Applying the US Highway Safety Manual to the Alternative Selection Process: A Case Study in Missoula, Montana

John Zegeer and Nick Foster
jzegeer@kittelson.com

Abstract

The recently-published Highway Safety Manual (HSM) provides methods for developing and managing a roadway safety management system, a catalogue of crash modification factors for various features, and a method to predict expected average crashes on roadways. The predictive method of the HSM will allow agencies to forecast the change in crash frequency on a roadway due to traffic or roadway cross-section changes. The City of Missoula, Montana commissioned Kittelson & Associates to conduct a corridor planning project on Russell Street in the City of Missoula. The expected change in future crash frequency was determined for seven scenarios of differing traffic volumes, intersection control, cross sections, and levels of access management. This information allowed the city to consider roadway safety with traffic operations and environmental information to support the decision process for selecting a final concept. This paper presents an overview of the HSM predictive methodology and a discussion of its application to the Russell Street corridor, including results and lessons learned in applying this tool in selecting a design alternative.

Introduction

The American Association of State Highway Transportation Officials (AASHTO) published the first edition Highway Safety Manual (HSM) earlier this year. Since 1999, the United States National Cooperative Highway Research Program has sponsored seven independent research projects to develop different parts and chapters of the manual.

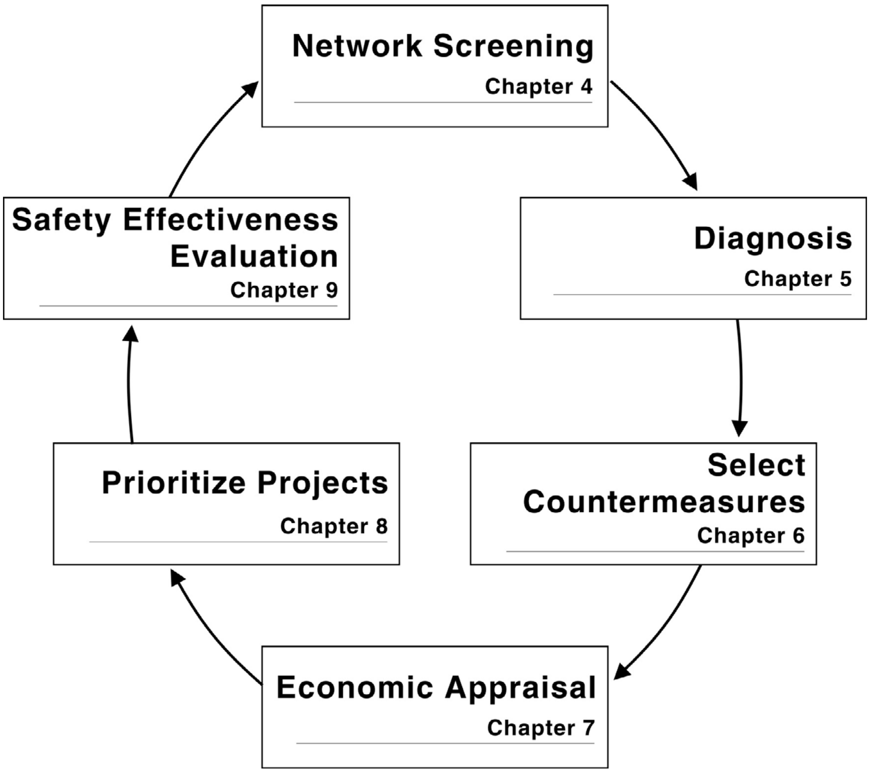
The HSM is a definitive, science-based manual that provides quantitative methods for conducting safety evaluations. By using the methods in the HSM, engineers and planners are able to predict expected average crash frequency for different facility types under various cross-sectional and traffic volume characteristics. With this method, the expected average crash frequency under one design alternative can be compared against a second design alternative. Thus, safety can be quantitatively integrated into alternatives analysis when considering the impacts to mobility, the environment, or other typical performance measures.

The manual is intended to be a guidebook; it is not a standard or recommended practice. It contains four major parts:

1. *Part A: Introduction, Human Factors and Fundamentals* describes the purpose and scope of the HSM, explaining the relationship of the HSM to planning, design, operations, and maintenance activities. *Part A* also includes fundamentals of the processes and tools described in the HSM.

2. *Part B: Roadway System Management* has six chapters. Each chapter covers one of the steps in the roadway safety management process. The roadway safety management process is used by most jurisdictions to monitor and reduce crash frequency and severity on existing roadway networks. It includes methods useful for identifying sites with the potential to respond to safety improvements, diagnosing issues, selecting countermeasures, conducting economic appraisals, prioritizing projects, and conducting safety effectiveness evaluations. Exhibit 1 shows a schematic of the Part B process.

Exhibit 1: The Roadway Safety Management Process



3. *Part C: Predictive Method* provides a method for estimating expected average crash frequency on a network, facility or on an individual site as a function of roadway cross-sectional features and traffic volume. The chapters in Part C provide the predictive method for segments and intersections for rural two-lane roadways, multilane roadways, and urban/suburban arterials.

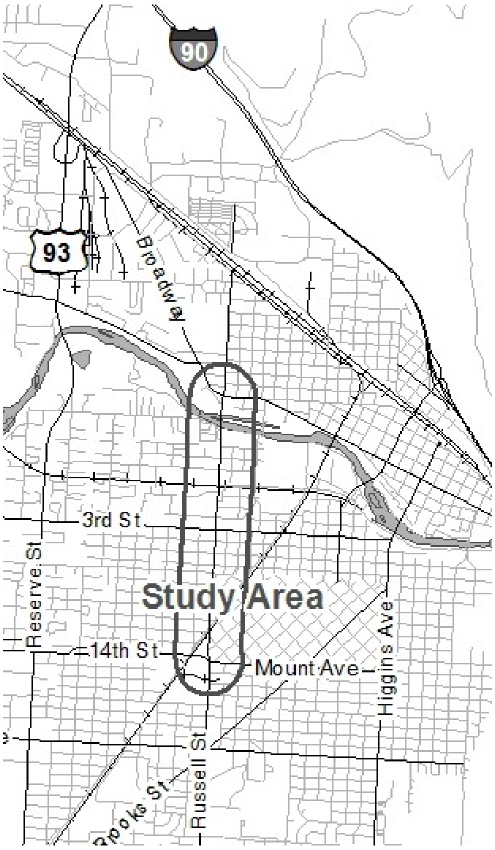
4. *Part D: Crash Modification Factors* provides a catalogue of treatments and crash modification factors for roadway segments, intersections, interchanges, special facilities, and road networks. Crash modification factors (CMFs) quantify the potential change in expected average crash frequency as a result of geometric or operational modifications to a site.

This paper presents a case study of the application of the HSM Part C Predictive Method to the Russell Street Corridor in Missoula, Montana. The purpose of the Russell Street project was to identify the most feasible corridor cross-sections for the entire corridor. The project quantitatively considered safety, traffic operations, and pedestrian and bicycle level of service.

Project Background

The Russell Street corridor is located in Missoula, Montana in the United States. Missoula has a population of approximately 57,000 residents. The city is also home to the University of Montana. As shown in Exhibit 2, the corridor has a length of approximately 2.5 kilometers miles from Broadway Street on the north to 14th Street-Mount Avenue on the south.

Exhibit 2: Study Area



This corridor includes one of five bridge crossings of the Clark Fork River in the city. Downtown Missoula is located on the north side of the river. The south side of the river is primarily residential neighborhoods. Large industrial parcels are located immediately south of the river.

The existing roadway is primarily either a two-lane undivided facility or a three-lane facility with a center two-way left-turn lane. The existing bridge is two-lanes wide with narrow sidewalks on either side. Paved bicycle lanes, sidewalks, and shoulders are generally absent from the corridor. Existing average daily traffic (ADT) volumes range from 20,000 to 25,000 vehicles per day. The crash rate along the corridor from July 2004 to June 2008 was approximately 8.4 crashes per million vehicle miles. Approximately one-third of these crashes resulted in an injury or fatality to at least one individual. Twenty-one crashes involved a bicyclist.

Project History and Objective

The objective of this project was to update a previous traffic analysis completed for the project environmental study required by the US Department of Transportation Federal Highway Administration (FHWA). The original analysis was completed in 2005 and the draft environmental study was submitted to FHWA in 2008. The draft environmental document recommended that the entire corridor be reconstructed as a five-lane roadway with a divided median or a center two-way left-turn lane, depending on the section. It also recommended traffic signals at the major intersections. Bicycle lanes and sidewalks would be provided along the length of the corridor.

In response to substantial resident opposition, these items, the Montana Department of Transportation (MDT) and City of Missoula, decided to undertake an update of the traffic analysis portion of the environmental study. The goal of this update was to incorporate the projections from the updated regional travel demand model, perform detailed traffic operational analyses, and incorporate quantitative performance measures for safety and non-motorized transportation. In order to analyze the safety performance of the different design alternatives, Kittelson & Associates utilized the predictive method from Part C of the HSM.

Calculating Predicted Crashes

Seven roadway alternatives were developed. The alternatives were categorised into either three-lane or five-lane cross-sections. Exhibit 3 illustrates the general roadway cross-section and intersection control planned for each alternative. Average crash frequency was determined for each roadway segment and intersection so that alternatives could be compared from a safety performance perspective.

Each build alternative was compared to the no-build alternative, assuming the respective volume scenario, to determine the relative change in predicted average crash frequency from the relative no-build scenario. Exhibit 4 shows the results of the analysis. Alternatives 2, 3, and 5-R would yield the largest reduction in crash frequency as compared to the respective base prediction. This is because Alternatives 2, 3, and 5-R include options for roundabouts at major intersections. In the 3-lane volume scenario, Alternative 3 shows an additional reduction in expected crash frequency as compared to Alternative 2 because there are more medians in Alternative 3, especially in the southern portion of the corridor. Option 6 has the smallest decline in crash frequency as compared to other alternatives in large part because it generally did not include median restrictions.

Exhibit 4: HSM Analysis Results

	3-Lane Scenario				5-Lane Scenario			
	Alt 1	Alt 2	Alt 3	Option 6	Alt 1	Alt 4	Alt 5-R	Option 7
Percentage of Crashes Compared to No-Build Scenario (Alternative 1)	100%	67%	65%	85%	100%	70%	63%	73%

Challenges and Conclusions

The methods in the HSM are new. Consequently, challenges were encountered along the way. The first challenge was calibrating the crash prediction models to local conditions. No appropriate calibration factors have been calculated for this area. To overcome this, the results of the analysis were reported on a relative basis to the no-build alternative. The second challenge was that the HSM does not contain predictive models for crashes involving bicyclists and pedestrians at roundabout intersections. Consequently, the team was not able to include bicyclist and pedestrian crashes in the analysis. This analysis allowed the residents to better understand the trade-offs between different design features. It allowed them to see that the installation of roundabouts would be expected to reduce crashes further than traffic signals.

References

Kittelson & Associates, Inc., *Russell Street Traffic Analysis Update*, August 2009

Kittelson & Associates, Inc., Midwest Research Institute, John Mason, Bhagwant Persuad, and Craig Lyon, *NCHRP 17-36: Production of the First Edition Highway Safety Manual*, April 2008.

Exhibit 3: Design Alternatives

Segment / Intersection	DEIS Alternatives					Option 6	Option 7
	Alt 1 (Existing)	Alt 2	Alt 3	Alt 4	Alt 5-R		
W. Broadway	Signal	Signal	Signal	Signal	Signal	Signal	Signal
W. Broadway to Wyoming	2+ Lanes	4+ Lanes	4+ Lanes	4+ Lanes	4+ Lanes	4+ Lanes	4+ Lanes
Wyoming	TWSC	ML rbt	ML rbt	Signal	Signal	SL rbt	Signal
Wyoming to S. 3rd	2+ Lanes	2+ Lanes	2+ Lanes	4+ Lanes	4+ Lanes	2+ Lanes	4+ Lanes
S. 3rd	Signal	ML rbt	ML rbt	Signal	ML rbt	SL rbt	Signal
S. 3rd to S. 5th	4+ Lanes	4+ Lanes	4+ Lanes	4+ Lanes	4+ Lanes	2+ Lanes	4+ Lanes
S. 5th	Signal	ML rbt	ML rbt	Signal	ML rbt	SL rbt	Signal
S. 5th to S. 6th	4+ Lanes	4+ Lanes	4+ Lanes	4+ Lanes	4+ Lanes	2+ Lanes	2+ Lanes
S 6th to S. 8th	2 Lanes	2+ Lanes	2+ Lanes	4+ Lanes	4+ Lanes	2+ Lanes	2+ Lanes
S. 8th to S. 11th-Knowles	2 Lanes	2 Lanes	2+ Lanes	4+ Lanes	4+ Lanes	2 Lanes	2+ Lanes
S. 11th-Knowles	TWSC	SL rbt	SL rbt	TWSC	TWSC	SL rbt	TWSC
S. 11th- Knowles to S. 14th-Mount	2 Lanes to 4 Lanes	2 Lanes to 4+ Lanes	2 Lanes to 4+ Lanes	4+ Lanes	4+ Lanes	2+ Lanes	2+ Lanes to 4+ Lanes
S. 14th-Mount	Signal	ML rbt	ML rbt	Signal	Signal	Signal	Signal

Symbol	Description	Symbol	Description
2 Lanes	This symbol represents one travel lane in each direction and no median.	TWSC	This symbol represents an unsignalized intersection with two-way, stop control.
4 Lanes	This symbol represents two travel lanes in each direction and no median.	Signal	This symbol represents an intersection with a traffic signal control.
2+ Lanes	This symbol represents one travel lane in each direction with a raised or painted median.	SL rbt	This symbol represents an intersection with a single lane roundabout.
4+ Lanes	This symbol represents two travel lanes in each direction with a raised or painted median.	ML rbt	This symbol represents an intersection with a multilane roundabout.