TRAFFIC OPERATIONS AND SAFETY LABORATORY
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University of Wisconsin - Madison

CITY OF MADISON HIGH INJURY NETWORK

Draft Proposal

1. Background

High Injury Network (HIN) consists of mapping roadway corridors of a network and evaluate the associated number of people killed and severely injured in traffic crashes. Adoption of a HIN is recommended in Vision Zero, which is a strategy aimed at eliminating all traffic fatalities and severe injuries, while increasing safe, healthy, and equitable mobility for all road users.

The City of Madison is in the process of adopting a Vision Zero strategy. Accounting for the resources available, a practical and repeatable process to develop and update a HIN is required. The Traffic Operations and Safety Laboratory (TOPS) at the University of Wisconsin – Madison has put together a proposal for the development of a HIN for the City of Madison. In this proposal, the proposed work plan, methodology, schedule, and budget are provided.

2. Proposed Work Plan

The proposed work plan consists of a collaborative effort between the City of Madison and the TOPS lab. The City of Madison will provide the data and the TOPS lab will provide the statistical expertise and develop the process to obtain and update a HIN. Table 1 provides and overview of the proposed work plan, tasks, data, and description.

Task 1 Network Segmentation

The City of Madison will use existing GIS network layers to divide the network according to the roadway facility. For intersections, a buffer of 250 ft will be used to delineate the area of influence of intersections. Segments will be designated as continuous roadway sections outside the 250 ft buffer of intersections. Some assumptions will be made in cases where intersections are closely spaced and have overlapping buffers. Each roadway element will be coded and assigned geometric and operational attributes to further categorize the type of intersection and roadway segment.

Task 2 Data Collection

With the network divided into intersections and segments; geometric, operational, and crash data will be collected and assigned to each of the roadway facilities in the network. Geometric data will consist of the number of approaching legs, number of lanes, divided/undivided roadway, or median type. Operational data will consist of signal control type, speed limit, and traffic. Crash data will focus on severe injury and fatal crashes. The periods of analysis must be carefully selected since the evaluation of severe injury and fatal crashes is characterized by low number of observations during short periods of analysis. Data will be collected for two different periods of analysis. One period will be considered for crash prediction model development and the second period will be considered for the analysis of safety at each of the roadway facilities in the network. Thus, for model development, 10 years (2007-2016) of crash data will be considered. The period of analysis will initially be of three years (2017-2019), followed by a four-year period (2017-2020) and five-year period (2017-2021), and subsequent periods of analysis will continue using a five-year rolling period (i.e., 2018-2022). The cutoff year of 2017 is used since the new crash report format in Wisconsin was introduced that year.

Task 3 Crash Prediction Model Development

To begin with, **what are crash prediction models?** Crashes are rare random events that occur over a period of time as a function of measures of exposure (i.e., amount of traffic). For instance, in figure 1, crashes at a roadway facility do not follow a particular trend and have high and low peaks. A period of high number of crashes will most likely be followed by a low number of crashes, also known as regression to the mean. Thus, for

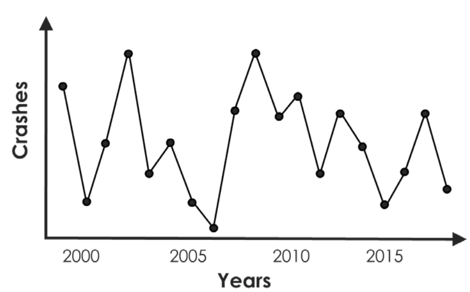

Fig. 1 Crashes over time

safety evaluation, crash frequency is commonly used which consists of the number of crashes divided by the number of years (i.e., crashes/year). Evaluating safety with crash frequency and short periods of analysis does not provide accurate safety measures and is biased towards the period studied, as illustrated in figure 2. Using long-term crash frequency would account for the effect of regression to the mean and short-term bias; however, long-term crash estimates in most cases are not directly obtainable or reliable because of limited crash data available, changes in crash reporting, changes in geometry, or fluctuations in operations over time (figure 3).

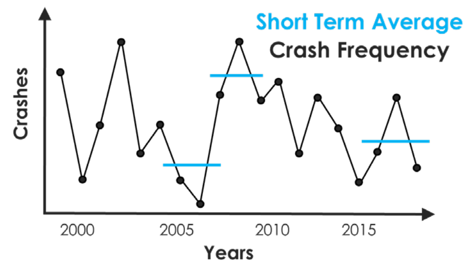

Fig. 2 Short period of analysis

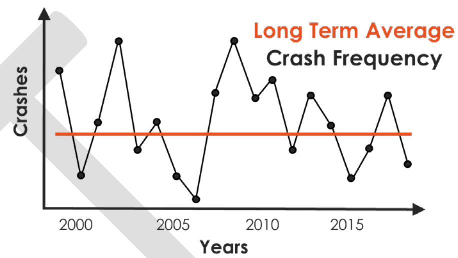

Fig. 3 Long-term crash frequency

How are long-term safety estimates used? Crash prediction models provide reliable long-term crash estimates that can be used to assess safety of a roadway facility. Crash prediction models serve as reference using data from a large group of sites that share similar geometric, operational, and crash trends. Evaluating only crash frequency calculated with observed data over a relatively short period of time does not provide reliable estimates because there is not a safety baseline reference as the long-term crash frequency to assess the level of safety at a roadway facility with specific geometric and operational traits. To confidently assess safety at a roadway facility, a long-term estimate is used to gage the level of safety of a roadway facility as illustrated in figure 4.

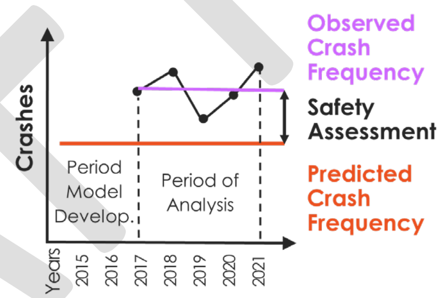

Fig. 4 Safety assessment

How is the safety level of a roadway facility quantified? There are different safety measures that could be evaluated to determine the safety level of a roadway facility including conventional crash frequency, crash rate, Equivalent Property Damage Only (EPDO), excess of expected crashes, or Level of Service of Safety (LOSS). The LOSS is a good example on how prediction models contribute to the process of finding unbiased and reliable estimates. In figure 5, the observed crash frequency of a roadway facility is compared to the long-term estimate, and using the LOSS method, there is a process to obtain confidence bands for different degrees of safety in relation to the deviation from the long-term estimate. The further up the observed crash frequency is, the lower safety is at the roadway facility (high number of crashes), resulting in greatest potential for safety treatment.

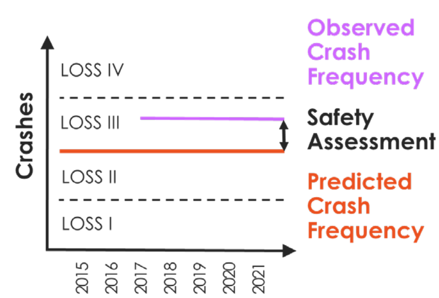

Fig. 5 LOSS safety assessment

Why do we need crash prediction models for a HIN since we just want to know where are fatal and severe injury crashes happening? Using the same criteria previously discussed, roadway facilities with fatal and severe injury crashes may seem to have safety issues during a short period of analysis. Without comparing observed crash data to a long-term safety estimate or the average crash occurrence of a group of sites with similar geometric and operational traits, the safety level of a roadway facility cannot confidently be determined.

Will crash prediction models need to be updated every year? Crash prediction models will be developed using geometric, operational, and crash data from a 10-year period (2007-2016). Models for different intersection and segment types will be developed. To answer the question, no, crash prediction models will not need to be updated every year. As the reader may notice, the period for model development ends in 2016, right before the change in crash reporting in Wisconsin. The TOPS lab has conducted research quantifying the effect in crash counts and distributions by crash severity before and after the 2017 intervention. The TOPS lab plans to use these findings to adjust the model that will be developed with data from 2007-2016 and make it applicable to periods post 2017.

Shouldn't data after the 2017 intervention be used to develop the crash prediction models? Ideally, yes. Unfortunately, there are only three years of data available and model development with such limited dataset is not feasible, specially when the focus is on fatal and severe injury crashes.

When should crash prediction models be updated then? Crash prediction models would be recommended to be updated when data for six complete years after 2017 becomes available (2017-2022).

Who can develop crash prediction models and what statistical expertise is required? Although advanced statistical expertise and a solid foundation in crash analysis is required, with proper training, anyone with basic excel skills, elemental statistical experience, and willingness to learn can develop crash prediction models. The TOPS lab as part of this proposal would like to train the City of Madison traffic engineers to not only be able to get familiar with the process of model development and interpretation of results but also to have the capacity to update and develop crash prediction models. The TOPS lab will schedule training sessions and develop training material for the City of Madison traffic engineers as part of this project.

Task 4 Development of HIN

Two approaches will be taken for the development of the HIN for the City of Madison. The first approach will consist of conducting a spatiotemporal analysis of crash locations in relation to roadway facilities in the network. The second approach will focus on introducing crash prediction models and rigorous statistical methods to assess the degree of safety of roadway facilities in the network.

For the first approach, the network segmentation will be used to assign fatal and severe injury crashes to the corresponding roadway facility and evaluate the number and frequency of crashes over a period of time and location within the network.

For the second approach, with the availability of crash prediction models, the Empirical Bayes method will be implemented. The Empirical Bayes method combines crash prediction model estimates with observed data to obtain a weighted estimate (expected crashes) which account for regression to the mean bias and is representative of a long-term crash trend. **The Empirical Bayes is commonly known as a method used to quantify the safety effectiveness of treatments before and after implementation. However, it is just one of the applications, and the Empirical Bayes is used in a wide array of safety analyses to obtain unbiased estimates in relation to the degree of safety of roadway facilities without treatments, crash projections, or assessment of past crash history.** Expected crashes will be used to assess the state of safety at each of the facilities in the network in relation to the crashes observed at similar facilities with specific geometric and operational traits. Safety will be evaluated in terms of crash frequency, crash rate, excess expected crashes, EPDO, and LOSS. These safety measures will be considered to evaluate the level of safety at each roadway facility in the network to identify facilities with high fatal and injury crash occurrence.

3. Meetings

The TOPS lab will schedule meetings on a regular basis to provide updates, coordinate efforts, and present results.

4. Deliverables

Deliverables will consist of a final report detailing the work performed, training material, crash prediction model development spreadsheets, results of the safety analysis, and HIN estimates.

5. Estimated Budget

Based on the collaboration between the City of Madison and the TOPS lab, data collection, effort, meetings, and tasks performed; the estimated budget for the work performed by the TOPS lab is $9,500.

6. Project Duration

The estimated project duration, after the data is provided by the City of Madison, is five (5) months.

7. Contact Information

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Table 1. Summary of Proposed Work Plan

Task	City of Madison			TOPS Lab	
	Facility	**Data**	**Description**	**Model/Method/Variable**	**Description**
Network Segmentation	Intersections	Roadway network	250 ft buffer from polygon centroid.	NA	The TOPS lab will collaborate with the City of Madison in the process of network segmentation, roadway classification, and data collection and assignment.
	Segments		Outside intersection buffers.		
Roadway Classification	Intersections	Type	Classification of roadway facilities according to geometric and operational designation.		
		Signal control			
		Number of legs			
	Segments	Functional class			
		Divided/undivided			
		Number of lanes			
Period of Analysis	All	AADT	May not be available for all roads. An estimate may be used. Average of multiple years if available.		
		Crashes	10 years (2007-2016) for model development and 3 years (2017-2019) for analysis.		
Data Collection and Assignment	Intersections	AADT	Total entering traffic		
		Crashes	Located within 250 ft from intersection centroid. If two or more intersection buffers overlap, crash should be assigned based on proximity to the closest centroid.		
	Segments	AADT	Bidirectional traffic		
		Crashes	Crashes located outside intersection buffer. Crashes at residential or commercial driveways not designated as intersections will be included.		
Model Development	NA			Crash prediction models	The Negative Binomial will be used to develop crash prediction models for intersections and segments based on facility classification.
				Distribution factors	
Crash Analysis	NA			Empirical Bayes	Safety estimates will be obtained for all facilities using crash prediction models and observed data during the period of analysis.
				Crash frequency	
				Crash rate	
				Excess expected crashes	
				EPDO	
				LOSS	
High Injury Network (HIN)	NA			Ranking	Identify facilities with high fatal and injury crash occurrence. Network intersections and segments will be color coded according to the rank and level of safety.
				Level of safety	