EVALUATION OF A WAYSIDE HORN AT TWO HIGHWAY-RAILROAD GRADE CROSSINGS

In an effort to alert motorists and pedestrians to the presence of an approaching train and avoid accidents at highway-railroad grade crossings, locomotive engineers regularly sound a train-mounted horn as they approach the intersection. Locomotive engineers begin sounding the horn approximately 1/4 mile from the highway-railroad grade crossing. This warning exposes a segment of the local community near the tracks to the sound of the train horn as well as motorists and pedestrians who may be approaching the grade crossing. However, residents living near the grade crossing are not the intended target of this auditory warning and the train horn noise is perceived by many residents living near grade crossings as highly annoying.

One alternative proposed to address the adverse effects of train horn noise is a stationary horn mounted at the grade crossing. The stationary horn, referred to here as a wayside horn, is sounded in place of the train horn as the train approaches the grade crossing. Previous research addressing wayside horns have examined whether the wayside horn is detectable by motorists. Wayside horns evaluated in the past were less detectable than commonly used train horns (Keller and Rickley, 1993). The train horns tested contain a broader band signal that is more difficult to mask than the wayside horn. Rapoza and Rickley (1995) using acoustical data determined that a wayside horn with a single tone and a maximum sound level of 87 dBA would be less detectable inside a moving motor vehicle than the Nathan 5 chime and Leslie 3 chime train horns that predominate most locomotives today. Another study (Saurenman and Robert, 1995) evaluating a different wayside horn, but with a maximum sound level of 85 dBA, found similar results. The motorist could detect the audible warning up to 400 feet from the grade crossing when the car was idling. However for a moving car in which the background noise level was in the 55-65 dBA range, the motorist would fail to detect the wayside horn in time to stop before arriving at the grade crossing.

Previous research on wayside horns still leaves many important questions unanswered. One critical question that needs to be answered is whether the community noise impact of a wayside horn reduces annoyance to the local community compared to a train-mounted horn or whether it simply moves the area of impact to a different part of the community? Currently, there is no research that specifically addresses whether a wayside horn would reduce the noise impact on the community. If the wayside horn is to be successful it must minimize the impact of the auditory warning on residents living in the vicinity of the grade crossing. The current study addresses this concern.

Another question that needs to be answered is whether safety is maintained when a wayside horn serves as the auditory warning in place of the train horn? Previous research has addressed the question of effectiveness in maintaining safety by looking at detectability of the horn. Using detectability of the train horn as a performance measure may not be directly related to motorist behavior. A different method of evaluating safety is to examine driver behavior directly. Observing motorist behavior at the grade crossing will help determine how auditory warnings influence driving behavior. The current study attempts to address this concern by examining how motorists respond in the presence of a wayside horn and a train horn.

It is important to emphasize that the current research evaluates the viability of the wayside horn as a warning concept. Although the study evaluated one particular device in terms of its effectiveness in warning motorists and minimizing community noise impact, the study is intended as a test of a class of auditory warnings located at the grade crossing. To the extent other auditory warnings are designed similarly, similar performance would be expected.

The study was conducted in Gering, Nebraska and compared the performance of train horns on Union Pacific locomotives (Leslie 3 chime) to a prototype wayside horn. The type of train horn evaluated was determined by the type of horn mounted on the locomotive. The majority of the trains observed moving through Gering (approximately 95%) consisted of Union Pacific locomotives carrying coal. These Union Pacific locomotives possessed a Leslie 3 chime horn. The wayside auditory warning device selected for evaluation was designed by Merrill Anderson of Railroad Consulting Services, Inc. The device consisted of a horn, a tone module containing the sound recording of an air horn, a control board that received the signal from the track circuitry and activated the horn. On top of the horn case was a strobe light that served as a visual signal for the locomotive engineer that the wayside horn was sounding. A small circuit board and detector installed inside the horn case activated the strobe light if the horn emitted a signal at least 80 dB. If the wayside horn was less than 80 dB, the strobe light remained off. The activation of the wayside horn was tied to the same circuitry that activated the crossing gates, flashing lights, and crossing bells.

For the current evaluation, two wayside horns were mounted on a utility pole with each horn directed toward oncoming traffic, at each of three grade crossings in Gering Nebraska. We monitored performance at two of these grade crossings: Tenth Street and Country Club Road.

Community Noise Impact

To evaluate the community noise impact of the wayside horn, two surveys were administered by telephone. The surveys asked respondents how annoyed they were by the two auditory warning devices, the activities it interfered with and what actions they took in response to the noise. The first survey measured the impact of the train horn on community noise. The second survey measured the impact of the wayside horn on community noise. Data from the two surveys were compared to evaluate the difference between the two warning devices on community noise impact.

The evaluation of community noise impact indicates that the wayside horn tested is considerably less annoying than the train horn. The wayside horn reduced noise levels to a point where far fewer residents were highly annoyed. The wayside horn was less likely to interfere with activities inside or outside the home and generated fewer actions to minimize the noise.

The variable that best predicted if someone was highly annoyed was the frequency with which the horn was heard. The greater the horn count, the more likely a resident was to be highly annoyed. High annoyance was also related to the activities that were interfered with. The relationship between activity interfered with and high annoyance varied by time of day. During the day, interference with conversation contributed to high annoyance. During the evening, interference with both conversation and reading contributed to high annoyance. Finally, during the night, only interference with sleep contributed to high annoyance.

Acoustic Analysis

The objective of the acoustic analysis was to document the sound level and frequency content of the in-service locomotive horn and the wayside horn. In addition, the acoustic data collected was compared to the community noise impact data collected from the survey of the local residents to examine the relationship between noise level and annoyance. The objectives were met by conducting sound level measurements of both the locomotive horn and the wayside horn at fourteen sites surrounding the three grade crossings in Gering, NE.

At peak sound levels, the wayside horn was approximately 13 dB quieter than the train horn. The lower sound level of the wayside horn compared to the train horn was a significant factor in explaining why the wayside horn was perceived as less annoying than the train horn. Unlike the train horn, the wayside horn did not meet the minimum sound level required of train horns. However, this study did not directly answer what the actual sound level should be for motorists to reliably detect this signal inside the vehicle. The frequency distribution of the wayside horn was similar to the train horns measured in this study.

For the 14 sites where sound measurements were collected, the wayside horn had a negative community impact only during nighttime hours using guidelines developed by the FTA. Only the sites defined as severe impact resulted in community annoyance high enough to require action to mitigate the noise. For the wayside horn, the location of the sights defined as severe were all within 100 feet of the track. By contrast, locations defined as severe impact for the train horn were located up to 1000 feet from the track. Clearly, the wayside horn impacted residents over a smaller geographical area.

The current study was unable to establish a relationship between measured sound level and perceived annoyance value, as measured in the two surveys. In part, this is due to measurement error in assigning sound level values to each respondent. However, previous research has been unable to attribute more than a small portion of the variance (20%) in perceived annoyance to physical noise levels. Other factors such as frequency with which the horns are heard and the activities the respondent is engaged in at the time the horn sounds also play a role.

Evaluation of driver behavior

The use of an alternative warning device to the train horn must also provide an effective warning to the motorist, if accidents are to be prevented. The primary objective of the driver behavior evaluation was to assess the safety of the wayside horn. To meet this objective, we used video cameras to record and observe driver behavior at two grade crossings for both the train horn and the wayside horn. We observed when motorists drove through the grade crossing following activation of the warning systems. We measured both the frequency of the violations and the time to collision. Violations were selected rather than accidents because they occur at a much higher frequency than accidents. Accidents at one or two grade crossings occur at too low a frequency to detect performance differences.

This evaluation of motorist behavior suggests that the wayside horn does not result in behavior that puts the driver at increased risk compared to the use of the train horn. The frequency of violations was lower for the wayside horn than the train horn, while the time to collision and violation time was not statistically or practically different for either warning system.

In both the train horn and wayside horn conditions, driver behavior was determined in part by the presence of the gates. To the extent that gate behavior controls motorist behavior, differences between the two warning devices may have been masked. Data from Richards et al's (1991) study on optimal warning times indicates that as the time delay increases between when the warning is initiated and the gates completely descend, motorists are more likely to continue through the grade crossing without stopping. The gate descent time in this study was relatively short (10 s). This short descent time may have reduced the overall violation rate compared to grade crossings with longer descent times. Motorist behavior with the two warning systems may or may not vary as gate descent time increases. Evaluating the two warning systems with longer gate descent times would provide an answer to this question. An evaluation of the two warning devices without gates at the crossing would indicate how these devices compare without the influence of gates.

Implementation Issues

The current study did not set out to evaluate how the wayside horn *should be implemented* to maximize safety while minimizing community noise impact. Nevertheless, a variety of implementation issues will impact safety at the grade crossing as well as community noise. Some of these issues were identified along with issues they raise and potential solutions. These issues included method of activation, hardware design and standardization.

Two methods of activation were identified: track circuitry and engineer activated. There are trade-offs that must be considered in selecting either method. The engineer activated method has not been subjected to evaluation in revenue service, but remains a promising approach. Activation by track circuitry with constant warning times is a viable approach if the track circuitry is reliable. Assuming the track circuitry is reliable, the opportunity to use this method will depend upon the availability of grade crossings with constant warning track circuitry. Currently constant warning time track circuits are available at only a small percentage (13 %) of the grade crossings protected by active warning systems (Volpe Center and PRC, In Preparation). Although the auditory warning could also be activated by fixed block track circuits, this approach is problematic. As the time between activation of the warning device and the actual presence of the train increases, motorists are less likely to heed the warning.

The current evaluation also identified several issues related to the design and maintenance of wayside horn. Exposure to the elements impaired the performance of several hardware components. The components of the wayside horn must be designed to withstand the extremes of weather found in the United States. The system also needs to be designed to facilitate ease of maintenance. Important design features that contribute to ease of maintenance include: minimizing the number of components, using modular components that are easy to replace, and designing the housing to facilitate ease of access. Finally, standardization of the auditory signal was recommended to facilitate quick motorist recognition and action.

Conclusions

In this study, the wayside horn reduced community noise without adversely affecting safety. However, this study was limited in scope. It evaluated community noise in only one community and measured safety at only two grade crossings. This type of evaluation needs to be repeated to determine to whether the results apply over a broader range of communities and grade crossings, and over a longer period of time. Evaluating this warning concept under a wider array of conditions (i.e., different sound levels, variable gate descent times, without gates, different activation method) will also help to determine whether the wayside horn can accommodate an adequate level of safety as well as an acceptable community noise level.

REFERENCES

Keller, A.S. and Rickley, E. (1993). *The Safety Of Highway-Railroad Grade Crossings: Study of the Acoustic Characteristics Of Railroad Horn Systems*. Report No. DOT/FRA/ORD-93/XX. Washington, D.C: U.S. Department of Transportation, Federal Railroad Administration.

Rapoza, A. and Rickley, E.J. (1995). *The Safety of Highway Railroad Grade Crossings: The Effectiveness of railroad Horn Systems*. Report No. DOT/FRA/ORD-95/XX. Washington, D.C: U.S. Department of Transportation, Federal Railroad Administration.

Richards, S.H., Margiotta, R.A. and Evans. G.A. (1991) *Warning Time Requirements at Railroad-Highway Grade Crossings with Active Traffic Control*. Report No. FHWA-SA-91-007. U.S. Department of Transportation, Federal Highway Administration.

Saurenman, H. and Robert, W.E. (1995). *Test of Wayside Horn Concept for Audio Warnings at Grade Crossings: Final Report*. Los Angeles, CA: Los Angeles Metropolitan Transportation Authority.

Volpe National Transportation Systems Center and PRC. (In Preparation). *Highway-Railroad Grade Crossing Active Signal Systems Analysis*. Washington, DC. Federal Railroad Administration.