KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING / PLANNING
354 SW Upper Terrace Drive, Suite 101, Bend, Oregon 97702 P 541.312.8300 F 541.312.4585

TECHNICAL MEMORANDUM

Bend Arterial and Collector Safety Project Program Development

Transportation Safety Framework Plan

Date:	July 9, 2012	Project #: 11645.0
To:	Robin Lewis, PE, City of Bend	
From:	Casey Bergh, PE and Brian Ray, PE	

The City of Bend and Kittelson & Associates, Inc. (KAI) are developing and implementing a data-driven transportation safety management program. This memorandum summarizes the framework plan that serves as the structure of the program. The framework plan outlines the purpose and desired outcomes of four program phases that will ultimately lead to a prioritized list of projects to reduce crash frequency and severity on arterial and collector streets in Bend.

As each phase of the program is completed, KAI will prepare a separate memorandum to document the evaluations conducted and the findings and recommendations of that phase.

BACKGROUND

This transportation safety framework plan was informed by the current status of the City's transportation safety program:

- The City does not have a formal and documented transportation system safety program and has lost 1.5 full-time equivalent staff (for budgetary reasons) that once focused on crash analysis and traffic safety.
- Multiple citizens and advisory committees in Bend want to help improve safety, but their goals often vary and the groups are not coordinated in their efforts.
- Past safety projects have been identified through citizen service requests or observations from City staff. These projects reflect perceived safety concerns and were not based on objective analysis because objective analysis tools have not been available.
- The City is in the process of creating a collector and arterials streets program and a separate bike and pedestrian program; these were previously combined. No safety project lists have been developed since this division.
- No formal criteria have been developed to prioritize projects for funding.
- The City is developing a traffic volume database and volume management program that will provide data needed to apply many of the tools and methods in the Highway Safety Manual (HSM).

Based on the City's desire for a comprehensive, systematic, and objective safety program, KAI has developed a program framework that applies crash analysis tools and methods provided in the HSM.

PROJECT GOALS

Goal #1: Systematically identify and prioritize safety projects

Goal #2: Establish a proactive approach to reducing crashes on Collector and Arterial Streets

Goal #3: Support a safety culture

Goal #4: Establish safety thresholds and measurable near- and long-term goals

Goal #5: Establish an objective process that can be repeated annually with input from the City of Bend Traffic Safety Advisory Committee (TSAC)

Goal #6: Apply engineering, education, enforcement, emergency response, and evaluation (a broad base of strategies) to achieve safety goals

FRAMEWORK PLAN

The overall framework includes four key phases, which can be performed as part of a cyclical process. The core phases of the safety management cycle are described in the flow chart in Figure 1. After an initial benchmarking phase is completed, benchmarking may not need to be repeated every cycle.

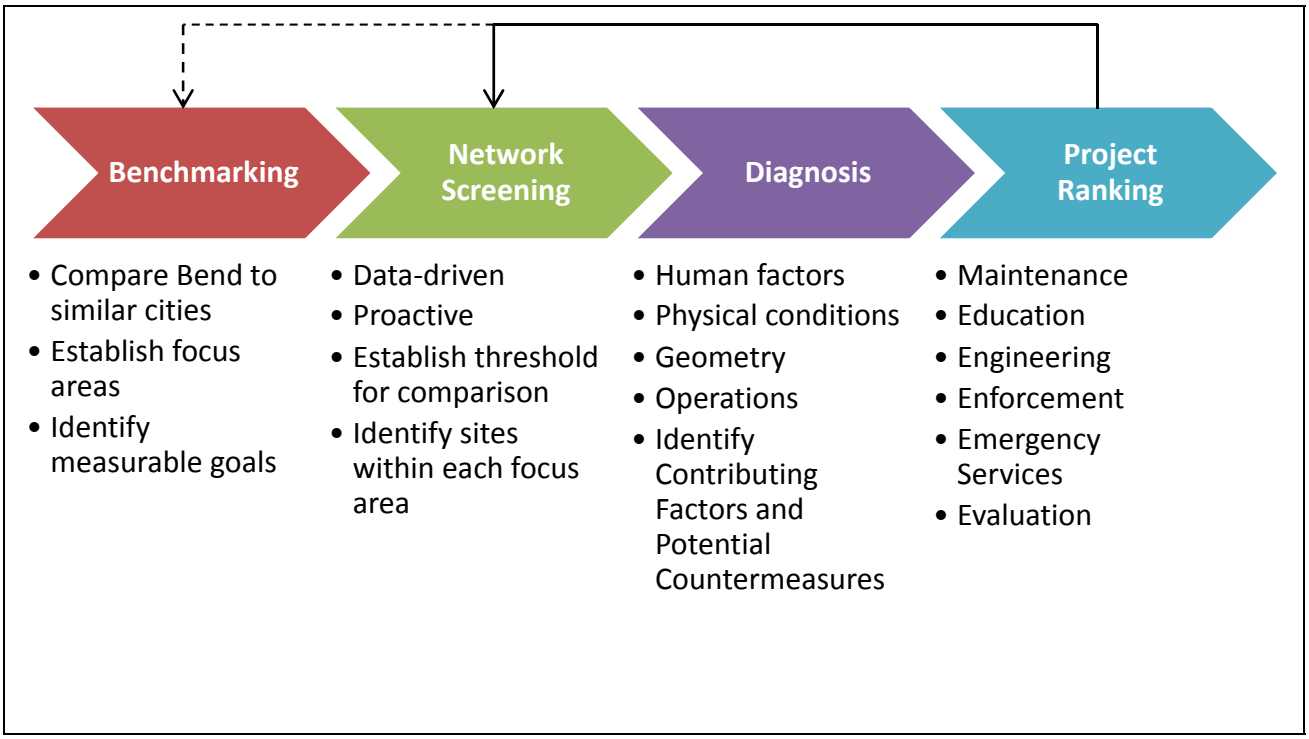

Figure 1 – Safety Program Management Framework

KAI will support the City of Bend in applying the safety management process on a limited basis to demonstrate the tools and methods. The goal and desired outcome of each phase shown in Figure 1 are described below.

BENCHMARKING

Goal: Understand crash trends and develop a point of reference for establishing safety priorities.

Benchmarking allows the City of Bend to compare its crash history with other cities of similar size. Although the safety program will focus on reducing specific crash types that have been frequently reported in Bend, this will provide an overall reference point for Bend. Overall, the City will use these comparisons and crash data analysis to determine crash trends that indicate opportunities to reduce frequency or severity of crashes. Those crash trends may reflect crash type (e.g., left-turn, angle, rear-end, etc.), severity (e.g., injury, fatality, property damage), or contributing factors (e.g., weather, aggressive driving, driving under the influence of alcohol, etc.).

This phase will inform the City and establish safety priorities (herein referred to as "focus areas") to define subsequent phases of the safety program for the duration of one or more program cycles. The benchmarking phase is not required to be completed every cycle and serves as an optional starting point. Benchmarking could also be conducted three to five years after implementation of the first round of safety countermeasures, as one measure of progress.

A two-tiered approach to benchmarking was developed to 1) qualitatively compare Bend crash experience with that of other cities and 2) evaluate specific crash characteristics and patterns for Bend to establish its focus.

While it is helpful to generally compare Bend with other Oregon cities, the primary value of the Bend crash data review is to identify opportunities to implement the 5 E's (engineering, education, enforcement, emergency response, and evaluation) to reduce the frequency or severity of crashes. The most valuable outcome of benchmarking is to identify three to five crash trends that indicate opportunities to reduce crash frequency and severity.

NETWORK SCREENING

Goal: apply objective methods to evaluate the City's network of arterial and collector streets to identify sites with potential for reducing crash frequency or severity

Network screening methods are described in detail in Chapter 4 of the HSM. The methods from the HSM have been adapted to fit the context of the City of Bend and the scope of this project. In general network screening includes the following steps:

1) Establish focus
2) Identify reference populations
3) Select performance measures
4) Screen and evaluate results

Establish Focus

Network screening is guided by the focus areas identified through the benchmarking phase. Once focus areas are established, they can be retained for multiple program cycles. Retaining the same focus areas for multiple cycles allows the City to apply adequate resources to address one area before moving onto another. New focus areas may be identified by City staff or through future benchmarking activities.

Identify Reference Populations

Network screening could be applied to all intersections on the arterial and collector street network, and it is likely that the screening would identify signalized intersections with the highest volumes as the top sites with potential to reduce crashes. Those screening results do not identify opportunities to improve crashes at unsignalized intersections or roundabouts, which may be more cost-effective. Therefore, several distinct subsets of the City's network (i.e., reference populations) will be established and network screening will be conducted for each to identify more opportunities to reduce crash frequency and severity throughout the City.

The HSM identifies the following as potential characteristics that can be used to establish reference populations:

- Traffic Control (e.g., signalized, unsignalized, roundabout, etc.);
- Number of approaches (e.g., three-leg or four-leg intersection);
- Cross-section (e.g., number of through lanes and turning lanes);
- Functional Classification (e.g., principal arterial, collector, local, etc.);

- Area type (e.g., urban, rural, suburban); and,
- Terrain (e.g., flat, rolling, mountainous).

Traffic control and functional classification data is available from the City of Bend GIS department, but at this time other reference populations cannot be established due to lack of GIS inventory data (e.g., roadway cross-section, posted speed, terrain, etc.).

Performance Measures

Performance measures are used to evaluate the crash data and result in a quantitative "score" at each site. The HSM identifies 13 performance measures that can be used in network screening. Selecting one or more performance measures is based on data available, desired statistical rigor, and the focus areas. Performance measures with the greatest statistical rigor apply crash prediction models to account for "regression to the mean" bias, which is commonly evident in safety evaluations. Although those methods provide the greatest reliability of the screening results, they require the greatest amount of data. Performance measures included in the HSM are summarized in Table 1.

While the statistical rigor of the performance measures influences the accuracy of the network screening, the accuracy of the crash data may have a greater influence on results. The crash data used in the network screening is provided by the Oregon Department of Transportation (ODOT). The ODOT crash database relies on individual drivers involved in a crash or local police departments to report the crash details if an injury results or damage exceeds $1,500. Therefore, many crashes are not reported and are not included in the network screening. Additionally, the crash details are not always consistently input, which further reduces the reliability of the data.

The City does not have traffic volume data in an electronic format from the last five years for all arterial and collector streets. Without average daily traffic volumes on all roadways the City is limited to applying the first four performance measures shown in Table 1. There are limitations to each of the four performance measures (e.g., some over emphasize severe crashes). Therefore, multiple measures can be applied to each focus area and the results factored together identify sites with the greatest potential for reducing crash frequency or severity.

The City is working with DKS Associates, Inc. to develop a model for collecting and managing traffic volume. The electronic volume data format will reflect the data needs of network screening to minimize data input efforts. As the volume database is populated (data will likely be obtained over a period of several years) and becomes available for use in network screening, additional network screening methods can be applied.

Table 1 Summary of Network Screening Performance Measures

Statistical Bias/Data Requirement Continuum*	City of Bend Implementation Category	Network Screening Performance Measure
	Short-Term – Data is available	Crash Frequency
		Equivalent Property Damage Only Crash Frequency
		Relative Severity Index
		Crash Type Performance Threshold
		Excess Proportion of Specific Crash Types
	Mid-Term – Requires volume data	Critical Rate
		Method of Moments
	Long-Term – Requires calibrated safety performance functions and detailed geometric information	Excess Predicted Crashes Using SPFs
		Level of Service of Safety
		Expected Crash Frequency with EB Adjustment
		EPDO Crash Frequency with EB Adjustment
		Excess Expected Crash Frequency with EB Adjustment

* Performance measures are sorted by implementation category, which generally reflects a reduction in statistical bias as additional data is included in analysis.

As shown in Table 1, three implementation categories have been identified for the City of Bend, which reflect data availability. The performance measures in the short-term implementation category will be considered in network screening. The City could begin applying performance measures from the mid-term implementation category as soon as volume data is available.

ODOT has developed calibration factors for Safety Performance Functions provided in Part C of the HSM. Although the models may be available from ODOT, application of these SPFs within network screening will require electronic inventory data including geometric information including: lane width, shoulder width, horizontal curve radius, etc.

Screen and Evaluate Results

Screening methods using data from the City of Bend and ODOT can help to identify sites having the greatest potential for reducing crash frequency and severity. The top four to six sites from each focus area can be identified for diagnosis and countermeasures selection.

Network screening methods can be applied to rank crash locations on roadway segments and at intersections (collectively referred to as "sites"). The most effective screening method can be determined based on the specific focus area. For example, left-turn crashes are most likely to occur at intersections, so intersection-based screening is most applicable.

DIAGNOSIS

Goal: Identify factors contributing to crashes and specific countermeasures to reduce the frequency and severity of those crashes.

Identify Contributing Factors

The diagnosis can include desktop and field reviews for those sites selected through network screening. For each site diagnosis could include reviewing the following three elements:

1) Crash data
2) Site history
3) Field conditions

Crash patterns and trends for each individual site should consider a five-year period. This data should be cross-checked with City records of construction or other factors that may have impacted the site over the same period. These activities are intended to identify factors that may have contributed to an increase or decrease in reported crashes over the five-year period. A list of questions and data to consider when reviewing historic information is provided in Appendix 5B of the HSM.

Field reviews following the desktop review can confirm contributing factors identified in the data and, potentially, identify other factors that may influence crashes. A comprehensive field review includes, as a minimum, travel through the site from all directions, considering elements of all travel modes. Specific items to consider during a field review are provided in Chapter 5, Section 5.4 of the HSM. A field review checklist provided in Appendix 5D of the HSM can serve as a reminder of various considerations and assessments that can be made in the field.

Identify Countermeasures

The contributing factors identified through the desktop and field reviews can be tied to countermeasures having the potential to reduce the number and/or severity of the crashes associated with contributing factors. In general, this step requires considering a range of countermeasures and narrowing the options to consider and select preferred countermeasures that have a documented ability (through empirical study) to reduce a specific crash type. This step uses Crash Modification Factors (CMFs) in the HSM and those identified in the Federal Highway Administration's (FHWA) website (www.cmfclearinghouse.org).

PROJECT RANKING

Goal: Evaluate the benefits and costs of identified safety improvement projects and rank each project to prioritize those that are expected to result in the greatest reduction in crash frequency and/or severity for the least cost.

Chapter 7 and 8 of the HSM outlines a variety of methods for ranking projects. The ranking is based on benefit-cost ratios for each project. Therefore, ranking requires monetary costs and benefits be identified for each project. Project cost estimates can be prepared based on unit costs established by the City. The CMFs identified for countermeasures can be used to estimate benefits in terms of crash reductions. Crash reductions are converted to monetary benefits based on estimates of design life and societal crash costs by crash severity.

When no quantitative estimates are available documenting the effectiveness of a countermeasure or project, the project may not be ranked. Therefore the ranked project list will only represent those projects with proven countermeasures having the greatest potential to reduce crash frequency or severity. Those projects that do not have proven countermeasures could still be implemented and their effectiveness in Bend could be studied through a before-and-after study.

NEXT STEPS

KAI will support the City of Bend in applying the safety management process outlined in this framework plan on a limited basis to demonstrate the tools and methods. As each phase of the program is completed, KAI will prepare a separate memorandum to document the evaluations conducted and the findings and recommendations of that phase.