Performance Measurement for Highway Winter Maintenance Operations

Tech transfer summary

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RESEARCH PROJECT TITLE

Performance Measurement for Highway Winter Maintenance Operations

SPONSORS

Iowa Highway Research Board
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IIHR's historic C. Maxwell Stanley Hydraulics Laboratory was dedicated as a National Historic Civil Engineering Landmark in 2005, placing it among the major structures of national importance to the engineering profession. The mission of the IIHR is to conduct research in water resources and environmental engineering.

Performance in winter maintenance operations can be measured by the speed reduction observed on the road. For a given road type and a given storm severity, a target speed reduction is given, and performance can be measured in relation to this speed reduction.

OBJECTIVES

The goal of this research project was to develop a method to measure the performance of winter maintenance operations. First, the impacts of winter weather on safety (crash rates) and mobility (average vehicle speeds) were measured. Second, a storm severity index was developed. Third, for a given road class and a given storm severity an expected speed reduction was developed, which can serve as a performance target for winter maintenance operations.

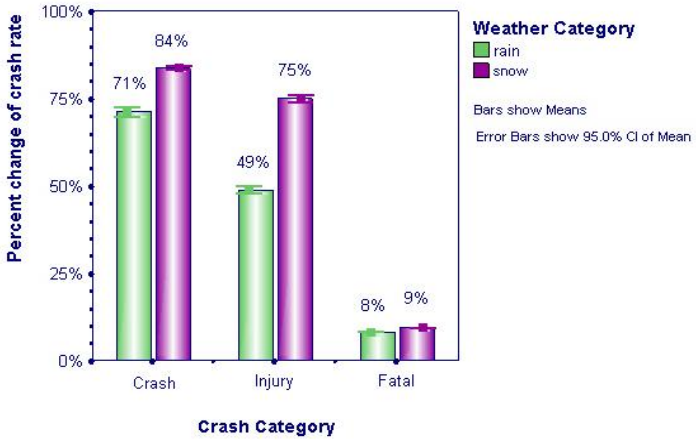

Figure 1: Impact of Weather on Crash Rates

PROBLEM STATEMENT

In any operational activity it is important to be able to determine how good a job is being done. In winter maintenance, this is difficult. Different storms pose different challenges. Different roads are maintained to different

levels of service. Additionally, a performance measure should have both strategic and tactical value – that is, it should allow not only a review of performance after a storm or a season, but an adjustment of actions during a storm in response to unacceptable performance measures.

The challenge is thus to find a measure that not only captures storm severity and road type, but also can be easily measured and acted upon in real time.

RESEARCH DESCRIPTION

A detailed meta-analysis of crash rates and mobility impacts gave clear measures of how much winter weather impacts the safety and mobility of the traveling public. Figure 1 shows that crash rates increase by 84% in snow conditions when compared to normal weather conditions. Using this information, an upper bound for losses of mobility and safety could be set and used as the maximum permissible degradation under the worst possible weather conditions. This result was extended to cover different road types as needed.

However, this result required further refinement to allow for the variation in winter storms. In order to do this it was first necessary to develop a simple yet comprehensive approach to describing a winter storm (see figure 2).

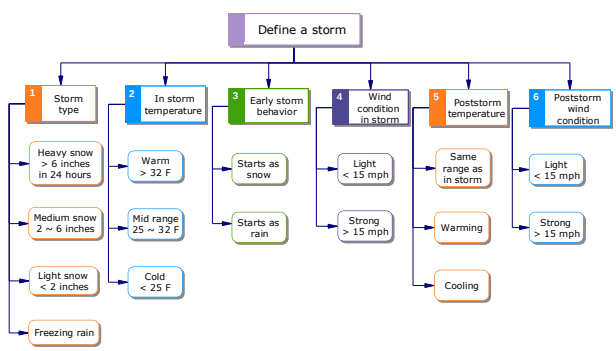

Figure 2: Schematic Description of a Winter Storm.

This description of a winter storm could be relatively easily converted into a storm severity index (SSI) using the equation:

$$SSI = \left[\frac{1}{b} * [(ST * Ti * Wi) + Bi + Tp + Wp - a]\right]^{0.5}$$

where a and b are constants, and the other variables correspond to the six descriptors in figure 2.

The maximum values of speed reduction due to adverse weather were found for three road priorities, using traffic data combined with weather data. For priority A roads, the maximum expected speed reduction is 17 mph, while for priority B and C roads it is 22 and 24 mph respectively. The performance goal is thus the product of the storm severity index for a given storm with the maximum expected speed reduction for a given road type. As long as winter operations keep the reduction in speed on a given road below this performance goal, then performance is judged to be acceptable.

KEY FINDINGS

The impact of winter weather on safety and mobility has been determined. Crash rates increase by 84% in winter weather compared to normal weather, and mobility losses may result in reductions of average speed of as much as 24 mph depending on storm severity and road type.

Winter storms have been described in a systematic and comprehensive, yet simple, way. This description is such that it can be converted into a storm severity index between 0 and 1. The index has been evaluated by maintenance supervisors, and has been adjusted to reflect their concepts of operational severity.

By combining road type and storm severity, a target speed reduction can be calculated for any road under any given storm condition. This speed reduction serves as a performance target that can be used both strategically and tactically. Provided speed reduction on a given snow route is less than the performance target, then performance is satisfactory.