RESEARCH NOTES

September 2007

Caltrans

Implementation of a Tool for Measuring ITS Impacts on Freeway Safety Performance

(ATMS TESTBED PHASE III FINAL REPORT)

Why Was This Research Undertaken?

Reduced congestion and smoothed traffic flow are likely to improve safety, as well as reduce psychological stress on drivers. Using data from the Testbed, we have begun to document the relationship between safety and improved traffic flow. Recent developments indicate that the time is right to refine and implement analytical tools that can be used in real-time monitoring of the safety level of the traffic flow on any instrumented segment of freeway. As opposed to tools that measure freeway performance in terms of throughput or travel time, the data indicate that the key elements of traffic flow affecting safety are not only mean volume and speed, but also variations in volume and speed. We further determined that it is important to capture variations in speed and flows separately across freeway lanes, and that such information is useful in differentiating types of crashes.

For more in depth discussion and technical analysis, refer to TTR3-04 (Testbed Technical Report).

What was done?

The objective of this joint effort between the Testbed and PATH is to implement a real-time tool for safety analysis. The overall project goal is to calibrate and verify a tool that translates traffic flow, as measured by ubiquitous single loop detectors, into safety performance in terms of expected numbers of crashes by type of crash per exposed vehicle mile of travel. This tool can be used in monitoring the safety performance of freeway operations and to evaluate and document improvements to safety arising from such ITS deployment as system-wide ramp metering (SWARM), freeway service patrol (FSP) and other incident response measures, and driver information.

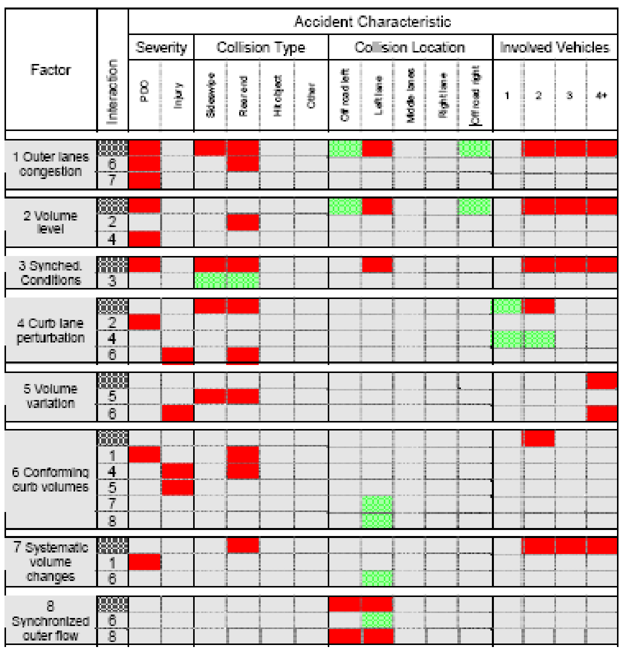
In work conducted thus far, we lay the groundwork for the development of a performance tool that gauges the level of safety of any type of traffic flow on a California freeway. The inputs to this tool are data from single loop detectors, so the tool can be implemented wherever such data are monitored or simulated. Our analyses are based on loop detector data for each of the freeway lanes for a short period of time preceding each of over 1,700 accidents in our case study. This case study covers the six major freeways in Orange County for a six-month period in 2001. The results have uncovered an extensive set of statistical parameters that capture those aspects of traffic flow that are strongly related to accident potential.

In this work we recognize that loop detector data at a specific time and place cannot be converted to speed, because it is not possible to know effective vehicle length at such a detailed level (that is, the mix of long and short vehicles is unknown at a specific place for a short period of time). Consequently, we avoid using any direct speed or density measures among the parameters. These parameters include not only central tendencies (means and medians), but also variations, and measures of systematic and synchronized traits that capture patterns in short period of loop detector data. Such patterns include breakdown from free flow to congested operations or recovery back to free flow, and differences in traffic conditions across lanes. We demonstrate that the parameters can account for speed and density, even though these are not used directly. Moreover, the parameters account for important differences among the types of accidents that occur under different type of traffic flow.

What can be concluded from the Research?

Eight Factors were found to account for approximately 79% of the variance in the original variables. In order to evaluate the effectiveness in describing derived parameters (speed and density), each of prohibited scaled measures was regressed on a set of forty-four variables, made up of the eight Factors, plus eight factor quadratic terms (the products of two like Factors), plus twenty-eight factor interactions (the products of any two different Factors). The regression results (not shown) for the means and standard deviations of occupancy and the ratio of volume to occupancy for each of the three lanes indicate that the Factors do very well to explain all of the prohibited variables that are proportional to traffic flow density and speed. The conclusion is that all of the original variables are sufficiently described by the eight Factors.

A summary of the main results of the analysis of accident propensity as a function of traffic flow is presented in the table below, in which the solid red cells indicate that the probability of the accident characteristic being present increases with the factor score, and the hatched green cells indicate a decreasing probability with an increase in the score. Each of the eight Traffic Flow factors is effectively related to at least two of the four sets of accident characteristics. This sensitivity bodes well for continued research into the development of hazard functions in the eight-dimensional space of the Factors and their second-level interactions.



Summary of Results

What do the Researchers recommend?

Work is needed to test the model's ability to distinguish locations and conditions with high accident rates from those with low accident rates. By quantifying the safety benefits accrued from smooth and efficient traffic operations, Caltrans should be able to incorporate safety measures in assessment of performance gains resulting from ITS deployment. Another application will be to forecast the safety implications of proposed projects by evaluating the levels of safety implied by traffic simulation model outputs. The safety aspects of costs and benefits can be assessed by comparing the levels of safety estimated by the tool for traffic flows before and after implementation of a treatment, such as a component of an intelligent transportation system (ITS) or infrastructure project. It can also be used to forecast the safety consequences of doing nothing. It is meant to complement performance measurement systems that focus on travel times and delay (e.g., PeMS).

Implementation Strategies

It has been demonstrated that an extensive set of statistical parameters, 36 in total, can be extracted from twenty minutes of loop detector data for three lanes at a specific location and time, without recourse to untenable assumptions that convert loop detector data to densities and speeds.

The objective in a follow up project is to test the model's ability to distinguish locations and conditions with high accident rates from those with low accident rates. In accomplishing this, we intend to establish accident rates in terms of vehicle exposure to different traffic conditions. Once exposure rates are established, code will be developed to deploy the model. The initial application will be as a stand-alone tool on the Testbed website using data from the Caltrans District 12 FEP as input.

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