Roadway Safety Data Program

STATE-SPECIFIC HIGHWAY SAFETY MANUAL AND SYSTEMIC SAFETY ANALYSIS IN ILLINOIS

ROADWAY SAFETY DATA AND ANALYSIS

CASE STUDY

FHWA-SA-17-014

Federal Highway Administration Office of Safety

Roadway Safety Data Program

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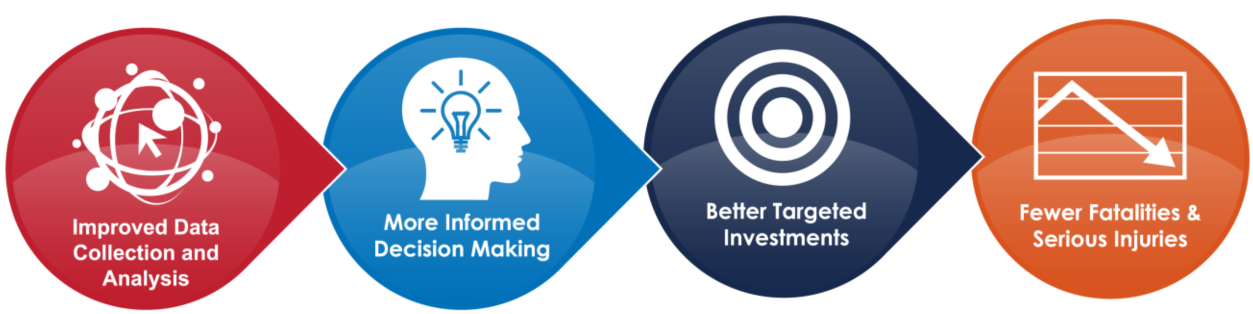

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Safe Roads for a Safer Future
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Notice

Quality Assurance Statement

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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ACRONYMS

BSPE	IDOT Bureau of Safety Programs and Engineering
FHWA	Federal Highway Administration
FYA	Flashing Yellow Arrow
GIS	Geographic Information System
HSM	Highway Safety Manual
ICT	Illinois Center for Transportation
IDOT	Illinois Department of Transportation
LTAP	Local Technical Assistance Program
MPO	Metropolitan Planning Organization
SHSP	Strategic Highway Safety Plan
SPF	Safety Performance Functions
SRI	Safer Roads Index

EXECUTIVE SUMMARY

The Illinois Department of Transportation (IDOT) published the *AASHTO Highway Safety Manual Illinois User Guide with Illinois Calibration Factor and Default Valu*es in 2014. This guidebook provides guidance on incorporating AASHTO Highway Safety Manual (HSM) methods into Illinois roadway safety management practices. IDOT calibrates Safety Performance Functions from the HSM for calculating the predicted crash frequency on specific roadway facility types and site types in Illinois. Also in 2014, IDOT published the *Systemic Safety Improvements: Analysis, Guidelines and Procedures* guidebook*,* and IDOT uses this guide to systemically analyze crash, roadway, and facility information, select countermeasures, and prioritize safety-related projects. IDOT employs a variety of tools and techniques to improve roadway safety in the State, including GIS integration, County Data Trees, Emphasis Area tables, Heat Maps, and a Five Percent Report.

INTRODUCTION

Through the *AASHTO Highway Safety Manual Illinois User Guide with Illinois Calibration Factor and Default Valu*es (hereafter referred to as the IDOT HSM Guide) and the *Systemic Safety Improvements: Analysis, Guidelines and Procedures* Guidebook (hereafter referred to as the IDOT Systemic Guide), the Illinois Department of Transportation (IDOT) provides guidance on incorporating AASHTO Highway Safety Manual (HSM) methods into Illinois roadway safety management practices and implements tools and techniques to systemically analyze crash, roadway, and facility information, respectively. This enables safety engineers to screen transportation networks, select countermeasures, and prioritize safety-related projects based on Illinois specific characteristics.

BACKGROUND

IDOT HSM Guide

In March 2014, IDOT published the IDOT HSM Guide. The purpose of this guidebook is to incorporate the HSM methodology into roadway safety management practices in Illinois. The AASHTO HSM provides analytic tools and techniques for quantifying the potential effects on crashes as a result of decisions made in planning, design, construction, and operations.

The HSM also presents the steps to monitor and reduce crash frequency and severity on existing roadway networks. The IDOT HSM Guide focuses on the application of the HSM Part C, Predictive Method, to roadway safety management practices in Illinois. The Predictive Method estimates expected average crash frequency of a network or individual site.

IDOT Systemic Guide

The HSM describes the reactive roadway safety management process, which includes network screening, diagnosis, countermeasure selection, economic appraisal, project prioritization, and safety effectiveness evaluation. The Federal Highway Administration (FHWA) Systemic Safety Project Selection Tool outlines an approach for proactive safety screening and project development. IDOT's Systemic Guide is similar but is focused on Illinois roadways. The IDOT Systemic Guide describes an approach for identifying high priority areas to integrate safety into projects and plans throughout the transportation management process. IDOT district staff, Metropolitan Planning Organizations (MPOs), and local agencies use these guidelines to direct and enhance their safety programs.

OBJECTIVE

Illinois uses the IDOT HSM Guide to:

- Describe the concepts of the HSM methods in detail, followed by examples with step-by-step application of HSM methodology to Illinois roadway safety management practices.
- Communicate the Illinois Safety Performance Function (SPF) calibration factors, developed based on Illinois data, to calculate the predicted crash frequency under existing and alternative conditions.

Illinois uses the IDOT Systemic Guide to:

- Identify locations that have potential for safety improvement using various tools and techniques.
- Provide methods to assess historical roadway, crash, and traffic information for systemic analysis for effective policy decisions.
- Economically assess the reduction in societal crash costs based on severity and produce benefit-cost ratios for various countermeasures.

AUDIENCE

This case study applies to the following audiences:

- State Departments of Transportation: Roadway Data System Managers, Program Developers, Safety Engineers, Geographic Information System (GIS) specialists, and IT project managers.
- Local Agencies: Regional Planning Commissions, MPOs, cities, and counties, plus Local Technical Assistance Programs (LTAPs).
- Consultants and researchers involved with safety data analysis and GIS use in transportation safety.

IDOT HSM GUIDE PREDICTIVE METHODS

The HSM Part C predictive method facilitates the calculation of predicted and/or expected crash frequency for an individual site or facility. Before the application of the predictive method, the safety analyst divides the entire roadway into individual sites that are either homogenous roadway segments or intersections. The roadway is converted into a contiguous set of individual intersections and roadway segments, each referred to as a “site.” Based on factors (e.g., surrounding land use, roadway cross-section), the safety engineer determines the facility type for different sites such as rural two-lane two-way roads, rural multilane highways, and urban and suburban arterials. Furthermore, for each facility type, a number of different site types may exist, such as divided and undivided roadway segments, or signalized and unsignalized intersections.

Based on the facility and site type for the designated location, the investigating agency selects the appropriate SPFs and Crash Modification Factors from relevant chapters in the IDOT HSM Guide. The agency uses the selected SPFs and coefficients for calculating the predicted crash frequency under existing conditions.

IDOT's Bureau of Safety Programs and Engineering (BSPE) has calibrated the HSM SPFs using Illinois data and derived all of the Illinois SPF calibration factors. Considering the differences in crash pattern and crash frequency level, BSPE calibrated the HSM SPFs for different IDOT jurisdictions and calendar years separately. Correspondingly, when applied to a specific site, the analyst selects the Illinois SPF calibration factor from the appropriate table based on the site type, IDOT jurisdiction for the site, and the time period for the analysis. In addition to the Illinois SPF calibration factors, BSPE also replaced all the default distribution values based on facility type, IDOT jurisdiction, and year.

To promote the implementation of the HSM in Illinois, BSPE developed the IDOT HSM Crash Prediction Tool, a Visual Basic for Application-based software for calculating the predicted and expected crash frequency for different facility types. The tool incorporates all the detailed procedures for crash frequency calculation, and only brief data input is required. With this tool, safety analysts can calculate the predicted and/or expected crash frequency for a site, facility, and network without any detailed knowledge about the HSM Part C predictive model. Therefore, the workload is greatly reduced.

The IDOT HSM Guide also provides examples of the incorporation of the predictive method into the calculation of predicted and/or expected crash frequency in Illinois. Reflecting the diversity of the applications in Illinois, the following example roadway sites under different facility types are presented: rural two-lane, two-way roadway segment; urban and suburban arterial; three-leg intersection with stop control on a rural two-lane, two-way road; and a four-leg signalized intersection on an urban and suburban arterial. Also, analysts calculate different crash frequencies for comparing different improvement alternatives and expected crash frequency using the Empirical Bayes method.

PROGRAM APPLICATIONS

The following example illustrates how IDOT used the IDOT HSM Guide to analyze historical roadway, crash, and traffic data for effective policy decisions.

FLASHING YELLOW ARROWS FOR LEFT TURN CONTROL

A 2016 Illinois Center for Transportation (ICT) report (Schattler et al.) investigated the effectiveness of Flashing Yellow Arrow (FYA) for permissive left-turns at signalized intersections. The study assessed crashes at 86 intersections. As part of the study, ICT collected comprehensive crash data for three years prior and three years after FYA installation. The study found a 23-percent reduction in left-turn related crashes. The study also assessed the age of the driver. Although there was no statistically significant crash reduction for older drivers (age 65 and over), there was a 25-percent crash reduction overall and a 36-percent crash reduction for young drivers (ages 16 to 21 years).

Employing techniques from the HSM, the study also economically assessed the reduction in societal crash costs based on severity (crash savings) balanced against the FYA installation cost of $6,000 over a 15-year period. The analysis found a benefit-cost ratio of 19.8.

ILLINOIS SYSTEMIC TOOLS AND TECHNIQUES

In 2014, IDOT published the IDOT Systemic Guide, which describes IDOT's systemic tools used to help identify high priority areas that may benefit from safety countermeasures. These tools include GIS, county data trees, emphasis area tables, heat maps, and the five percent report. IDOT also employs a detailed systemic analysis process.

GEOGRAPHIC INFORMATION SYSTEM

GIS is one of the primary tools IDOT uses to analyze crash data. GIS enables the user to view and manipulate a wide variety of roadway, crash, and jurisdiction data layers. Safety analysts perform queries focusing on specific crash, roadway, and traffic criteria. Users may also investigate safety experience at individual locations on a crash-by-crash basis.

COUNTY DATA TREES

County Data Trees help safety engineers determine which roadway systems to analyze. The Data Tree separates crash data between the State, toll/private, county, township, and municipal roadway systems. Depending on the jurisdiction of interest, the Data Tree may branch out into more detail such as urban/rural classifications and intersections. The primary focus is on severe crashes from the most recent five-year period. The five-year period provides a more comprehensive understanding of the crashes, rather than random crashes for each year. This helps ensure the consideration of severe crash locations for safety improvements. Based on a large area data set, data trees allow users to identify the priority jurisdiction, facility and crash type to focus additional analysis and subsequent treatment.

EMPHASIS AREA TABLES

Emphasis Area tables compare a county's crash numbers to the entire State's numbers for safety concerns noted in the Strategic Highway Safety Plan (SHSP). Roadway systems are divided into State and County/Local. This is similar to Data Trees, but unlike Data Trees, the Emphasis Area Tables also show overrepresented categories and behavioral categories. The addition of behavioral categories allows analysts to examine crash experiences specific to young drivers, older drivers, aggressive drivers, drug/alcohol related crashes, inattentive/distracted/sleeping drivers and unrestrained occupants. By comparing each Emphasis Area against the others, safety analysts can determine which types of crashes should be considered for implementing safety efforts.

HEAT MAPS

Heat Maps provide another method to screen locations based on driver behavior and crash patterns. These maps cover a range of engineering and non-engineering focus areas, such as impaired drivers, older drivers, unrestrained drivers and/or occupants, young drivers, intersection related crashes, non-intersection related crashes, and roadway departure crashes. Using the crash count intervals per section square in the legend, heat maps show areas experiencing high levels of a certain problem, as seen in Figure 1. For example, heat maps act as a screening tool for law enforcement by pinpointing areas with an overrepresentation of crashes involving impaired or unrestrained drivers.

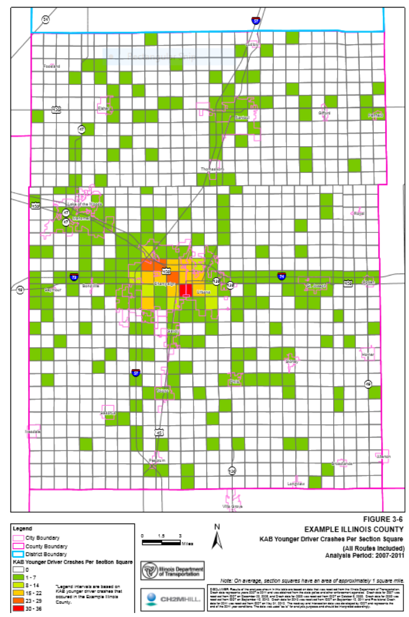

Figure 1. Example of a Heat Map showing young driver severe crashes.

FIVE PERCENT REPORT

IDOT develops the Five Percent Report, which describes at least five percent of State jurisdiction highway locations exhibiting the most pressing safety needs. The report enables a better understanding of the characteristics of the roads and the nature of the road's safety problems. The report also provides another network screening tool that gives users more insight on where to implement countermeasures.

DETAILED SYSTEMIC ANALYSIS PROCESS

To isolate each component of study, the systemic analysis process breaks down roadways into intersection or segment categories. If a cluster of severe crashes is occurring on a specific stretch of road, the analyst identifies this stretch as a potential "site" to review. Once these types of locations are identified, the agency gathers and reviews all of the crash data for that particular segment/corridor or intersection to help determine the contributing factors of a crash.

Another approach considers several elements using a star rating system. The safety engineer assigns stars to locations based on characteristics that have a potential safety concern, such as skewed intersections, curves with intersections, or hazardous roadside characteristics. If a location acquires multiple stars, it is an indication that the location needs further attention.

RESULTS

LESSONS LEARNED

Illinois strives to incorporate the concept of safety into planning and design of the public roadway system and to establish a data-driven process for roadway safety management. However, given the complexity of safety engineering and the breadth of potential users, the adoption of HSM processes and tools is challenging.

Planned implementation and communication is key for effective adoption by safety engineering decision makers. IDOT actively promotes the IDOT HSM Guide and provides guides, training, technical support, and user friendly-locally adapted tools for district and local agency safety engineers. IDOT also encourages the integration of these safety practices into the design and program development process to support safety decisions.

BARRIERS AND HOW THEY WERE OVERCOME

Illinois recognized that a knowledge gap existed between the HSM methodologies and the engineering practices. To advance the practice, IDOT developed the IDOT HSM Guide and provided training, tools and case studies. As an example, to address the current needs of local agencies, IDOT provides resources to determine contributing factors and to identify optimal locations for potential safety improvements with the use of safety funds. IDOT continues to develop support materials, analytical tools, and application techniques.

IDOT found that a major challenge was establishing and supporting integration between different traffic records component systems as needed for HSM analyses. Integration attempts had to overcome technical, organizational, and policy barriers. Illinois has achieved major successes integrating multiple datasets within the injury surveillance and other traffic records components to meet specific study requests. The active support and involvement of the Traffic Records Coordinating Committee has been instrumental in advancing these data integration efforts. These efforts are described in the Roadway Safety Data Governance in Illinois: Roadway Safety Data and Analysis Case Study (FHWA-SA-16-108).

NEXT STEPS

IDOT plans to continue advancing HSM practices into safety engineering decision making. IDOTs HSM implementation plan is a multifaceted approach focused on data collection, calibration and SPF development, training, policy, manuals and guides, analysis tool development, technical support, and countermeasure effectiveness evaluation. IDOT is evaluating additional data requirements from MIRE guidelines to provide robust data sets for analysis. In particular, IDOT is collecting curve, intersection geometry, and traffic control along with roadway and roadside attributes such as signing, guardrail, and guardrail terminals. IDOT also plans to expand efforts to further integrate key safety data sets for safety decision makers. For example, IDOT is pursuing multiple linkages of roadway, crash, driver, and hospital data to enable more extensive analyses. IDOT is also considering improving online access to data and resources.

IDOT is enhancing the statewide network screening models used to develop the Five Percent and Safer Roads Index (SRI) and is in the process of developing Safety Performance Functions for local roadways. The SRI is used to integrate safety performance in the planning and programming process by combined evaluation of pavements and safety for project prioritization.

Evaluation is an integral part of road safety management in Illinois. Flexibility and adaptation is necessary to continually improve road safety and achieve project and program goals. Illinois is working on evaluating the effectiveness of centerline and shoulder rumble strips, high friction surface treatment applications, and spot improvements.

IDOT will continue to advance tools and techniques focused on Illinois characteristics such as SRI for local roadways, full implementation of AASHTOWare Safety Analyst™, and continue to advance policy to provide specific guidance and criteria for integrating quantitative and systemic approaches.

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