.	6				● 100
8	driver / operator inattention	7		● 80		● 90
9	driver confusion from: too many decisions (especially at higher speeds); driver/operator unfamiliarity; inadequate/confusing traffic control	9,10		● 100		● 90
10	extra traffic volume through the work zone from: construction traffic; civic events; holidays; seasonal traffic/road use	45-56	● 100	● 80	○	● 90
11	falling debris/material from: overhead structures & blasting	11	● 100	● 80		● 80
12	high risk traffic: Fridays, evenings – (bar time), rush hour traffic	38-44		● 60	○	● 100

Table B.2. Consolidated work zone hazards by project phase: hazards # 13 through #24 listed alphabetically

			PROJECT PHASE			
	IDENTIFIED HAZARD	Assess #'s	PLANNING & PROGRAMMING	DESIGN	LETTING & AWARD	CONSTRUCTION
13	inadequate buffer distance from travel lane to work area	12		100		100
14	inadequate contractor accountability for safety					
15	inadequate internal traffic control plans (ITCPs)					90
16	inclement weather			75		60
17	increased demand of, inadequate capacity/geometry & confusing layout of: detours; road closures; lane closures (moving & stationary)			80		90
18	increased number of commercial trucks on existing routes or alternate routes	16	50	80		50
19	jobsite congestion & traffic resulting in local traffic congestion and delays			80		100
20	lack of accident/near-miss reporting structure					
21	lack of contractor innovation in traffic control methods			40		60
22	lack of contractor project management (directed toward safety)					
23	lack of positive control of traffic			100		100
24	lack of visibility: glare (from headlights or sun); lighting conditions	17,18, & 19		80		80

Table B.3. Consolidated work zone hazards by project phase: hazards # 25 through #35 listed alphabetically

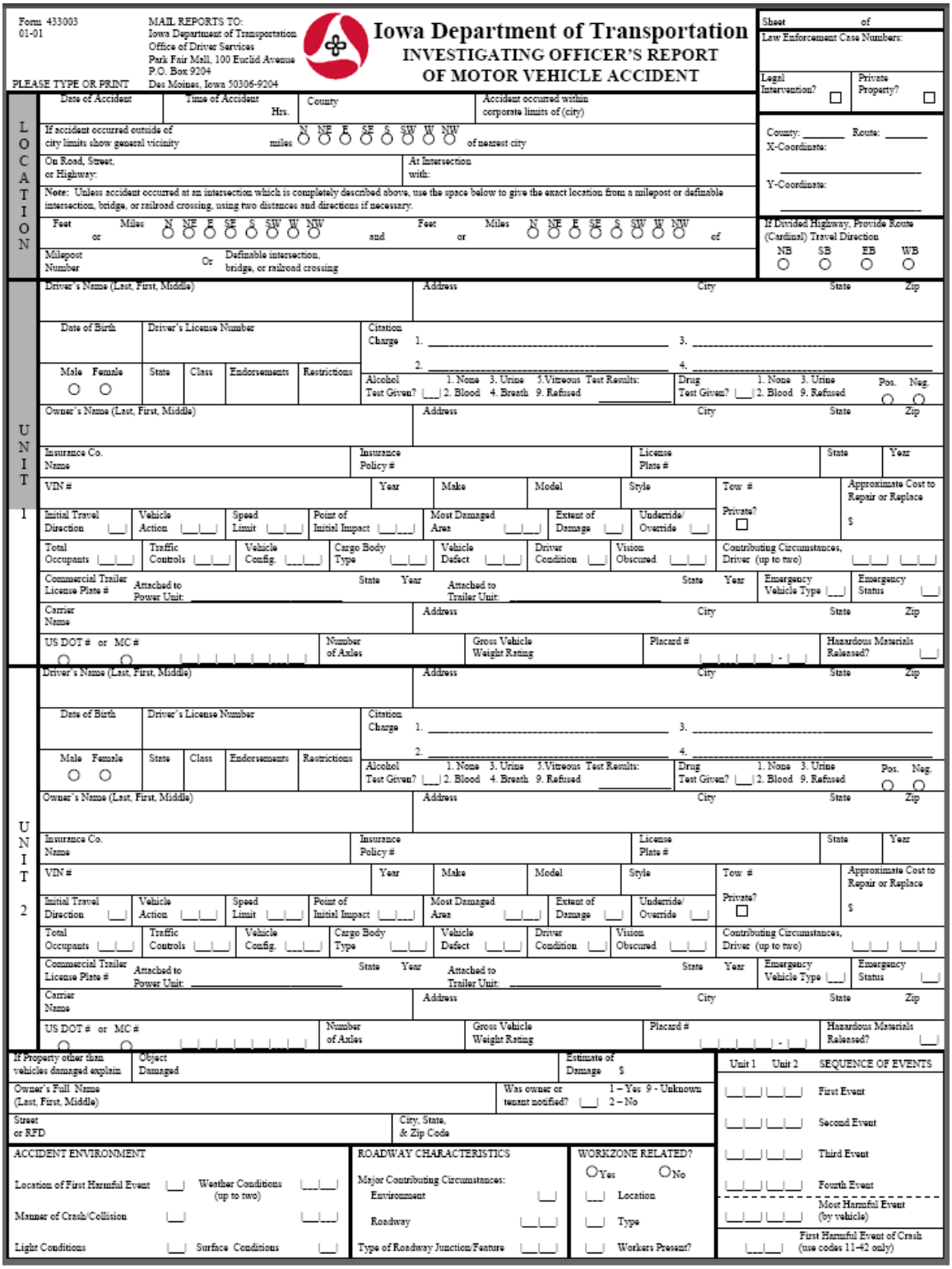
			PROJECT PHASE			
	IDENTIFIED HAZARD	Assess #'s	PLANNING & PROGRAMMING	DESIGN	LETTING & AWARD	CONSTRUCTION
25	missing information (documentation of risk assessment); incomplete plans (TCP's); and incomplete bid requirements				○	
26	multiple prime in general proximity (resulting in discontinuous work zone signage & discontinuous traffic control)			● 80	○	● 56
27	non-credible/non-current signs during interim season				○	● 89
28	poor driver skills: operator error; aggressive driving	20, 21		○ 20	○	○ 30
29	poor visibility of workers	22		● 80		● 100
30	previous paint lines (confusion)			● 100		● 90
31	railroads, pedestrian paths/travel routes & trail crossings	23, 23b	● 100	● 100		● 70
32	road characteristics through the work zone: roadway classifications; narrow bridges; narrower shoulders; intersections (intersections, ramps); fore slopes: blind spots; line of sight obstructions; limited visibility due to topography	24-28		● 100		● 80
33	the condition of roadway & extra traffic volume of: detours; head-to-head traffic shifts; and shoulder shifts	29	● 50	● 80		● 70
34	the points of merge	30	● 50	● 80		● 67
35	the posted speed through the work zone	31-35	● 100	● 100		● 78

● 100% agreement ● 50-99% agreement ○ <50% agreement or no-response ◌ "write-in"

Table B.4. Consolidated work zone hazards by project phase: hazards # 36 through "survey write-ins"

			PROJECT PHASE			
	IDENTIFIED HAZARD	Assess #'s	PLANNING & PROGRAMMING	DESIGN	LETTING & AWARD	CONSTRUCTION
36	the work zone area being laid out long before construction actually begins				○	
37	too long of work zone length			◌		● 60
38	traffic congestion & delay through the work zone	36	● 100			
39	traffic speed & speeding (i.e., excess traffic speed, and limited stopping distance)	37		● 100	○	● 90
A	*Gawker slow downs (mitigation strategy: acknowledge the disruptive traffic pattern for the area – this could affect outside of project limits*		◌			
B	*Cell phone use by drivers (mitigation strategy: signage that prohibits use)*			◌		
C	*Oversized Vehicles (mitigation strategy: alternate routes for oversized vehicle traveling routes)*			◌		
D	*Unprotected pavement drop-offs*					◌
E	*Jobsite enter / egress points*					◌

APPENDIX C. INVESTIGATING OFFICER'S REPORT OF MOTOR VEHICLE ACCIDENT



Form 433003
01-01

MAIL REPORTS TO:
Iowa Department of Transportation
Office of Driver Services
Park Fair Mall, 100 Euclid Avenue
P.O. Box 9204
Des Moines, Iowa 50306-9204

PLEASE TYPE OR PRINT

Iowa Department of Transportation
INVESTIGATING OFFICER'S REPORT OF MOTOR VEHICLE ACCIDENT

Sheet ____ of ____
Law Enforcement Case Numbers:
Legal Intervention? ☐ Private Property? ☐

LOCATION

Date of Accident | Time of Accident Hrs. | County | Accident occurred within corporate limits of (city)

If accident occurred outside of city limits show general vicinity | miles ○N ○NE ○E ○SE ○S ○SW ○W ○NW of nearest city

On Road, Street, or Highway: | At Intersection with:

Note: Unless accident occurred at an intersection which is completely described above, use the space below to give the exact location from a milepost or definable intersection, bridge, or railroad crossing, using two distances and directions if necessary.

Feet ____ Miles ____ ○N ○NE ○E ○SE ○S ○SW ○W ○NW or ____ and Feet ____ Miles ____ ○N ○NE ○E ○SE ○S ○SW ○W ○NW of

Milepost Number | Or | Definable intersection, bridge, or railroad crossing

County: ____ Route: ____
X-Coordinate:
Y-Coordinate:

If Divided Highway, Provide Route (Cardinal) Travel Direction
NB ○ SB ○ EB ○ WB ○

UNIT 1

Driver's Name (Last, First, Middle) | Address | City | State | Zip

Date of Birth | Driver's License Number | Citation Charge 1. ____ 2. ____ 3. ____ 4. ____

Male ○ Female ○ | State | Class | Endorsements | Restrictions

Alcohol Test Given? ___ 1. None 2. Blood 3. Urine 4. Breath 5.Vitreous 9. Refused Test Results: ____
Drug Test Given? ___ 1. None 2. Blood 3. Urine 9. Refused Pos. ○ Neg. ○

Owner's Name (Last, First, Middle) | Address | City | State | Zip

Insurance Co. Name | Insurance Policy # | License Plate # | State | Year

VIN # | Year | Make | Model | Style | Tow # Private? ☐ | Approximate Cost to Repair or Replace $

Initial Travel Direction ___ | Vehicle Action ___ | Speed Limit ___ | Point of Initial Impact ___ | Most Damaged Area ___ | Extent of Damage ___ | Underride/ Override ___

Total Occupants ___ | Traffic Controls ___ | Vehicle Config. ___ | Cargo Body Type ___ | Vehicle Defect ___ | Driver Condition ___ | Vision Obscured ___ | Contributing Circumstances, Driver (up to two) ___ ___

Commercial Trailer License Plate # | Attached to Power Unit: ____ State Year | Attached to Trailer Unit: ____ State Year | Emergency Vehicle Type ___ | Emergency Status ___

Carrier Name | Address | City | State | Zip

US DOT # ○ or MC # ○ ___ | Number of Axles | Gross Vehicle Weight Rating | Placard # ___ - ___ | Hazardous Materials Released? ___

UNIT 2

Driver's Name (Last, First, Middle) | Address | City | State | Zip

Date of Birth | Driver's License Number | Citation Charge 1. ____ 2. ____ 3. ____ 4. ____

Male ○ Female ○ | State | Class | Endorsements | Restrictions

Alcohol Test Given? ___ 1. None 2. Blood 3. Urine 4. Breath 5.Vitreous 9. Refused Test Results: ____
Drug Test Given? ___ 1. None 2. Blood 3. Urine 9. Refused Pos. ○ Neg. ○

Owner's Name (Last, First, Middle) | Address | City | State | Zip

Insurance Co. Name | Insurance Policy # | License Plate # | State | Year

VIN # | Year | Make | Model | Style | Tow # Private? ☐ | Approximate Cost to Repair or Replace $

Initial Travel Direction ___ | Vehicle Action ___ | Speed Limit ___ | Point of Initial Impact ___ | Most Damaged Area ___ | Extent of Damage ___ | Underride/ Override ___

Total Occupants ___ | Traffic Controls ___ | Vehicle Config. ___ | Cargo Body Type ___ | Vehicle Defect ___ | Driver Condition ___ | Vision Obscured ___ | Contributing Circumstances, Driver (up to two) ___ ___

Commercial Trailer License Plate # | Attached to Power Unit: ____ State Year | Attached to Trailer Unit: ____ State Year | Emergency Vehicle Type ___ | Emergency Status ___

Carrier Name | Address | City | State | Zip

US DOT # ○ or MC # ○ ___ | Number of Axles | Gross Vehicle Weight Rating | Placard # ___ - ___ | Hazardous Materials Released? ___

If Property other than vehicles damaged explain | Object Damaged | Estimate of Damage $

Owner's Full Name (Last, First, Middle) | Was owner or tenant notified? ___ 1 – Yes 9 - Unknown 2 – No

Street or RFD | City, State, & Zip Code

SEQUENCE OF EVENTS (Unit 1 / Unit 2)
First Event ___ ___
Second Event ___ ___
Third Event ___ ___
Fourth Event ___ ___
Most Harmful Event (by vehicle) ___ ___
First Harmful Event of Crash (use codes 11-42 only) ___

ACCIDENT ENVIRONMENT
Location of First Harmful Event ___ | Weather Conditions (up to two) ___ ___
Manner of Crash/Collision ___ ___
Light Conditions ___ | Surface Conditions ___

ROADWAY CHARACTERISTICS
Major Contributing Circumstances:
Environment ___
Roadway ___ ___
Type of Roadway Junction/Feature ___ ___

WORKZONE RELATED?
○Yes ○No
___ Location
___ Type
___ Workers Present?

NON-MOTORIST

Type ___ Location ___

Action ___ Condition ___

Safety Equipment ___

Contributing Circumstances ___ ___

Unit No. of Vehicle Striking ___

Motorcycle Seating Position
01 - Motorcycle Driver
04 - Motorcycle Passenger
88 - Other (explain in narrative)

SEATING POSITION

01	02	03
04	05	06
07	08	09

10 - Sleeper Section
11 - Enclosed Cargo Area
12 - Unenclosed Cargo Area
13 - Trailing Unit
14 - Exterior
15 - Pedestrian
16 - Pedalcyclist
17 - Pedalcyclist, passenger
88 - Other (explain in narrative)
99 - Unknown

DRIVERS

	Phone	Sex	Unit No.	Seating Position	Injury Status	Occupant Protection	Airbag Deployment	Airbag Switch Status	Ejection	Ejection Path	Trapped
DRIVER OF UNIT 1	Transported to:										
	Transported by:										
DRIVER OF UNIT 2	Phone										
	Transported to:										
	Transported by:										

PERSONS INJURED

		Sex	Unit No.	Seating Position	Injury Status	Occupant Protection	Airbag Deployment	Airbag Switch Status	Ejection	Ejection Path	Trapped
Name 1.	Date of Birth										
Address	Transported to:				Transported by:						
Name 2.	Date of Birth										
Address	Transported to:				Transported by:						
Name 3.	Date of Birth										
Address	Transported to:				Transported by:						
Name 4.	Date of Birth										
Address	Transported to:				Transported by:						

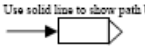
DIAGRAM

DIAGRAM WHAT HAPPENED: *Instruction*

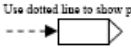
Number each vehicle and show direction of travel by arrow:

INDICATE NORTH

Use solid line to show path before accident.:



Use dotted line to show path after accident.:



Show pedestrian by.:

Show railroad by.:

Show utility poles by.:

Show motorcycles by.:

Show animal by.:

NARRATIVE

Describe what happened (refer to vehicles by number)

WITNESS

Name (Last, First)	Street or RFD	City	State	Zip	Phone

Signature of Officer	Badge No.	Time Officer Notified of Accident Hrs.	Time Officer Arrived At Scene Hrs.
Name of Agency	Date of Report	Investigation made at scene? Y N	Supplemental Information Will Follow? Y N / T.I. #
Report Reviewed by	Date Reviewed	Report Given to All Drivers? Y N	Other Technical Investigating Agency

Form 433013
01-01

MAIL REPORTS TO:
Iowa Department of Transportation, Office of Driver Services
Park Fair Mall, 100 Euclid Avenue, P.O. Box 9204
Des Moines, Iowa 50306-9204

PLEASE TYPE OR PRINT

Supplemental

Iowa Department of Transportation

INVESTIGATING OFFICER'S REPORT OF MOTOR VEHICLE ACCIDENT

Sheet ____ of ____

Law Enforcement Case Numbers:

Date of Accident | Time of Accident ____ Hrs. | Accident occurred within corporate limits of (city) | On Road, Street, or Highway: | At Intersection with: | County

UNIT

Driver's Name (Last, First, Middle) | Address | City | State | Zip

Date of Birth | Driver's License Number | Citation Charge 1. ____ 2. ____ 3. ____ 4. ____

Male ○ Female ○ | State | Class | Endorsements | Restrictions

Alcohol Test Given? [ ] 1. None 2. Blood 3. Urine 4. Breath 5.Vitreous 9. Refused Test Results: ____

Drug Test Given? [ ] 1. None 2. Blood 3. Urine 9. Refused Pos. ○ Neg. ○

Owner's Name (Last, First, Middle) | Address | City | State | Zip

Insurance Co. Name | Insurance Policy # | License Plate # | State | Year

VIN # | Year | Make | Model | Style | Tow # | Private ☐ | Approximate Cost to Repair or Replace $

Initial Travel Direction [ ] | Vehicle Action [ ] | Speed Limit [ ] | Point of Initial Impact [ ] | Most Damaged Area [ ] | Extent of Damage [ ] | Underride/ Override [ ]

Total Occupants [ ] | Traffic Controls [ ] | Vehicle Config. [ ] | Cargo Body Type [ ] | Vehicle Defect [ ] | Driver Condition [ ] | Vision Obscured [ ] | Contributing Circumstances, Driver (up to two) [ ] [ ]

Commercial Trailer License Plate # | Attached to Power Unit: ____ | State | Year | Attached to Trailer Unit: ____ | State | Year | Emergency Vehicle Type [ ] | Emergency Status [ ]

Carrier Name | Address | City | State | Zip

US DOT # ○ or MC # ○ [ ] | Number of Axles | Gross Vehicle Weight Rating | Placard # [ ] - [ ] | Hazardous Materials Released? [ ]

UNIT

Driver's Name (Last, First, Middle) | Address | City | State | Zip

Date of Birth | Driver's License Number | Citation Charge 1. ____ 2. ____ 3. ____ 4. ____

Male ○ Female ○ | State | Class | Endorsements | Restrictions

Alcohol Test Given? [ ] 1. None 2. Blood 3. Urine 4. Breath 5.Vitreous 9. Refused Test Results: ____

Drug Test Given? [ ] 1. None 2. Blood 3. Urine 9. Refused Pos. ○ Neg. ○

Owner's Name (Last, First, Middle) | Address | City | State | Zip

Insurance Co. Name | Insurance Policy # | License Plate # | State | Year

VIN # | Year | Make | Model | Style | Tow # | Private ☐ | Approximate Cost to Repair or Replace $

Initial Travel Direction [ ] | Vehicle Action [ ] | Speed Limit [ ] | Point of Initial Impact [ ] | Most Damaged Area [ ] | Extent of Damage [ ] | Underride/ Override [ ]

Total Occupants [ ] | Traffic Controls [ ] | Vehicle Config. [ ] | Cargo Body Type [ ] | Vehicle Defect [ ] | Driver Condition [ ] | Vision Obscured [ ] | Contributing Circumstances, Driver (up to two) [ ] [ ]

Commercial Trailer License Plate # | Attached to Power Unit: ____ | State | Year | Attached to Trailer Unit: ____ | State | Year | Emergency Vehicle Type [ ] | Emergency Status [ ]

Carrier Name | Address | City | State | Zip

US DOT # ○ or MC # ○ [ ] | Number of Axles | Gross Vehicle Weight Rating | Placard # [ ] - [ ] | Hazardous Materials Released? [ ]

UNIT

Driver's Name (Last, First, Middle) | Address | City | State | Zip

Date of Birth | Driver's License Number | Citation Charge 1. ____ 2. ____ 3. ____ 4. ____

Male ○ Female ○ | State | Class | Endorsements | Restrictions

Alcohol Test Given? [ ] 1. None 2. Blood 3. Urine 4. Breath 5.Vitreous 9. Refused Test Results: ____

Drug Test Given? [ ] 1. None 2. Blood 3. Urine 9. Refused Pos. ○ Neg. ○

Owner's Name (Last, First, Middle) | Address | City | State | Zip

Insurance Co. Name | Insurance Policy # | License Plate # | State | Year

VIN # | Year | Make | Model | Style | Tow # | Private ☐ | Approximate Cost to Repair or Replace $

Initial Travel Direction [ ] | Vehicle Action [ ] | Speed Limit [ ] | Point of Initial Impact [ ] | Most Damaged Area [ ] | Extent of Damage [ ] | Underride/ Override [ ]

Total Occupants [ ] | Traffic Controls [ ] | Vehicle Config. [ ] | Cargo Body Type [ ] | Vehicle Defect [ ] | Driver Condition [ ] | Vision Obscured [ ] | Contributing Circumstances, Driver (up to two) [ ] [ ]

Commercial Trailer License Plate # | Attached to Power Unit: ____ | State | Year | Attached to Trailer Unit: ____ | State | Year | Emergency Vehicle Type [ ] | Emergency Status [ ]

Carrier Name | Address | City | State | Zip

US DOT # ○ or MC # ○ [ ] | Number of Axles | Gross Vehicle Weight Rating | Placard # [ ] - [ ] | Hazardous Materials Released? [ ]

If Property other than vehicles damaged explain	Object Damaged		Estimate of Damage $
Owner's Full Name (Last, First, Middle)		Was owner or tenant notified? |__|	1 – Yes 2 – No 9 - Unknown
Street or RFD	City, State, & Zip Code		
If Property other than vehicles damaged explain	Object Damaged		Estimate of Damage $
Owner's Full Name (Last, First, Middle)		Was owner or tenant notified? |__|	1 – Yes 2 – No 9 - Unknown
Street or RFD	City, State, & Zip Code		

Unit __	Unit __	Unit __	SEQUENCE OF EVENTS
|__|__|	|__|__|	|__|__|	First Event
|__|__|	|__|__|	|__|__|	Second Event
|__|__|	|__|__|	|__|__|	Third Event
|__|__|	|__|__|	|__|__|	Fourth Event
|__|__|	|__|__|	|__|__|	Most Harmful Event (by vehicle)

NON-MOTORIST

Type |__| Location |__|

Action |__| Condition |__|

Safety Equipment |__|

Contributing Circumstances |__|__|

Unit No. of Vehicle Striking |__|

Motorcycle Seating Position
01 - Motorcycle Driver
04 - Motorcycle Passenger
88 - Other (explain in narrative)

SEATING POSITION

01	02	03
04	05	06
07	08	09

10 - Sleeper Section
11 - Enclosed Cargo Area
12 - Unenclosed Cargo Area
13 - Trailing Unit
14 - Exterior
15 - Pedestrian
16 - Pedalcyclist
17 - Pedalcyclist, passenger
88 - Other (explain in narrative)
99 - Unknown

Sex | Unit No. | Seating Position | Injury Status | Occupant Protection | Airbag Deployment | Airbag Switch Status | Ejection | Ejection Path | Trapped

DRIVERS

DRIVER OF UNIT ___	Phone	
	Transported to:	Transported by:
DRIVER OF UNIT ___	Phone	
	Transported to:	Transported by:
DRIVER OF UNIT ___	Phone	
	Transported to:	Transported by:

PERSONS INJURED

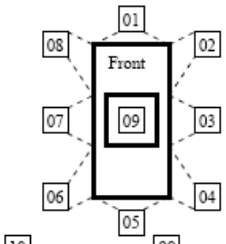
Name	Date of Birth	
Address	Transported to:	Transported by:
Name	Date of Birth	
Address	Transported to:	Transported by:
Name	Date of Birth	
Address	Transported to:	Transported by:
Name	Date of Birth	
Address	Transported to:	Transported by:
Name	Date of Birth	
Address	Transported to:	Transported by:
Name	Date of Birth	
Address	Transported to:	Transported by:
Name	Date of Birth	
Address	Transported to:	Transported by:
Name	Date of Birth	
Address	Transported to:	Transported by:
Name	Date of Birth	
Address	Transported to:	Transported by:
Name	Date of Birth	
Address	Transported to:	Transported by:
Name	Date of Birth	
Address	Transported to:	Transported by:

Driver/Vehicle Characteristics

Initial Travel Direction
(prior to coded Vehicle Action)
1 - North
2 - East
3 - South
4 - West
9 - Unknown

Vehicle Action
01 - Movement essentially straight
02 - Turning left
03 - Turning right
04 - Making U-turn
05 - Overtaking/passing
06 - Changing lanes
07 - Entering traffic lane (merging)
08 - Leaving traffic lane
09 - Backing
10 - Slowing/stopping
11 - Stopped for stop sign/signal
12 - Legally Parked
13 - Illegally Parked/Unattended
88 - Other (explain in narrative)
99 - Unknown

Point of Initial Impact
Most Damaged Area



10 Under-Carriage
99 Unknown

Extent of Damage
1 - None
2 - Minor damage
3 - Functional damage
4 - Disabling damage
5 - Severe, vehicle totaled
9 - Unknown

Underride/Override
1 - None
2 - Underride, compartment intrusion
3 - Underride, no compartment intrusion
4 - Underride, compartment intrusion unknown
5 - Override, moving vehicle
6 - Override, parked/stationary vehicle
9 - Unknown

Traffic Controls
01 - No controls present
02 - Traffic signals
03 - Flashing traffic control signal
04 - Stop signs
05 - Yield signs
06 - No Passing Zone (marked)
07 - Warning sign
08 - School zone signs
09 - Railway crossing device
10 - Traffic director
11 - Workzone signs
88 - Other control (explain in narrative)
99 - Unknown

Vehicle Configuration
01 - Passenger car
02 - Four-tire light truck (pick-up, panel)
03 - Van or mini-van
04 - Sport utility vehicle
05 - Single-unit truck (2-axle, 6-tire)
06 - Single-unit truck (>= 3 axles)
07 - Truck/trailer
08 - Truck tractor (bobtail)
09 - Tractor/semi-trailer
10 - Tractor/doubles
11 - Tractor/triples
12 - Other heavy truck (cannot classify)
13 - Motor home/recreational vehicle
14 - Motorcycle
15 - Moped/All-Terrain Vehicle
16 - School bus (seats > 15)
17 - Small school bus (seats 9 - 15)
18 - Other bus (seats > 15)
19 - Other small bus (seats 9 - 15)
20 - Farm vehicle/equipment
21 - Maintenance/construction vehicle
22 - Train
88 - Other (explain in narrative)
99 - Unknown

Cargo Body Type
01 - Not applicable

Truck Cargo Type:
02 - Van/enclosed box
03 - Dump truck (grain, gravel)
04 - Cargo tank
05 - Flatbed
06 - Concrete mixer
07 - Auto transporter
08 - Garbage/refuse
09 - Other truck cargo type (explain in narrative)

Trailer type:
10 - Small utility (one axle)
11 - Large utility (2+ axles)
12 - Boat
13 - Camper
14 - Large mobile home
15 - Oversize load
16 - Towed vehicle
17 - Pole
18 - Other trailer type (explain in narrative)
99 - Unknown

Vehicle Defect
01 - None
02 - Brakes
03 - Steering
04 - Blowout
05 - Other tire defect (explain in narrative)
06 - Wipers
07 - Trailer hitch
08 - Exhaust
09 - Headlights
10 - Tail lights
11 - Turn signal
12 - Suspension
88 - Other (explain in narrative)
99 - Unknown

Driver Condition
1 - Apparently normal
2 - Physical impairment
3 - Emotional (e.g., depressed, angry, disturbed)
4 - Illness
5 - Asleep, fainted, fatigued, etc.
6 - Under the influence of alcohol/drugs/medications
8 - Other (explain in narrative)
9 - Unknown

Vision Obscured
01 - Not obscured
02 - Trees/crops
03 - Buildings
04 - Embankment
05 - Sign/billboard
06 - Hillcrest
07 - Parked vehicles
08 - Moving vehicles
09 - Person/object in or on vehicle
10 - Blinded by sun or headlights
11 - Frosted windows/windshield
12 - Blowing snow
13 - Fog/smoke/dust
88 - Other (explain in narrative)
99 - Unknown

Contributing Circumstances, Driver (up to two)
01 - Ran traffic signal
02 - Ran stop sign
03 - Exceeded authorized speed
04 - Driving too fast for conditions
05 - Made improper turn
06 - Traveling wrong way or on wrong side of road
07 - Crossed centerline
08 - Lost Control
09 - Followed too close
10 - Swerved to avoid: vehicle, object, non-motorist, or animal in roadway
11 - Over correcting/over steering
12 - Operating vehicle in an erratic, reckless, careless, negligent, or aggressive manner

Failed to yield right-of-way:
13 - From stop sign
14 - From yield sign
15 - Making left turn
16 - Making right turn on red signal
17 - From driveway
18 - From parked position
19 - To pedestrian
20 - At uncontrolled intersection
21 - Other (explain in narrative)

Inattentive/distracted by:
22 - Passenger
23 - Use of phone or other device
24 - Fallen object
25 - Fatigued/asleep

Other (explain in narrative):
26 - Vision obstructed
27 - Other improper action
28 - No improper action

99 - Unknown

Emergency Vehicles

Emergency Vehicle Type
1 - Not applicable
2 - Police
3 - Fire
4 - Ambulance
5 - Towing
6 - Military
7 - Maintenance
9 - Unknown

Emergency Status
1 - Yes, in emergency
2 - No, not in emergency
3 - Not applicable
9 - Unknown

Hazardous Materials Released? (Cargo Only)

1 - Yes
2 - No
3 - Not applicable
9 - Unknown

Iowa Department of Transportation

INVESTIGATING OFFICER'S REPORT OF MOTOR VEHICLE ACCIDENT CODE SHEET

Form 433014
01-01

Workzone Related?

Location
1 - Before work zone warning sign
2 - Between advance warning sign and work area
3 - Within transition area for lane shift
4 - Within or adjacent to work activity
5 - Between end of work area and "End Work Zone" sign
8 - Other work zone area (explain in narrative)
9 - Unknown

Type
1 - Lane closure
2 - Lane shift/crossover (head-to-head traffic)
3 - Work on shoulder or median
4 - Intermittent or moving work
8 - Other type of work zone (explain in narrative)
9 - Unknown

Workers Present?
1 - Yes
2 - No
9 - Unknown

Accident Environment

Location of First Harmful Event
1 - On Roadway
2 - Shoulder
3 - Median
4 - Roadside
5 - Gore
6 - Outside trafficway
9 - Unknown

Manner of Crash/Collision
1 - Non-collision
2 - Head-on
3 - Rear-end
4 - Angle, oncoming left turn
5 - Broadside
6 - Sideswipe, same direction
7 - Sideswipe, opposite direction
9 - Unknown

Light Conditions
1 - Daylight
2 - Dusk
3 - Dawn
4 - Dark, roadway lighted
5 - Dark, roadway not lighted
6 - Dark, unknown roadway lighting
9 - Unknown

Weather Conditions (up to two)
01 - Clear
02 - Partly cloudy
03 - Cloudy
04 - Fog, smoke
05 - Mist
06 - Rain
07 - Sleet, hail, freezing rain
08 - Snow
09 - Severe winds
10 - Blowing sand, soil, dirt, snow
88 - Other (explain in narrative)
99 - Unknown

Surface Conditions
1 - Dry
2 - Wet
3 - Ice
4 - Snow
5 - Slush
6 - Sand, mud, dirt, oil, gravel
7 - Water (standing, moving)
8 - Other (explain in narrative)
9 - Unknown

Roadway Characteristics

Contributing Circumstances, Environment
1 - None apparent
2 - Weather conditions
3 - Physical obstruction
4 - Pedestrian action
5 - Glare
6 - Animal in roadway
7 - Previous accident
8 - Other (explain in narrative)
9 - Unknown

Contributing Circumstances, Roadway
01 - None apparent
02 - Road surface condition
03 - Debris
04 - Ruts, holes, bumps
05 - Work Zone (construction, maintenance, utility)
06 - Worn, travel-polished surface
07 - Obstruction in roadway
08 - Traffic control device inoperative, missing, obscured
09 - Shoulders (none, low, soft, high)
10 - Non-highway work
11 - Non-contact vehicle
99 - Unknown

Type of Roadway Junction/Feature
Non-intersection:
01 - No special feature
02 - Bridge/overpass/underpass
03 - Railroad crossing
04 - Business drive
05 - Farm/residential drive
06 - Alley intersection
07 - Crossover in median
08 - Other non-intersection (explain in narrative)
Intersection:
11 - Four-way intersection
12 - T - intersection
13 - Y - intersection
14 - Five-leg or more
15 - Offset four-way intersection
16 - Intersection with ramp
17 - On-ramp merge area
18 - Off-ramp diverge area
19 - On-ramp
20 - Off-ramp
21 - With bike/pedestrian path
22 - Other intersection (explain in narrative)
99 - Unknown

Harmful Events

Sequence of Events
Most Harmful Event
First Harmful Event
Pre-crash events:
01 - Ran off road, right
02 - Ran off road, straight
03 - Ran off road, left
04 - Crossed centerline/median
05 - Animal or object in roadway
06 - Evasive action (swerve, panic braking, etc.)
07 - Downhill runaway
08 - Cargo/equipment loss or shift
09 - Equipment failure (tires, brakes, etc.)
10 - Separation of units
Non-collision events:
11 - Overturn/rollover
12 - Jackknife
13 - Other non-collision (explain in narrative)
Collision with:
20 - Non-motorist (see non-motorist type)
21 - Vehicle in traffic
22 - Vehicle in/from other roadway
23 - Parked motor vehicle
24 - Railway vehicle/train
25 - Animal
26 - Other non-fixed object (explain in narrative)
Collision with fixed object:
30 - Bridge/bridge rail/overpass
31 - Underpass/structure support
32 - Culvert
33 - Ditch/embankment
34 - Curb/island/raised median
35 - Guardrail
36 - Concrete barrier (median or right side)
37 - Tree
38 - Poles (utility, light, etc.)
39 - Sign post
40 - Mailbox
41 - Impact attenuator
42 - Other fixed object (explain in narrative)
Misc. events:
50 - Fire/explosion
51 - Immersion
52 - Hit and run
99 - Unknown

Injury/Protective Devices

Injury Status
1 - Fatal
2 - Incapacitating
3 - Non-incapacitating
4 - Possible
5 - Uninjured
9 - Unknown

Occupant Protection
1 - None used
2 - Shoulder and lap belt used
3 - Lap belt only used
4 - Shoulder belt only used
5 - Child safety seat used
6 - Helmet used
8 - Other (explain in narrative)
9 - Unknown

Airbag Deployment
1 - Deployed front of person
2 - Deployed side of person
3 - Deployed both front/side
4 - Other deployment (explain in narrative)
5 - Not deployed
6 - Not applicable
9 - Unknown

Airbag Switch Status
1 - Switch in ON position
2 - Switch in OFF position
3 - No ON/OFF switch present
9 - Unknown

Ejection
1 - Not ejected
2 - Partially ejected
3 - Totally ejected
4 - Not applicable (motorcycle, bicycle, etc.)
9 - Unknown

Ejection Path
1 - Not ejected/not applicable
2 - Through front windshield
3 - Through side window/door
4 - Through roof
5 - Through back window/tailgate
9 - Unknown

Trapped
1 - Not trapped
2 - Freed by non-mechanical means
3 - Extricated by mechanical means
9 - Unknown

Non-Motorist

Type
1 - Pedestrian
2 - Pedalcyclist (bicycle, tricycle, unicycle, pedal car)
3 - Skater
8 - Other (explain in narrative)
9 - Unknown

Location (prior to impact)
1 - Marked crosswalk at intersection
2 - At intersection, no crosswalk
3 - Non-intersection crosswalk
4 - Driveway access crosswalk
8 - Other non-intersection (explain in narrative)
9 - Unknown

Action
1 - Entering or crossing roadway
2 - Walking, running, jogging, playing, cycling
3 - Working
4 - Pushing vehicle
5 - Approaching or leaving vehicle
6 - Playing or working on vehicle
7 - Standing
8 - Other (explain in narrative)
9 - Unknown

Condition
1 - Apparently normal
2 - Physical impairment
3 - Emotional (e.g., depressed, angry, disturbed)
4 - Illness
5 - Asleep, fainted, fatigued, etc.
6 - Under the influence of alcohol/drugs/medications
8 - Other (explain in narrative)
9 - Unknown

Safety Equipment
1 - Helmet
2 - Reflective clothing
3 - Lighting
4 - None
8 - Other (explain in narrative)
9 - Unknown

Contributing Circumstances
01 - Improper crossing
02 - Darting
03 - Lying or sitting in roadway
04 - Failure to yield right of way
05 - Not visible (dark clothing)
06 - Inattentive (talking, eating, etc.)
07 - Failure to obey traffic signs, signals, or officer
08 - Wrong side of road
88 - Other (explain in narrative)
99 - Unknown

APPENDIX D. WORK ZONE CRASH DATABASE PARAMETERS

Work Zone Crash Parameters (zwks)

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
Crash_Key	Crash Key - SAVER Internal Unique Identifier		4 digit year + arbitrarily assigned unique number (e.g., 2001000025)	Numeric: Integer	10	0
WZ_Related	Workzone Related?			Character	1	0
		1	Yes			
		2	No			
WZ_Loc	Location			Numeric: Integer	2	0
		1	Before work zone warning sign			
		2	Between advance warning sign and work area			
		3	Within transition area for lane shift			
		4	Within or adjacent to work activity			
		5	Between end of work area and End Work Zone sign			
		8	Other work zone area (explain in narrative)			
		9	Unknown			
		77	Not reported.			
WZ_Type	Type			Numeric: Integer	2	0
		1	Lane closure			
		2	Lane shift/crossover (head-to-head traffic)			
		3	Work on shoulder or median			
		4	Intermittent or moving work			
		8	Other type of work zone (explain in narrative)			
		9	Unknown			
		77	Not reported.			
Workers	Workers Present?			Numeric: Integer	2	0
		1	Yes			
		2	No			
		9	Unknown			
		77	Not reported.			

Crash Type Parameters 1 (zcta)

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
Crash_Key	Crash Key - SAVER Internal Unique Identifier		4 digit year + arbitrarily assigned unique number (e.g., 2001000025)	Numeric: Integer	10	0
FirstHarm	First Harmful Event			Numeric: Integer	2	0
		11	Non-collision events: Overturn/rollover			
		12	Non-collision events: Jackknife			
		13	Non-collision events: Other non-collision (explain in narrative)			
		20	Collision with: Non-motorist (see non-motorist type)			
		21	Collision with: Vehicle in traffic			
		22	Collision with: Vehicle in/from other roadway			
		23	Collision with: Parked motor vehicle			
		24	Collision with: Railway vehicle/train			
		25	Collision with: Animal			
		26	Collision with: Other non-fixed object (explain in narrative)			
		30	Collision with fixed object: Bridge/bridge rail/overpass			
		31	Collision with fixed object: Underpass/structure support			
		32	Collision with fixed object: Culvert			
		33	Collision with fixed object: Ditch/embankment			
		34	Collision with fixed object: Curb/island/raised median			
		35	Collision with fixed object: Guardrail			
		36	Collision with fixed object: Concrete barrier (median or right side)			
		37	Collision with fixed object: Tree			
		38	Collision with fixed object: Poles (utility, light, etc.)			
		39	Collision with fixed object: Sign post			
		40	Collision with fixed object: Mailbox			
		41	Collision with fixed object: Impact attenuator			
		42	Collision with fixed object: Other fixed object (explain in narrative)			
		50	Miscellaneous events: Fire/explosion			
		51	Miscellaneous events: Immersion			
		52	Miscellaneous events: Hit and run			
		77	Not Reported			
		99	Unknown			
CrCoManner	Manner of Crash/Collision			Numeric: Integer	2	0
		1	Non-collision			
		2	Head-on			
		3	Rear-end			
		4	Angle, oncoming left turn			
		5	Broadside			
		6	Sideswipe, same direction			
		7	Sideswipe, opposite direction			
		9	Unknown			
		77	Not Reported			

Crash Type Parameters 1 (zcta) – cont.

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
MajorCause	Major Cause		Derived.	Numeric: Integer	2	0
		1	Animal			
		2	Ran Traffic Signal			
		3	Ran Stop Sign			
		4	Crossed centerline			
		5	FTYROW: At uncontrolled intersection			
		6	FTYROW: Making right turn on red signal			
		7	FTYROW: From stop sign			
		8	FTYROW: From yield sign			
		9	FTYROW: Making left turn			
		10	FTYROW: From driveway			
		11	FTYROW: From parked position			
		12	FTYROW: To pedestrian			
		13	FTYROW: Other (explain in narrative)			
		14	Traveling wrong way or on wrong side of road			
		15	Driving too fast for conditions			
		16	Exceeded authorized speed			
		17	Made improper turn			
		18	Improper Lane Change			
		19	Followed too close			
		20	Disregarded RR Signal			
		21	Disregarded Warning Sign			
		22	Operating vehicle in an erratic/reckless/careless/negligent/aggressive manner			
		23	Improper Backing			
		24	Illegally Parked/Unattended			
		25	Swerving/Evasive Action			
		26	Over correcting/over steering			
		27	Downhill runaway			
		28	Equipment failure			
		29	Separation of units			
		30	Ran off road - right			
		31	Ran off road - straight			
		32	Ran off road - left			
		33	Lost Control			
		34	Inattentive/distracted by: Passenger			
		35	Inattentive/distracted by: Use of phone or other device			
		36	Inattentive/distracted by: Fallen object			
		37	Inattentive/distracted by: Fatigued/asleep			
		38	Other (explain in narrative): Vision obstructed			
		39	Oversized Load/Vehicle			
		40	Cargo/equipment loss or shift			
		41	Other (explain in narrative): Other improper action			
		42	Unknown			
		43	Other (explain in narrative): No improper action			
		77	Not Reported			
DrugAlcRel	Drug or Alcohol Related		Derived from Alcohol results, Drug results, and driver conditions.	Numeric: Integer	1	0
		1	Drug-related			
		2	Alcohol-related (under 0.08)			
		3	Alcohol-related (0.08 or over)			
		4	Drug- and alcohol-related (under 0.08)			
		5	Drug- and alcohol-related (0.08 or over)			
		6	Refused			
		7	A driver indicated as under the influence of alcohol/drugs/medications			
		8	Not drug- or alcohol-related			

Severity Level Crash Parameters (zsev)

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
Crash_Key	Crash Key - SAVER Internal Unique		4 digit year + arbitrarily assigned unique number (e.g., 2001000025)	Numeric: Integer	10	0
CSeverity	Crash Severity			Numeric: Integer	1	0
		1	Fatal			
		2	Major Injury			
		3	Minor Injury			
		4	Possible/Unknown			
		5	Property Damage Only			
Fatalities	Number of Fatalities		Crashwide total of all fatalities.	Numeric: Integer	3	0
Injuries	Number of Injuries		Crashwide total of all injuries, excluding fatalities.	Numeric: Integer	3	0
MajInjury	Number of Major Injuries		Crashwide total of all major injuries.	Numeric: Integer	3	0
MinInjury	Number of Minor Injuries		Crashwide total of all minor injuries.	Numeric: Integer	3	0
PossInjury	Number of Possible Injuries		Crashwide total of all possible injuries.	Numeric: Integer	3	0
UnkInjury	Number of Unknown Injuries		Crashwide total of all unknown injuries.	Numeric: Integer	3	0
PropDmg	Amount of Property Damage		Crashwide total of property damage, including non-vehicular.	Numeric: Integer	9	0
Vehicles	Number of Vehicles		Number of vehicles involved in the crash.	Numeric: Integer	2	0
TOccupants	Total Number of Occupants		Crashwide total of occupants in all vehicles.	Numeric: Integer	3	0

Location/Time Crash Parameters (zltp)

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
Crash_Key	Crash Key - SAVER Internal Unique Identifier		4 digit year + arbitrarily assigned unique number (e.g., 2001000025)	Numeric: Integer	10	0
Date	Date of Crash		Crash date in YYYYMMDD format (e.g., 20010422)	Numeric: Integer	8	0
Month	Month			Numeric: Integer	2	0
		1	January			
		2	February			
		3	March			
		4	April			
		5	May			
		6	June			
		7	July			
		8	August			
		9	September			
		10	October			
		11	November			
		12	December			
DayOfMonth	Day of Month	1-31	Valid values depend on month and year (leap year).	Numeric: Integer	2	0
Year	Year			Numeric: Integer	4	0
Day	Day of Week			Numeric: Integer	1	0
		1	Sunday			
		2	Monday			
		3	Tuesday			
		4	Wednesday			
		5	Thursday			
		6	Friday			
		7	Saturday			
Time	Time of Crash		Crash time in 24-hour format (HHMM) (e.g., 1230)	Numeric: Integer	4	0
TimeStr	Time of Crash in String Format		Crash time in 24-hour format (HH:MM) (e.g., 12:30)	String	5	0

Location/Time Crash Parameters (zltp) – cont.

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
TimeDay	Time of Day/Day of Week in Bins		Time of Day and Day of Week combined and into bin definitions	Numeric: Integer	3	0
		101	Sunday, 12 midnight to 1:59 AM			
		201	Monday, 12 midnight to 1:59 AM			
		301	Tuesday, 12 midnight to 1:59 AM			
		401	Wednesday, 12 midnight to 1:59 AM			
		501	Thursday, 12 midnight to 1:59 AM			
		601	Friday, 12 midnight to 1:59 AM			
		701	Saturday, 12 midnight to 1:59 AM			
		102	Sunday, 2:00 AM to 3:59 AM			
		202	Monday, 2:00 AM to 3:59 AM			
		302	Tuesday, 2:00 AM to 3:59 AM			
		402	Wednesday, 2:00 AM to 3:59 AM			
		502	Thursday, 2:00 AM to 3:59 AM			
		602	Friday, 2:00 AM to 3:59 AM			
		702	Saturday, 2:00 AM to 3:59 AM			
		103	Sunday, 4:00 AM to 5:59 AM			
		203	Monday, 4:00 AM to 5:59 AM			
		303	Tuesday, 4:00 AM to 5:59 AM			
		403	Wednesday, 4:00 AM to 5:59 AM			
		503	Thursday, 4:00 AM to 5:59 AM			
		603	Friday, 4:00 AM to 5:59 AM			
		703	Saturday, 4:00 AM to 5:59 AM			
		104	Sunday, 6:00 AM to 7:59 AM			
		204	Monday, 6:00 AM to 7:59 AM			
		304	Tuesday, 6:00 AM to 7:59 AM			
		404	Wednesday, 6:00 AM to 7:59 AM			
		504	Thursday, 6:00 AM to 7:59 AM			
		604	Friday, 6:00 AM to 7:59 AM			
		704	Saturday, 6:00 AM to 7:59 AM			
		105	Sunday, 8:00 AM to 9:59 AM			
		205	Monday, 8:00 AM to 9:59 AM			
		305	Tuesday, 8:00 AM to 9:59 AM			
		405	Wednesday, 8:00 AM to 9:59 AM			
		505	Thursday, 8:00 AM to 9:59 AM			
		605	Friday, 8:00 AM to 9:59 AM			
		705	Saturday, 8:00 AM to 9:59 AM			
		106	Sunday, 10:00 AM to 11:59 AM			
		206	Monday, 10:00 AM to 11:59 AM			
		306	Tuesday, 10:00 AM to 11:59 AM			
		406	Wednesday, 10:00 AM to 11:59 AM			
		506	Thursday, 10:00 AM to 11:59 AM			
		606	Friday, 10:00 AM to 11:59 AM			
		706	Saturday, 10:00 AM to 11:59 AM			
		107	Sunday, 12:00 noon to 1:59 PM			
		207	Monday, 12:00 noon to 1:59 PM			
		307	Tuesday, 12:00 noon to 1:59 PM			
		407	Wednesday, 12:00 noon to 1:59 PM			
		507	Thursday, 12:00 noon to 1:59 PM			
		607	Friday, 12:00 noon to 1:59 PM			
		707	Saturday, 12:00 noon to 1:59 PM			
		108	Sunday, 2:00 PM to 3:59 PM			
		208	Monday, 2:00 PM to 3:59 PM			
		308	Tuesday, 2:00 PM to 3:59 PM			
		408	Wednesday, 2:00 PM to 3:59 PM			
		508	Thursday, 2:00 PM to 3:59 PM			
		608	Friday, 2:00 PM to 3:59 PM			
		708	Saturday, 2:00 PM to 3:59 PM			
		109	Sunday, 4:00 PM to 5:59 PM			
		209	Monday, 4:00 PM to 5:59 PM			
		309	Tuesday, 4:00 PM to 5:59 PM			
		409	Wednesday, 4:00 PM to 5:59 PM			
		509	Thursday, 4:00 PM to 5:59 PM			
		609	Friday, 4:00 PM to 5:59 PM			
		709	Saturday, 4:00 PM to 5:59 PM			
		110	Sunday, 6:00 PM to 7:59 PM			
		210	Monday, 6:00 PM to 7:59 PM			
		310	Tuesday, 6:00 PM to 7:59 PM			
		410	Wednesday, 6:00 PM to 7:59 PM			
		510	Thursday, 6:00 PM to 7:59 PM			
		610	Friday, 6:00 PM to 7:59 PM			
		710	Saturday, 6:00 PM to 7:59 PM			
		111	Sunday, 8:00 PM to 9:59 PM			
		211	Monday, 8:00 PM to 9:59 PM			
		311	Tuesday, 8:00 PM to 9:59 PM			
		411	Wednesday, 8:00 PM to 9:59 PM			
		511	Thursday, 8:00 PM to 9:59 PM			
		611	Friday, 8:00 PM to 9:59 PM			
		711	Saturday, 8:00 PM to 9:59 PM			
		112	Sunday, 10:00 PM to 11:59 PM			
		212	Monday, 10:00 PM to 11:59 PM			
		312	Tuesday, 10:00 PM to 11:59 PM			
		412	Wednesday, 10:00 PM to 11:59 PM			
		512	Thursday, 10:00 PM to 11:59 PM			
		612	Friday, 10:00 PM to 11:59 PM			
		712	Saturday, 10:00 PM to 11:59 PM			
		113	Sunday, unknown time			
		213	Monday, unknown time			
		313	Tuesday, unknown time			
		413	Wednesday, unknown time			
		513	Thursday, unknown time			
		613	Friday, unknown time			
		713	Saturday, unknown time			

Location/Time Crash Parameters (zltp) – cont.

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
LocFstHarm	Location of First Harmful Event			Numeric: Integer	2	0
		1	On Roadway			
		2	Shoulder			
		3	Median			
		4	Roadside			
		5	Gore			
		6	Outside trafficway			
		9	Unknown			
		77	Not reported.			
RuralUrban	Rural/Urban			Character	1	0
		R	Rural			
		U	Urban			
Field Name	**Field Description**	**Values**	**Values Descriptions**	**Field Type**	**Field Width**	**Field Precision**
County	County			Numeric: Integer	2	0
		1	Adair			
		2	Adams			
		3	Allamakee			
		4	Appanoose			
		5	Audubon			
		6	Benton			
		7	Black Hawk			
		8	Boone			
		9	Bremer			
		10	Buchanan			
		11	Buena Vista			
		12	Butler			
		13	Calhoun			
		14	Carroll			
		15	Cass			
		16	Cedar			
		17	Cerro Gordo			
		18	Cherokee			
		19	Chickasaw			
		20	Clarke			
		21	Clay			
		22	Clayton			
		23	Clinton			
		24	Crawford			
		25	Dallas			
		26	Davis			
		27	Decatur			
		28	Delaware			
		29	Des Moines			
		30	Dickinson			
		31	Dubuque			
		32	Emmet			
		33	Fayette			
		34	Floyd			
		35	Franklin			
		36	Fremont			
		37	Greene			
		38	Grundy			
		39	Guthrie			
		40	Hamilton			
		41	Hancock			
		42	Hardin			
		43	Harrison			
		44	Henry			
		45	Howard			
		46	Humboldt			
		47	Ida			
		48	Iowa			
		49	Jackson			
		50	Jasper			
		51	Jefferson			
		52	Johnson			
		53	Jones			
		54	Keokuk			
		55	Kossuth			
		56	Lee			
		57	Linn			
		58	Louisa			
		59	Lucas			
		60	Lyon			
		61	Madison			
		62	Mahaska			
		63	Marion			
		64	Marshall			
		65	Mills			
		66	Mitchell			
		67	Monona			
		68	Monroe			
		69	Montgomery			
		70	Muscatine			
		71	O'Brien			
		72	Osceola			
		73	Page			
		74	Palo Alto			
		75	Plymouth			
		76	Pocahontas			
		77	Polk			
		78	Pottawattamie			

Location/Time Crash Parameters (zltp) – cont.

		79	Poweshiek			
		80	Ringgold			
		81	Sac			
		82	Scott			
		83	Shelby			
		84	Sioux			
		85	Story			
		86	Tama			
		87	Taylor			
		88	Union			
		89	Van Buren			
		90	Wapello			
		91	Warren			
		92	Washington			
		93	Wayne			
		94	Webster			
		95	Winnebago			
		96	Winneshiek			
		97	Woodbury			
		98	Worth			
		99	Wright			
Field Name	**Field Description**	**Values**	**Values Descriptions**	**Field Type**	**Field Width**	**Field Precision**
City	City		Crash records city number. Unique within a county.	Numeric: Integer	2	0
CityBR	Base Records City Number		City number from Base Records.	Numeric: Integer	4	0
CityName	City Name		Text city name.	Character	25	0
Cardinal	Cardinal Travel Direction		Primary direction of travel for the route.	Character	2	0
		NB	Northbound (NB)			
		SB	Southbound (SB)			
		EB	Eastbound (EB)			
		WB	Westbound (WB)			
Route	Route Number			Character	3	0
		Route #	(e.g., 030 = US 30, 035 = Interstate 35)			
		"A" - "Z" + ##	County Road with Route Designator Noted			
		990	County Road			
		991	County Park			
		995	City Street			
		996	City Park, Frontage, Alley			
Milepoint	Milepoint		Milepoint along primary highways.	Numeric: Decimal	6	2
Milepost	Milepost		Milepost along primary highways.	Numeric: Decimal	6	2

Roadway Crash Parameters 1 (zrda)

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
Crash_Key	Crash Key - SAVER Internal Unique		4 digit year + arbitrarily assigned unique number (e.g., 2001000025)	Numeric: Integer	10	0
Road_Class	Road Classification	1	Interstate	Numeric: Integer	1	0
		2	US or State Highway			
		3	County Road			
		4	City Street			
		5	Other			
		77	Not Reported			
		99	Unknown			
IntClass	Intersection Class			Numeric: Integer	2	0
		1	Interstate/Interstate			
		2	Interstate/US or State Highway			
		3	Interstate/City or County Road			
		4	US or State Highway/US or State Highway			
		5	US or State Highway/County Road or City Street			
		6	US or State Highway/Other			
		7	County Road or City Street/County Road or City Street			
		8	County Road or City Street/Other			
		77	Not reported.			
		99	Not an Intersection (Unknown)			
RContCirc	Contributing Circumstances - Roadway			Numeric: Integer	2	0
		1	None apparent			
		2	Road surface condition			
		3	Debris			
		4	Ruts/holes/bumps			
		5	Work Zone (construction/maintenance/utility)			
		6	Worn/travel-polished surface			
		7	Obstruction in roadway			
		8	Traffic control device inoperative/missing/obscured			
		9	Shoulders (none/low/soft/high)			
		10	Non-highway work			
		11	Non-contact vehicle			
		77	Not reported.			
		99	Unknown			
RoadType	Type of Roadway Junction/Feature			Numeric: Integer	2	0
		1	Non-intersection: No special feature			
		2	Non-intersection: Bridge/overpass/underpass			
		3	Non-intersection: Railroad crossing			
		4	Non-intersection: Business drive			
		5	Non-intersection: Farm/residential drive			
		6	Non-intersection: Alley intersection			
		7	Non-intersection: Crossover in median			
		8	Non-intersection: Other non-intersection (explain in narrative)			
		11	Intersection: Four-way intersection			
		12	Intersection: T - intersection			
		13	Intersection: Y - intersection			
		14	Intersection: Five-leg or more			
		15	Intersection: Offset four-way intersection			
		16	Intersection: Intersection with ramp			
		17	Intersection: On-ramp merge area			
		18	Intersection: Off-ramp diverge area			
		19	Intersection: On-ramp			
		20	Intersection: Off-ramp			
		21	Intersection: With bike/pedestrian path			
		22	Intersection: Other intersection (explain in narrative)			
		77	Not reported.			
		99	Unknown			
RoadGeo	Roadway Geometrics			Numeric: Integer	2	0
		1	Straight and Level			
		2	Straight and Up/Downgrade			
		3	Straight and Hillcrest			
		4	Curve and Level			
		5	Curve and Up/Downgrade			
		6	Curve and Hillcrest			
		7	Intersection and Level			
		8	Intersection and Up/Downgrade			
		9	Intersection and Hillcrest			
		77	Not reported.			
		99	Unknown			

Environmental Crash Parameters (zenv)

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
Crash_Key	Crash Key - SAVER Internal Unique Identifier		4 digit year + arbitrarily assigned unique number (e.g., 2001000025)	Numeric: Integer	10	0
EContCirc	Contributing Circumstances - Environment			Numeric: Integer	2	0
		1	None apparent			
		2	Weather conditions			
		3	Physical obstruction			
		4	Pedestrian action			
		5	Glare			
		6	Animal in roadway			
		7	Previous accident			
		8	Other (explain in narrative)			
		9	Unknown			
		77	Not Reported			
Weather1	Weather Conditions 1			Numeric: Integer	2	0
		1	Clear			
		2	Partly cloudy			
		3	Cloudy			
		4	Fog/smoke			
		5	Mist			
		6	Rain			
		7	Sleet/hail/freezing rain			
		8	Snow			
		9	Severe winds			
		10	Blowing sand/soil/dirt/snow			
		77	Not Reported			
		88	Other (explain in narrative)			
		99	Unknown			
Weather2	Weather Conditions 2		See Weather1 values.	Numeric: Integer	2	0
Light	Light Conditions			Numeric: Integer	2	0
		1	Daylight			
		2	Dusk			
		3	Dawn			
		4	Dark - roadway lighted			
		5	Dark - roadway not lighted			
		6	Dark - unknown roadway lighting			
		9	Unknown			
		77	Not Reported			
Locality	Locality		Not currently in crash data.		2	
		77	Not Reported			
CSurfCond	Surface Conditions		Crashwide surface conditions.	Numeric: Integer	2	0
		1	Dry			
		2	Wet			
		3	Ice			
		4	Snow			
		5	Slush			
		6	Sand/mud/dirt/oil/gravel			
		7	Water (standing/moving)			
		8	Other (explain in narrative)			
		9	Unknown			
		77	Not Reported			

Vehicle Crash Parameters (zveh)

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
Crash_Key	Crash Key - SAVER Internal Unique		4 digit year + arbitrarily assigned unique number (e.g., 2001000025)	Numeric: Integer	10	0
V1UnitNum	Vehicle Unit Number		Number indicating which vehicle the driver was operating.	Numeric: Integer	3	0
		777	Not reported.			
V1UnitKey	Combined Crash_Key and V1UnitNum		Crash_Key*1000+V1UnitNum	Numeric: Integer	13	0
VConfig	Vehicle Configuration			Numeric: Integer	2	0
		1	Passenger car			
		2	Four-tire light truck (pick-up/panel)			
		3	Van or mini-van			
		4	Sport utility vehicle			
		5	Single-unit truck (2-axle/6-tire)			
		6	Single-unit truck (>= 3 axles)			
		7	Truck/trailer			
		8	Truck tractor (bobtail)			
		9	Tractor/semi-trailer			
		10	Tractor/doubles			
		11	Tractor/triples			
		12	Other heavy truck (cannot classify)			
		13	Motor home/recreational vehicle			
		14	Motorcycle			
		15	Moped/All-Terrain Vehicle			
		16	School bus (seats > 15)			
		17	Small school bus (seats 9-15)			
		18	Other bus (seats > 15)			
		19	Other small bus (seats 9-15)			
		20	Farm vehicle/equipment			
		21	Maintenance/construction vehicle			
		22	Train			
		23	Other (explain in narrative)			
		77	Not reported.			
		99	Unknown			
VYear	Vehicle Year		Vehicle year in YYYY format.	Numeric: Integer	4	0
		7777	Not reported.			
Make	Vehicle Make		(currently undefined)	Character	4	0
Model	Vehicle Model		(currently undefined)	Character	12	0
Style	Vehicle Style		(currently undefined)	Character	12	0
EmerVeh	Emergency Vehicle Type			Numeric: Integer	2	0
		1	Not applicable			
		2	Police			
		3	Fire			
		4	Ambulance			
		5	Towing			
		6	Military			
		7	Maintenance			
		9	Unknown			
		77	Not reported.			
EmerStatus	Emergency Status			Numeric: Integer	2	0
		1	Yes - in emergency			
		2	No - not in emergency			
		3	Not applicable			
		9	Unknown			
		77	Not reported.			
Occupants	Total Occupants		Occupants in vehicle.	Numeric: Integer	2	0
		777	Not reported.			
CargoBody	Cargo Body Type			Numeric: Integer	2	0
		1	Not applicable			
		2	Truck Cargo Type: Van/enclosed box			
		3	Truck Cargo Type: Dump truck (grain/gravel)			
		4	Truck Cargo Type: Cargo tank			
		5	Truck Cargo Type: Flatbed			
		6	Truck Cargo Type: Concrete mixer			
		7	Truck Cargo Type: Auto transporter			
		8	Truck Cargo Type: Garbage/refuse			
		9	Truck Cargo Type: Other truck cargo type (explain in narrative)			
		10	Trailer type: Small utility (one axle)			
		11	Trailer type: Large utility (2+ axles)			
		12	Trailer type: Boat			
		13	Trailer type: Camper			
		14	Trailer type: Large mobile home			
		15	Trailer type: Oversize load			
		16	Trailer type: Towed vehicle			
		17	Trailer type: Pole			
		18	Trailer type: Other trailer type (explain in narrative)			
		77	Not reported.			
		99	Unknown			

Vehicle Crash Parameters (zveh) – cont.

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
Defect	Vehicle Defect			Numeric: Integer	2	0
		1	None			
		2	Brakes			
		3	Steering			
		4	Blowout			
		5	Other tire defect (explain in narrative)			
		6	Wipers			
		7	Trailer hitch			
		8	Exhaust			
		9	Headlights			
		10	Tail lights			
		11	Turn signal			
		12	Suspension			
		77	Not reported.			
		88	Other (explain in narrative)			
		99	Unknown			
InitDir	Initial Direction of Travel			Numeric: Integer	2	0
		1	North			
		2	East			
		3	South			
		4	West			
		9	Unknown			
		77	Not reported.			
VAction	Vehicle Action			Numeric: Integer	2	0
		1	Movement essentially straight			
		2	Turning left			
		3	Turning right			
		4	Making U-turn			
		5	Overtaking/passing			
		6	Changing lanes			
		7	Entering traffic lane (merging)			
		8	Leaving traffic lane			
		9	Backing			
		10	Slowing/stopping			
		11	Stopped for stop sign/signal			
		12	Legally Parked			
		13	Illegally Parked/Unattended			
		14	Other (explain in narrative)			
		77	Not reported.			
		99	Unknown			
VLP_State	License Plate State			Character	2	0
		AL	Alabama			
		AK	Alaska			
		AZ	Arizona			
		AR	Arkansas			
		CA	California			
		CO	Colorado			
		CT	Connecticut			
		DE	Delaware			
		FL	Florida			
		GA	Georgia			
		HI	Hawaii			
		ID	Idaho			
		IL	Illinois			
		IN	Indiana			
		IA	Iowa			
		KS	Kansas			
		KY	Kentucky			
		LA	Louisiana			
		ME	Maine			
		MD	Maryland			
		MA	Massachusetts			
		MI	Michigan			
		MN	Minnesota			
		MS	Mississippi			
		MO	Missouri			
		MT	Montana			
		NE	Nebraska			
		NV	Nevada			
		NH	New Hampshire			
		NJ	New Jersey			
		NM	New Mexico			
		NY	New York			
		NC	North Carolina			
		ND	North Dakota			
		OH	Ohio			
		OK	Oklahoma			
		OR	Oregon			
		PA	Pennsylvania			

Vehicle Crash Parameters (zveh) – cont.

		RI	Rhode Island			
		SC	South Carolina			
		SD	South Dakota			
		TN	Tennessee			
		TX	Texas			
		UT	Utah			
		VT	Vermont			
		VA	Virginia			
		WA	Washington			
		DC	Washington DC			
		WV	West Virginia			
		WI	Wisconsin			
		WY	Wyoming			
		XX	Not reported.			
VLP_Year	License Plate Year		License plate year in YYYY format.	Numeric: Integer	4	0
		7777	Not reported.			

Vehicle Damage Parameters (zvdm)

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
Crash_Key	Crash Key - SAVER Internal Unique Identifier		4 digit year + arbitrarily assigned unique number (e.g., 2001000025)	Numeric: Integer	10	0
V2UnitNum	Vehicle Unit Number		Number indicating which vehicle the driver was operating.	Numeric: Integer	3	0
		777	Not reported.			
V2UnitKey	Combined Crash_Key and V2UnitNum		Crash_Key*1000+V2UnitNum	Numeric: Integer	13	0
InitImpact	Point of Initial Impact			Numeric: Integer	2	0
		1	Front			
		2	Passenger side - front			
		3	Passenger side - middle			
		4	Passenger side - rear			
		5	Rear			
		6	Driver side - rear			
		7	Driver side - middle			
		8	Driver side - front			
		9	Top			
		10	Under-Carriage			
		77	Not reported.			
		99	Unknown			
MostDamage	Most Damaged Area			Numeric: Integer	2	0
		1	Front			
		2	Passenger side - front			
		3	Passenger side - middle			
		4	Passenger side - rear			
		5	Rear			
		6	Driver side - rear			
		7	Driver side - middle			
		8	Driver side - front			
		9	Top			
		10	Under-Carriage			
		77	Not reported.			
		99	Unknown			
Damage	Extent of Damage			Numeric: Integer	2	0
		1	None			
		2	Minor damage			
		3	Functional damage			
		4	Disabling damage			
		5	Severe - vehicle totaled			
		9	Unknown			
		77	Not reported.			
UnderOver	Underride/Override			Numeric: Integer	2	0
		1	None			
		2	Underride - compartment intrusion			
		3	Underride - no compartment intrusion			
		4	Underride - compartment intrusion unknown			
		5	Override - moving vehicle			
		6	Override - parked/stationary vehicle			
		9	Unknown			
		77	Not reported.			
RepairCost	Approximate Cost to Repair or Replace		Estimated dollar value of repairs to vehicle.	Numeric: Integer	9	0

Commercial Vehicle Crash Parameters (zcvo)

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
Crash_Key	Crash Key - SAVER Internal Unique		4 digit year + arbitrarily assigned unique number (e.g., 2001000025)	Numeric: Integer	10	0
CUnitNum	Commercial Vehicle Unit Number		Number indicating which commercial vehicle.	Numeric: Integer	3	0
		777	Not reported.			
CUnitKey	Combined Crash_Key and CUnitNum		Crash_Key*1000+CUnitNum	Numeric: Integer	13	0
Axles	Number of Axles		Number of axles for the commercial vehicle.	Numeric: Integer	2	0
GVWR	Gross Vehicle Weight Rating		Gross vehicle weight rating (GVWR) for the commercial vehicle.	Numeric: Integer	6	0
Placard	Placard #		The placard number for the hazardous materials being transported.	Numeric: Integer	6	0
		777777	Not reported.			
HazMatRel	Hazardous Materials Released?		Indication of release of hazardous materials.	Character	2	0
		1	Yes			
		2	No			
		3	Not applicable			
		9	Unknown			
		77	Not reported.			
HazMat_PL	HazMat_PL		Indication of a placard.	Numeric: Integer	6	0
		7	Not reported.			
CVLPState1	License Plate State (power unit attached)		State the unit attached to the power unit is licensed in.	Character	2	0
		AL	Alabama			
		AK	Alaska			
		AZ	Arizona			
		AR	Arkansas			
		CA	California			
		CO	Colorado			
		CT	Connecticut			
		DE	Delaware			
		FL	Florida			
		GA	Georgia			
		HI	Hawaii			
		ID	Idaho			
		IL	Illinois			
		IN	Indiana			
		IA	Iowa			
		KS	Kansas			
		KY	Kentucky			
		LA	Louisiana			
		ME	Maine			
		MD	Maryland			
		MA	Massachusetts			
		MI	Michigan			
		MN	Minnesota			
		MS	Mississippi			
		MO	Missouri			
		MT	Montana			
		NE	Nebraska			
		NV	Nevada			
		NH	New Hampshire			
		NJ	New Jersey			
		NM	New Mexico			
		NY	New York			
		NC	North Carolina			
		ND	North Dakota			
		OH	Ohio			
		OK	Oklahoma			
		OR	Oregon			
		PA	Pennsylvania			
		RI	Rhode Island			
		SC	South Carolina			
		SD	South Dakota			
		TN	Tennessee			
		TX	Texas			
		UT	Utah			
		VT	Vermont			
		VA	Virginia			
		WA	Washington			
		DC	Washington DC			
		WV	West Virginia			
		WI	Wisconsin			
		WY	Wyoming			
		XX	Not reported.			
CVLPYear1	License Plate Year (power unit attached)		License year for unit attached to the power unit.	Numeric: Integer	4	0
		7777	Not reported.			
CVLPState2	License Plate State (power unit attached)		State the unit attached to a trailer unit is licensed in.	Character	2	0
			(see CVLPState1 definitions)			
CVLPYear2	License Plate Year (power unit attached)		License year for unit attached to a trailer unit.	Numeric: Integer	4	0
		7777	Not reported.			

Driver Crash Parameters (zdrv)

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
Crash_Key	Crash Key - SAVER Internal Unique Identifier		4 digit year + arbitrarily assigned unique number (e.g., 2001000025)	Numeric: Integer	10	0
D1UnitNum	Vehicle Unit Number		Number indicating which vehicle the driver was operating.	Numeric: Integer	3	0
		777	Not reported.			
D1UnitKey	Combined Crash_Key and D1UnitNum		Crash_Key*1000+D1UnitNum	Numeric: Integer	13	0
DriverAge	Driver Age		Age of driver derived from Date of Birth and Crash Date.	Numeric: Integer	3	0
DAgeBin1	Driver Ages by primarily 5 year bins		Driver Age field divided into bins by primarily 5 year age ranges.	Numeric: Integer	2	0
		1	DriverAge < 14			
		2	DriverAge = 14			
		3	DriverAge = 15			
		4	DriverAge = 16			
		5	DriverAge = 17			
		6	DriverAge = 18			
		7	DriverAge = 19			
		8	DriverAge = 20			
		9	DriverAge >= 21 and DriverAge <= 24			
		10	DriverAge >= 25 and DriverAge <= 29			
		11	DriverAge >= 30 and DriverAge <= 34			
		12	DriverAge >= 35 and DriverAge <= 39			
		13	DriverAge >= 40 and DriverAge <= 44			
		14	DriverAge >= 45 and DriverAge <= 49			
		15	DriverAge >= 50 and DriverAge <= 54			
		16	DriverAge >= 55 and DriverAge <= 59			
		17	DriverAge >= 60 and DriverAge <= 64			
		18	DriverAge >= 65 and DriverAge <= 69			
		19	DriverAge >= 70 and DriverAge <= 74			
		20	DriverAge >= 75 and DriverAge <= 79			
		21	DriverAge >= 80 and DriverAge <= 84			
		22	DriverAge >= 85 and DriverAge <= 89			
		23	DriverAge >= 90 and DriverAge <= 94			
		24	DriverAge >= 95 and DriverAge <= 98 (actually, 98 is 98 and greater)			
		77	Not reported.			
		99	Unknown			
DriverDOB	Driver Date of Birth		Driver's date of birth in YYYYMMDD format (e.g., 19850316).	Numeric: Integer	8	0
		77777777	Not reported.			
DriverGen	Driver Gender			Character	2	0
		M	Male			
		F	Female			
		U	Unknown			
		NR	Not reported.			
Charged	Driver Charged?			Numeric: Integer	2	0
		1	Yes			
		2	No			
		3	Not applicable.			
		9	Unknown			
		77	Not reported.			
AlcTest	Alcohol Test Administered			Numeric: Integer	1	0
		1	None			
		2	Blood			
		3	Urine			
		4	Breath			
		5	Vitreous			
		9	Refused			
		77	Not reported.			
AlcResult	Alcohol Test Results		Number in decimal format (e.g., 0.10) representing Blood Alcohol Content.	Numeric: Decimal	5	3
DrugTest	Drug Test Administered			Numeric: Integer	2	0
		1	None			
		2	Blood			
		3	Urine			
		9	Refused			
		77	Not reported.			
DrugResult	Drug Test Results			Numeric: Integer	2	0
		1	Positive			
		2	Negative			
		77	Not reported.			
DriverCond	Driver Condition			Numeric: Integer	2	0
		1	Apparently normal			
		2	Physical impairment			
		3	Emotional (e.g. depressed/angry/disturbed)			
		4	Illness			
		5	Asleep/fainted/fatigued/etc.			
		6	Under the influence of alcohol/drugs/medications			
		8	Other (explain in narrative)			
		9	Unknown			
		77	Not reported.			

Driver Crash Parameters (zdrv) – cont.

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
DContCirc1	Contributing Circumstances 1 - Driver			Numeric: Integer	2	0
		1	Ran traffic signal			
		2	Ran stop sign			
		3	Exceeded authorized speed			
		4	Driving too fast for conditions			
		5	Made improper turn			
		6	Traveling wrong way or on wrong side of road			
		7	Crossed centerline			
		8	Lost Control			
		9	Followed too close			
		10	Swerved to avoid: vehicle/object/non-motorist/or animal in roadway			
		11	Over correcting/over steering			
		12	Operating vehicle in an erratic/reckless/careless/negligent/aggressive manner			
		13	FTYROW: From stop sign			
		14	FTYROW: From yield sign			
		15	FTYROW: Making left turn			
		16	FTYROW: Making right turn on red signal			
		17	FTYROW: From driveway			
		18	FTYROW: From parked position			
		19	FTYROW: To pedestrian			
		20	FTYROW: At uncontrolled intersection			
		21	FTYROW: Other (explain in narrative)			
		22	Inattentive/distracted by: Passenger			
		23	Inattentive/distracted by: Use of phone or other device			
		24	Inattentive/distracted by: Fallen object			
		25	Inattentive/distracted by: Fatigued/asleep			
		26	Other (explain in narrative): Vision obstructed			
		27	Other (explain in narrative): Other improper action			
		28	Other (explain in narrative): No improper action			
		77	Not reported.			
		99	Unknown			
DContCirc2	Contributing Circumstances 2 - Driver		See DContCirc1 values.	Numeric: Integer	2	0
VisionObs	Vision Obscurement			Numeric: Integer	2	0
		1	Not obscured			
		2	Trees/crops			
		3	Buildings			
		4	Embankment			
		5	Sign/billboard			
		6	Hillcrest			
		7	Parked vehicles			
		8	Moving vehicles			
		9	Person/object in or on vehicle			
		10	Blinded by sun or headlights			
		11	Frosted windows/windshield			
		12	Blowing snow			
		13	Fog/smoke/dust			
		77	Not reported.			
		88	Other (explain in narrative)			
		99	Unknown			

Driver Crash Parameters (zdrv) – cont.

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
DL_State	Driver's License State			Character	2	0
		AL	Alabama			
		AK	Alaska			
		AZ	Arizona			
		AR	Arkansas			
		CA	California			
		CO	Colorado			
		CT	Connecticut			
		DE	Delaware			
		FL	Florida			
		GA	Georgia			
		HI	Hawaii			
		ID	Idaho			
		IL	Illinois			
		IN	Indiana			
		IA	Iowa			
		KS	Kansas			
		KY	Kentucky			
		LA	Louisiana			
		ME	Maine			
		MD	Maryland			
		MA	Massachusetts			
		MI	Michigan			
		MN	Minnesota			
		MS	Mississippi			
		MO	Missouri			
		MT	Montana			
		NE	Nebraska			
		NV	Nevada			
		NH	New Hampshire			
		NJ	New Jersey			
		NM	New Mexico			
		NY	New York			
		NC	North Carolina			
		ND	North Dakota			
		OH	Ohio			
		OK	Oklahoma			
		OR	Oregon			
		PA	Pennsylvania			
		RI	Rhode Island			
		SC	South Carolina			
		SD	South Dakota			
		TN	Tennessee			
		TX	Texas			
		UT	Utah			
		VT	Vermont			
		VA	Virginia			
		WA	Washington			
		DC	Washington DC			
		WV	West Virginia			
		WI	Wisconsin			
		WY	Wyoming			
		XX	Not reported.			
DLRestComp	Driver's License Restrictions Complied With?		Not currently in crash database.			
		1	Yes			
		2	No			
		7	Not reported.			

Crash Type Parameters 2 (zctb)

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
Crash_Key	Crash Key - SAVER Internal Unique		4 digit year + arbitrarily assigned unique number (e.g., 2001000025)	Numeric: Integer	10	0
V3UnitNum	Vehicle Unit Number		Number indicating which vehicle.	Numeric: Integer	3	0
		777	Not reported.			
V3UnitKey	Combined Crash_Key and V3UnitNum		Crash_Key*1000+V3UnitNum	Numeric: Integer	13	0
SeqEvents1	Sequence of Events 1st Event			Numeric: Integer	2	0
		1	Ran off road, right			
		2	Ran off road, straight			
		3	Ran off road, left			
		4	Crossed centerline/median			
		5	Animal or object in roadway			
		6	Evasive action (swerve, panic braking, etc.)			
		7	Downhill runaway			
		8	Cargo/equipment loss or shift			
		9	Equipment failure (tires, brakes, etc.)			
		10	Separation of units			
		11	Non-collision events: Overturn/rollover			
		12	Non-collision events: Jackknife			
		13	Non-collision events: Other non-collision (explain in narrative)			
		20	Collision with: Non-motorist (see non-motorist type)			
		21	Collision with: Vehicle in traffic			
		22	Collision with: Vehicle in/from other roadway			
		23	Collision with: Parked motor vehicle			
		24	Collision with: Railway vehicle/train			
		25	Collision with: Animal			
		26	Collision with: Other non-fixed object (explain in narrative)			
		30	Collision with fixed object: Bridge/bridge rail/overpass			
		31	Collision with fixed object: Underpass/structure support			
		32	Collision with fixed object: Culvert			
		33	Collision with fixed object: Ditch/embankment			
		34	Collision with fixed object: Curb/island/raised median			
		35	Collision with fixed object: Guardrail			
		36	Collision with fixed object: Concrete barrier (median or right side)			
		37	Collision with fixed object: Tree			
		38	Collision with fixed object: Poles (utility, light, etc.)			
		39	Collision with fixed object: Sign post			
		40	Collision with fixed object: Mailbox			
		41	Collision with fixed object: Impact attenuator			
		42	Collision with fixed object: Other fixed object (explain in narrative)			
		50	Miscellaneous events: Fire/explosion			
		51	Miscellaneous events: Immersion			
		52	Miscellaneous events: Hit and run			
		77	Not reported			
		99	Unknown			
SeqEvents2	Sequence of Events 2nd Event		See SeqEvents1 values.	Numeric: Integer	2	0
SeqEvents3	Sequence of Events 3rd Event		See SeqEvents1 values.	Numeric: Integer	2	0
SeqEvents4	Sequence of Events 4th Event		See SeqEvents1 values.	Numeric: Integer	2	0
MostHarm	Most Harmful Event		See SeqEvents1 values.	Numeric: Integer	2	0

Roadway Crash Parameters 2 (zrdb)

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
Crash_Key	Crash Key - SAVER Internal Unique		4 digit year + arbitrarily assigned unique number (e.g., 2001000025)	Numeric: Integer	10	0
RUnitNum	Vehicle Unit Number		Number indicating which vehicle.	Numeric: Integer	3	0
		777	Not reported.			
RUnitKey	Combined Crash_Key and RUnitNum		Crash_Key*1000+RUnitNum	Numeric: Integer	13	0
SpeedLimit	Speed Limit			Numeric: Integer	2	0
		0	0 MPH			
		5	5 MPH			
		10	10 MPH			
		15	15 MPH			
		20	20 MPH			
		25	25 MPH			
		30	30 MPH			
		35	35 MPH			
		40	40 MPH			
		45	45 MPH			
		50	50 MPH			
		55	55 MPH			
		60	60 MPH			
		65	65 MPH			
TrafCont	Traffic Controls			Numeric: Integer	2	0
		1	No controls present			
		2	Traffic signals			
		3	Flashing traffic control signal			
		4	Stop signs			
		5	Yield signs			
		6	No Passing Zone (marked)			
		7	Warning sign			
		8	School zone signs			
		9	Railway crossing device			
		10	Traffic director			
		11	Workzone signs			
		77	Not reported.			
		88	Other control (explain in narrative)			
		99	Unknown			
Trafficway	Type of Trafficway			Numeric: Integer	2	0
		1	One Lane or Ramp			
		2	Two Lanes			
		3	Three Lanes			
		4	Four or More/Undivided			
		5	Four or More/Divided			
		6	Alley			
		7	Driveway			
		8	Other			
		77	Not reported.			
		99	Unknown			
TrfficFlow	Traffic Flow			Numeric: Integer	2	0
		1	One-Way Traffic			
		2	Two-Way Traffic			
		77	Not reported.			
		99	Unknown			
SurfaceTyp	Surface Type			Numeric: Integer	2	0
		1	Cement/Concrete			
		2	Asphalt			
		3	Gravel/Rock			
		4	Dirt			
		5	Brick			
		6	Steel (Bridge Floor)			
		7	Wood (Bridge Floor)			
		8	Other			
		77	Not reported.			
		99	Unknown			

Injury Crash Parameters (zinj)

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
Crash_Key	Crash Key - SAVER Internal Unique		4 digit year + arbitrarily assigned unique number (e.g., 2001000025)	Numeric: Integer	10	0
IUnitNum	Vehicle Unit Number		Number indicating which vehicle the injured person was in.	Numeric: Integer	3	0
		777	Not reported.			
IUnitKey	Combined Crash_Key and IUnitNum		Crash_Key*1000+IUnitNum	Numeric: Integer	13	0
INumber	Injured Person Number		Number indicating which injured person.	Numeric: Integer	3	0
		777	Not reported.			
INumKey	Combined Crash_Key and INumber		Crash_Key*1000+INumber	Numeric: Integer	13	0
InjStatus	Injury Status/Severity			Numeric: Integer	2	0
		1	Fatal			
		2	Incapacitating			
		3	Non-incapacitating			
		4	Possible			
		5	Uninjured			
		9	Unknown			
		77	Not reported.			
InjuredAge	Age of Injured Person		Age of injured person derived from Date of Birth and Crash Date.	Numeric: Integer	3	0
InjuredDOB	Date of Birth of Injured Person		Driver's date of birth in YYYYMMDD format (e.g., 19850316).	Numeric: Integer	8	0
		77777777	Not reported.			
InjuredGen	Gender of Injured Person			Character	2	0
		M	Male			
		F	Female			
		U	Unknown			
		NR	Not reported.			
Seating	Seating Position			Numeric: Integer	2	0
		1	Driver/Motorcycle Driver			
		2	Front Seat Middle			
		3	Front Seat Passenger Side			
		4	Rear Seat Driver Side/Motorcycle Passenger			
		5	Rear Seat Middle			
		6	Rear Seat Passenger Side			
		7	Third Seat Driver Side			
		8	Third Seat Middle			
		9	Third Seat Passenger Side			
		10	Sleeper Section			
		11	Enclosed Cargo Area			
		12	Unenclosed Cargo Area			
		13	Trailing Unit			
		14	Exterior			
		15	Pedestrian			
		16	Pedalcyclist			
		17	Pedalcyclist passenger			
		77	Not reported.			
		88	Other (explain in narrative)			
		99	Unknown			
OccProtect	Occupant Protection			Numeric: Integer	2	0
		1	None used			
		2	Shoulder and lap belt used			
		3	Lap belt only used			
		4	Shoulder belt only used			
		5	Child safety seat used			
		6	Helmet used			
		8	Other (explain in narrative)			
		9	Unknown			
		77	Not reported.			
Ejection	Ejection			Numeric: Integer	2	0
		1	Not ejected			
		2	Partially ejected			
		3	Totally ejected			
		4	Not applicable (motorcycle/bicycle/etc.)			
		9	Unknown			
		77	Not reported.			
EjectPath	Ejection Path			Numeric: Integer	2	0
		1	Not ejected/not applicable			
		2	Through front windshield			
		3	Through side window/door			
		4	Through roof			
		5	Through back window/tailgate			
		9	Unknown			
		77	Not reported.			

Injury Crash Parameters (zinj) – cont.

AirbagDep	Airbag Deployment			Numeric: Integer	2	0
		1	Deployed front of person			
		2	Deployed side of person			
		3	Deployed both front/side			
		4	Other deployment (explain in narrative)			
		5	Not deployed			
		6	Not applicable			
		9	Unknown			
		77	Not reported.			
AirbagSw	Airbag Switch Status			Numeric: Integer	2	0
		1	Switch in ON position			
		2	Switch in OFF position			
		3	No ON/OFF switch present			
		9	Unknown			
		77	Not reported.			
Trapped	Occupant Trapped?			Numeric: Integer	2	0
		1	Not trapped			
		2	Freed by non-mechanical means			
		3	Extricated by mechanical means			
		9	Unknown			
		77	Not reported.			
TransTo	Transported To:		Medical facility the injured person was transported to.	Character	20	0
TransBy	Transported By:		Medical service the injured person was transported by.	Character	20	0

Non-Motorist Crash Parameters (znmt)

Field Name	Field Description	Values	Values Descriptions	Field Type	Field Width	Field Precision
Crash_Key	Crash Key - SAVER Internal Unique		4 digit year + arbitrarily assigned unique number (e.g., 2001000025)	Numeric: Integer	10	0
NMUnitNum	Unit Number of Vehicle Striking (Vehicle Unit Number)		Number indicating which vehicle struck the non-motorist.	Numeric: Integer	3	0
		777	Not reported.			
NMUnitKey	Combined Crash_Key and NMUnitNum		Crash_Key*1000+NMUnitNum	Numeric: Integer	13	0
NMNumber	Number of Non-Motorist		Number indicating which non-motorist.	Numeric: Integer	3	0
		777	Not reported.			
NMNumKey	Combined Crash_Key and NMNumber		Crash_Key*1000+NMNumber	Numeric: Integer	13	0
NM_Type	Non-Motorist Type			Numeric: Integer	2	0
		1	Pedestrian			
		2	Pedalcyclist (bicycle/tricycle/unicycle/pedal car)			
		3	Skater			
		8	Other (explain in narrative)			
		9	Unknown			
		77	Not reported.			
NM_Loc	Non-Motorist Location			Numeric: Integer	2	0
		1	Marked crosswalk at intersection			
		2	At intersection - no crosswalk			
		3	Non-intersection crosswalk			
		4	Driveway access crosswalk			
		8	Other non-intersection (explain in narrative)			
		9	Unknown			
		77	Not reported.			
NM_Action	Non-Motorist Action			Numeric: Integer	2	0
		1	Entering or crossing roadway			
		2	Walking/running/jogging/playing/cycling			
		3	Working			
		4	Pushing vehicle			
		5	Approaching or leaving vehicle			
		6	Playing or working on vehicle			
		7	Standing			
		8	Other (explain in narrative)			
		9	Unknown			
		77	Not reported.			
NM_Cond	Non-Motorist Condition			Numeric: Integer	2	0
		1	Apparently normal			
		2	Physical impairment			
		3	Emotional (e.g. depressed/angry/disturbed)			
		4	Illness			
		5	Asleep/fainted/fatigued/etc.			
		6	Under the influence of alcohol/drugs/medications			
		8	Other (explain in narrative)			
		9	Unknown			
		77	Not reported.			
NM_Safety	Non-Motorist Safety Equipment			Numeric: Integer	2	0
		1	Helmet			
		2	Reflective clothing			
		3	Lighting			
		4	None			
		8	Other (explain in narrative)			
		9	Unknown			
		77	Not reported.			
NMContCirc	Contributing Circumstancs - Non-Motorist			Numeric: Integer	2	0
		1	Improper crossing			
		2	Darting			
		3	Lying or sitting in roadway			
		4	Failure to yield right of way			
		5	Not visible (dark clothing)			
		6	Inattentive (talking/eating/etc.)			
		7	Failure to obey traffic signs/signals/officer			
		8	Wrong side of road			
		77	Not reported.			
		88	Other (explain in narrative)			
		99	Unknown			

APPENDIX E. IDENTIFIED HAZARDS: RISK SCORE

Table E.1. Identified hazards (assessment #1 through #23): risk score

Assess #	IDENTIFIED HAZARD	Average Severity Ratio	Severity rank	Freq.	Freq. rank	Risk Score
1	#3) build/rebuild under traffic - work on shoulder	0.8	2	0.15	4	8
2	#3) build/rebuild under traffic - intermittent or moving work	1.3	3	0.05	3	9
3	#4) construction vehicle traffic - dump trucks	2.1	4	0.02	2	8
4	#4) construction vehicle traffic – flatbed	2.8	5	0.01	2	10
5	#4) construction vehicle traffic - concrete mixer	0	1	0.002	1	1
6	#7) dirty/non-serviceable signs - traffic control device inoperative/missing/obscured	0.7	2	0.002	1	2
7	#8) driver/operator inattention	1.7	4	0.02	2	8
9	#9) driver/operator unfamiliarity (out-of-state driver license)	1.5	4	0.19	4	16
10	#9) inadequate/confusing traffic control (no controls present)	0.9	3	0.47	4	12
11	#11) falling debris/material (fallen object)	2.1	4	0.003	1	4
12	#13) inadequate buffer distance (crashes within or adjacent to work activity)	0.8	2	0.42	4	8
13	#16) inclement weather	1.2	3	0.09	3	9
14	#17) increased demand, inadequate capacity/geometry & confusing layout of: (lane closures)	0.9	3	0.46	4	12
15	#17) increased demand, inadequate capacity/geometry & confusing layout of: (lane shift/crossover)	1.6	4	0.12	3	12
16	#18) increased number of commercial trucks	2.1	4	0.1	3	12
17	#24) lack of visibility/glare/lighting (blinded by sun or headlights)	1.8	4	0.01	2	8
18	#24) lack of visibility/glare/lighting (dark-roadway lighted)	1.1	3	0.09	3	9
19	#24) lack of visibility/glare/lighting (dark-roadway not lighted)	2.8	5	0.06	3	15
20	#28) poor driver skills (operator error)	1	3	0.25	4	12
21	#28) poor driver skills (aggressive driving)	2.4	5	0.02	2	10
22	#29) poor visibility of workers (#veh involved in crash w/ worker)	14.7	5	0.004	1	5
23	#31) railroads	3.1	5	0.003	1	5

Table E.2. Identified hazards (assessment #24 through #37): risk score

Assess #	IDENTIFIED HAZARD	Average Severity Ratio	Severity rank	Freq.	Freq. rank	Risk Score
24	#32) road characteristics through the work zone (intersections)	0.8	2	0.22	4	8
25	#32) road characteristics through the work zone (ramps)	1.2	3	0.11	3	9
26	#32) road characteristics through the work zone (blind spot/obscurement)	0.3	1	0.03	2	2
27	#32) road characteristics through the work zone (bridge/overpass/underpass)	0.9	3	0.09	3	9
28	#32) road characteristics through the work zone (shoulders - none/low/soft/high)	0	1	0.001	1	1
29	#33) the condition of roadway (road surface condition/debris /ruts/holes/bumps/worn surface)	1.1	3	0.02	2	6
30	#34) the points of merge (between advance warning & work area; within transition area for lane shift)	1	3	0.32	4	12
31	#35) the posted speed through the work zone (65 mph)	2.7	5	0.06	3	15
32	#35) the posted speed through the work zone (55-60 mph)	1.4	3	0.37	4	12
33	#35) the posted speed through the work zone (40-50 mph)	0.5	1	0.14	4	4
34	#35) the posted speed through the work zone (30-35 mph)	0.5	1	0.26	4	4
35	#35) the posted speed through the work zone (< 25 mph)	0.5	1	0.14	4	4
36	#38) traffic congestion & delay through the work zone (evasive action)	1.1	3	0.07	3	9
37	#39) traffic speed & speeding (exceeded authorized speed)	2.8	5	0.01	2	10

Table E.3. Identified hazards (assessment #38 through #56): risk score

Assess #	IDENTIFIED HAZARD	Average Severity Ratio	Severity ranking	Frequency	Frequency ranking	Risk Score
38	#12) high risk traffic – Sundays	1.4	3	0.06	3	9
39	#12) high risk traffic – Mondays	0.5	1	0.15	4	4
40	#12) high risk traffic – Tuesdays	0.8	2	0.16	4	8
41	#12) high risk traffic – Wednesdays	0.9	3	0.17	4	12
42	#12) high risk traffic – Thursdays	1	3	0.18	4	12
43	#12) high risk traffic – Fridays	1.2	3	0.18	4	12
44	#12) high risk traffic – Saturdays	1.4	3	0.09	3	9
45	#10) seasonal road use – January	0.9	3	0.02	2	6
46	#10) seasonal road use – February	0.7	2	0.02	2	4
47	#10) seasonal road use – March	0.5	1	0.03	2	2
48	#10) seasonal road use – April	1	3	0.07	3	9
49	#10) seasonal road use – May	0.8	2	0.1	3	6
50	#10) seasonal road use – June	1.5	4	0.13	4	16
51	#10) seasonal road use – July	0.9	3	0.13	4	12
52	#10) seasonal road use – August	0.7	2	0.14	4	8
53	#10) seasonal road use – September	1.5	4	0.14	4	16
54	#10) seasonal road use – October	0.7	2	0.12	3	6
55	#10) seasonal road use – November	1.2	3	0.07	3	9
56	#10) seasonal road use – December	1	3	0.02	2	6

APPENDIX F. MITIGATING STRATEGIES

Table F.1. Mitigation strategies by project phase (hazard #1 thru #4)

		Mitigation Strategies By Project Phase			
	Identified Hazard	**Planning & Programming**	**Design**	**Letting & Award**	**Construction**
1	**a contract that does not include a final schedule showing project duration and event planning**			• Require that the schedule and sequencing are conditions of the contract including: meetings, specific requirements	

2	**accelerated project completion requirements (i.e., overexposure of workers; inclement weather construction; external construction completion date requirement -harvest, overlay cure time, etc.)**	• Select materials that may minimize construction duration
		  • PCC/ACC, etc.
		  • Full Depth vs. Overlay
		• Use innovative contracting methods (A+B, I/D Clauses, lane rental specifications)
		• Early letting to allow for early procurement to meet long lead times
		• Accept risk and manage/control during subsequent phases
		  • Design phase
		  • Construction phase
			• Awareness initiatives, speed control, driver training
			• Reflectorized barriers, rails, etc.
			• High visibility worker apparel
			• Develop innovative contracting methods (A+B, I/D Clauses, lane rental specifications)
			• Specify early letting to allow for early procurement to meet long lead times
			• Conduct constructability reviews
			• Accept risk and manage/control during subsequent phases
			  • Construction phase
					• Awareness initiatives, speed control, driver training
					• Reflectorized barriers, rails, etc.
					• High visibility worker apparel
					• Rumble strips

3	**build/rebuild under traffic**	• Detours
		• Road Closures
		• Lane Closures
		• Accept risk and manage/control during subsequent phases
		  • Design phase (construction phasing for demo work,etc.)
		  • Construction phase
			• Determine construction phasing for demo work,etc.
			• Conduct constructability reviews
			• Accept risk and manage/control during construction phase
					• Traffic awareness
					• Monitor traffic safety issues
					• Truck mounted attenuators
					• High visibility worker apparel
					• *Temp. stop work during some periods of heavy traffic*
					• *Public out-reach*
					• *ITS signs*

4	**construction vehicle traffic**		• Develop schematic Internal Traffic Control Plans (use early contractor involvement) • Specify Ingress/egress points • Accept risk and manage/control during construction phase		• Implement and adjust Internal Traffic Control Plans • Employ & enforce points of ingress/egress • *Construction sequencing meetings* • *Back-up alarms*

Table F.2. Mitigation strategies by project phase (hazard #5 thru #8)

		Mitigation Strategies By Project Phase			
	Identified Hazard	**Planning & Programming**	**Design**	**Letting & Award**	**Construction**

5	**contractor complacency**			• Outline contractor fines and sanctions as contract requirements
				  • For lack of project management
				  • For lack of proper traffic control
				• Use of contractor evaluations for bid capacity	

6	**contractor selection process**			• Prequalify contractor based on worker safety training program • Use of contractor evaluations for bid capacity • Prequalify contractor using safety record • Insurance rate factors	
7	**dirty/non-serviceable signs/reflectors, etc.**				• Clean and maintain signs, reflectors, etc • Ensure that sign maintenance is part of safety compliance program • *Dis-incentive for non-compliance with maintenance*
8	**driver / operator inattention**		• Design/specify rumble strips • Taper Designs follow up-to-date MUTCD (reflective) • Specify high visibility worker apparel • Specify CB Radio message in vicinity of transition area • Specify use of ITS (intelligent transportation systems) • Accept risk and manage/control during construction phase		• Taper designs to follow up-to-date MUTCD (reflective) • Utilize/employ ITS systems • Ensure high visibility worker apparel • install portable rumble strips • Announcement on CB radios in transition areas • *Presence of law enforcement*

Table F.3. Mitigation strategies by project phase (hazard #9 and #10)

		Mitigation Strategies By Project Phase			
	Identified Hazard	**Planning & Programming**	**Design**	**Letting & Award**	**Construction**

9	**driver confusion from: too many decisions (especially at higher speeds); driver/operator unfamiliarity; and inadequate/confusing traffic control**		• Design for Positive Traffic Control - Signage (get signs made up ahead of time)
			  • detour
			  • temporary barrier rails (channelizing)
			  • minimize posted signage (less is more)
			  • use CMS (changeable message signs), but minimally before entering area
			  • flashing arrows
			• Education/Information for unfamiliar drivers
			• Media (radio/TV), website, advanced warning signs)
			• Visualization in 3D (information prior to driving in work zones) used in Council Bluffs
			• Accept risk and manage/control during subsequent phases
					• Employ ITS - early warning (multiple simultaneous methods) place in sufficient distance ahead of decision area
					• CMS (changebale message signs)
					• Flashing arrow
					• Properly Constructed Taper (updated MUTCD)
					• Increase use of reflectorized arrow, signs, painting, etc.
					• Information OUTLETS
					  • Resident Engineer office
					  • 511 (cell phones)
					  • IA.org (internet)
					• Media outlet for project information
					  • Lane Closures
					  • Traffic information
					  • Alternate routes
					  • Detours

10	**extra traffic volume through the workzone from: construction traffic; civic events; holidays; and seasonal traffic/road use**	• Accept risk and manage/control during subsequent phases
		  • Design phase (alignment, geometry, etc.)
		  • Final Design (schedule, standard specs, etc.)
		  • Letting & Award phase (construction schedule)
		  • Construction phase (Construction Scheduling)
			• Design phase (alignment, geometry, etc.)
			• Final Design (schedule, standard specs, etc.)
			• Planning Calendar as part of Bid Documents
			  • Special events
			  • Harvest season completions
			• Schedule Visualization in 3D
			• Accept risk and manage/control during subsequent phases
			  • Letting & Award phase (construction schedule)
			  • Construction phase (Construction Scheduling)
				• Pre-bid meeting to discuss construction schedule
				• Spell out limitations to contract
				  • Minimize construction operations
				  • No major activities
				  • Minimize excess traffic
				• Manage During Construction Phase (scheduling)
					• Coordination meetings
					• Construction scheduling
					• Restricted construction activities based on planning calendar (updated by district)
					  • Special events
					  • Harvest season completions
					• Visualization in 3D of schedule provided

Table F.4. Mitigation strategies by project phase (hazard #11 thru #15)

		Mitigation Strategies By Project Phase			
	Identified Hazard	**Planning & Programming**	**Design**	**Letting & Award**	**Construction**

11	**falling debris/material from: overhead structures & blasting**	• Detours
		• Road Closures
		• Lane Closures
		• Accept risk and manage/control during subsequent phases
		  • Design phase (construction phasing for demo work,etc.)
		  • Construction phase
			• Construction Phasing
			• Construction Schedule
			• Traffic Control Plans
			• Accept risk and manage/control during subsequent phases
			Construction phase (contractor mitigation)
					• Require constractor submittal of protection plan
					• Implement construction phasing
					• Uphold construction schedule
					Monitor traffic control effectiveness

12	**high risk traffic (i.e., Fridays, evenings – (bar time), and rush hour traffic)**		• Develop limits to contract (workday restrictions, etc) • Accept risk and manage/control during subsequent phases	• Review limits to contract (workday restrictions, etc) Accept risk and manage/control during subsequent phases	• Uphold limitations to contract • Event Calendar Updates from District • Coordination meetings Law Enforcement
13	**inadequate buffer distance from travel lane to work area**		• Design adequate buffer space • Provide positive protection (barriers) • Accept risk and manage/control during construction phase		• Ensure/maintain adequate buffer space • Worker safety training • Reduce traffic speed (positive control & law enforcement) • Barriers • *Communicate inadequacies with possible corrections* • *Crash attenuators*
14	**inadequate contractor accountability for safety**			• Establish contractor management structure addressing safety as a qualification requirement • Use of contractor evaluations for bid capacity Prescribe minimum site visits by safety director	

Table F.5. Mitigation strategies by project phase (hazard #16 thru #18)

		Mitigation Strategies By Project Phase			
	Identified Hazard	**Planning & Programming**	**Design**	**Letting & Award**	**Construction**
15	**inadequate internal traffic control plans (ITCPs)**				• Develop ITCP specifically for the anticipated traffic and operating procedures • *Discuss problems & solutions with contract authority* • *Communicate inadequacies with possible corrections*
16	**inclement weather**		• Awareness initiatives • Speed control • Reflectorized barriers, rails, etc • High visibility worker apparel • *Consider signage & CBM warnings*		• Driver awareness initiatives • Speed control • Driver training • Reflectorized barriers, rails, etc • High visibility worker apparel

17	**increased demand of, inadequate capacity/geometry & confusing layout of: detours; road closures; and lane closures (moving & stationary)**		• Upgrade conditions/geometry
			• *Change or modify detour route layout & devices*
			• Traffic control plans (signs, barriers, etc)
			• Accept risk and manage/control during subsequent phases (media outlets/education/information/closure dates)
					• Field upgrade conditions/geometry
					• Employ traffic control plans (signs, barriers, etc)
					• Utilize Media outlets
					  • Education
					  • Information (closure dates, etc)
					• Monitor and recommend improvements

18	**increased number of commercial trucks on existing routes or alternate routes**	• *hazard was identified but no strategies were listed*	• *detour signage* • *review traffic control on possible parallel routes w/ local jurisdictions* • *consider traffic control plans for those routes* • *Specify commercial vehicle routes* • *Modify traffic control on designated routes* • *Acknowledge the existence of commercial trucks using signage*		• Awareness initiatives, speed control, driver training • Reflectorized barriers, rails, etc. • High visibility worker apparel • Rumble strips • *Outreach to trucking associations*

Table F.6. Mitigation strategies by project phase (hazard #19 thru #22)

		Mitigation Strategies By Project Phase			
	Identified Hazard	**Planning & Programming**	**Design**	**Letting & Award**	**Construction**
19	**jobsite congestion & traffic resulting in local traffic congestion and delays**		• Ensure constructability reviews and sequencing for concept of work (reverse schedule construction) • Provide schedule and allowance incentives & workday constraints • Accept risk and manage/control during construction phase		• Implement sequencing for the concept of work • Satisfy schedule and allowance incentives & workday constraints • Communicate traffic restrictions on DOT website (particularly for oversized loads through workzones) • Ground guides (on-site) to prevent motorists from entering worksite • Use of ground guides to manage on-site construction traffic (particularly large trucks) • *Reduce jobsite congestion to reduce traffic congestion!*
20	**lack of accident/near miss reporting structure**			• Bid item for on-site safety technician • Bid item for on-site surveillance	

21	**lack of contractor innovation in traffic control methods**		• Bid Items for traffic control adjustments
			• Assign bid items for traffic control
			• Assign responsibility – bid items
			• Accept risk and manage/control during subsequent phases
			  • Letting
			  • construction
				• Bid items for traffic control adjustments
				• Assign bid items for traffic control
				• Assign project responsibility
				• Manage During Construction Phase
					• Bid items for traffic control adjustment
					• Encourage value engineering proposals
					• Assign bid items for traffic control
					• Assign responsibility for bid items
					• *Strong inspection and accountability for action*

Table F.7. Mitigation strategies by project phase (hazard #23 thru #26)

		Mitigation Strategies By Project Phase			
	Identified Hazard	**Planning & Programming**	**Design**	**Letting & Award**	**Construction**
22	**lack of contractor project management (directed toward safety)**			• Prequalify contractors based on expertise of project management team • Use of contractor evaluations for bid capacity	
23	**lack of positive control of traffic**		• Develop contracting language & constraints (training, flaggers, barricades, signs/signals, traffic control, etc.) • Provide bid items for use of barriers • Specify use of ITS (intelligent transportation systems) • Accept risk and manage/control during construction phase		• Training • Flaggers • Barricades • Signs/signals • Law enforcement • *Public outreach*
24	**lack of visibility/glare/lighting**		• Specify/Design Glare Screen • Specify/Design Lighting • Specify/design reflectors • Accept risk and manage/control during construction phase		• Install glare screen • Install lighting • Ensure proper placement of portable lighting unit to prevent blinding and glare for motorists • *Communicate problems with DOT* • *Remove site obstructions*
25	**missing information (documentation of risk assessment); incomplete plans (TCP's); and incomplete bid requirements**			• Bid item identification • Preliminary plan review • Pre-bid meetings & communications	

Table F.8. Mitigation strategies by project phase (hazard #27 thru #30)

		Mitigation Strategies By Project Phase			
	Identified Hazard	**Planning & Programming**	**Design**	**Letting & Award**	**Construction**
26	**multiple prime in general proximity (resulting in discontinuous workzone signage & discontinuous traffic control)**		• Specify Contracting and Project Management responsibility • Specify Continuity of Traffic Control devices & signs • Accept risk and manage/control during subsequent phases	• Packaging of lettings to ensure continuity of work zone signage and project management responsibility	• Enforce Contracting and Project Management responsibility • Ensure Continuity of Traffic Control devices & signs • *Coordination traffic control with primes (between projects)* • *Communicate inadequacies w/ possible corrections*
27	**non-credible/non-current signs during interim season**			• Interim phase coordination – season to season signage during project transitions	• Remove non-credible signs (follow up with enforcement) • Signage and traffic control reviews (check credibility) • *Continuous or periodic monitoring on high volume projects* • *Communicate inadequacies w/ possible corrections*
28	**poor driver skills**		• Education • Training • Initiate smart work zone initiatives at letting	• Education • Training • Testing • Initiate smart work zone initiatives at letting	• Education • Training • Testing • Smart workzone initiatives
29	**poor visibility of workers**		• Project specification for worker safety training • Project Specification for high visibility worker apparel • Accept risk and manage/control during subsequent phases • *Consider lighting the area*		• Worker safety training • Enforce wear of high visibility worker apparel • *Back-up alarms* • *Ensure equipment and personal vehicles are not obscuring*

Table F.9. Mitigation strategies by project phase (hazard #31 thru #33)

		Mitigation Strategies By Project Phase			
	Identified Hazard	**Planning & Programming**	**Design**	**Letting & Award**	**Construction**
30	**previous paint lines (confusion)**		• Specify effective removal techniques (sandblasting is preferred but causes other environmental issues *& may be restricted by specifications)* • Specify use of temporary pavement marking tape during staging • Accept risk and manage/control during construction phase		• Remove previous paint lines (sandblasting is preferred but causes other environmental issues) • Use temporary pavement marking tape in leiu of paint during staging • *Water blast* • *Re-pave roadway (min. depth)*

31	**railroads, pedestrian paths/travel routes & trail crossings**	• Integration with Third Parties (coordination)
		  • ITS – Integrating Strategies (Intelligent Transportation Systems)
		• Accept risk and manage/control during subsequent phases
		  • Final design phase (TCP's, etc.)
		  • Construction phase (flaggers)
		• *Closure of paths/trails during construction*
			• Initiate coordination with local jurisdiction agreement and 3rd Party (railroad, etc.)
			• Design for Pedestrian protection (no standards yet – assign to contractors)
			• Integrate into the Design of Traffic Control Plans, etc.
			• Integration with Third Parties
			  • ITS – Integrating Strategies (Intelligent Transportation Systems)
			• Accept risk and manage/control during subsequent phases
			  • Construction phase(flaggers)
					• Coordination with 3rd Parties (railroad, etc.)
					• Monitor ITS effectiveness (deployment monitoring)
					• Monitor effectiveness of Traffic Control Plans.
					• Provided flaggers, etc. as needed
					• *Communicate inadequacies with possible corrections*
					• *Public/stakeholder engagement*

32	**road characteristics through the work zone (i.e., roadway classifications; narrow bridges; narrower shoulders; intersections; fore slopes; blind spots; line of sight obstructions; limited visibility due to topography)**		• Re-design – modify standard design when appropriate • Standards • Adjustments to standard documents • Engineering & design (widen, remove, modify) • Traffic control devices • Inform Motorist (signs, media, etc.) • Traffic Staging Plans (complex urban areas, etc) • Accept risk and manage/control during subsequent phases		• Inform motorist (signs, etc) • Employ Traffic Control Devices • Erect signs • Implement traffic staging plans • Field modifications (with approval) • *Communicate inadequacies with possible solutions* • *Remove site obstructions at merge or intersections*

Table F.10. Mitigation strategies by project phase (hazard #34 thru #37)

		Mitigation Strategies By Project Phase			
	Identified Hazard	**Planning & Programming**	**Design**	**Letting & Award**	**Construction**

33	**the condition of roadway & extra traffic volume of: detours; head-to-head traffic shifts; and shoulder shifts**	• Recon/drive detour to identify potential problems
		• Upgrade route prior to letting (if possible)
		• Accept risk and manage/control during subsequent phases
		  • Design phase (road geometry/condition)
		  • Construction phase (flaggers, pace vehicles, law enforcement)
			• Upgrade route prior to letting (if possible)
			• Re-design road geometry/condition
			• Accept risk and manage/control during subsequent phases
			  • Construction phase (flaggers, pace vehicles, law enforcement)
			• *Consider traffic modeling and signage*
					• Flaggers
					• Pilot Cars
					• Law enforcement

34	**the points of merge**	• Accept risk and manage/control during subsequent phases
		  • Design phase
		  • Construction phase
			• Design points of merge for traffic & construction requirements
			• Develop techniques for implementing the merge area (painted pavement arrows & markings, etc)
			• Specify use of ITS (merge point ahead)
			• Accept risk and manage/control during subsequent phases
			  • Construction phase
			• *Proper signing and coordination with public*
					• Monitor and adjust as necessary (flexibility provided in contract documents)
					• Utilize/employ ITS
					• *Advanced warning signs*
					• *Communicate inadequacies with possible corrections*

35	**the posted speed through the work zone**	• Policy Change
		• Accept risk and manage/control during subsequent phases
		  • Design phase
		  • Construction phase
			• Traffic Control Plans and designs to reduce speed
			• Accept risk and manage/control during subsequent phases
			  • Construction phase
					• Law enforcement
					• Monitor traffic control affectiveness & modify as necessary
					• *ITS signage noting speed limit*

36	**the work zone area being laid out long before construction actually begins**			• Set contract period to reflect actual construction schedule (this prevents contractors from setting out the work zone to satisfy the contract but waits for construction to begin)	

Table F.11. Mitigation strategies by project phase (hazard #38 and #39)

		Mitigation Strategies By Project Phase			
	Identified Hazard	**Planning & Programming**	**Design**	**Letting & Award**	**Construction**
37	**too long of workzone length**				• Lane rental specifications • *Appropriate phasing* • *Limitations in the specs referencing length of closures* • *Reduce length and add additional warnings at 6 mile, 4 mile,& 2 mile*

38	**traffic congestion & delay through the work zone**	• Detours (& Alternate Routes)
		  • Off site
		  • On site
		• Road Closures
		• Lane Closures
		• Shoulder shift
		• Accelerated Project Completion Scheduling (to limit exposure of traveling public)
		• *Communicate with public*			

39	**traffic speed & speeding (i.e., excess traffic speed, and limited stopping distance)**		• Temporary signals
			• Project Specified Design Speed (advisory speed) – written in specs
			• Lane narrowing & barriers (design)
			• Speed cameras (written in specs)
			• Enforcement details in specifications
			• Policy enforcement
			• Accept risk and manage/control during subsequent phases
			  • Letting
			  • construction
				• Policy for adding extra enforcement
				• Legislation (such as fines double in work zones)
				• Manage During Construction Phase
					• Temporary Signals
					• Project Specified design speed
					• Lane narrowing
					• Speed Cameras
					• Law enforcement posted at critical timeframes (may cause other problems)
					• *Communicate inadequacies w/ possible corrections*
					• *ITS spped signs noting speed*