MID-AMERICA
TRANSPORTATION CENTER

Development of Railroad Highway Grade Crossing Consolidation Rating Formula

Zachary Hans, M.S.
Senior Research Engineer
Center for Transportation Research and Education
Iowa State University

Chris Albrecht, M.S.
The Narwhal Group

Patrick Johnson, B.S.
Research Assistant
Civil, Construction, and Environmental Engineering
Iowa State University

IOWA STATE UNIVERSITY

2015

University of Nebraska–Lincoln
K·STATE Kansas State University
KU THE UNIVERSITY OF KANSAS
MISSOURI S&T University of Science & Technology
LINCOLN University
University of Missouri
IOWA STATE UNIVERSITY
THE UNIVERSITY OF IOWA

MATC

Development of Railroad Highway Grade Crossing Consolidation Rating Formula

ctre

Center for Transportation Research and Education

Final Report
February 2015

IOWA STATE UNIVERSITY

Institute for Transportation

Technical Report Documentation Page

1. Report No. WBS: 25-1121-0003-234	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Development of Railroad Highway Grade Crossing Consolidation Rating Formula		**5. Report Date** February 2015	
		6. Performing Organization Code	
7. Author(s) Zachary Hans, Chris Albrecht, Patrick Johnson, and Inya Nlenanya		**8. Performing Organization Report No.** InTrans Project 13-477	
9. Performing Organization Name and Address Center for Transportation Research and Education Iowa State University 2711 South Loop Drive, Suite 4700 Ames, IA 50010-8664		**10. Work Unit No. (TRAIS)**	
		11. Contract or Grant No. DTRT12-G-UTC07	
12. Sponsoring Organization Name and Address Iowa Department of Transportation, 800 Lincoln Way, Ames, IA 50010 Mid-America Transportation Center, 2200 Vine Street, PO Box 830851, Lincoln, NE 68583-085 U.S. DOT Research and Innovative Technology Administration (RITA) and Federal Highway Administration, 1200 New Jersey Avenue, SE, Washington, DC 20590		**13. Type of Report and Period Covered** Final Report	
		14. Sponsoring Agency Code MATC TRB RiP No. 34768	

15. Supplementary Notes

Visit www.intrans.iastate.edu for color pdfs of this and other research reports.

16. Abstract

The goal of this project was to provide an objective methodology to support public agencies and railroads in making decisions related to consolidation of at-grade rail-highway crossings. The project team developed a weighted-index method and accompanying Microsoft Excel spreadsheet based tool to help evaluate and prioritize all public highway-rail grade crossings systematically from a possible consolidation impact perspective.

Factors identified by stakeholders as critical were traffic volume, heavy-truck traffic volume, proximity to emergency medical services, proximity to schools, road system, and out-of-distance travel. Given the inherent differences between urban and rural locations, factors were considered, and weighted, differently, based on crossing location. Application of a weighted-index method allowed for all factors of interest to be included and for these factors to be ranked independently, as well as weighted according to stakeholder priorities, to create a single index. If priorities change, this approach also allows for factors and weights to be adjusted.

The prioritization generated by this approach may be used to convey the need and opportunity for crossing consolidation to decision makers and stakeholders. It may also be used to quickly investigate the feasibility of a possible consolidation. Independently computed crossing risk and relative impact of consolidation may be integrated and compared to develop the most appropriate treatment strategies or alternatives for a highway-rail grade crossing. A crossing with limited- or low-consolidation impact but a high safety risk may be a prime candidate for consolidation. Similarly, a crossing with potentially high-consolidation impact as well as high risk may be an excellent candidate for crossing improvements or grade separation.

The results of the highway-rail grade crossing prioritization represent a consistent and quantitative, yet preliminary, assessment. The results may serve as the foundation for more rigorous or detailed analysis and feasibility studies. Other pertinent site-specific factors, such as safety, maintenance costs, economic impacts, and location-specific access and characteristics should be considered.

17. Key Words	18. Distribution Statement		
at-grade crossing—closure rating formula—rail-highway crossing—railroad crossing consolidation	No restrictions.		
19. Security Classification (of this report) Unclassified.	**20. Security Classification (of this page)** Unclassified.	**21. No. of Pages** 76	**22. Price** NA

Form DOT F 1700.7 (8-72)   **Reproduction of completed page authorized**

DEVELOPMENT OF RAILROAD HIGHWAY GRADE CROSSING CONSOLIDATION RATING FORMULA

Final Report
February 2015

Principal Investigator
Zachary Hans
Senior Research Engineer
Center for Transportation Research and Education, Iowa State University

Co-Principal Investigator
Chris Albrecht
The Narwhal Group

Research Assistant
Patrick Johnson
Civil, Construction, and Environmental Engineering, Iowa State University

Authors
Zachary Hans, Chris Albrecht, Patrick Johnson, and Inya Nlenanya

A report from
Institute for Transportation
Iowa State University
2711 South Loop Drive, Suite 4700
Ames, IA 50010-8664
Phone: 515-294-8103 / Fax: 515-294-0467
www.intrans.iastate.edu

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

EXECUTIVE SUMMARY

Background

Crashes between motor vehicles and trains at highway-rail grade crossings is a significant concern to government agencies and railroad companies. The U.S. Department of Transportation (DOT) and railroad companies recognize the problem and have developed various programs that include incentives to encourage consolidation of these crossings.

This is particularly relevant to Iowa, which is a non-regulatory state and, therefore, does not have the authority to force the consolidation of highway-rail grade crossings on county (secondary) roads or municipal streets. Currently, even if various considerations identify a crossing as a candidate for consolidation, other factors and pressures often lead local agencies to leave a crossing open.

Problem Statement

While the literature documents many attempts to address various issues related to safety and risks at highway-rail grade crossings and strategies to minimize these risks and improve safety, limited information exists on a formula-based or systematic approach to evaluate crossings for consolidation.

While, the Iowa DOT Office of Rail Transportation Modal Division has an established procedure for evaluating highway-rail grade crossing safety and risk, as outlined in Federal-Aid Railroad-Highway Grade Crossing Program: Use of Benefit-Cost Ratio to Prioritize Projects for Funding, the purpose of the Federal-Aid Railroad-Highway Grade Crossing program is to eliminate hazards to vehicles and pedestrians at existing railroad crossings.

While the traditional basis for highway-rail grade crossing consolidation may be safety-related, safety does not necessarily need to be the impetus for consideration. Additional opportunities may exist in a more comprehensive and proactive assessment. General crossing necessity within the highway system may be systematically assessed through consideration of various factors beyond those that are strictly safety-related.

Ranking of crossings may be based on the potential impact on the public if a crossing is closed or consolidated. Safety-related factors may be considered independently and integrated, or evaluated in conjunction, with the general crossing assessment.

Project Objectives

The objectives were to develop and present a quantitative approach to assess crossings for possible consolidation, focusing predominantly on factors beyond safety and risk.

Research Description/Methodology

The project team developed a weighted-index method and accompanying Microsoft Excel spreadsheet-based tool to systematically evaluate and prioritize all public highway-rail grade crossings in the state from a possible consolidation impact perspective. A technical advisory committee (TAC) was established to provide broad, diverse insight and guidance, including identification of pertinent factors of interest and their corresponding weighting.

To ensure that potentially differing perspectives and interests were represented, the TAC was comprised of individuals from local and state government as well as railroad, industry, and non-profit organizations.

Local agency representatives included a city engineer from a municipality with a population of approximately 28,000 and 50 highway-rail grade crossings, and a county engineer from a small, rural county with approximately 15 rural highway-rail grade crossings. Two individuals from the Iowa DOT Office of Rail Transportation were also on the TAC, representing the areas of crossing safety and rail regulation and analysis.

Non-government TAC members included a public project manager from Burlington Northern Santa Fe (BNSF) Railway, the executive director of the Soy Transportation Coalition, and an educator from Operation Lifesaver.

While the TAC served as the primary guidance for the project, the group was limited in number. Therefore, an effort was made to survey a more comprehensive stakeholder group via email. The objective was to elicit input from additional key stakeholders regarding their views and concerns with closing of highway-rail crossings within their jurisdictions.

In developing the survey, input was solicited from several pertinent stakeholder groups, including primary and secondary education transportation providers as well as statewide agriculture and insurance-based organizations. While these organizations chose not to participate in the survey or distribute it to their members, they provided valuable input in shaping its content.

Ultimately, the survey was distributed to all county engineers in Iowa, representing all 99 counties, and all Iowa League of Cities members. A benefit of distributing the survey to all county engineers was that individuals in a common position provided responses. This was not necessarily the case with city-based responses, in which a more diverse group of staff had the ability to respond.

Detailed results of the survey are included in this report.

Key Findings

Factors identified by stakeholders as critical were: traffic volume, truck traffic volume, proximity to emergency medical services, proximity to schools, road system, and out-of-distance travel. The survey revealed that primary factors considered by both cities and counties when assessing the necessity of a highway-rail grade crossing are traffic safety and access to residential areas. Farm access was also a primary factor for counties, while emergency vehicle blockage and access to businesses were additional, primary factors for cities.

Given the inherent differences between urban and rural locations, factors were considered, and weighted, differently, based on crossing location.

Application of a weighted-index method allowed for all factors of interest to be included and for these factors to be ranked independently, as well as weighted according to stakeholder priorities, to create a single index. If priorities change, this approach also allows for factors and weights to be adjusted.

Microsoft Excel served as an ideal data repository and prioritization tool platform, given its ease of use, flexibility, accessibility, and transferability. In addition, existing functionality could be employed easily, allowing users flexibility in refining analyses by filtering (or limiting) crossings of interest by any attribute, or attributes, associated with each crossing.

Highway-rail grade crossing consolidation prioritization is very data-reliant. Appropriate data update and maintenance practices are essential.

Many of the factors employed require only limited updates. Attributes may also be updated in a piecemeal fashion, as necessary, and all normalized factors, factor ranks, and the final composite rank will be automatically recalculated for each crossing.

Implementation Readiness and Benefits

The prioritization generated by this approach may be used to convey the need and opportunity for crossing consolidation to decision makers and stakeholders. It may also be used to quickly investigate the feasibility of a possible consolidation. In addition, the prioritized list may be used in conjunction with Iowa's existing safety-based benefit-cost ratio calculations.

Independently computed crossing risk and relative impact of consolidation may be integrated and compared to develop the most appropriate treatment strategies or alternatives for a highway-rail grade crossing. A crossing with limited or low consolidation impact but a high safety risk may be a prime candidate for consolidation. Similarly, a crossing with potentially high consolidation impact as well as high risk may be an excellent candidate for crossing improvements or grade separation.

The results of the highway-rail grade crossing prioritization represent a consistent and quantitative, yet preliminary, assessment. The results may serve as the foundation for more rigorous or detailed analysis and feasibility studies. Other pertinent site-specific factors, such as safety, maintenance costs, economic impacts, and location-specific access and characteristics should be considered.

INTRODUCTION

Crashes between motor vehicles and trains at highway-rail grade crossings is a significant concern to government agencies and railroad companies. In 2009, there were 1,896 incidents at public highway-rail grade crossings in the US that resulted in 247 deaths and 705 injuries (US DOT 2013). The U.S. Department of Transportation (DOT) and railroad companies recognize this as a problem and have developed various programs to enhance safety at these crossings (US DOT 2004, US Code 2006, FHWA 2007). The programs include providing incentives to encourage consolidation of such crossings.

While the literature documents many additional attempts to address various issues related to safety and risks at highway-rail grade crossings and strategies to minimize these risks and improve safety (Horton 2008, Horton et al. 2009, Murphy 1994, Ries et al. 2002, Russell and Mutabazi 1998, FRA 2009, Saks and Carroll 2004, Weart 2008), limited information exists on a formula-based or systematic approach to evaluate crossings for consolidation.

This is particularly relevant to Iowa, which is a non-regulatory state and, therefore, does not have the authority to force the consolidation of highway-rail grade crossings on county (secondary) roads or municipal streets. Currently, even if various considerations identify a crossing as a candidate for consolidation, other factors and pressures often lead local agencies to leave a crossing open.

State and local government agencies and railroad companies face the challenge of identifying highway-rail grade crossing locations for potential closure. The Iowa DOT has not only examined options to enhance safety at rail-highway grade crossings (Iowa DOT 2002, Iowa DOT 2006), but Action G of the Iowa DOT 2012 Safety Action Plan, specifically, is to develop criteria for consolidating such crossings (Iowa DOT 2012). Developing the criteria also supports Actions H and I of the plan.

While the traditional basis for highway-rail grade crossing consolidation may be safety-related, safety does not necessarily need to be the impetus for consideration. Additional opportunities may exist in a more comprehensive and proactive assessment. General crossing necessity within the highway system may be systematically assessed through consideration of various factors beyond those that are strictly safety-related. Ranking of crossings may be based on the potential impact on the public if a crossing is closed or consolidated. Safety-related factors may be considered independently and integrated, or evaluated in conjunction, with the general crossing assessment.

Since the Iowa DOT has an established procedure for evaluating highway-rail grade crossing safety and risk, outlined in *Federal-Aid Railroad-Highway Grade Crossing Program: Use of Benefit-Cost Ratio to Prioritize Projects for Funding* (Iowa DOT 2006), the objective of this report is to present the development of a quantitative approach to assess crossings for possible consolidation, focusing predominantly on factors beyond safety and risk.

A weighted-index method and accompanying Microsoft Excel spreadsheet-based tool were developed to systematically evaluate and prioritize all public highway-rail grade crossings, based predominately on the relative necessity of the crossing and potential impact of its closure. The prioritization generated by this approach may be used, in part, to convey the need and opportunity for crossing consolidation to decision makers and stakeholders. It may be used to quickly investigate the feasibility of a possible consolidation.

In addition, the prioritized list may be used in conjunction with Iowa's existing safety-based benefit-cost ratio calculations. The independently computed crossing risk and relative impact of consolidation may be integrated and compared to develop the most appropriate treatment strategies or alternative for a highway-rail grade crossing.

For example, a crossing with limited or low consolidation impact but a high safety risk may be a prime candidate for consolidation. Similarly, a crossing with potentially high consolidation impact as well as high risk may be an excellent candidate for crossing improvements or grade separation.

As part of this project, a technical advisory committee (TAC) was established to provide broad, diverse insight and guidance, including identification of pertinent factors of interest and their corresponding weighting. To ensure that potentially differing perspectives and interests were represented, the TAC was comprised of individuals from local and state government as well as railroad, industry, and non-profit organizations.

Local agency representatives included a city engineer from a municipality with a population of approximately 28,000 and 50 highway-rail grade crossings, and a county engineer from a small, rural county with approximately 15 rural highway-rail grade crossings. Two individuals from the Iowa DOT Office of Rail Transportation were also on the TAC, representing the areas of crossing safety and rail regulation and analysis. Non-government TAC members included a public project manager from Burlington Northern Santa Fe (BNSF) Railway, the executive director of the Soy Transportation Coalition, and an educator from Operation Lifesaver. A primary emphasis area of the Soy Transportation Coalition is "a transportation system that delivers cost effective, reliable, and competitive service" (Soy Transportation Coalition 2013), while Operation Lifesaver provides public education focusing on highway-rail grade crossing safety (Operation Lifesaver 2015).

Additional feedback was also sought from a more comprehensive stakeholder group, which is discussed later in this report.

The remainder of this report is divided into five chapters:

The Literature Review provides an overview of past studies and existing practices related to highway-rail grade crossing consolidation, including formula-based approaches, factors considered, risk assessment, and recommendations.

Stakeholder Input discusses the results of a survey of cities and counties regarding highway-rail crossing concerns, essential crossing characteristics, and consolidation considerations.

Factor Development provides an overview of the development the factors necessary for consideration in assessing the relative necessity of a highway-rail grade crossing and the impact of its closure.

Prioritization Approach discusses the development and application of a modified, weighted-index method to rank, or prioritize, crossings, based on the factors identified in Factor Development. The manner in which the individual factor weights were established are also discussed.

Conclusions provides a wrap-up of this project and describes how the results of this work can be used and leveraged going forward.

LITERATURE REVIEW

Literature Review Overview

The objective of the literature review was to identify recent studies and existing practices related to highway-rail grade crossing consolidation rating formulas. Of particular interest were the factors and variables considered, as well as approaches that were not safety- or risk-focused. However, from the review of existing literature, safety was often the predominant, influencing factor. Additional factors are typically considered, to a lesser degree, on a case-by-case or site-specific basis, and not systematically.

Rating Formulas

A study conducted by Russell and Mutabazi (1998) at Kansas State University developing a highway-rail grade crossing consolidation rating formula in Kansas is most akin to the effort discussed in this report. The model that was developed consisted of eight variables: road type, average daily traffic (ADT), accessibility, obstruction, crossing angle, approach horizontal alignment, approach vertical alignment, and rideability.

Road type, ADT, and accessibility were used as elimination variables. Roads that were classified as collectors were designated as the objective for closure and higher function types of roads were excluded. Roads with ADT greater than 150 vehicles per day for rural or 750 vehicles per day for urban were excluded. Accessibility was defined as alternative access if travel between opposing sides of the crossing was still possible using some other route if the crossing were closed. Finally, crossings that served as the only access to an area were excluded.

In Phase 1, the remaining variables, with their cutoff values, were applied to the non-excluded crossings. In Phase 2, the eliminating variables from Phase 1 were unchanged and the remaining variables were weighted according to input from the expert advisor panel. Rideability and approach horizontal alignment were removed from consideration. In Phase 3, the eliminating variables were modified to increase the cutoff value for urban ADT from 750 vehicles per day to 1,300 vehicles per day in Kansas City, Wichita, Topeka, and Lawrence. The weight for the number of through trains was doubled (Russell and Mutabazi 1998).

California employs the following formula from the California Public Utilities Commission (CPUC) to determine the priority for crossings nominated for grade separation or elimination (CPUC 2013).

$$P = \frac{V \times (T + 0.1 \times LRT) \times (AH + 1)}{C} + SCF$$

The formula includes factors for annual average daily traffic (V), train traffic (T), light-rail train traffic (LRT), the project cost share to be allocated from the grade separation fund (C), accident history at the crossing (AH), and a special conditions factor (SCF).

Several other rating formulas were also found to focus mainly on safety and generate an exposure to accidents for crossings. For example, the US DOT Accident Prediction Formula calculates predicted accidents at crossings using a two-step calculation that combines predicted accidents and actual accident history. The resulting accident prediction can be used to rank crossings based on risk. The formula contains factors for several crossing attributes such as number of tracks, number of daily trains, train speed, highway type, number of highway lanes, whether the highway is paved, and an exposure index based on the product of highway and train traffic (FHWA 2007, Bowman 1994).

The New Hampshire Index is a hazard index computed using three factors: annual average daily traffic (AADT), average daily train traffic, and a protection factor based on the existing crossing protection (gates, lights, and crossbucks only). Several states modify the formula to include other types of crossing protection or to incorporate more factors into the calculation. As with the US DOT formula, this index is used to rank based on risk (FHWA 2007).

Texas uses a formula called the Texas Priority Index to prioritize projects for Federal crossing upgrade funds:

$$PI = V \times T \times (S \times 0.10) \times P_f \times A^{1.15} \times 0.01$$

The formula uses five factors: ADT (V), number of trains in 24 hours (T), train speed (S), a crossing protection factor (P_f), and the number of crashes in the last five years (A). The protection factor is based on the existing traffic control devices at the crossing and ranges from 0.10 (for gates) to 1.00 (for crossbucks or other). When more than one track is present and switching and main line operations occur over the same crossing at different speeds, a priority index is calculated for both and then added together to equal the total priority index for the crossing (TxDOT 1998).

Additional Consolidation Considerations

Oregon evaluates individual highway-rail grade crossings on multiple criteria during the process of determining consolidation suitability. The process begins with determining the classification of the road, the jurisdiction, and official designations, such as freight routes. The road is evaluated for its use by emergency services and evacuation. Adjacent crossings are evaluated to determine a suitable alternate route for traffic currently using the crossing to be consolidated. The crossing is evaluated for engineering concerns, such as approach visibility, sight distance along tracks, ground clearance at the crossing, and vehicle storage distance. The use of the crossing is considered by accounting for AADT, average number of daily train movements, type of train movements, and frequency of crossing blockage due to a train occupying the crossing. The alternative route is evaluated by determining the distance and time needed to get to the same point if the crossing is eliminated, traffic origination, the ability of the local network to absorb the additional traffic, and adjacent intersection level of service. In addition to these criteria, Oregon also evaluates the impact a consolidation may have on businesses and public facilities (Oregon DOT Rail Division n.d.).

Washington (state) selects projects based on perceived safety benefits, cost of implementation, and geographic diversity. No additional details regarding the definition of geographic diversity could be located in the literature (Horton 2008).

Iowa Efforts

The Iowa DOT conducted a corridor study of the Union Pacific West-East mainline across Iowa in 2002. The study investigated grade separation and crossing consolidation. Factors considered in the grade separation recommendation included: road traffic, train traffic, crossing angle, topography, sight distance, construction cost, community impact, land use, and collision history. The study found issues with data consistency. Data had not been collected on a regular basis, and some data were determined to be out of date. Another issue was that some crossings had a low exposure rating and a high predicted accident rating (Iowa DOT 2002).

The Iowa DOT developed a safety action plan for highway-rail grade crossings in 2012. The purpose of the action plan is to reduce collisions at highway-rail grade crossings in Iowa. The plan is intended to identify specific solutions for improving crossing safety, focusing on crossings that have experienced multiple accidents or are at high risk for accidents. In 2009, there were 52 vehicle-train collisions, 1 for every 37,616,421 vehicles estimated to use an at-grade crossing.

Currently, Iowa uses a benefit-cost ratio to prioritize projects for 23 U.S.C § 130 funding. The benefit-cost ratio considers exposure of the crossing to collisions and calculates the benefit of proposed upgrades and the societal cost of collisions. The exposure calculation takes into consideration road traffic, train traffic, urban or rural conditions, number of highway lanes, pavement type, number of tracks, train speed, number of switching movements, and number of collisions over the past five years. Great sensitivity is placed on historical collisions to predict future collisions (Iowa DOT 2012).

Federal Recommendations

The Federal Railroad Administration (FRA) and Federal Highway Administration (FHWA) have issued a document on crossing consolidation and closure detailing recommendations for regulatory agencies to follow (FHWA 2007). The guide states that local opposition is a major roadblock to crossing closure. According to the guide, thousands of redundant crossings could be consolidated without significant effects on travel time or convenience; however. a qualified professional should evaluate the plans to ensure that public safety is not diminished as a result of rerouting traffic. Previously abandoned crossings should be removed after abandonment. And, motorists may become inattentive to other, active crossings due to lack of activity at abandoned crossings.

The FHWA criteria for closing crossings on mainlines designates that a mainline section of track with more than five crossings in a one-mile segment should be evaluated for closure. The criteria for crossing closure consideration on branch lines are as follows:

- Less than 2,000 ADT
- More than two trains per day
- An alternate crossing within one-quarter mile that has less than 5,000 ADT if two lanes, or less than 15,000 ADT if four lanes

The criteria for crossing closure consideration on spur tracks are as follows:

- Less than 2,000 ADT
- More than 15 trains per day
- An alternate crossing within one-quarter mile that has less than 5,000 ADT if two lanes or less than 15,000 ADT if four lanes

STAKEHOLDER INPUT

As mentioned in the Introduction, a TAC consisting of individuals from local and state government as well as railroad, industry, and non-profit organizations was established to provide diverse perspectives regarding highway-rail grade crossing issues and key emphasis areas. While the TAC served as the primary guidance for the project, the group was limited in number. Therefore, an effort was made to survey additional key stakeholders to elicit input regarding their views and concerns with closing of highway-rail crossings within their jurisdictions.

In developing the survey, input was solicited from several pertinent stakeholder groups, including primary- and secondary-education transportation providers as well as statewide agriculture and insurance-based organizations. While these organizations chose not to participate in the survey or distribute it to their members, they provided valuable input in shaping its content. Ultimately, the survey was distributed to all county engineers in Iowa, representing all 99 counties, and all Iowa League of Cities members. A benefit of distributing the survey to all county engineers was that individuals in a common position provided responses. This was not necessarily the case with city-based responses, in which a more diverse group of staff had the ability to respond. The email solicitation for survey responses, the original survey itself, and a summary of survey responses may be found in Appendix A.

A total of 63 cities and 21 counties responded to the survey. It is important to note that not all agencies surveyed had highway-rail grade crossing in their jurisdictions and, specifically, four responding cities. In addition, respondents were not required to answer all questions.

More than 60 percent of the counties responding had at least 20 highway-rail grade crossings in their county, with the number of crossings ranging from 5 to 100. More than 85 percent of the cities responding had 5 or fewer crossings. In contrast, one city had 86 crossings.

Just over half of the responding agencies indicated they had concerns regarding highway-rail grade crossings in their jurisdictions. More than 70 percent of the city respondents had concerns compared to only 45 percent of the county respondents.

Collectively, need for active warning devices was the top concern, reported by 56 percent of the respondents answering the question (24 total responses), followed closely by crossing surface (53 percent) and train visibility (51 percent). One-third of the respondents reported blockage of the crossing by a train as a safety concern. Blockage of crossing by a train and the need for active warning devices were much less of a concern for the counties. When considering cities only, train horn noise was a major concern, second only to need for active warning devices.

Emergency vehicle blockage (69 percent and 56 responses) was reported as the top factor that the respondent governing bodies would consider in determining if a grade crossing is essential. Access to businesses and traffic safety tied at 65 percent, followed closely by access to residential areas (63 percent). More than half of the responses also reported public convenience and school bus traffic (57 and 56 percent, respectively) as factors determining whether a crossing

is essential. Effect on major traffic flows and farm vehicle access were reported by less than half of the responses (44 percent each).

The distribution of responses between cities and counties was fairly similar. The greatest differences in distribution pertained to farm vehicle access and school bus traffic, receiving more emphasis by the counties. Emergency vehicle blockage received more emphasis by cities. Of these factors, the top three were collectively refined by respondents to emergency vehicle blockage (53 percent), traffic safety (45 percent), and access to businesses and residential areas (tied at 41 percent). Traffic safety, farm vehicle access, and access to residential areas were the top county responses compared to emergency vehicle blockage, access to businesses, access to residential areas, and traffic safety for the cities.

More than half of the respondents indicated that they were unsure if their governing body would consider highway-rail grade consolidation if safety was improved, with nearly half of the cities and approximately 65 percent of the counties. Thirty percent indicated that their governing body would not consider consolidation. However, the collective summary may be somewhat misleading as only one county indicated that their governing body would not consider consolidation, compared to more than 40 percent of the cities.

Responses were similar when asked if their governing body would consider consolidation of one or more non-essential grade crossings if safety improvements would be made at other essential crossings in their jurisdiction. A small increase in affirmative yes responses was found for the cities.

When asked if their governing body would consider consolidation if it was of no cost to the agency, affirmative yes responses increased by 10 percent for both cities and counties, compared to the initial responses regarding consolidation and safety. However, this represented only 20 percent of the cities and less than half of the counties (40 percent). Nearly half of the respondents indicated that they were unsure whether their governing body would consider consolidation if it was of no cost to the agency.

Collectively, 57 percent of the respondents indicated that they were unsure if their agency would consider consolidation if the risk and cost of a crossing significantly outweighed the convenience of the crossing. More than one-third of the counties indicated that their agency would consider consolidation; conversely, one-third of the cities indicated that their agency would not consider consolidation.

The percent of responses indicating that the governing body would consider consolidation if appropriate financial incentives were available to offset the impact of the crossing closure increased to 50 percent of the counties but increased by only 4 percent, to 18 percent, for the cities. Collectively, 46 percent of the respondents were unsure, while one-third of the cities reported that the governing body would not consider consolidation.

Finally, respondents were allowed to supply comments or issues that they felt were not addressed in the survey questions. These free-form responses, as well as the high percentage of responses indicating either no governing body consideration for consolidation or uncertainty in possible governing body action, appear to confirm the literature findings, and specifically the sensitivity, pressures, and challenges associated with consolidation, particularly in cities.

As stated previously, the vast majority of the responding cities had five or fewer crossings. Given the limited number of crossings for these agencies, their crossing consolidation opinions may be impacted by possibly perceived reduced alternatives or access limitations. Furthermore, there may have been a hesitancy to broadly respond to consolidation considerations given that each potential closure or consolidation possesses unique conditions and circumstances. And other respondents may have not felt qualified to definitively address such consolidation questions.

The survey revealed that primary factors considered by both cities and counties when assessing the necessity of a highway-rail grade crossing are: traffic safety and access to residential areas. Farm access was also a primary factor for counties, while emergency vehicle blockage and access to businesses were additional, primary factors for cities.

FACTOR DEVELOPMENT

Overview

This chapter provides an overview of the development of the factors necessary for inclusion in a formula and tool set designed to assess the relative necessity of a highway-rail grade crossing and the impact of its closure. This includes evaluating TAC and stakeholder proposed factors, assessing data availability and database content, assimilating and reducing datasets, database creation, and database maintenance considerations.

To identify an initial set of highway-rail grade crossings to evaluate, the most recent (2012), statewide georeferenced Iowa DOT-maintained rail crossing database was obtained. This database is very similar in nature and content to the national FRA rail crossing database, which is not limited to public, grade crossings, which was the focus of this project. Therefore, the Iowa DOT database was used, resulting in data for approximately 4,300 public, at-grade crossings, as depicted in Figure 1.
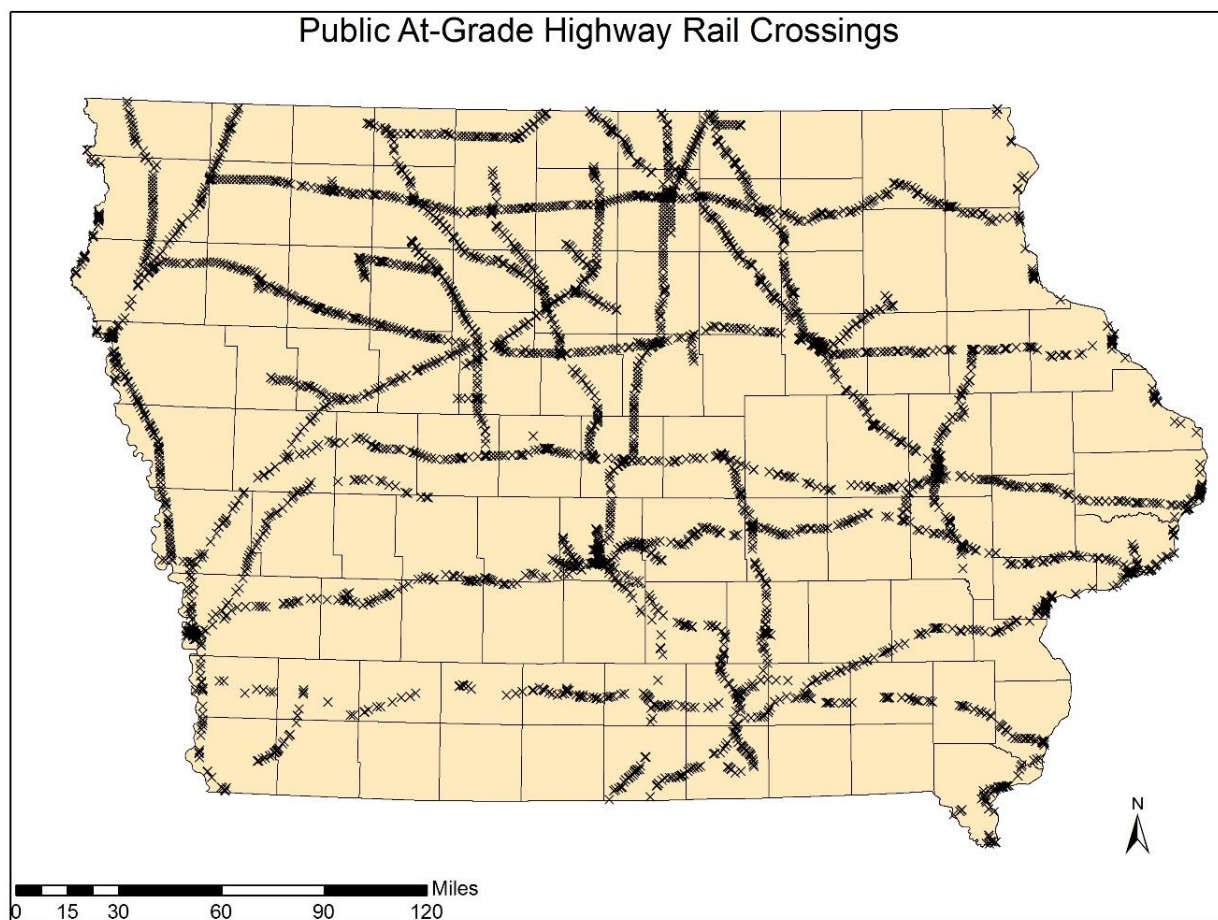
Figure 1. Iowa public highway-rail grade crossings

The resulting dataset and comprehensive attributes were extracted and retained for further analysis. The factors to be discussed in the following sections—both those only considered and those ultimately included in the final formula and tool—are broadly grouped into three main categories: demand factors, alternate route factors, and railroad/roadway-related factors. While not all factors fit perfectly into these categories, the categories serve as a means to organize similar concepts.

Demand Factors

Demand factors are broadly considered any factors that represent access provided by the highway-rail grade crossing and the actual and potential use of the crossing by motorists.

Traffic Volume – Annual Average Daily Traffic

The TAC initially suggested consideration of population and demographic characteristics surrounding each crossing. This suggestion was also consistent with one of the stakeholder-reported factors of essential crossings being access to residential areas.

Use of Topologically Integrated Geographic Encoding and Referencing (TIGER) data from the U.S. Census Bureau was investigated to determine if these crossings could be systematically associated with each highway-rail grade crossing. However, the TIGER-based block- and tract-level polygon datasets did not exist at a small enough scale to provide the precision needed for factor development. In addition, given the extent of the variable geographic size of the blocks and tracts, both among and between urban and rural areas, consistent and accurate representation of an appropriate crossing influence area was not feasible. Spatial disaggregation of the datasets may have been possible, but many assumptions would have been necessary to spatially allocate the attribute data, likely resulting in inaccuracies.

Another TAC consideration, as well as a highly reported stakeholder factor, was access to businesses. North American Industry Classification System (NAICS) business data were evaluated for possible association and assignment to individual crossings. Upon investigation, it was determined that these data would be prohibitive to obtain and, similar to the TIGER data, challenging to consistently and systematically assign to crossings.

Given possible limitations with the TIGER and NAICS datasets, AADT of the crossing roadway was selected as a proxy for the general activity level of the area and the crossing itself, as well as the population and demand in the area surrounding a crossing. Crossing AADT is maintained in the Iowa DOT rail crossing database. Since AADT already exists in a standard, regularly updated database, necessary maintenance of this factor in the formula should be limited.

Truck Traffic Volume – Heavy-Truck Annual Average Daily Traffic

Heavy-truck traffic, representing commodity and industry use of the crossing, was another initial consideration of the TAC. A truck percentage attribute is currently maintained in the Iowa DOT

rail crossing database. During evaluation, it was determined that the actual heavy-truck traffic count would be a better representation of the overall truck demand at each crossing. For example, the actual truck demand for a crossing with 10 percent heavy-truck traffic is very different when considering crossings with 200 vehicles per day compared to 2,000 vehicles per day. Final heavy-truck AADT was estimated by multiplying truck percentage and AADT. Since both of these attributes exist in the Iowa DOT rail crossing database, necessary maintenance of this factor in the formula should be limited.

Proximity to Emergency Medical Services

The highest, city-reported factor in determining whether a crossing was essential was emergency vehicle blockage. Since this factor does not currently exist in a standard statewide database, crossing proximity to emergency medical services (EMS) had to be derived. First, a database of emergency medical service demographics (including name, type, and address) and individual providers on each service's roster (including name and address) was obtained from the Iowa Department of Public Health (IDPH) Bureau of Emergency Medical Services (EMS). For simplification, the database was limited to only services and not individual providers.

Next, using ArcGIS (from Environmental Systems Research Institute/Esri), each record in the database was geocoded through address matching with the Esri StreetMap North America Data Composite US Locator. Some issues were encountered during the geocoding process based on the provided addresses. For example, upon reviewing initial address matching results, some addresses were manually corrected to better accommodate the matching algorithm. In addition, only post office box numbers were provided for some services. These services, as well as those where an address could not be resolved, were ultimately geocoded to the geometric center of the ZIP code polygon. These services represented less than 20 percent of the approximately 800 services provided by the IDPH Bureau of EMS. The end result of the geocoding process was an ArcGIS point coverage of service locations. Figure 2 shows an example of an EMS provider location with respect to the highway-rail grade crossings within the city.
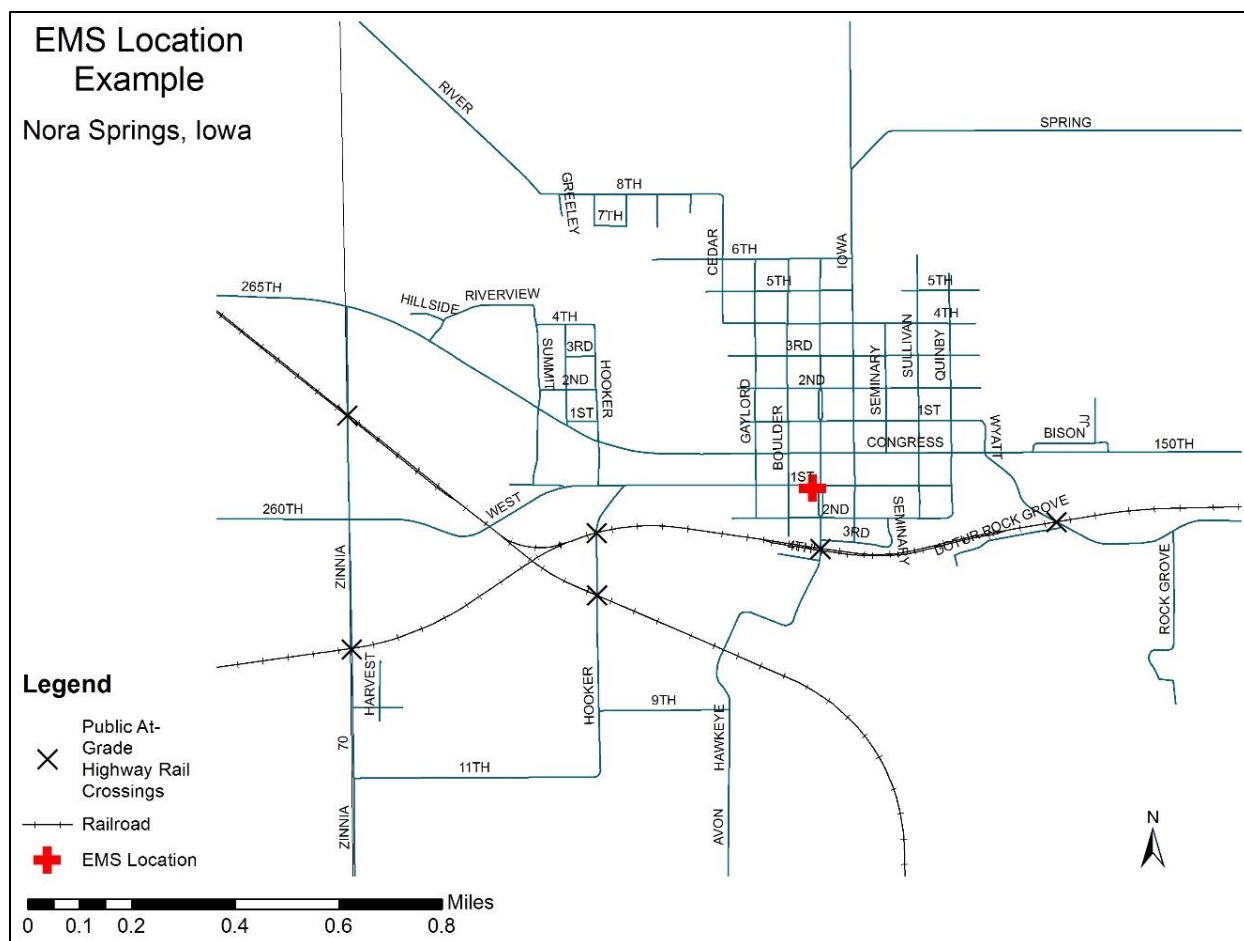
Figure 2. Sample EMS provider location map

Upon geocoding provider locations, approximate service area sizes were estimated. In the 2001 Emergency Response Information System (ERIS) project (www.ctre.iastate.edu/research/eris/index.htm), EMS service areas were found to be variably sized and irregularly shaped (Hans 2015). An example showing service area boundaries and cities in one Iowa county is shown in Figure 3.
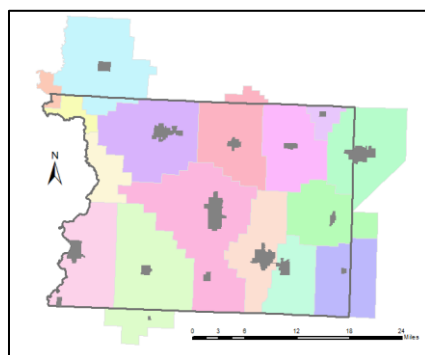
Figure 3. Sample EMS service areas for one county

14

Since the ERIS project was a demonstration effort, only a limited number of services within the state were mapped, and not maintained. Therefore, Thiessen polygons were generated in ArcGIS, based on the point location of EMS providers, to define the approximate area of influence around each service (Figure 4).
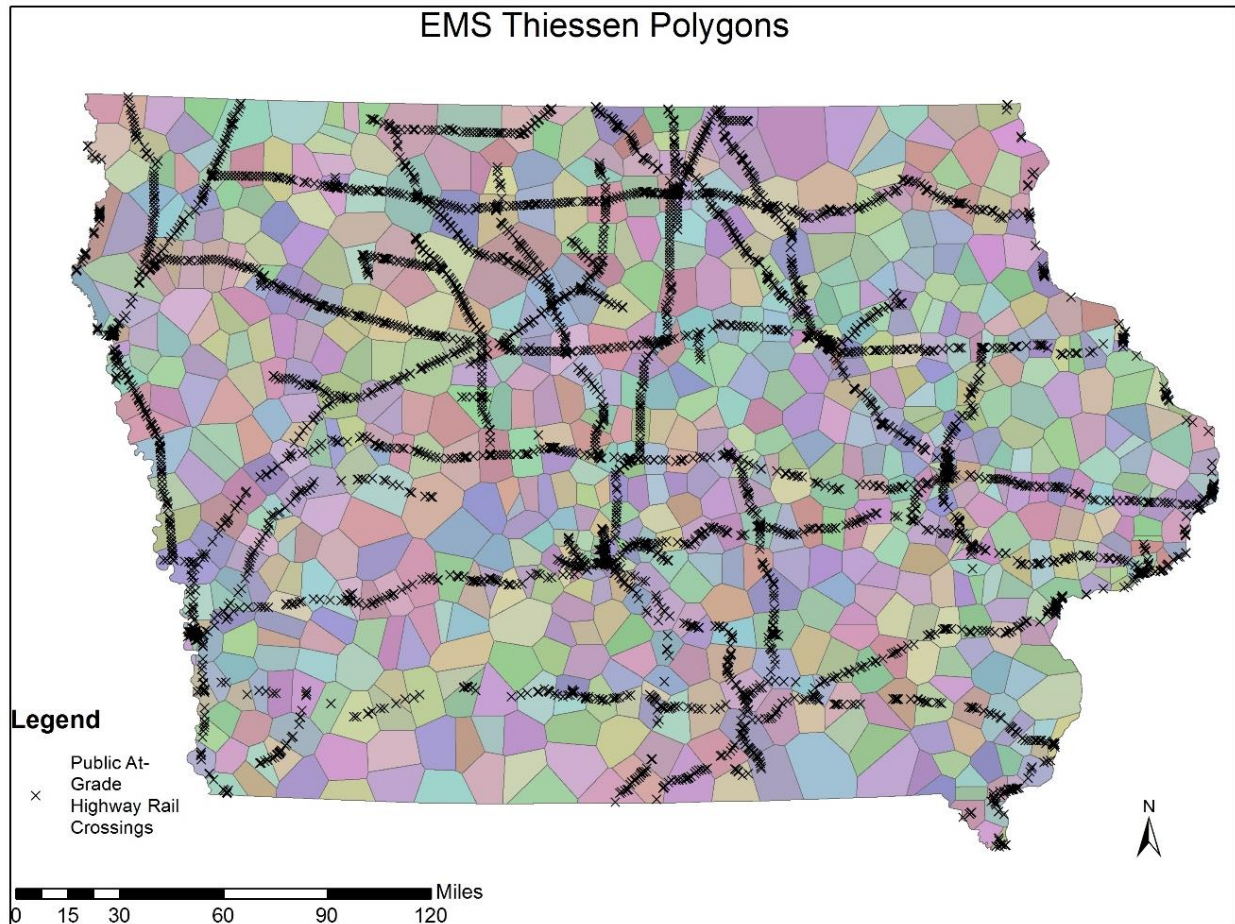
Figure 4. EMS Thiessen polygons showing approximate area of influence around each service

Thiessen polygon boundaries define the area closest to each point relative to all other points. (Esri n.d.). Based on the average area of the resulting Thiessen polygons, a radius of 15 miles was identified as an appropriate maximum area of influence. Attribute tables, also known as near tables, were generated for each crossing, reporting each service located within 15 miles of the crossing. The Euclidian distance between each service and the corresponding crossings was also computed.

The cumulative number of services within specified, incremental Euclidian distances of each crossing was then summarized. Incremental distances employed were 0.5 miles and 1 mile through 15 miles at one-mile increments. Ultimately, based on the distribution of services within the incremental distances, the distances of interest were identified as six miles for rural crossings and three miles for urban crossings. Based on TAC recommendations, two separate EMS-based

15

factors were established: number of services within the specified distance(s) and minimum distance to the nearest service. The additional factor of distance to nearest service was established to better account for services in close proximity to a crossing, which may not be adequately represented by simply considering the number of services. In other words, more emergency vehicles will likely use a crossing in very close proximity to a service.

This dataset may require minor maintenance as services are added or removed statewide. Attribute data may be updated for individual crossings, if needed. In addition, the comprehensive dataset may be reconsidered if more accurate service locations and/or service areas become available. A future consideration may be to employ traveled distance instead of Euclidian distance, if feasible.

Proximity to Primary and Secondary Schools

While stakeholders ranked school bus traffic as a lesser factor in determining whether a crossing was essential by stakeholders, the TAC contended that it still warranted consideration. Rerouting bus traffic through highway-rail grade crossing consolidation could potentially impact the trip length of many students. Because actual school bus pickup locations are not comprehensively available statewide, a point coverage of school buildings (approximately 1,900) was obtained from the Iowa Department of Natural Resources (DNR) as well as a polygon coverage of the most recent (2014) school district boundaries, representing approximately 350 districts. Figure 5 shows statewide school district boundaries with respect to highway-rail grade crossings.
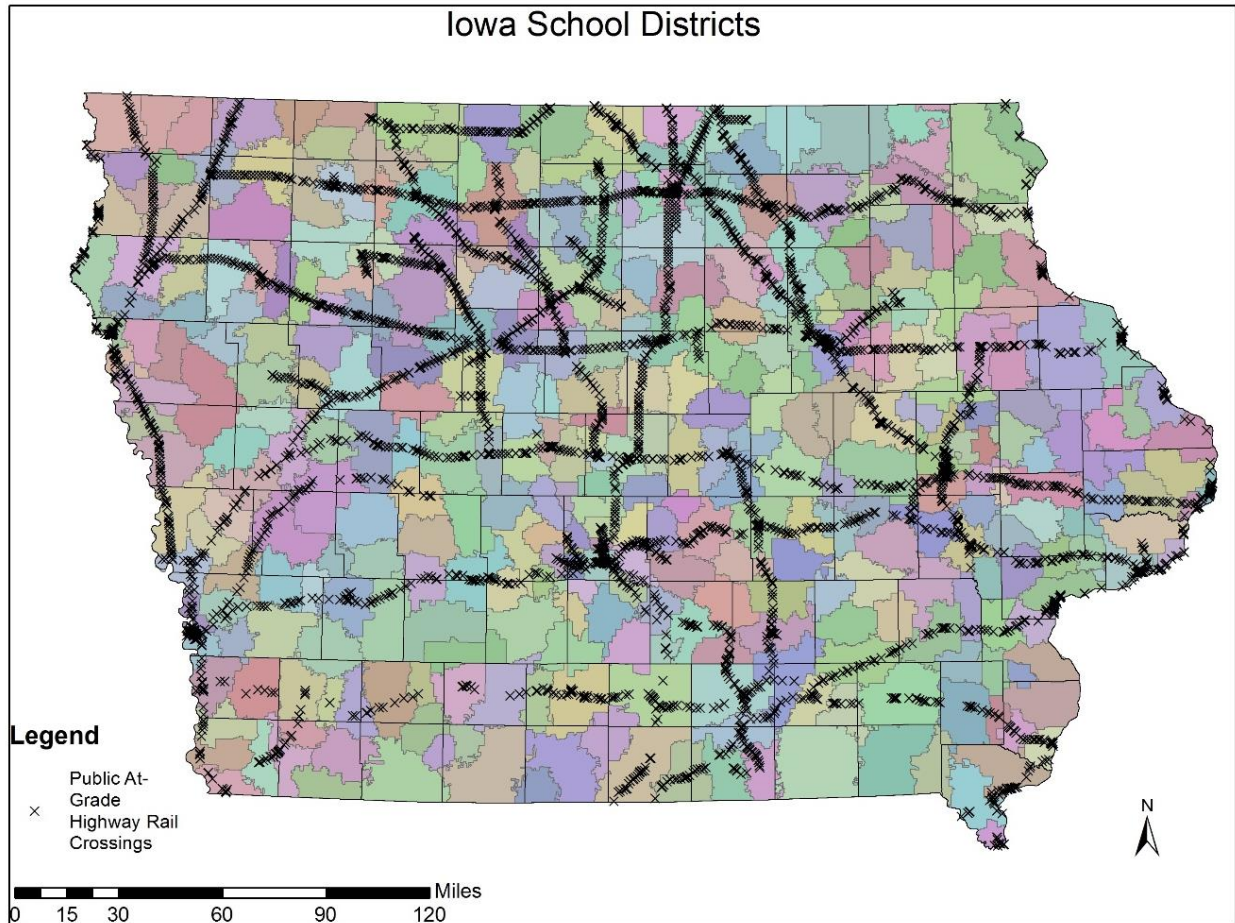
Figure 5. Highway-rail crossings in relation to school district boundaries

First, the school district boundaries were used to estimate an appropriate size, or area, for consideration. Based on the average area of combined urban and rural school districts in Iowa, a radius of 15 miles was identified as an appropriate area of influence.

Then, utilizing the actual school building locations (see example in Figure 6), near attribute tables were generated for each crossing.
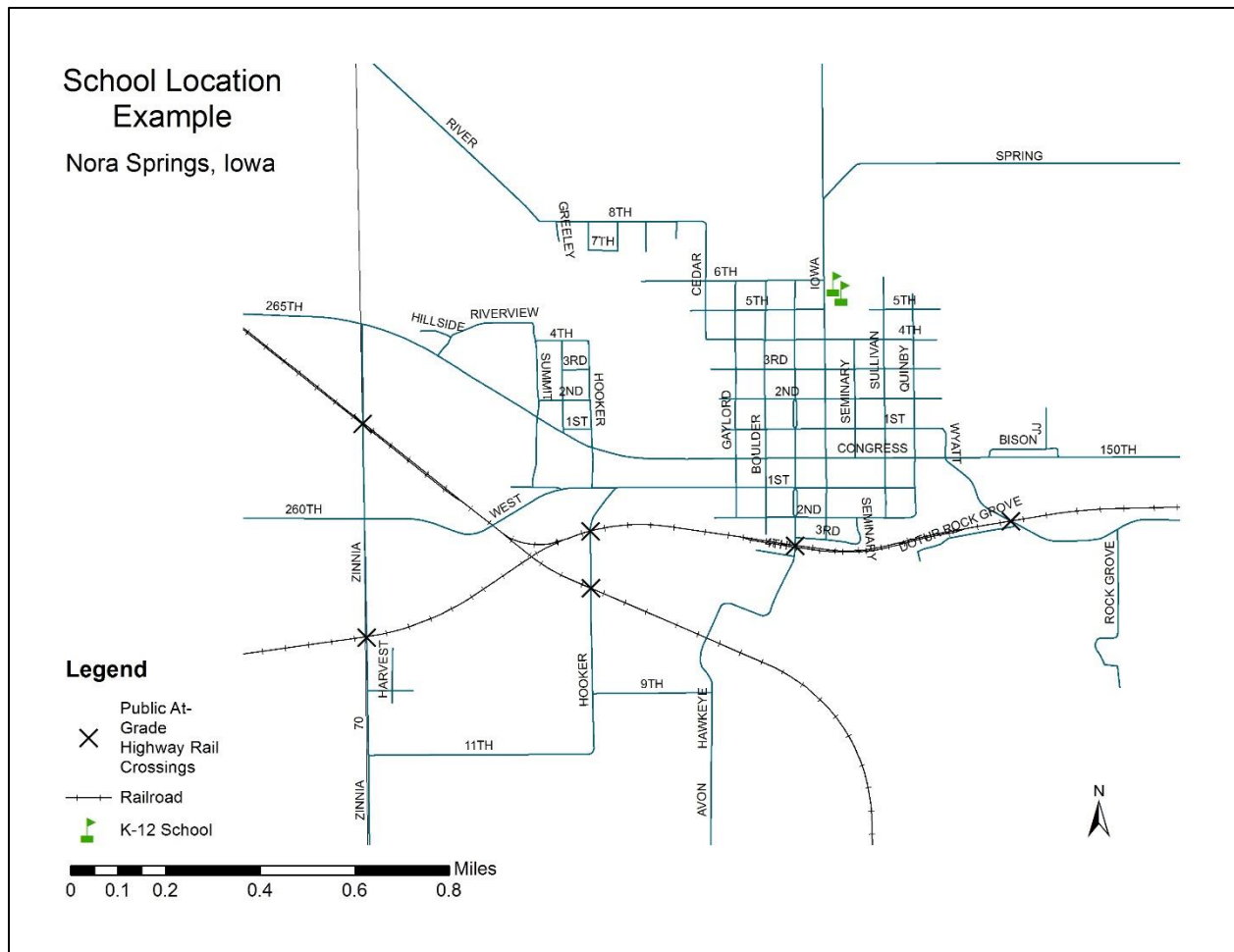
Figure 6. Sample school location map

The resulting tables contained each school located within 15 miles of the crossing. The cumulative number of schools within specified, incremental Euclidian distances of each crossing were then summarized. Incremental distances employed were 0.5 miles and 1 through 15 miles at one-mile increments. Ultimately, based on the distribution of schools within the incremental distances, the distances of interest were reduced to six miles for rural crossings and two miles for urban crossings. Similar to the EMS-based factors, two separate school-based factors were established: number of schools within the specified distance(s) and minimum distance to the nearest school. The additional factor of distance to nearest school was established to better account for schools in close proximity to a crossing, which may not be adequately represented by simply considering the number of schools. In other words, more buses will likely use a crossing in very close proximity to a school.

This dataset may require minor maintenance as school buildings are built or closed, and/or school districts are consolidated. Attribute data may be updated for individual crossings, if needed. A future consideration may be to employ traveled distance instead Euclidian distance, if feasible.

18

Roadway System

The road system, specifically farm-to-market and primary, crossing the railroad was determined by the TAC to be a factor of interest. The farm-to-market system is a designation defined by Iowa Code section 306.3 as "county jurisdiction intracounty and intercounty roads which serve principal traffic generating areas and connect such areas to other farm-to-market roads and primary roads." In part, the farm-to-market system was determined to warrant special consideration due to the nature of making changes to the system, including highway-rail grade crossing closures on the system. Modifications to the farm-to-market system are subject to review by the farm-to-market review board and may introduce unique challenges as routes removed from the farm-to-market system must be replaced with other existing or new routes.

The primary road system is defined in Iowa Code section 306.3 as "those roads and streets both inside and outside the boundaries of municipalities which are under (state) department (of transportation) jurisdiction." The primary road system was identified for special consideration in evaluation because they are less likely to be closed, or removed from the system, and their highway-rail grade crossings may be more likely to be upgraded.

The status of each crossing with respect to both the farm-to-market and primary road systems was assigned as a single, combined factor through spatial proximity, using the system code attribute of the Iowa DOT Geographic Information Management System (GIMS) roadway database. Additional roadway attributes from the GIMS database were also associated with each crossing for possible consideration in site-specific analyses. This dataset may require minor maintenance as changes are made to the farm-to-market or primary systems. Any such changes will likely be very isolated and may be addressed on a case-by-case basis.

Alternate Route Factors

Alternate route factors are broadly considered any factors that represent an impact on motorists of having to select a different route, other than the preferred choice, due to a highway-rail grade crossing closure.

Out-of-Distance Travel

Out-of-distance travel is defined as the additional distance a driver would need to travel on the next shortest path to get to the opposite side of a closed crossing. In other words, it is the difference between the shortest alternate route and the original route travel distance.

When considering different trip types, such as personal, business, or freight-related, more rigorous economic analyses may be conducted regarding the actual costs associated with this out-of-distance travel. Factors such as fuel usage, pollution, roadway usage, vehicle maintenance/repair/depreciation, operating costs, and time value may be taken into consideration.

For simplicity, this project focuses only the increased mileage. However, detailed economic analysis may be warranted for site-specific evaluations prior to formal decision making.

The shortest alternate route was calculated using the Network Analyst extension of ArcGIS. Specifically, a navigable route network was created using the Iowa DOT-maintained linear referencing system (LRS) transport links and nodes. Transport links represent road segments that extend between intersecting roadways but may also terminate at other locations, such as a change in jurisdiction. Each crossing was evaluated independently. Using Network Analyst, the transport link spanning the highway-rail crossing of interest was excluded from the network, and the shortest alternate route along the network between the nearest intersections (transport nodes) on opposing sides of the crossing computed. The resulting route/path (transport links) was saved as an ArcGIS polyline coverage with the corresponding Iowa DOT crossing number, which can be cross-referenced to the FRA crossing number. The aforementioned process was applied to each crossing, initially 4,300 of them, independently, and the resulting alternative, geographically represented path combined into a single polyline coverage for later application. The shortest alternate route for each crossing may be queried and reviewed visually within geographic information system (GIS) software. Figure 7 shows an example of the shortest alternate route (detour) associated with closing a highway-rail grade crossing.
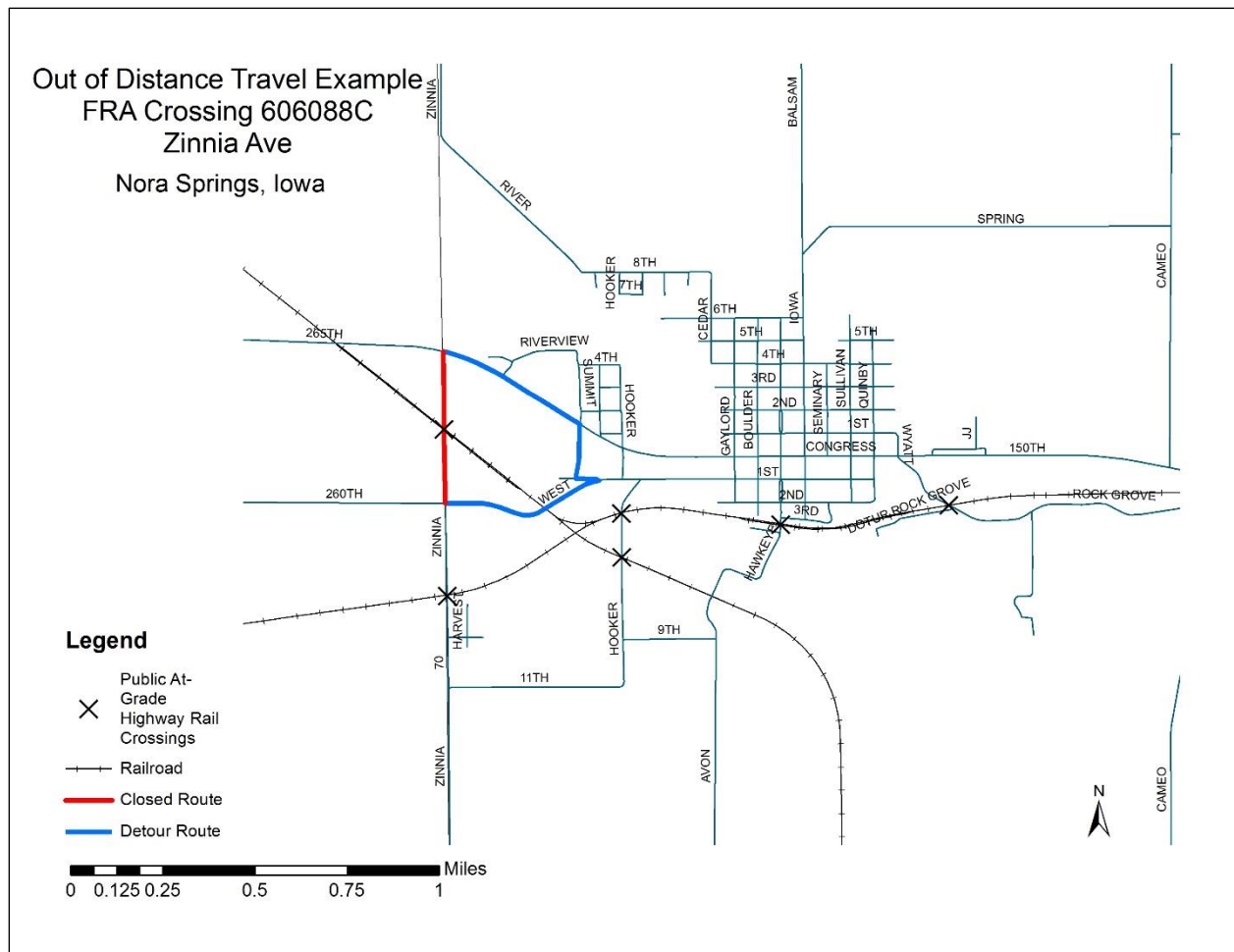
Figure 7. Sample shortest alternate route map

The alternate path utilized a grade separated crossing. The distance of each shortest alternate route was computed and associated with each crossing as was the original travel distance. The difference between these two distances yielded the out-of-distance travel. Possible automated approaches were evaluated for computing out-of-distance travel but could not be developed and implemented within the timeframe of the project.

While automated computation of alternate paths may have been desirable from a time standpoint, the manual process precipitated more in-depth review of each crossing. Specifically, during derivation of the shortest alternate path for each crossing, the crossings were evaluated to determine if they satisfied one of the following conditions and were categorized accordingly: abandoned, closed, only access, or unlocatable.

Abandoned crossings were designated as those that were clearly abandoned either from visual inspection on aerial imagery, Google Street View image, or found in the list of completed abandonment proceedings. Closed crossings were designated as those that were clearly closed from visual inspection of an aerial photo or Google Street View image. Crossings that were determined to be the only access to the opposite side of the railroad tracks were designated as

21

only access. Crossings were designated as unlocatable if they could not be linked to a specific grade crossing. Typically, this occurred when a crossing point was placed at a location where there was no roadway.

Out-of-distance travel was not computed for abandoned, closed, only access or unlocatable crossings, and they were excluded from final prioritization. This eliminated approximately 434 crossings, yielding a total of 3,789 crossings.

A minor challenge in deriving alternate routes was that the underlying roadway network was not an entirely topologically correct system, meaning grade separations and access control were not always honored. When such occurrences were encountered, an attempt was made to appropriately adjust the shortest path. A limited number of such occurrences may exist in the final dataset, which should be considered when reviewing prioritization results, particularly at crossings near access-controlled facilities.

An additional consideration of the resulting shortest alternate routes is that they may not necessarily represent actual motorist choices. Motorist choices may be influenced by a number of factors, such as roadway characteristics including road type (paved, unpaved), traffic control, and speed limit, and origin and destination locations. Motorists with origins and/or destinations located farther from a closed crossing may often have more alternate paths available to them. While all of these factors could not be taken into consideration in deriving alternate routes, those computed consistently represent the shortest alternative.

This dataset may require minor maintenance as changes are made to the roadway network, crossings are closed, and/or if any of the aforementioned anomalies regarding the resulting shortest path are identified. Any such changes will likely be isolated and may be addressed on a case-by-case basis and individual records updated as needed.

ArcGIS Network Analyst may be employed to yield similar spatially based results, or the out-of-distance travel may be manually calculated from reviewing aerial images or the appropriate roadway network. This second alternative is possible because only the resulting out-of-distance travel distance is ultimately used as a factor in the formula.

General Highway Safety

Because highway-rail crossing closures impact the roadways that motorists may use, an attempt was made to account for the possible change in traffic safety risk associated with use of alternate routes. Specifically, historical crash experience along the transport link removed from consideration as a result of a crossing closure, as well as crash experience along the shortest alternate route, were evaluated. This was possible, in part, because the Iowa DOT maintains a crash database, which includes all public roads in the state (approximately 116,000 miles).

Three primary metrics were initially considered in this evaluation: crash frequency, crash rate, and crash severity. These metrics are consistent with those computed and utilized in the Iowa

DOT Office of Traffic and Safety's Safety Improvement Candidate Location (SICL) intersection methodology (Pawlovich 2015). Furthermore, the most recent SICL dataset, which includes crash history from 2008 through 2012 for each intersection in the state with at least one crash during the analysis period, was utilized in the evaluation.

Crash frequency simply represents the frequency of crashes at a specific location during the five-year analysis period. Crash rate utilizes frequency as well but takes into consideration traffic exposure. In other words, crash rate is the number of crashes divided by the number of vehicles entering an intersection (daily entering vehicles, DEV) or traveling along a segment of roadway (vehicle miles traveled, VMT) during the analysis period.

$$Intersection\ Crash\ Rate = \frac{Crashes \times 1{,}000{,}000}{(DEV \times Analysis\ Period\ [in\ years] \times 365\ days\ per\ year)}$$

$$Segment\ Crash\ Rate = \frac{Crashes \times 100{,}000{,}000}{(Daily\ VMT \times Analysis\ Period\ [in\ years] \times 365\ days\ per\ year)}$$

Lastly, crash severity is represented by an index, computed by summing the total number and severity levels of injuries occurring during the analysis period. In the SICL, the following values are multiplied by each severity level:

- Fatality $\times$ 200
- Major injury $\times$ 100
- Minor injury $\times$ 10
- Possible or unknown injury $\times$ 1

For any given location, the first fatality is reduced to a major injury to mitigate the impact of severity possible factors.

Several steps were necessary to compute the aforementioned metrics for each original route and alternate route.

First, transport links and intersections were assigned to the appropriate crossings. The unique Iowa crossing number was associated with each transport link traversing the crossing. Each intersection, from the Iowa DOT statewide intersection database, at the termini or along these transport links, was also assigned the corresponding unique Iowa crossing number. Note that transport links and intersections may be associated with multiple crossings; therefore, unique transport links and intersections were repeated, for each applicable crossing, in the resulting cross-reference datasets.

All transport links comprising the shortest alternate route for a crossing were then identified and assigned the corresponding Iowa crossing number.

Each intersection at the termini or along these transport links was also assigned the corresponding unique Iowa crossing number. As mentioned previously, transport links and intersections could be repeated in the resulting cross-reference datasets as they may be associated with multiple crossings.

Using the SICL summary dataset and the crossing-intersection dataset, the total number of intersection crashes and injuries, by severity, was summarized for the original and alternate route at each crossing.

The Iowa statewide crash database was then limited to non-intersection crashes, specifically those not included in the SICL, occurring along the transport links.

These crashes were assigned to the appropriate transport links, and the total number of non-intersection crashes and injuries, by severity, was summarized for the original and alternate route at each crossing based on the crossing-transport link dataset.

The total number of intersection and non-intersection crashes and injuries, by severity, were combined for the original and alternate route at each crossing. Crashes occurring at the highway-rail grade crossing, either on the original or alternate route, were not explicitly isolated, or considered independently, as this is addressed in Iowa's benefit-cost ratio to prioritize projects for funding.

Since crash rate was a potential metric of interest, the vehicle miles traveled (VMT) along the original and shortest alternate route of each crossing had to be computed. Unfortunately, only a limited number of attributes, not including AADT, are maintained with the transport links. However, in an unrelated effort, the Iowa DOT Office of Traffic and Safety is in the process of integrating AADT data with the transport links, and a preliminary version of this database was obtained by the research team. Upon review and update, this dataset was used in conjunction with the crossing-transport link dataset to calculate VMT for each original and alternate crossing route.

For each transport link that was a component of either the original route or shortest alternate route, the daily VMT was computed by multiplying the link length (in miles) and its AADT.

The sum of VMT values for each transport link along the original or alternate route was computed, independently, for each crossing, yielding the total VMT for the original route and shortest alternate route for each crossing.

Given the summarized crash and VMT data, the following metrics were computed for both the original route and alternate route at each crossing:

- Total frequency of crashes and frequency of crashes by severity
- Crash rate
- Severity index per mile

The severity index was computed slightly differently than the SICL method. Specifically, since the original and alternate routes may be of different lengths, the initial index was divided by the length of the route to yield a severity index per mile, which can be more appropriately compared among crossings. Also, two versions of the severity index was computed, with and without reducing the first fatality to a major injury.

Several additional metrics were also computed, comparing the original and alternate route, such as the difference in crash rate and difference in severity index. In some cases, the alternate route metric may be less than the original.

Ultimately, the TAC chose to limit the general highway safety considerations to the crash rate of the alternate route. The resulting crash rate values could be relatively large, given the impact of low VMT values (from short and/or low AADT alternate routes) serving as the denominator of the crash rate equation. Although only alternate route crash rate was identified as a factor of interest, all other metrics were retained for each crossing and may be used for more in depth site-specific evaluations or comparisons.

Creation of the datasets necessary to compute the aforementioned metrics required assimilation and integration of several databases. The resulting cross-reference datasets of crossings-intersections and crossings-transport links should facilitate maintenance and update of the computed metrics.

For example, the intersection SICL is updated annually by the Office of Traffic and Safety for the most recent five-year analysis period and may be used directly with the crossings-intersections dataset to update intersection crash experience along the routes of interest. Maintenance may be further facilitated as the Office of Traffic and Safety continues to maintain a transport link database integrated with AADT data.

As with other previously discussed factors, maintenance may be primarily required as changes are made to the roadway network or crossings are closed. However, the final metrics are more temporal in nature, relying on crash experience, which is constantly changing. A maintenance-based decision regarding the frequency in which to update these metrics, and more specifically the primary factor of interest of alternate route crash rate, may need to be made.

Integration and update of the mainline crashes along the original and alternate routes may require the most effort; however, only one year of data may need to be updated annually. A future opportunity may exist with the Office of Traffic and Safety's current efforts to implement a segmental SICL. For example, a relationship (cross-reference) between the segmental SICL and both the original and alternate routes may potentially be established, allowing crash data to be simply aggregated, similar to the SICL intersection process.

Other Railroad- and Roadway-Related Factors Considered

This section discusses several railroad- and roadway-related factors that were suggested by the TAC but not included in the final formula or prioritization consideration. The primary reasons for exclusion were data completeness, data accuracy, and duplication in the Iowa DOT's existing benefit-cost safety assessment. Factors initially considered but already included in Iowa DOT's benefit-cost safety assessment were skew angle of railroad to roadway, crossing crash history and predicted risk, exposure index, which is a function of the number of trains, maximum train speed, crossing angle, and number of tracks..

Proximity of an intersection to a highway-rail crossing was considered a possible attribute of interest. This attribute is maintained in the rail crossing database as Hwynear. It indicates if an adjacent roadway intersection exists within 500 feet of the crossing. If an intersection is present, the approximate distance is reported in ranges from less than 75 feet, 75 to 200 feet, and 200 to 500 feet. This attribute was ultimately removed from consideration but was retained for each crossing for use in more in depth site-specific evaluations or comparisons.

Lastly, humped crossings were identified by the TAC as a potential attribute of interest, in part as a proxy for roadway approach grade. The rail crossing database contains an attribute indicating if a humped crossing sign is present.

A preliminary assessment was initiated to investigate the accuracy of this attribute. Only 10 crossings of the 3,789 included in analysis reported that a sign was present. Through random visual inspection using aerial imagery and Google Street View, the attribute value was found to be generally inaccurate or not present. The humped crossing sign was often not present at the reported crossings, and, in some cases, the crossing was not humped where a sign was reported. Because of these inaccuracies, the presence of a humped crossing was not included as a factor in the final ranking.

Approximation of roadway approach grade using other sources, such as statewide aerial light detection and ranging (LiDAR) data, was considered but determined not feasible within the scope of the project.

PRIORITIZATION APPROACH

Overview

The pertinent attributes discussed in the Factor Development chapter as well as all attributes contained in the Iowa DOT rail crossing database and selected GIMS roadway attributes were integrated into a new, highway-rail crossing database. This database served as the basis for the formula development and application.

This chapter discusses development and application of a modified, weighted-index method to rank, or prioritize, crossings based on the factors identified in Factor Development. The manner in which the individual factor weights were established are also discussed.

Weighted-Index Method

Background

Upon consultation with Iowa DOT staff and the TAC, a weighted-index method, similar to that utilized in the Iowa DOT SICL methodology, was identified as the preferred method for ranking or prioritizing highway-rail grade crossings. Current SICL development employs a somewhat modified combination of weighted rank and index methods.

Through use of a weighted rank index method, all factors of interest are identified, ranked independently, and weighted according to priorities to create a single index, which may then be ranked. The benefits of each factor are retained, and their disadvantages may be minimized. Additionally, weights can be adjusted as, or if, priorities change. However, establishing appropriate weightings may be somewhat subjective (Pawlovich 2007). Factor weighting in this study is discussed later in this chapter.

In a more traditional weighted rank method, as well as the modified approach, sites are ranked by each factor independently, yielding different ranked lists for each factor. For example, a site may be ranked first among all sites based on one factor but last based on another factor. The resulting ranks are then combined, based on a weighting schema, and a final combined rank list created (Pawlovich 2007).

A potential issue with combining the rank value of each factor is that large rank values within any one factor may impact the final, combined results significantly. This may be minimized by normalizing the resulting rank value, or specifically, by dividing the rank value for a given factor by the maximum rank value of the same factor. (Pawlovich 2015). However, this does not completely resolve the issue.

Factors with a limited number of discreet values (and tied ranks) among sites may also impact final rankings. For example, AADT differences and rank differences are not necessarily

proportional. An equivalent difference in AADT between sites does not necessarily yield an equivalent difference in rank between sites. This is, in part, a function of the distribution of AADT values among sites as well as the number of sites with equal AADT values, resulting in rank ties. For urban crossings, a rank difference of one could represent sites with AADT differences of one vehicle or 1,000 vehicles. Furthermore, if five sites possess the same AADT value, the rank for the next highest AADT site would increase by five, regardless of the actual difference in AADT between the sites.

The current Iowa DOT SICL method attempts to reduce the impact of large differences in original factor values further by normalizing theses values. This is accomplished by dividing each factor value by the highest value within that factor. This technique better addresses the relative magnitude differences between factor values. The appropriate weights are then applied to the normalized values themselves. A combined index value is then calculated by summing the resulting weighted values. The final composite ranking, which is an ordered list, is based on these values (Pawlovich 2015).

Modified Approach

While the SICL-based approach served as a model for development of the weighted-index method for the highway-rail grade crossing consolidation prioritization, several adjustments were necessary. For example, only three factors are included in the SICL. Nine different factors were identified for inclusion and consideration in crossing consolidation. Additionally, for all SICL factors, large values are considered undesirable and, as a result, sites with higher values may represent those with greater opportunities for possible safety improvements. Therefore, all SICL factor ranks are based on values in descending order of magnitude.

Descending order rank is not applicable to all crossing consolidation factors, particularly in assessing the relative necessity of a crossing. For example, a crossing with a low AADT value may potentially be considered less essential than a crossing with a greater AADT value. In other words, as AADT values increase among crossings, they may be considered increasingly more essential.

Urban and rural crossings were also segregated for the highway-rail grade crossing consolidation. Urban crossings were ranked among urban crossings, and rural crossings were ranked among rural crossings. Segregation was accomplished through use of the Nearcity attribute in the Iowa rail crossing database, which indicates whether a crossing is within or outside of corporate limits. This was done primarily due to the inherent differences between urban and rural areas.

For several factors, evaluating urban and rural crossings together would have skewed closure prioritization towards rural crossings. For example, the out-of-distance travel for urban crossings is typically less than for rural crossings. Furthermore, emergency management services and schools are predominantly located in cities, generally resulting in more services and schools, in closer proximity, to urban crossings.

As discussed previously, common factors were considered for both urban and rural crossings. Adjustments were simply made to the threshold distances employed for urban and rural crossings when evaluating the number of proximate emergency services and schools.

Two values were computed for each factor of interest: a normalized factor and factor rank, which is based on the normalized factor value. Normalization yields values near 0 for crossings that may potentially be considered more essential. As normalized values approach 1, a crossing may potentially be considered less essential and a better candidate for possible consolidation. The top ranked crossings for closure, based on any individual factor or the composite index, will have a rank value of 1.

During development, two different composite indices and ranks were initially computed for each crossing, based on normalized factor ranks (the original SICL approach) and normalized factor values (the current SICL approach). Ultimately, the normalized factor values approach was preferred as the results were less sensitive to differences within and between factors. This approach is in the next section.

Factors

Traffic Volume – Annual Average Daily Traffic (AADT)

When evaluated independently, an inverse relationship exists between AADT and possible crossing necessity. In other words, crossings with lower AADT values may potentially be considered less essential. Such crossings are represented by AADT-based normalized values nearer to 1.

AADT values were normalized by dividing each crossing's AADT by the maximum AADT among all crossings and subtracting the resulting value from one, ensuring that lower AADT crossings had values nearer to one.

$$AADT_{n(norm)} = 1 - \frac{AADT_n}{AADT_{max}}$$

To more accurately convey the possible importance of higher AADT crossings, a rank was computed, in descending order, based on the normalized AADT value. For example, among the 1,767 urban crossings, a 290 AADT crossing was ranked 378, and an 8,900 AADT crossing was ranked 1,686.

Only the normalized AADT values were utilized in the composite index and rank calculations. Rank values were simply provided to serve as a frame of reference within and among the different factors.

Truck Traffic Volume – Heavy-Truck Annual Average Daily Traffic (TAADT)

As discussed previously, heavy-truck AADT was estimated by multiplying truck percentage and AADT from the Iowa rail crossing database. Similar to total AADT, when evaluated independently, an inverse relationship exists between heavy-truck AADT and possible crossing necessity. In other words, crossings with lower heavy-truck AADT values may potentially be considered less essential. Such crossings are represented by heavy-truck AADT-based normalized values nearer to 1.

Truck AADT values were first normalized by dividing each crossing's heavy-truck AADT by the maximum heavy-truck AADT among all crossings and subtracting the resulting value from 1, ensuring that lower heavy-truck AADT crossings had normalized values nearer to 1. A rank value was computed, in descending order, based on the normalized heavy-truck AADT.

Only the normalized heavy-truck AADT values were utilized in the composite index and rank calculations.

Proximity to Emergency Medical Services

Two EMS-related factors were included in crossing ranking: number of services within six miles of a rural crossing or three miles of an urban crossing and minimum Euclidian distance, in miles, to the nearest service.

Services within a Specified Distance of Crossing (EMSFRQ3, EMSFREQ6)

When evaluated independently, the more services within the specified vicinity of a crossing, the more essential the crossing may potentially be considered. Such crossings will be represented by normalized values nearer to 0. The number of services values were normalized by dividing each crossing's number of services by the maximum number of services among all crossings and subtracting the resulting value from 1, ensuring that crossings with fewer services had normalized values nearer to 1. The resulting normalized values were then ranked, in descending order.

Only the normalized number of services values were utilized in the composite index and rank calculations. In general, there was limited diversity among the number of services factor. For example, only eight different values were present for urban crossings, ranging from no services to seven services within three miles. More than half of the urban crossings had only one service within three miles. The distance-based factor was much more discreet in nature.

Distance to the Nearest Service (EMSDIST)

The closer an emergency service is to a crossing, the more essential the crossing may potentially be considered. Such crossings are represented by normalized values nearer to 0. Crossings with

services located at greater distances from the crossing are represented by normalized values nearer to 1.

The distance to nearest service values were first normalized by dividing each crossing's distance by the maximum distance among all crossings, ensuring that crossings at a greater distance from the nearest emergency service had normalized values nearer to 1.

To accurately convey the possible relative importance of crossings nearer to emergency services, a rank value was computed, in descending order, based on the normalized distance. For example, a crossing within 0.03 miles of the nearest service was ranked 1,763, and a crossing within 1.02 miles of the nearest service was ranked 597.

Only the normalized distance to nearest service values were utilized in the composite index and rank calculations.

Proximity to Primary and Secondary Schools

Schools within a Specified Distance of Crossing (SCHFRQ2, SCHFRQ6)

In general, the more schools within the specified vicinity of a crossing, the more essential the crossing may potentially be considered. Such crossings are represented by normalized values nearer to 0.

The number of schools values were normalized by dividing each crossing's number of schools by the maximum number of schools among all crossings and subtracting the resulting value from 1, ensuring that crossings with fewer schools had normalized values nearer to 1. A rank value was then computed, in descending order, based on the normalized number of schools.

Only the normalized number of schools values were utilized in the composite index and rank calculations. There was more diversity among the number of schools factor compared to the number of emergency services factor. Twenty-three different values were present for urban crossings, ranging from 0 to 22 schools within two miles.

Distance to the Nearest School (SCHDIST)

The closer a school is to a crossing, the more essential the crossing may potentially be considered. Such crossings are represented by normalized values nearer to 0. Crossings with schools located at greater distances from the crossing are represented by normalized values nearer to 1.

The distance to nearest school values were first normalized by dividing each crossing's distance by the maximum distance among all crossings, ensuring that crossings at a greater distance from the nearest emergency service had normalized values nearer to 1. To convey the possible

importance of crossings nearer to schools, a rank was computed, in descending order, based on the normalized distance.

Only the normalized distance to nearest school values were utilized in the composite index and rank calculations.

Roadway System (RDSYS)

The combined farm-to-market and primary road factor was included in the weighted rank index for the highway-rail grade crossing consolidation to represent both importance of these roadways in the Iowa transportation system as well as the potential challenges associated with closing their crossings. Only two values are present in this factor: 0 and 1. A value of 1 indicates that the road crossing the railroad is part of the farm-to-market system or is state maintained. Conversely, a normalized factor value of 1 represents that the crossing is not traversed by a farm-to-market or primary road. Such crossings may potentially be less essential, based on this factor alone.

The normalized factor values and final ranks are computed in the same manner as the AADT, heavy-truck AADT, proximity to EMS (number of services), and proximity to schools (number of schools) factors. Only 25 percent of the urban crossings and 35 percent of the rural crossings were located on the farm-to-market or primary system.

The normalized factor values were utilized in the composite index and rank calculations. Only two possible values existed for each.

Out-of-Distance Travel (ALTDIST)

The greater the out-of-distance travel value, the more essential a highway-rail grade crossing may potentially be considered, as its closure would have a more quantifiable, or measurable, impact on motorists. More opportunities for closure may exist at crossings with shorter resulting out-of-distance travel lengths.

The out-of-distance values were normalized by dividing each crossing's out-of-distance value by the maximum distance among all crossings and subtracting the resulting value from 1, ensuring that lower distance crossings had normalized values nearer to 1. A rank value was then computed, in descending order, based on the normalized out-of-distance value.

This yielded rank values conveying the relative necessity of a crossing considering out-of-distance travel only. For example, a crossing with an alternative length of 0.75 miles had a rank of 1,248, compared to 1,669 for a crossing with an out-of-distance travel of 3.34 miles. Considering travel distance alone, of these two crossings, closure of the 0.75 mile crossing would potentially have less impact on motorists and commerce.

Only the normalized out-of-distance measure values were utilized in the composite index and rank calculations.

Alternate Route Crash Rate (ALTRATE)

As discussed previously, of the general traffic safety-related metrics calculated, the TAC chose to limit consideration to the crash rate along the alternate route of shortest length. Alternate routes with higher crash rates represented those with a greater possible negative impact on motorists. Therefore, alternate routes with no crashes, or a crash rate of 0 crashes per hundred million vehicle miles of travel (HVMT), would potentially be more attractive for closure, as they would have less of a safety-related impact on motorists. Crossings with such an alternate route crash rate would have a rank value of 1.

The crash rate values were normalized by dividing each crossing's crash rate by the maximum alternate route crash rate among all crossings and subtracting the resulting value from one, ensuring that lower alternate route crash rate crossings had normalized values nearer to 1. A rank value was then computed, in descending order, based on the normalized crash rate rank.

Only the normalized alternate route crash rate values were utilized in the composite rank calculations.

Factor Weighting Schema

Upon computing the normalized values for each factor, all factors needed to be combined through a weighting schema. This weighting schema defines the relative importance of each factor with respect to each other factor and the cumulative total of all factor weights must be 1. The weighting schema, and individual factor weights, were developed through application of a modified Pugh method or decision-matrix method (Terpenny n.d.).

During the project TAC meeting in which all factors of interest were formally selected, TAC members were also asked to determine the importance of each identified factor relative to each other factor. A matrix was prepared with each factor represented within both a row and a column. Each cell in the resulting matrix represented a comparison of the row factor to the column factor. In other words, the value recorded in each cell represented the importance of the row factor compared to column factor.

When comparing factors, a row factor was assigned a value of 1 if it, and the comparison (column) factor, were of equal importance. A value of 2 was assigned to a factor if it was more important than the comparison factor. A factor was assigned a value of 1/2 if it was less important than the comparison factor.

A factor was not compared to itself. Therefore, cells located along the diagonal of the matrix received null values (see Tables 1 and 2). In addition, only the cells located left of the diagonal initially received values.

Table 1. Urban factor weighting matrix

URBAN	AADT	ALTDIST	TAADT	RDSYS	EMSFRQ3	EMSDIST	SCHFRQ2	SCHDIST	ALTRATE	TOTAL	WEIGHT
AADT		1	2	1	2	2	2	2	2	14	0.16185
ALTDIST	1		2	2	2	2	2	2	2	15	0.17341
TAADT	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5	4	0.04624
RDSYS	1	0.5	2		1	1	0.5	0.5	1	7.5	0.08671
EMSFRQ3	0.5	0.5	2	1		1	2	2	2	11	0.12717
EMSDIST	0.5	0.5	2	1	1		2	2	2	11	0.12717
SCHFRQ2	0.5	0.5	2	2	0.5	0.5		1	0.5	7.5	0.08671
SCHDIST	0.5	0.5	2	2	0.5	0.5	1		0.5	7.5	0.08671
ALTRATE	0.5	0.5	2	1	0.5	0.5	2	2		9	0.10405

Table 2. Rural factor weighting matrix

RURAL	AADT	ALTDIST	TAADT	RDSYS	EMSFRQ6	EMSDIST	SCHFRQ6	SCHDIST	ALTRATE	TOTAL	WEIGHT
AADT		1	2	1	2	2	2	2	2	14	0.16185
ALTDIST	1		2	2	2	2	2	2	2	15	0.17341
TAADT	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5	4	0.04624
RDSYS	1	0.5	2		1	1	2	2	1	10.5	0.12139
EMSFRQ6	0.5	0.5	2	1		1	2	2	2	11	0.12717
EMSDIST	0.5	0.5	2	1	1		2	2	2	11	0.12717
SCH6	0.5	0.5	2	0.5	0.5	0.5		1	0.5	6	0.06936
SCHDIST	0.5	0.5	2	0.5	0.5	0.5	1		0.5	6	0.06936
ALTRATE	0.5	0.5	2	1	0.5	0.5	2	2		9	0.10405

Once the corresponding factors were compared, and a value assigned, the cells to the right of the diagonal could be automatically populated. Specifically, the values for row-column factor comparisons were inverse for the corresponding column-row factor comparisons. Cells representing factors of equal importance both received values of 1, while row-column factor comparison values of 2 yielded a column-row factor comparison value of 1/2, and vice versa. This is because, if the row factor was considered more important than the column factor, the column factor must, by default, be considered less important than the row factor. This is more clearly presented in Table 1 and Table 2.

Before discussing Table 1 and Table 2 in more detail, note that, while developing the weighting schemas, it was determined that some factors should be weighted differently based on their

location, and specifically whether the crossing was located within an urban or rural area. Therefore, the two weighting schemes, one for urban crossings and one for rural crossings, were established. The school proximity, school distance, and roadway system factors were ultimately affected by the refined weighting schemes. For rural crossings, the roadway system factor was determined to be more important than both of the school proximity factors. Conversely, for urban crossings, both of the school proximity factors were considered more important than the roadway system factor.

Table 1 presents the results of the urban factor weight matrix. To demonstrate how the table may be interpreted, the distance to the nearest school factor (SCHDIST) will be used as a reference. In urban areas, the distance to the nearest school factor was considered less important than: AADT, out-of-distance travel (ALTDIST), both EMS factors (EMSFRQ3, EMSDIST), and alternate route crash rate (ALTRATE). However, the distance to the nearest school factor was considered more important than truck AADT (TAADT) and roadway system (RDSYS).

The two, far right columns were added to compute the final weighting of each factor. The values for each row were summed and placed in the TOTAL column. All values in the TOTAL column were then summed. The far right column (WEIGHT) presents the final weight for each factor. The final factor weights were computed by dividing the TOTAL value for each factor by the sum of all factor TOTAL, yielding the proportional weight for each factor. For presentation purposes, the factor weights presented in Table 1, Table 2, and Table 3 have been rounded to hundred thousandths. The actual factor weights are used in all computations. Table 2 presents the results of the rural factor weight matrix.

In Table 3, which presents the final factor weights, it is clear that for both urban and rural crossings, out-of-distance travel (ALTDIST) is the highest weighted factor, representing approximately 17 percent of the weighting. Traffic volume (AADT) is a very close second at approximately 16 percent of the weighting. Combined, these factors represent one-third of crossing necessity. The combined EMS-related factors (EMSFRQ3/EMSFRQ6 and EMSDIST) represent more than 25 percent of the weight.

Table 3. Urban and Rural factor weights

Factor	Urban	Rural
AADT	0.16185	0.16185
ALTDIST	0.17341	0.17341
TAADT	0.04624	0.04624
RDSYS	0.08671	0.12139
EMSFRQ3	0.12717	-
EMSFRQ6	-	0.12717
EMSDIST	0.12717	0.12717
SCHFRQ2	0.08671	-
SCHFRQ6	-	0.06936
SCHDIST	0.08671	0.06936
ALTRATE	0.10405	0.10405

Truck AADT (TAADT) was the lowest weighted factor for both urban and rural crossings, representing approximately one-quarter of the weight of out-of-distance travel (ALTDIST) and total traffic volume (AADT) factors. Both of the school-related factors (SCHFRQ2/SCHFRQ6 and SCHDIST) had the next lowest weights. The urban school factors received slightly more weight than the rural school factors. Roadway system (RDSYS) weight was nearly equal to the EMS factors in rural areas but was of lesser importance in urban areas, receiving a weight equal to both school factors.

A primary benefit of using the Pugh method to develop factor weights was that all factors were evaluated systematically with respect to each other. TAC discussion was critical in the scoring and evaluation of each factor, and consensus was required before moving to subsequent factors. This technique also makes it somewhat difficult to maintain preconceived ideas regarding the importance of any single factor, since all factors must receive equal consideration. Some of the final factor weights were ultimately different than initially anticipated, conveying the strength of the technique.

However, application of the Pugh method is not without challenges. Consensus may be difficult to obtain, particularly when the assessment group becomes large and more perspectives, potentially conflicting, are represented. Priorities may also change over time. As more factors are included, less variation (or differences) may exist in the final factor weights. Yet, inclusions of all factors considered pertinent, all perspectives, and all priorities should not be viewed as a limitations.

Earlier in this report, potential data maintenance needs, protocols, and levels of effort were included for continued, future highway-rail grade crossing consolidation prioritization. Factor weights may not only convey the relative importance of each factor but may be generally used to assess importance with respect to data maintenance and accuracy. While all datasets should be as accurate as possible and maintained as frequently as possible, this may not always be possible given time and resource constraints. Therefore, if prioritization is necessary, the more highly weighted factors may warrant the most attention in this regard.

Lastly, upon identifying and weighting the final factors, the more comprehensive groups of city and county stakeholders were again engaged and input solicited regarding the factors and their respective weights. Unfortunately, very limited feedback was received.

One county did indicate that they would not be in favor of closing primary or farm-to-market crossings, unless the closure was part of a general route replacement. They also indicated that they had previously targeted closing very low traffic volume crossings, which required large investments to keep them open, but did not have the political support to ultimately do so.

Spreadsheet Tool

The primary criteria in selecting a software tool for highway-rail grade crossing consolidation prioritization were ease of use and maintenance, flexibility, accessibility, and transferability.

Through testing, evaluation, and demonstration of the prioritization methodology, Microsoft Excel was identified as the preferred tool. No existing programming or customization was required to implement the prioritization approach within Microsoft Excel. Existing functionality was simply employed. Other software tools, both off-the-shelf and customized, could certainly have been utilized as well.

Six worksheets were created using Microsoft Excel: 1) All Crossings, 2) Excluded Crossings, 3) Weighting Matrix, 4) Metadata, 5) Urban, and 6) Rural. All Crossings served as the repository for all integrated rail-crossing attributes, including all attributes from the Iowa rail crossing database, pertinent Iowa DOT GIMS roadway attributes, factors, normalized factors, and factor ranks.

While all of the attributes included were not utilized in prioritization, they were made available for more detailed review, assessment, and comparison of crossings. Each record in this worksheet represented a unique highway-rail grade crossing. In addition, the normalized factors and factor ranks were based on all highway-rail grade crossings statewide. This worksheet did not include a composite index and it did not include overall rank.

Excluded Crossings only contained crossings that were removed from prioritization consideration because they were determined to 1) provide the only access to adjacent property, 2) be abandoned, 3) be closed, or 4) be unlocatable. The Weighting Matrix worksheet simply contained the decision matrix and resulting factor weights detailed earlier in this report.

The computed, unrounded factor weights within this worksheet were referenced directly in factor weighting calculations in the Urban and Rural worksheets. The Metadata worksheet contained descriptions of each of the attributes in the Urban and Rural worksheets. In some cases, a reference to the original source metadata, such as the Iowa rail crossing database or the GIMS road database, was provided.

Crossings from the All Crossings worksheet were segregated into the Urban and Rural worksheets through use of the Iowa rail crossing database Nearcity attribute. Normalized factors and factor ranks were recomputed in each of these worksheets based on the refined set of crossings in each. The composite index, based on the previously discussed weighting schema and unrounded factor weights, was computed for each crossing using the following equations.

$Urban\ Composite\ Index$
$$= 0.16185 \times AADT + 0.17341 \times ALTDIST + 0.04624 \times TAADT + 0.08671 \times RDSYS + 0.12717 \times EMSFRQ3 + 0.12717 \times EMSDIST + 0.08671 \times SCHFRQ2 + 0.08671 \times SCHDIST + 0.10405 \times ALTRATE$$

$Rural\ Composite\ Index$
$$= 0.16185 \times AADT + 0.17341 \times ALTDIST + 0.04624 \times TAADT + 0.12139 \times RDSYS + 0.12717 \times EMSFRQ3 + 0.12717 \times EMSDIST + 0.06936 \times SCHFRQ2 + 0.06936 \times SCHDIST + 0.10405 \times ALTRATE$$

The rank for each crossing, among all rural or urban crossings, was then computed using the Microsoft Excel Rank function. Composite index values were ranked as if sorted in descending order. The highest ranked crossing, with a rank value of 1, represented potentially the least-essential crossing with the least impact of closure.

Given the number of attributes retained for each crossing, additional columns were added immediately to the right of the crossing rank to more clearly present, in a single location, the value and rank of each factor. With these grouped columns, users can better compare the individual rank values within and among each factor. These columns simply reference the corresponding columns in their original location within the spreadsheet.

Through use of Microsoft Excel, users may refine analyses by filtering (or limiting) crossings of interest by any attribute, or attributes, associated with each crossing. To investigate possible opportunities for consolidation along a specific branch or within a specific city or county, users may want to focus on location-specific attributes, such as city, county, railroad division, or railroad branch. Other crossing features, or characteristics, may also be considered and used to refine which crossings are presented, such as the presence or absence of certain safety-related features.

While all rank values within a filtered set will be based on the comprehensive set of either urban or rural crossings, rank numbers are relative, and the crossings may be sorted by the composite rank to convey importance. Another key element of the spreadsheet is that, as factor values are updated, either systematically or as inaccuracies are encountered, all normalized factors, factor ranks, and the final composite rank will be automatically recalculated for each crossing.

Table 4, Table 5, Table 6, Table 7, and Table 8 present sample highway-rail grade crossing ranking results, refined by specific cities, specific branch within a city, top 10 urban, and top 10 rural. While the crossing number and additional crossing characteristics are provided in the appropriate spreadsheet worksheets, these attributes have been excluded from Table 4, Table 5, Table 6, Table 7, and Table 8 for demonstration purposes.

The left-most (white) Rank column represents the final computed index value for the crossing, while the adjacent column to the right (gray) presents the final statewide rank. The top row above each factor conveys their corresponding, rounded factor weights. As noted previously, the actual factor weights were applied in all calculations and sum to 1, which is presented above the Rank columns. The left-most column (white) under each factor represents the actual factor value, such as the AADT for the crossing. The adjacent right column (gray) under each factor represents its statewide rank.

Table 4. Highway-rail grade crossing prioritization for City A

1		0.16		0.05		0.09		0.17		0.13		0.13		0.09		0.09		0.10	
RANK		AADT		TAADT		RDSYS		ALTDIST		EMSFRQ3		EMSDIST		SCHFRQ2		SCHDIST		ALTRATE	
0.72421	810	310	397	22	721	0	1	0.14	281	2	1075	1.61	306	10	1356	0.63	522	629.30	1206
0.690169	1069	160	187	11	553	0	1	0.18	495	2	1075	0.80	765	16	1581	0.34	1066	661.50	1226
0.688543	1077	610	675	43	933	0	1	0.12	86	2	1075	0.88	697	16	1581	0.39	942	764.82	1321
0.674349	1152	1120	985	67	1108	0	1	0.10	41	2	1075	0.75	803	17	1626	0.16	1628	1311.09	1558
0.67365	1160	1914	1185	134	1322	0	1	0.14	288	2	1075	0.78	782	17	1626	0.16	1634	701.90	1261
0.663545	1245	2750	1344	193	1416	0	1	0.83	1289	2	1075	0.93	662	16	1581	0.22	1489	1150.16	1515
0.662316	1259	3480	1430	209	1438	0	1	0.49	1053	2	1075	0.95	648	16	1581	0.21	1498	1298.43	1556
0.657936	1292	4240	1499	297	1539	0	1	0.81	1275	2	1075	0.95	650	16	1581	0.14	1677	623.37	1199
0.652962	1333	4350	1507	0	1	0	1	1.79	1523	2	1075	1.27	422	16	1581	0.07	1760	351.69	861
0.648996	1367	4850	1548	0	1	0	1	0.73	1230	2	1075	0.60	939	17	1626	0.40	912	1215.86	1541
0.628321	1509	3700	1448	259	1507	1	1323	2.45	1591	1	173	2.03	233	7	1128	0.71	444	293.96	766
0.611835	1598	10800	1713	756	1710	0	1	0.78	1257	2	1075	0.58	956	17	1626	0.20	1533	593.24	1168
0.475842	1753	18800	1753	1316	1758	1	1323	0.46	1019	2	1075	0.61	924	17	1626	0.43	818	1550.95	1604
0.475313	1754	18800	1753	1316	1758	1	1323	0.46	1019	2	1075	0.57	971	17	1626	0.42	844	1550.95	1604

Table 5. Highway-rail grade crossing prioritization for single branch within City A

1		0.16		0.05		0.09		0.17		0.13		0.13		0.09		0.09		0.10	
RANK		AADT		TAADT		RDSYS		ALTDIST		EMSFRQ3		EMSDIST		SCHFRQ2		SCHDIST		ALTRATE	
0.674349	1152	1120	985	67	1108	0	1	0.10	41	2	1075	0.75	803	17	1626	0.16	1628	1311.09	1558
0.67365	1160	1914	1185	134	1322	0	1	0.14	288	2	1075	0.78	782	17	1626	0.16	1634	701.90	1261
0.657936	1292	4240	1499	297	1539	0	1	0.81	1275	2	1075	0.95	650	16	1581	0.14	1677	623.37	1199
0.652962	1333	4350	1507	0	1	0	1	1.79	1523	2	1075	1.27	422	16	1581	0.07	1760	351.69	861
0.648996	1367	4850	1548	0	1	0	1	0.73	1230	2	1075	0.60	939	17	1626	0.40	912	1215.86	1541
0.628321	1509	3700	1448	259	1507	1	1323	2.45	1591	1	173	2.03	233	7	1128	0.71	444	293.96	766
0.611835	1598	10800	1713	756	1710	0	1	0.78	1257	2	1075	0.58	956	17	1626	0.20	1533	593.24	1168
0.475313	1754	18800	1753	1316	1758	1	1323	0.46	1019	2	1075	0.57	971	17	1626	0.42	844	1550.95	1604

Table 6. Highway-rail grade crossing prioritization for City B

	1		0.16		0.05		0.09		0.17		0.13		0.13		0.09		0.09		0.10	
RANK			AADT		TAADT		RDSYS		ALTDIST		EMSFRQ3		EMSDIST		SCHFRQ2		SCHDIST		ALTRATE	
0.776142	190	70	51	3	368	0	1	4.01	1697	1	173	2.81	173	0	1	2.65	168	121.34	360	
0.737904	643	580	654	41	916	0	1	0.15	353	2	1075	0.56	985	4	764	0.36	1003	0.00	1	
0.726826	781	780	789	8	476	0	1	0.56	1127	2	1075	0.56	986	4	764	0.46	781	925.65	1424	
0.726296	787	540	622	16	630	0	1	0.36	881	2	1075	0.23	1447	4	764	0.33	1112	867.08	1396	
0.720271	854	1570	1116	63	1088	0	1	0.28	716	2	1075	0.32	1320	4	764	0.32	1155	1090.39	1492	
0.706203	966	4610	1527	323	1552	0	1	0.51	1077	2	1075	0.54	1008	4	764	0.34	1072	378.07	904	
0.704797	981	2650	1332	186	1407	0	1	1.77	1521	2	1075	0.61	929	4	764	0.35	1040	402.04	938	
0.703239	993	3060	1395	122	1296	0	1	1.96	1548	2	1075	0.64	895	4	764	0.46	769	273.02	709	
0.645791	1393	1280	1046	90	1213	1	1323	1.09	1385	2	1075	1.13	504	4	764	0.93	316	276.26	719	
0.63529	1455	1470	1094	29	797	1	1323	0.28	714	2	1075	0.21	1484	4	764	0.39	935	928.19	1426	

Table 7. Highway-rail grade crossing prioritization for statewide Urban top 10

	1		0.16		0.05		0.09		0.17		0.13		0.13		0.09		0.09		0.10	
RANK			AADT		TAADT		RDSYS		ALTDIST		EMSFRQ3		EMSDIST		SCHFRQ2		SCHDIST		ALTRATE	
0.931045	1	289	316	0	1	0	1	0.13	161	0	1	8.07	19	0	1	6.87	20	0.00	1	
0.925952	2	50	27	0	1	0	1	0.13	188	0	1	7.22	41	0	1	7.03	15	0.00	1	
0.914603	3	270	296	8	489	0	1	0.26	670	0	1	7.42	35	0	1	6.03	53	0.00	1	
0.91255	4	190	216	0	1	0	1	0.39	921	0	1	6.53	64	0	1	6.86	21	198.06	519	
0.912361	5	110	112	6	419	0	1	0.39	936	0	1	6.47	65	0	1	6.80	23	92.01	289	
0.911412	6	289	316	3	370	0	1	0.13	145	0	1	6.21	72	0	1	6.68	27	0.00	1	
0.910458	7	250	275	3	366	0	1	0.13	148	0	1	6.15	76	0	1	6.62	29	0.00	1	
0.910272	8	70	51	1	331	0	1	0.13	157	0	1	6.09	78	0	1	6.57	31	0.00	1	
0.9095	9	660	717	0	1	0	1	0.79	1265	0	1	6.78	57	0	1	7.06	14	260.45	683	
0.908786	10	25	6	0	1	0	1	0.21	557	0	1	6.18	74	0	1	6.41	35	0.00	1	

Table 8. Highway-rail grade crossing prioritization for statewide Rural top 10

	1	0.16		0.05		0.12		0.17		0.13		0.13		0.07		0.07		0.10	
RANK		AADT		TAADT		RDSYS		ALTDIST		EMSFRQ3		EMSDIST		SCHFRQ2		SCHDIST		ALTRATE	
0.9354	1	50	836	6	1093	0	1	2.07	1205	0	1	13.22	1	2	366	5.10	321	60.69	508
0.9338	2	100	1279	4	930	0	1	1.98	780	0	1	12.19	2	0	1	6.14	179	146.82	1134
0.9229	3	15	132	2	401	0	1	2.28	1293	0	1	8.58	37	0	1	11.13	1	1103.89	1981
0.9176	4	50	836	3	643	0	1	0.23	44	0	1	7.11	107	0	1	7.83	34	0.00	1
0.9174	5	25	328	1	132	0	1	0.32	64	0	1	7.12	106	0	1	7.93	28	0.00	1
0.9173	6	40	656	2	388	0	1	0.37	76	0	1	7.46	80	0	1	7.52	46	0.00	1
0.9127	7	150	1417	17	1515	0	1	2.03	1168	0	1	8.98	28	0	1	7.81	36	45.13	439
0.911	8	10	37	2	494	0	1	0.28	54	0	1	7.05	117	0	1	7.10	82	263.34	1569
0.9106	9	60	957	7	1184	0	1	2.01	1103	0	1	8.80	32	0	1	7.61	43	65.28	542
0.9103	10	210	1504	15	1486	0	1	0.94	219	0	1	8.09	54	0	1	6.92	98	265.45	1575

Table 4 presents a sample ranking of all highway-rail grade crossings in a city of approximately 25,000 population. Within the city, there are 14 crossings along five different branches. All rankings presented in the table are based on the statewide set of 1,768 urban crossings. The top ranked crossing for consolidation consideration is near the middle of the statewide urban set at 810. Conversely, the lowest ranked crossing in the city could be considered one of the most essential urban crossing in the state at 1,754 of 1,768. Following are several observations from this demonstration.

- Limited variation exists within the road system factor, school frequency factor, and EMS frequency factor.

- Incomplete or inaccurate attribute data may influence ranking results. For example, two crossings with an AADT of greater than 4,000 have no heavy-truck AADT reported, which appears somewhat suspect. However, the appropriate attributes may be updated, as necessary, and all normalized factors, factor ranks, and the final composite rank will be automatically recalculated for each crossing.

- Fairly large rank differences may exist within a given factor. For example, a rank difference of 1,550 exists within the out-of-distance travel factor.

- Ranks of individual factors are not necessarily in the same order as the final, composite ranking. This conveys the influence of factor weights on the final results.

- By presenting the factor values and corresponding ranks, a user may quickly assess whether relative ranking among all factors is generally consistent or whether marked rank differences existed among factors. One such difference is observed in the top-ranked crossing in the city, with the out-of-distance factor rank of 281 and school proximity rank of 1,356. This suggests that limited additional travel would be required with closure of the crossing, but, based on statewide assessment, a fairly high number of schools are located near the crossing and may be impacted.

- As mentioned previously, some of the crash rate values are relatively large, given the impact of low VMT values (from short and/or low AADT alternate routes) serving as the denominator of the crash rate equation.

Table 5 simply presents the results of limiting the crossings considered to only those along a specific branch within the city.

Table 6 presents a citywide example, similar to Table 4. This city is smaller in size, with a population of approximately 7,000, has fewer crossings (10), and has three branch lines. Based on population, the city has proportionally more crossings compared to the city presented in Table 4. The highest ranked crossing in the city is in the top 200 statewide. When reviewing this crossing in more detail, the out-of-distance travel, school distance, and EMS distance factors are significantly different from the other crossings within the city.

For example, the crossing's out-of-distance travel is more than four times greater than average for all other crossings. Such differences may indicate a potential attribute (factor) accuracy issue. However, upon further inspection, all distance factors for the crossing were accurate. Specifically, the crossing was located in a small, incorporated area of the city located approximately one mile away from the city's primary incorporated area (see Figure 8).

Figure 8. Spatial distribution of highway-rail grade crossings in City B

Table 7 and Table 8 present the top 10 urban and rural highway-rail grade crossings, respectively. Both tables convey that the top crossings are not located near schools or EMS facilities. Therefore, when conducting more in-depth analysis of any crossing, assessing and verifying the accuracy of locations of schools and emergency service providers may be essential. That said, due to school-district consolidation within the state, it is not uncommon for small towns in Iowa, which are included in the urban list, to no longer have a primary or secondary school.

AADT and heavy-truck AADT were consistently low among all crossings in Table 7 and Table 8. Several of the alternate routes also experienced no crashes during the five-year analysis period. Out-of-distance travel distances were consistently low among the top 10 urban crossings, but a greater range existed among rural crossings, from less than one-quarter mile to more than two miles.

In general, the results of the highway-rail grade crossing prioritization represent a consistent and quantitative, yet preliminary, assessment. The results may serve as the foundation for more rigorous or detailed analysis and feasibility studies. Other pertinent, site-specific factors, such as safety, maintenance costs, economic impacts, and location-specific access and characteristics should be considered. While crossing consolidations may provide benefits in many areas, unintended impacts may occur. For example, in some rural areas, roads terminating in a dead end become used for illegal dumping of trash and appliances.

CONCLUSIONS

While many attempts have been made to address the various issues related to safety and risks at highway-rail grade crossings and strategies to minimize these risks and improve safety, limited consideration has been given to a systematic, quantitative approach to evaluate crossings for consolidation. State and local government agencies, as well as railroad companies, face the challenge of identifying highway-rail grade-crossing locations for potential closure. Crossing consolidation continues to be viewed with some trepidation by many county and city stakeholders.

While the traditional basis for highway-rail grade crossing consolidation may be safety-related, additional opportunities exist in a more comprehensive, quantitative, and proactive assessment. General crossing necessity within the highway system, and potential impact of closure on the public, may be systematically assessed through consideration of various factors beyond those that are strictly safety-related. Safety-related factors, such as those outlined in the Iowa DOT's *Federal-Aid Railroad-Highway Grade Crossing Program: Use of Benefit-Cost Ratio to Prioritize Projects for Funding* (Iowa DOT 2006) may be considered independently and evaluated in conjunction with the general crossing assessment.

The project team developed a weighted-index method and accompanying Microsoft Excel spreadsheet-based tool to systematically evaluate and prioritize all public highway-rail grade crossings in the state from a possible consolidation impact perspective. Factors identified by stakeholders as critical were: traffic volume, truck traffic volume, proximity to emergency medical services, proximity to schools, road system, and out-of-distance travel.

Given the inherent differences between urban and rural locations, factors were considered, and weighted, differently, based on crossing location. Application of a weighted-index method allowed for all factors of interest to be included and for these factors to be ranked independently, as well as weighted according to stakeholder priorities, to create a single index. If priorities change, this approach also allows for factors and weights to be adjusted.

Microsoft Excel served as an ideal data repository and prioritization tool platform, given its ease of use, flexibility, accessibility, and transferability. In addition, existing functionality could be employed simply, allowing users flexibility in refining analyses by filtering (or limiting) crossings of interest by any attribute, or attributes, associated with each crossing.

Highway-rail grade crossing consolidation prioritization is very data-reliant. Appropriate data update and maintenance practices are essential. That said, many of the factors employed require only limited updates. Attributes may also be updated in a piecemeal fashion, as necessary, and all normalized factors, factor ranks, and the final composite rank will be automatically recalculated for each crossing.

The prioritization generated by this approach may be used to convey the need and opportunity for crossing consolidation to decision makers and stakeholders. It may also be used to quickly

investigate the feasibility of a possible consolidation. Independently computed crossing risk and relative impact of consolidation may be integrated and compared to develop the most appropriate treatment strategies or alternatives for a highway-rail grade crossing. A crossing with limited or low consolidation impact but a high safety risk may be a prime candidate for consolidation. Similarly, a crossing with potentially high consolidation impact as well as high risk may be an excellent candidate for crossing improvements or grade separation.

The results of the highway-rail grade crossing prioritization represent a consistent and quantitative, yet preliminary, assessment. The results may serve as the foundation for more rigorous or detailed analysis and feasibility studies. Other pertinent site-specific factors, such as safety, maintenance costs, economic impacts, and location-specific access and characteristics should be considered.

REFERENCES

Bowman, Brian L. 1994. *Assessment of the State of Alabama Rail-Highway Safety Program.*
Submitted to Bureau of Multimodal Transportation Montgomery, AL.

CPUC (California Public Utilities Commission). 2013. *Section 190 Grade Separation Program.*
California Public Utilities Commission Rail Crossings Engineering Section. Los Angeles,
CA.

Esri (Environmental Systems Research Institute, Inc.). n.d. *Thiessen polygons.* GIS Dictionary.
support.esri.com/en/knowledgebase/GISDictionary/term/Thiessen%20polygons.

FHWA (Federal Highway Administration). 2007. *Railroad-Highway Grade Crossing Handbook
– Revised Second Edition 2007.* Federal Highway Administration, Office of Safety
Design. Washington, DC.

FHWA. 2009. *Crossing Consolidation Guidelines.* Federal Railroad Administration.
Washington, DC.

Hans, Zachary. 2015. Personal knowledge and access to dataset from working on project:
Emergency Response Information System (ERIS).
www.ctre.iastate.edu/research/eris/index.htm.

Horton, Suzanne M. 2008. *Highway-Rail Grade Crossing Consolidation Guidelines.* US
Department of Transportation Research and Innovative Technology Administration. John
A. Volpe National Transportation Systems Center. Cambridge, MA.

Horton, Suzanne, Anya Carroll, Mina Chaudhary, Tashi Ngamdung, Jonathan Mozenter, and
David Skinner. 2009. *Success Factors In The Reduction Of Highway-Rail Grade
Crossing Incidents From 1994 To 2003.* Volpe National Transportation Systems Center;
Federal Railroad Administration.

Iowa Code § 306.3 *Definition Throughout Code.* coolice.legis.iowa.gov/Cool-
ICE/default.asp?category=billinfo&service=IowaCode&input=306.3.

Iowa DOT. 2002. *Union Pacific Railroad Crossing Study West-East Main Line Corridor.* Iowa
Department of Transportation Office of Systems Planning. Ames, IA.

Iowa DOT. 2006. *Federal-Aid Railroad-Highway Grade Crossing Program: Use of Benefit-Cost
Ratio to Prioritize Projects for Funding.* Iowa Department of Transportation Office of
Rail Transportation, Modal Division. Ames, IA.
www.iowadot.gov/iowarail/assistance/130/130SelectionProcess_final.pdf.

Iowa DOT. 2012. *State of Iowa Highway-Rail Grade Crossing Safety Action Plan: Program for
Implementation in Calendar Years 2012-2016.* Iowa Department of Transportation;
Office of Rail Transportation. Ames, IA.

Murphy, John F. 1994. A Guide to Crossing Consolidation and Closure. Third International
Symposium on Railroad-Highway Grade Crossing Research and Safety. Knoxville, TN.

Operation Lifesaver. 2015. *About Us.* Alexandria, Virginia: Operation Lifesaver. oli.org/about-
us.

Oregon DOT Rail Division. n.d. *Highway-Rail Grade Crossing Elimination Process.* Oregon
Department of Transportation Rail Division, Crossing Safety Section. Salem, OR.

Russell, E. R., and M. I. Mutabazi. 1998. Rail-Highway Grade Crossing Consolidation in
Kansas. *Transportation Research Record* Issue 1648.
trb.metapress.com/content/p3730t4483142q0n/fulltext.pdf.

Pawlovich, Michael D. 2007. *Safety Improvement Candidate Location (SICL) Methods.* Ames, Iowa: Iowa Department of Transportation, Highway Division, Engineering Bureau, Office of Traffic and Safety.

Pawlovich, Michael D. 2015. *Iowa Safety Improvement Candidate Location Methodology.* Iowa Department of Transportation Office of Traffic and Safety.

Ries, R., A. A. Carroll, and J. D. Warren. 2002. Closure of U.S. Highway-Railroad Grade Crossings: A Status Report. 7th International Symposium on Railroad-Highway Grade Crossing Research and Safety. Melbourne, Victoria, Australia.

Saks, J., A. Carroll. 2004. *North Carolina DOT Traffic Separation Studies. Volume One: Assessment.* Volpe National Transportation Systems Center; Research and Special Programs Administration; Federal Railroad Administration.

Soy Transportation Coalition. 2013. *About Us*.Soy Transportation Coalition. Ankeny, Iowa. www.soytransportation.org/aboutus.html.

Terpenny, Janis. n.d. *Pugh Method or decision-matrix method.* www.enge.vt.edu/terpenny/Smart/Virtual_econ/Module2/pugh_method.htm.

TxDOT (Texas Department of Transportation). 1998. *Railroad Operations Volume: Chapter 6, Section 4: The Texas Priority Index.* Austin, Texas: Texas Department of Transportation. onlinemanuals.txdot.gov/txdotmanuals/tfe/the_texas_priority_index.htm.

US DOT (U.S. Department of Transportation). 2004. *Secretary's Action Plan for Highway-Rail Crossing Safety and Trespass Prevention.* Secretary of Transportation. Washington, DC.

United States Code, 2006 Edition, Supplement 5, Title 23 – HIGHWAYS. *23 U.S.C. 130 - Railway-highway crossings.* www.gpo.gov/fdsys/granule/USCODE-2011-title23/USCODE-2011-title23-chap1-sec130/content-detail.html.

Weart, Walter. 2008. Closing Time: Railroads Ramp Up Efforts To Sell Local Officials, Residents On A Crossing Closure's Safety Benefits. *Progressive Railroading.* Volume 51, Issue 1.

APPENDIX A: STAKEHOLDER SURVEY

Email Survey Solicitation

Crashes between motor vehicles and trains are a significant concern to government agencies and railroads, and both face the challenge of identifying rail crossing locations for potential closure. There is limited information on a formula-based approach to improving safety through closings of such crossings. Thus, there has been a need to develop a quantitative approach to address this challenge.

The Iowa DOT and Iowa State University's Institute for Transportation are undertaking an effort to provide an objective methodology to support public agencies and railroads in making decisions related to closures of at-grade rail-highway crossings. This project will develop a formula to evaluate candidate crossings for potential closure based on various factors such as relative risks, safety, infrastructure, operational, economic, emergency response, societal, and mobility considerations.

The formula would be used to rate at-grade rail-highway crossings to identify potential locations for closure. In turn, this would enable comparing crossings across a geographic region (e.g., the state) and to develop a prioritized list of crossings for closure.

As part of this effort, the research team is surveying cities and counties about their views and concerns with closing of highway-rail crossings within their jurisdictions. The survey can be accessed at: …

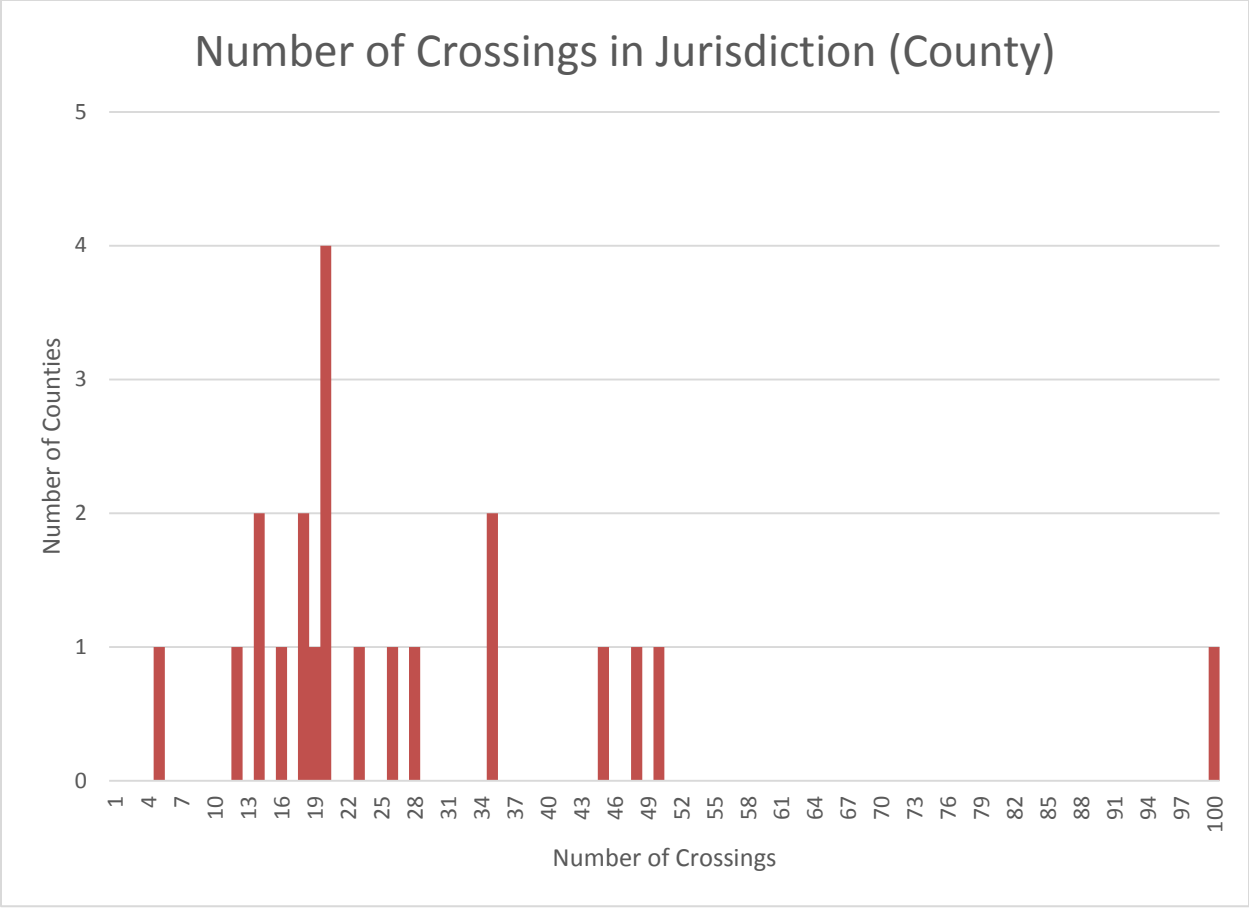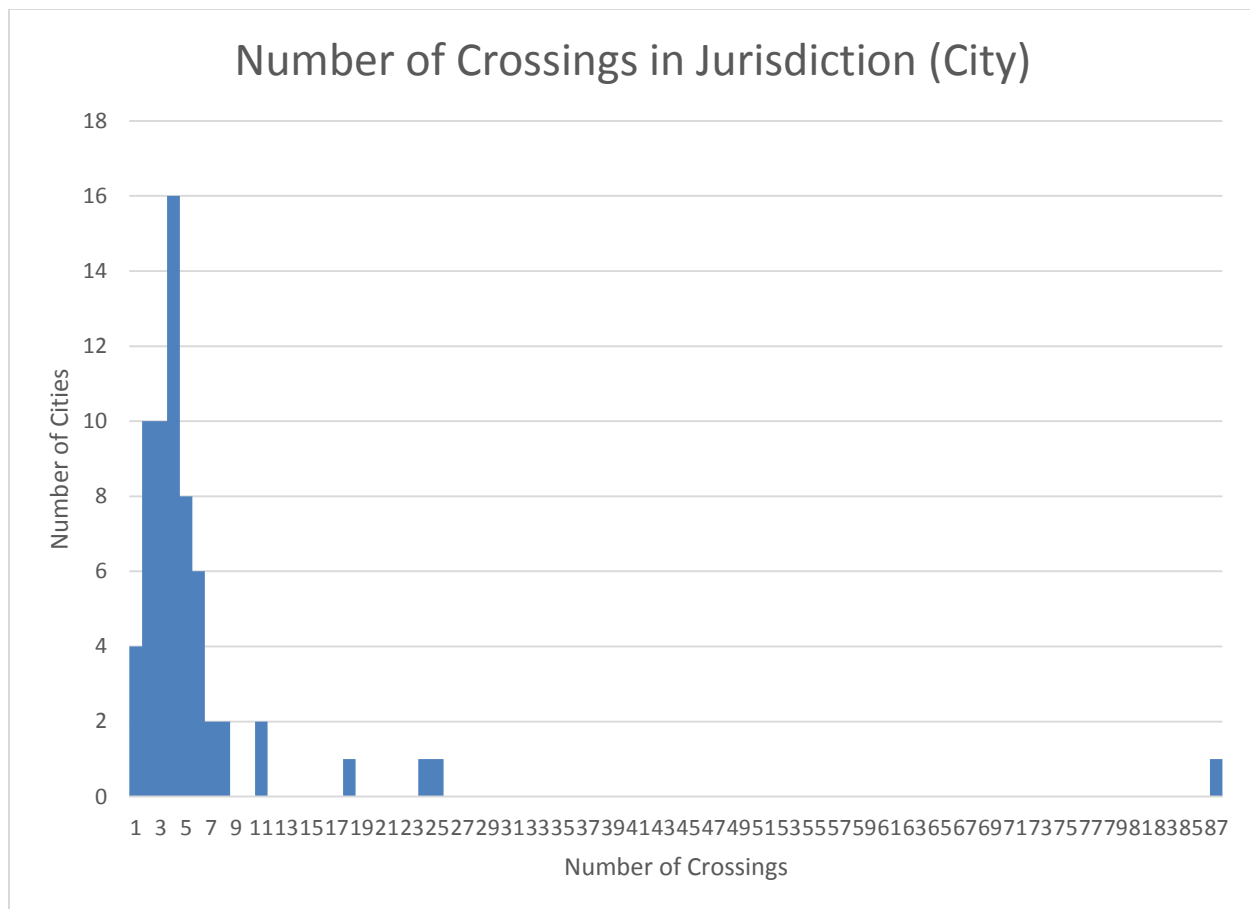**Highway-Rail Grade Crossing Survey**

1. What agency do you represent?

2. Approximately how many railroad grade crossings are there on road systems in your jurisdiction?

3. Do you have concerns regarding safety at railroad grade crossings in your jurisdiction?

- Yes

- No

4. How can your safety concerns be summarized? (Choose all that apply)

- Need active warning devices

- Train visibility

- Crossing surface

- Blockage of crossing by trains

- Signal malfunction

- Train horn noise

- Train speed

- Steep approach grades

- Other

5. What factors would your governing body consider in determining if a grade crossing is essential?

- Access to businesses

- Access to residential areas

- Emergency vehicle blockage

- Effect on major traffic flows

- Traffic safety

- Public convenience

- Farm vehicle access

- School bus traffic

- Other

- Unsure

6. Of the factors that were chosen in Question 5, what are the top three (3) factors that your governing body would consider in determining if a grade crossing is essential?(If fewer than three factors were chosen in Question 5, please mark the top factor)

7. If safety was improved, would your governing body consider consolidating grade crossings?

- Yes

- No

- Unsure

8. If there was no cost to your agency, would your governing body consider the consolidation of grade crossings?

- Yes

- No

- Unsure

9. If safety improvements would be made at other essential crossings in your jurisdiction, would your governing body consider the consolidation of one or more non-essential grade crossings?

- Yes

- No

- Unsure

10. If the risk and cost of a crossing significantly outweighs the convenience of the crossing, would your governing body consider the consolidation of grade crossings?

- Yes

- No

- Unsure

11. If appropriate financial incentives were available to offset the impact of the crossing closure, would your governing body consider the consolidation of grade crossings?

- Yes

- No

- Unsure

12. Please write any comments or issues that were not addressed

Highway-Rail Grade Crossing Survey Summary

1. What agency do you represent?

- City: 63

- County: 21

2. Approximately how many railroad grade crossings are there on road systems in your jurisdiction?

Number of Crossings in Jurisdiction (County)

Number of Crossings

Number of Counties

Number of Crossings in Jurisdiction (City)
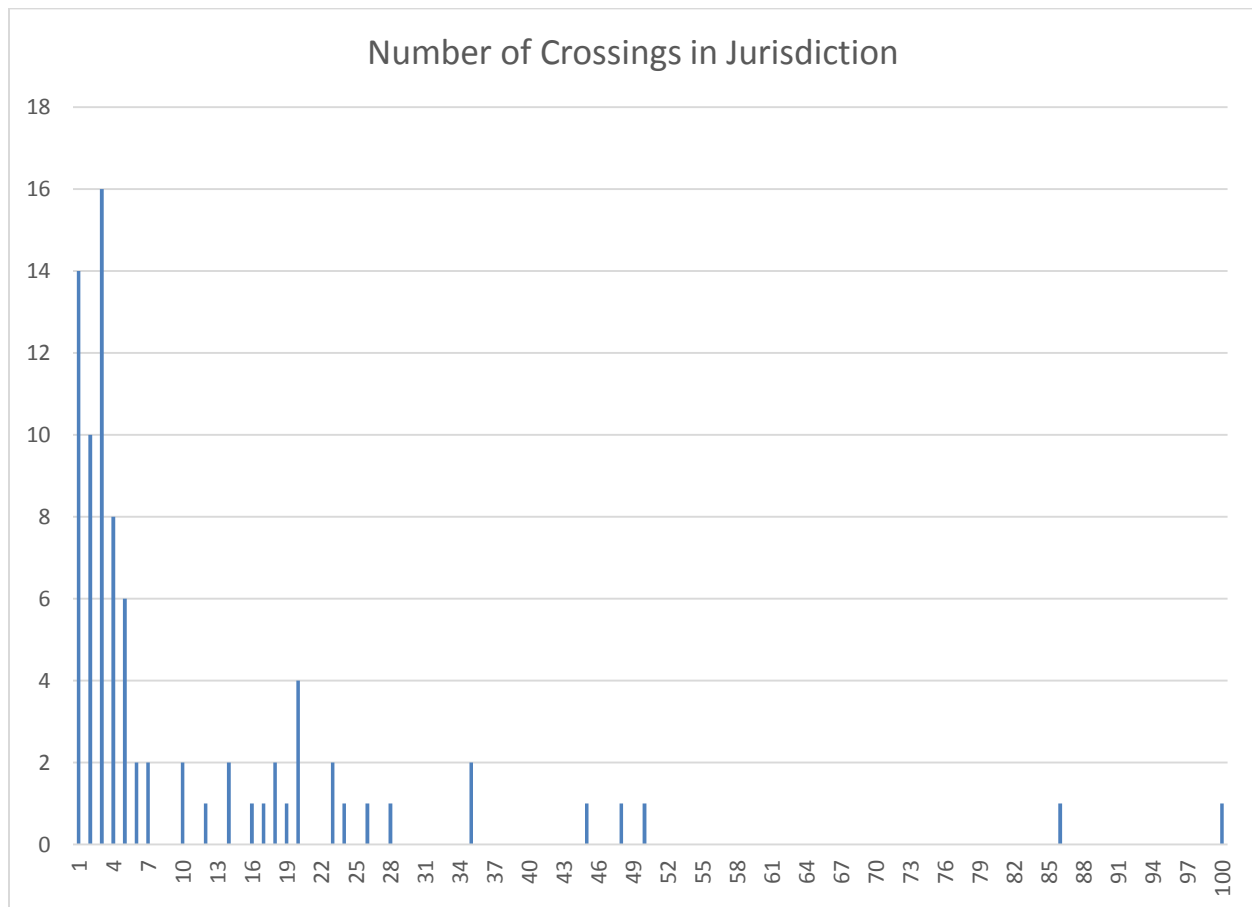
3. Do you have concerns regarding safety at railroad grade crossings in your jurisdiction?

#	Answer		Response	%
1	Yes		45	52%
2	No		41	48%
	Total		86	100%

County:

Yes	15
No	6

City:

Yes	29
No	35

4. How can your safety concerns be summarized? (Choose all that apply)
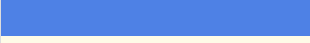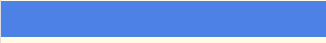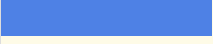
#	Answer		Response	%
1	Need active warning devices		24	56%
2	Train visibility		22	51%
3	Crossing surface		23	53%
4	Blockage of crossing by train		14	33%
5	Signal malfunction		3	7%
6	Train horn noise		12	28%
7	Train speed		5	12%
8	Steep approach grades on roadway		7	16%
9	Other		4	9%

#	Answer	County	City	
1	Need active warning devices	9	15	
2	Train visibility	12	10	
3	Crossing surface	12	11	
4	Blockage of crossing by train	4	10	
5	Signal malfunction	1	2	
6	Train horn noise	0	12	
7	Train speed	1	4	
8	Steep approach grades on roadway	5	2	
9	Other	2	2	

Other

- driver distraction/ comfort with crossing and ignore yielding

- Warning devices and visibility at certain intersection

- Must stop on tracks to access main highway. Cannot see traffic if not on tracks.

- Where trains are concerned there is always a concern for safety, but we do not have any specific concern at this time.

5. What factors would your governing body consider in determining if a grade crossing is essential?
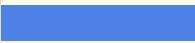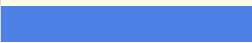
#	Answer		Response	%
1	Access to businesses		53	65%
2	Access to residential areas		51	63%
3	Emergency vehicle blockage		56	69%
4	Effect on major traffic flows		36	44%
5	Traffic safety		53	65%
6	Public convenience		46	57%
7	Farm vehicle access		36	44%
8	School bus traffic		45	56%
9	Other		7	9%
10	Unsure		4	5%

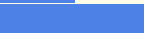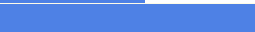| #	Answer	County	City	
1	Access to businesses	15	38	
2	Access to residential areas	14	37	
3	Emergency vehicle blockage	14	42	
4	Effect on major traffic flows	10	26	
5	Traffic safety	16	37	
6	Public convenience	16	30	
7	Farm vehicle access	16	20	
8	School bus traffic	14	21	
9	Other	2	5	
10	Unsure	0	4	

Other

- All these issues need to be addressed or reviewed or you are not making a good decision based off all the information

- distance to next crossing

- n/a

- Access to wastewater lift station and sewage treatment facility.

- No longer a railroad going through **City …**

- We don't have a grade crossing, only a bride that passes over the train tracks

6. Of the factors that were chosen in Question 5, what are the top three (3) factors that your governing body would consider in determining if a grade crossing is essential?(If fewer than three factors were chosen in Question 5, please mark the top factor)

#	Answer		Response	%
1	Access to businesses		27	41%
2	Access to residential areas		27	41%
3	Emergency vehicle blockage		35	53%
4	Effect on major traffic flows		15	23%
5	Traffic safety		30	45%
6	Public convenience		18	27%
7	Farm vehicle access		18	27%
8	School bus traffic		5	8%
9	Other		5	8%
10	Unsure		0	0%
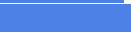
#	Answer	County	City	
1	Access to businesses	5	22	
2	Access to residential areas	8	19	
3	Emergency vehicle blockage	6	29	
4	Effect on major traffic flows	5	10	
5	Traffic safety	11	19	
6	Public convenience	6	12	
7	Farm vehicle access	10	8	
8	School bus traffic	1	4	
9	Other	1	4	
10	Unsure	0	0	

7. If safety was improved, would your governing body consider consolidating grade crossings?

#	Answer		Response	%
1	Yes		11	16%
2	No		21	30%
3	Unsure		37	54%
	Total		69	100%

#	Answer	County	City	
1	Yes	6	5	
2	No	1	20	
3	Unsure	13	24	

8. If there was no cost to your agency, would your governing body consider the consolidation of grade crossings?

#	Answer		Response	%
1	Yes		18	26%
2	No		19	28%
3	Unsure		32	46%
	Total		69	100%
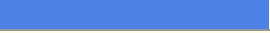
#	Answer	County	City	
1	Yes	8	10	
2	No	2	17	
3	Unsure	10	22	

9. If safety improvements would be made at other essential crossings in your jurisdiction, would your governing body consider the consolidation of one or more non-essential grade crossings?

#	Answer		Response	%
1	Yes		14	20%
2	No		19	28%
3	Unsure		36	52%
	Total		69	100%
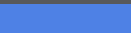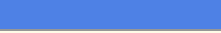
#	Answer	County	City	
1	Yes	6	8	
2	No	2	17	
3	Unsure	12	24	

10. If the risk and cost of a crossing significantly outweighs the convenience of the crossing, would your governing body consider the consolidation of grade crossings?

#	Answer		Response	%
1	Yes		14	20%
2	No		16	23%
3	Unsure		39	57%
	Total		69	100%

#	Answer	County	City	
1	Yes	7	7	
2	No	1	15	
3	Unsure	12	27	

11. If appropriate financial incentives were available to offset the impact of the crossing closure, would your governing body consider the consolidation of grade crossings?

#	Answer		Response	%
1	Yes		19	28%
2	No		18	26%
3	Unsure		32	46%
	Total		69	100%

#	Answer	County	City	
1	Yes	10	9	
2	No	2	16	
3	Unsure	8	24	

12. Please write any comments or issues that were not addressed

- All crossings are essential to some degree.

- A lot of this comes down to costs. If there is no money available, the project cannot move forward. Also, in a county situation, to close a crossing, motorists could have to drive significantly out of the way to get around. It is not like in town where they may have to go around the block.

- There are very few crossings that the County would want to close, but some are in very poor shape.

- County … is seeking assistance to relocate a road to avoid a quarry crossing; and looking to buy out a resident to abandon a grade separation structure in another instance. So in some regards the answer is yes to seeking a closure in order to improve safety. However

each of the crossings is unique and would have to be a case by case consideration for closure, in many instances RR crossing are co-located with Interstate ramps or overpasses making them very important for local access. Also grade separation structures are difficult to maintain and reconstruct; perhaps the RR's could also accept responsibility for the grade separation structures they own or simplify reconstruction to reduce our costs?

- Each crossing has unique factors so difficult to provide yes/no decisions on closure of crossings. To close a crossing, other than by grade separation, will be very unpopular with our residents. They will ask if other safety improvements can be made to reduce accidents before a last resort of closing a crossing. This may be more viable in the low volume rural Iowa roads.

- The last five questions would take action by the Board of Supervisors so I do not want to speak for them.

- Grade crossing projects have been driven by the railroad and based upon cost savings. The Board sees safety as a worthy goal, but it has a hard time looking past unhappy in this. Residents need to be involved and need to be given an incentive to support grade crossing elimination. If incentives are not the approach, a cost needs to be required of the jurisdiction that is involved. We had a road with 10 vpd and a crossing cost of $200,000 that the Board indicated was satisfactory, as long as most of the funds were supplied by the Federal government. The local resident leading the conversation was not paying for any of this cost or the future cost of this decision. The fact that traffic crashes had resulted in deaths at this crossing did not sway the resident. The jurisdiction needs to be provided the cost of a decision in such a way that it acts responsibly for all residents and for the traffic that uses its road system.

- It is very difficult to consolidate existing RR crossings. Agricultural Operators use the roads. They need access to their farm fields. Driving a few miles to get on the other side of RR tracks vs. driving over the tracks. The operators are going to want to use the crossings.   The consolidation of crossings makes me feel uncomfortable. Example: The railroad will repair the crossing on … street if the county closes … and … streets. The county cannot operate this way.

- The … has asked … County to close two crossings recently that have safety issues. I have supported the closures with both safety and road maintenance related benefits and the … has offered substantial funds to close the crossings ($100,000), however if there is public resistance to the closure the Board has declined to close the crossings. The two crossings both have been within 1/2 mile of a town and the cities and schools were worried about when trains block city crossings.

- We no longer have any railroad tracks in our area. They have all been converted to bike trails.

- Our crossing go to independent areas which cannot be accessed from the other crossing.

- We have signed a contract with the **…** Railroad governing all issues associated with the railroad and the City of **…**. We are not interested in changing the terms of that agreement.

- We only have 2 crossings, 1 going South to our waste water treatment facilities, and 1 going West by our waste water lift station and cemetery. Closing either 1 would result in a 4 mile drive to access the other. That would be unacceptable.

- The closure of our one crossing would result in a 1.3 mile detour to get to the other side of the railroad crossing. The 1.3 mile detour would also include crossing the rail road tracks at another location out in the county, hence not really making the closure of the crossing any safer just less convenient.

- As I do not make the decisions, "unsure" has to be the response to the questions

- Do not know why we were included in this survey because the railway has been closed and removed for many years. The area now is a bike trail.

- I have been the City Clerk in our Community for 8 years and in that 8 years at our 15 crossings we have had no accidents at crossings. The safety of the crossing does not seem to be an issue in our community.

- I don't know how crossings could be consolidated given the topography and development of the area. I would think we would consider it if a plan were proposed given the situation.

- THERE IS NO LONGER A RAILROAD TRACK GOING THROUGH CITY …!

- The city cannot afford the price the railroad wants to fix the tracks.

- We only have one crossing in our community other than a bridge crossing over the rails and does not create any safety issues. The one roadway which is controlled by lights and arms has not presented a safety issues in a great number of years. This street is the only other hard surface access to our community and connects the industrial park and a housing development. We would not want to consolidate this crossing.

- The safety concern is more the traffic being able to turn off from highway **…** into town, when the RR crossing is blocked by a train. Those wanting to turn vs those going straight through on the highway.

63

- We currently only have 3 crossings in town. If those were reduced, it would eventually cut the town in half. This would be a large inconvenience to our citizens. We have one crossing with gates and lights. The other two crossings are in need of the same thing.

- We would like more crossings not less. We are expanding and have no access across the tracks. To reach the south side of the tracks in an emergency situation crews have to go around town on highway … and come back in on highway …. The RR needs to worry about the pipes that convey storm water under the tracks and also when they raise track they slope the ditches and change flow lines. Our tracks that run through town make a fairly effective dike.

- As the Public Works Director I cannot speak for the City Council, but I believe every rail crossing in City … is essential and should not be closed.

- There are no options to close the three crossings we have as they are all for the same railroad and on heavily traveled roads or roads that would cause significant inconvenience for the motoring public including polis, fire, and rescue.

- The City of … has already reluctantly agreed to a crossing being closed a couple years ago. It is definitely an inconvenience

- We would consider a trade of crossings.

- Our railroad crossing are in horrible shape. I am unsure how they have passed inspection. They are terrible. I would appreciate someone to come and take a look at our crossings. Thanks.   We have 3 crossings.... There is one crossing in particular that is terrible.