STATEMENT OF PHILOSOPHY

The efficient and responsible investment of resources in addressing safety problems is a difficult task. Since crashes occur on all highways in use, it is inappropriate to say of any highway that it is safe. Road safety is a matter of degree. When making decisions effecting road safety it is critical to understand that expenditure of limited available funds on improvements in places where it prevents few injuries and saves few lives can mean that injuries will occur and lives will be lost by not spending them in places where more crashes could have been prevented[1]. It is MDT's objective to maximize crash reduction within the limitations of available budgets by making road safety improvements at locations where it would do the most good in avoiding the most crashes.

SAFETY PERFORMANCE FUNCTIONS and LEVEL OF SERVICE OF SAFETY

The assessment of the magnitude of safety problems on highway segments has been refined through the use of Safety Performance Functions (SPF). The SPF reflects the relationship between traffic exposure measured in Average Annual Daily Traffic (AADT), and crash count for a unit of road section measured in crashes per mile per year. The SPF models provide an estimate of the normal or expected crash frequency and severity for a range of AADT among similar facilities. Two kinds of Safety Performance Functions were calibrated to evaluate non-junction related crashes. The first one addresses the total number of crashes and the second one looks only at crashes involving an injury or fatality. Together they allow MDT to assess the magnitude of the safety problem from the frequency and severity standpoint. Additionally, SPF's were developed for total road departure crashes as well as road departure fatal and injury crashes.

Development of the SPF lends itself well to the conceptual formulation of the Level of Service of Safety (LOSS). The concept of level of service uses quantitative measures and qualitative description that characterize safety of a roadway segment in reference to its expected frequency and severity. If the level of safety predicted by the SPF will represent a normal or expected number of crashes at a specific level of AADT, then the degree of deviation from the norm can be stratified to represent specific levels of safety.

LOSS I - Indicates low potential for crash reduction
LOSS II - Indicates low to moderate potential for crash reduction
LOSS III - Indicates moderate to high potential for crash reduction
LOSS IV - Indicates high potential for crash reduction

LOSS boundaries are calibrated by computing the 20th and the 80th percentiles using the Gamma Distribution Probability Density Function. Gradual change in the degree of

[1] Hauer, E., (1999) Safety Review of Highway 407: Confronting Two Myths. TRB

deviation of the LOSS boundary line from the fitted model mean reflects the observed increase of variability in crashes/mile as AADT increases. This increase is consistent with a Gamma Distribution error structure and reflects dispersion around the mean typical of this highway environment. LOSS reflects how the roadway segment is performing in regard to its expected crash frequency and severity at a specific level of ADT. If the safety problem is present, LOSS will only describe its magnitude from the frequency and severity standpoint. The nature of the problem is determined through diagnostic analysis using direct diagnostics and pattern recognition techniques.

Additional detail on development of the SPF's and LOSS boundaries for rural state maintained routes can be found in the linked documents.

CORRECTING FOR REGRESSION TO THE MEAN BIAS USING THE EMPIRICAL BAYES METHOD

In road safety the average of several years of crash history of a highway segment or of an intersection provides us with an estimate of what is likely to be observed in the future. The precision of this estimate, however, can be improved upon by correcting it for the Regression to the Mean (RTM) bias. RTM phenomenon reflects the tendency for random events, such as vehicle crashes to move toward the average during the course of an experiment or over time. For instance if a segment or an intersection exhibits unusually high or unusually low crash frequency in a particular year, because of RTM we need to be aware that over the long run its true average is closer to the mean representing safety performance of similar facilities. The existence of the RTM bias has been long recognized and is now effectively addressed by using the Empirical Bayes (EB) method[2]. The use of the EB method is particularly effective when it takes a long time for a few crashes to occur, as is often the case on Montana rural roads.

The EB method for the estimation of safety increases the precision of estimation and corrects for the regression to the mean bias. It is based on combining the information contained in crash counts (known crash history) with the information contained in knowing the safety of similar entities. The information about safety of similar entities is brought into the EB procedure by the SPF through use of expected mean value and over-dispersion parameter associated with the specific SPF. EB corrected values of frequency and severity of crashes will be used in the SPF analysis to assess the magnitude of the safety problem.

[2] Hauer et al. Estimating Safety by the Empirical Bayes Method. In *Transportation Research Record 1174,* TRB, National Research Council, Washington, D.C., 2002, pp 126-131.

PATTERN RECOGNITION ANALYSIS AND DIRECT DIAGNOSTICS METHODOLOGIES

In the course of in-depth project-level safety studies of hundreds of locations, a comprehensive methodology was developed to conduct diagnostic analysis of safety problems for different classes of roads in various Montana environments. Direct diagnostics methods and a pattern recognition algorithm are described by Kononov[9] and Kononov and Janson[10].

Because traffic crashes can be viewed as random Bernoulli trials, it is possible to detect deviations from the random statistical process by computing the observed cumulative probability for each of the normative parameters. This continuous testing for deviations from the norms was achieved using a pattern recognition algorithm. The process of continuous pattern recognition was used to delineate boundaries of "abnormal" crash occurrence within the project limits on Montana state highways.

A framework of normative parameters was developed specifically for the Montana highways to provide a knowledge base for the diagnostic analysis. These parameters can be grouped into the following general categories: crash type, severity, crash location, road condition, direction of travel, lighting condition, vehicle type, human factors, driver condition, weather condition, and time of day. It is important to note that some, but not all, normative parameters within the same SPF change with AADT. For instance, in general, the severity of crashes gradually decreases and the distribution of crashes by crash type changes with AADT. With this in mind, normative parameters were stratified for three ranges of AADT: low, medium and high, when AADT used to calibrate the SPF contained all three categories. In the process of assessing the nature and magnitude of safety problems at specific locations, SPF analysis should be used in conjunction with an appropriate diagnostic investigation by using the pattern recognition algorithm. The stratification of the diagnostic parameters by AADT improves the ability to identify crash patterns more accurately.

[9] Kononov, J., (2003) Identifying Locations with Potential for Accident Reduction: Use of Direct Diagnostics and Pattern Recognition Methodologies. In Transportation Research Record No. 1840, TRB, National Research Council, Washington, D.C. 2002, pp 57-66

[10] Kononov, J. and Janson, B. (2003) Diagnostic Methodology for the Detection of Safety Problems at Intersections. In Transportation Research Record No. 1840, TRB, National Research Council, Washington, D.C. 2002, pp 51-56.