FIELD STUDY OF A WAYSIDE AUDITORY WARNING FOR MOTORISTS

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An Unintended Effect of Train Horn Noise

As part of the warning system designed to protect motorists and avoid accidents at highway-railroad grade crossings, train engineers are required to blow a horn as they approach the intersection. Federal regulations require the train horn to be at least 96 dB(A) 100 feet in front of the train in its direction of travel (CFR 229.129, 1992). The noise from the train horn is considered by many residents living near grade crossings as unacceptable.

Locomotive engineers begin sounding the long-long-short-long sequence that typifies the train horn signal approximately 1/4 mile from the highway-railroad grade crossing. The duration of this auditory warning signal varies with the speed of the moving locomotive, but it ranges between 20 and 40 seconds and covers the distance from the whistle board to the grade crossing (approximately 1/4 mile). This 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. The train horn noise is perceived by many residents living near grade crossings as highly annoying. As economic conditions improve and railroad traffic increases, the degree of exposure to the noise from train horns also increases resulting in greater impact on the local community.

To minimize the impact of noise from the train horn, residents may take a variety of actions that may include: closing their windows, wearing ear plugs, turning up the volume on their TV or radio, moving to another location and complaining to local and state officials. In Florida, the state legislature passed a law, allowing communities to ban the sounding of train horns during certain hours of the day. However, the Federal Railroad Administration (Florida's Train Whistle Ban, 1992) found that the whistle ban lead to an increase in the number of accidents at those grade crossings. While the FRA preempted the Florida whistle ban, the original problem remains. The daily exposure to train horns for many people living near grade crossing reduces their enjoyment of life. Pressure remains to reduce the annoying effects of the train horn noise. The question is, how do we achieve this goal while still maintaining safety at the grade crossing for motorists and pedestrians?

A Solution that Maintains Safety at the Crossing

One solution for reducing the impact of train horn noise is to place a horn at the grade crossing and direct it toward oncoming traffic. Instead of blowing the horn mounted on the

train, a stationary, wayside-mounted horn would be activated when the train approaches the grade crossing. For a typical application in which traffic approaches from two opposing directions, two horns would be mounted at the grade crossing, one facing oncoming traffic in each direction. Thus, the noise from the horn would be directed where it is needed most, down the road toward traffic approaching the grade crossing. Residents living near the tracks, but out of the path of the wayside horn, would receive less exposure to the noise from a stationary device located at the grade crossing. However, residents living in the path of the wayside horn might receive greater exposure. Although residents living in the path of the wayside horn may receive greater noise exposure, this exposure can be mitigated through the use of barriers or home insulation.

One critical question that needs to be answered before such a device should be implemented is to determine whether safety is maintained when a wayside horn serves as the auditory warning in place of the train horn. Another question that needs to be answered before deciding whether this is an effective solution, is to learn 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?

The purpose of our research is to answer both these questions. This project is part of a cooperative effort supported by the FRA and involving the City of Gering, Nebraska, Railroad Consulting Services, Union Pacific, and Volpe National Transportation Systems Center (Volpe Center). The remainder of this paper describes how the wayside mounted auditory warning works, describes the methodology developed to evaluate community noise impact and safety, and presents preliminary observations on the operation of the system and how it affects the local community.

Description of the Auditory Warning Device

The auditory warning device selected for evaluation was designed by Merrill Anderson of Railroad Consulting Services, Inc. The device, shown in Figure 1, consists of a Federal Signal selectone horn (model 302-GSX), a tone module that contains the sound recording of a dual air horn designed for boats (Alpex sound blaster), a control board which receives a signal from the railroad and activates the horn. The circuit board activates the horn at the same time as the crossing gates are activated. On top of the horn case is a Federal Signal strobe light (model 131ST) that serves as a visual signal for the locomotive engineer that the wayside horn is sounding. A small circuit board and detector installed inside the horn case activate the strobe light if the horn emits an 80 dB signal. If the wayside horn fails to activate, the strobe light remains off. In this situation, the engineer would blow the train horn.

The activation of the wayside horn is tied to the same circuitry that activates the crossing gates. When the track circuitry activates the wayside horn, it repeats the following sequence until the train reaches the grade crossing:

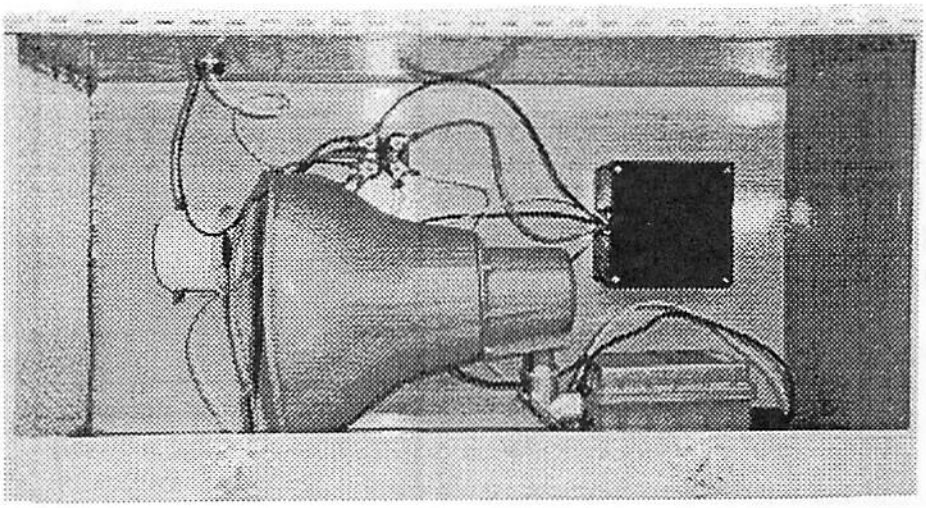

Figure 1. Wayside Horn.

Sequence	Duration On (seconds)	Duration Off (seconds)
1	3	1.5
2	3	1.5
3	1.5	1.5
4	3	1.5

When the train reaches the grade crossing the wayside horn sounds for five seconds. The horn produces a sound pressure level of 114 dB at 10 feet and 98.9 dB at 50 feet.

For the current evaluation, the wayside horn system is mounted on telephone poles as shown in Figure 2 on both sides of the street at three grade crossings in Gering, Nebraska. We are monitoring performance at two of these grade crossings: Tenth street and Country Club road. The Tenth street grade crossing intersects a busy main road (Average Daily Traffic Count = 11,240) running through a commercially zoned part of town. The Country Club road grade crossing intersects a relatively quiet road (Average Daily Traffic Count = 2,415) running through a residential neighborhood.

Methodology

To assess the safety and community noise impact of the wayside horn, we are performing a comparative evaluation in which community noise impact and motorist behavior are measured for both a wayside horn and a conventional train-mounted horn. Acoustical measurements will also be collected to determine the acoustic characteristics (i.e., sound level, frequency content, and directivity) of the wayside horn. Community noise impact will be measured by collecting acoustical measurements for the two warning devices and analyzing data from two surveys conducted by the City of Gering. Motorist behavior will be evaluated by measuring the number of motor vehicles that go around fully descended crossing gates, using video recordings of motorist behavior. A brief description of each method follows.

Acoustical Analysis

Previous research evaluating the design of wayside horns as auditory warning devices addressed whether the signal was loud enough to be heard by the motorist. Keller and Rickley (1993) found that the previous designs using a pure tone were not as loud as commonly found train horns such as the Leslie 3 chime and the Nathan 5 chime, and was too quiet to be reliably detected by the motorist. The current auditory signal differs from the previous version by using a multi-tone signal modeled after a boat horn.

To evaluate the new multi-tone signal, acoustical measurements will be collected at the two grade crossings, Tenth street and Country Club road for both the wayside horn and for

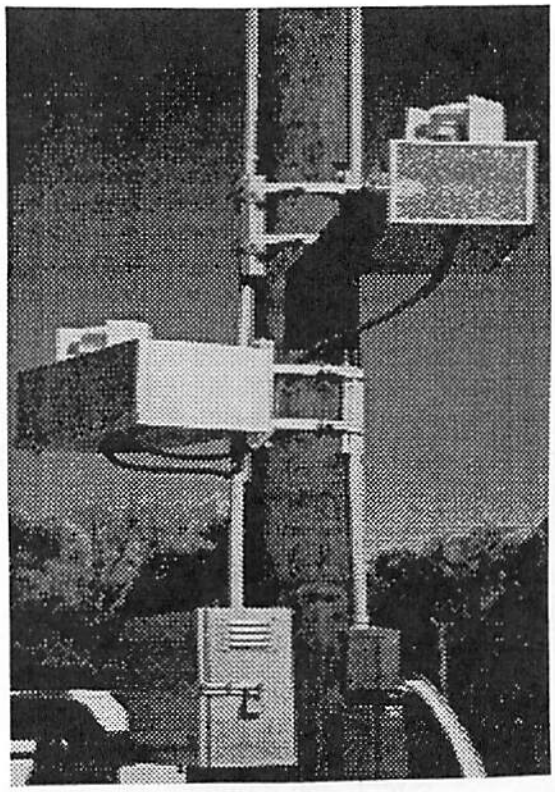

Figure 2. Wayside Horn on Utility Pole.

conventional train horns. Twelve acoustic measurement sites will be located within an 800 ft radius half circle centered on the grade crossing as shown in Figure 3. Four of these sites will be located down the approaching roadway, 100, 200, 400, and 800 feet from the crossing and the remaining eight along the radials $\pm 45°$ to the roadway at the same four distances. Eleven of the twelve sites will be instrumented with sound measurement equipment capable of determining the Sound Exposure Level (SEL) and maximum A-weighted sound levels (LAmax) of individual noise events, as well as capturing the A-weighted time history (i.e., the A-weighted sound level of the event over time) of these events. The other site will be instrumented with sound measurement equipment capable of recording the frequency content, as well as the SEL and maximum A-weighted sound levels of individual noise events. The system will be placed 100 feet from the crossing down the approaching roadway and used as a reference position for calibrating levels from one event to the next. The acoustic analysis will compare the following acoustic characteristics for both devices: sound level, frequency content and directivity.

Survey of Community Noise Impact

To evaluate the community noise impact of the two warning devices, the City of Gering is conducting two telephone surveys. A Pretest-Posttest design was selected to compare the impact of community noise of the wayside horn to a train horn. The pretest condition will measure the effect of the train-mounted horn on community noise prior to the installation and operation of the wayside horn. The posttest condition will measure the effect of the wayside horn on community noise after the wayside horn has been in operation for at least three months. For each survey, volunteers working for the City of Gering will interview approximately 300 residents living in the vicinity of the two grade crossings, Tenth street and Country Club Road. The Volpe Center will offer technical expertise to the City of Gering in designing the surveys and analyze the data for the City, following their completion.

The questions in the survey address the following issues:

1. How annoying is each warning device?

2. What activities does each warning device interfere with?

3. What actions were taken to minimize the effects of the noise?

We will attempt to determine how the residents' attitudes and behaviors change as a function of the two types of warning devices. More specifically we will try to answer the following questions:

1. Are fewer residents annoyed by one device than the other?

2. Does the location of residents who are annoyed change for the two warning devices?

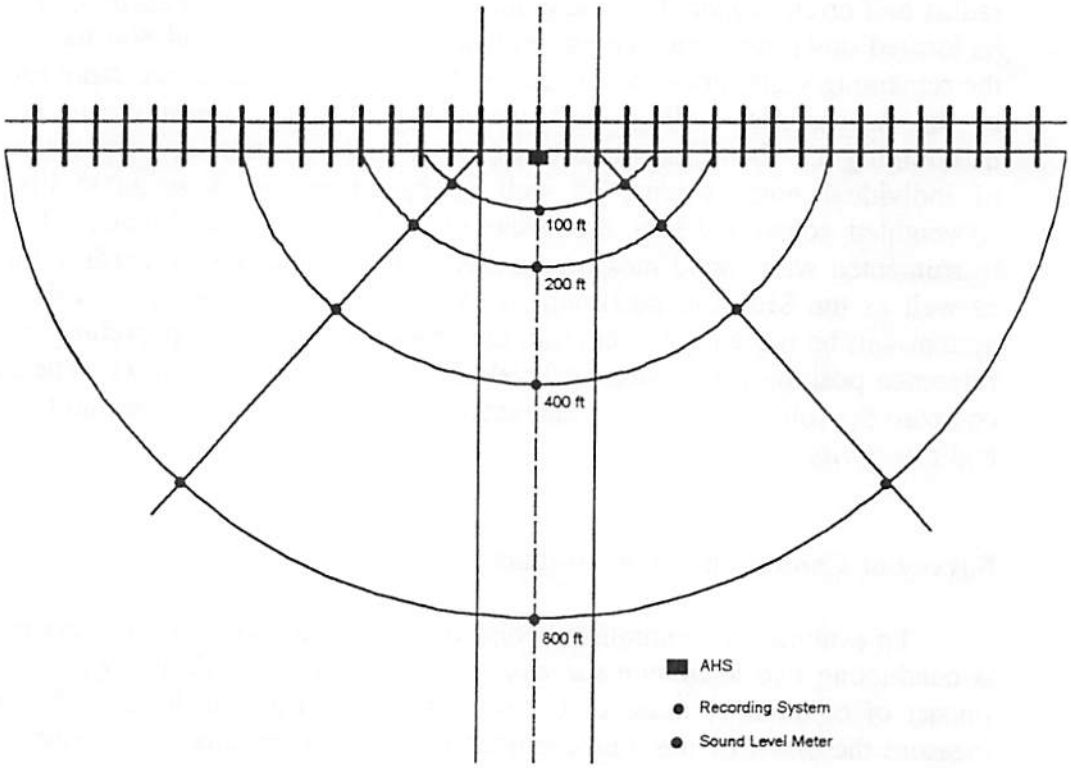

Figure 3. Acoustical Measurement Sites.

Video Analysis of Motorist Behavior

The primary objective of the video analysis is to determine if the wayside horn provides a warning to the driver comparable to existing train-mounted horns. To meet this objective, we will compare the number of violations in the two warning systems. Three types of violations will be defined that measure motorist behavior. The three types of violations vary in the degree of risk associated with each behavior:

Violation	Description
Type 1	Vehicle drives over crossing after horn activated, but before gates descend
Type 2	Vehicle drives over crossing as gates descend
Type 3	Vehicle drives

A violation is defined as a vehicle driving around the gates after they have descended. Once we know the number of violations for each warning device, we can determine whether there are any statistically significant differences between the two devices.

We will use a Pretest-Posttest design to compare driver behavior on the wayside horn to a train horn. The pretest condition will measure the effect of the train-mounted horn on driver behavior. The posttest condition will measure the effect of the wayside horn on driver behavior. There will be at least a three month gap between the pretest measurements and the posttest measurements to give motorists time to adjust to the new warning device.

For both conditions, we plan to collect 12 weeks of data, with data being collected for a period of 60 seconds following activation of the grade crossing signal. A video camera located at both the Tenth Street grade crossing and Country Club road grade crossing will be mounted on utility poles at the grade crossings. The same circuitry that activates the crossing gates and wayside horn will also signal the video camera to begin recording.

Current Status of Evaluation and Preliminary Observations

The following observations cover perceptions of the train horn noise and the wayside horn, as well as the operation of the wayside horn. These observations came from personal observation by Volpe Center staff and informal discussions with local residents, city officials, and Union Pacific personnel. Because the comments were solicited informally from a small number of residents, they may not be representative of the community at-large. However, they do illustrate some of the attitudes toward these devices and the problems associated with them.

Perception of Train Horn Noise

Thus far, the first survey soliciting information about the community noise impact of the train horn has been completed. The data are being coded and prepared for analysis. In addition to the survey, Gering town officials, local residents and Union Pacific personnel were interviewed with regard to their perceptions of the train horn noise.

Gering Nebraska is a community of approximately 8,000 people, living in an area of 3.2 square miles. Figure 4 shows a map of Gering and the location of the grade crossings. The number of trains passing through Gering ranges between 35 and 50. The perceptions of the train horn noise varies with residents' location with respect to the tracks and grade crossings. This is due in part to the proximity of the grade crossings to each other. There are four grade crossings in Gering, two of which are within a quarter mile of each other. The proximity of the two crossings to each other results in almost continuous blowing of the train horn through these grade crossings. This condition exposes people living near these two crossings to more noise than other segments of the community.

Comments by local residents found in newspaper articles and letters to city officials as well as informal interviews indicate that the noise from the train horn interferes with an array of activities both in the home and in public settings. Residents complain of difficulty hearing conversations in person and on the telephone and listening to TV or to radio. Sleep disturbance is also a common complaint. One resident indicated that during the night, noise from the train horn also disturbed dogs living in the area, who respond by howling. This added to the annoyance associated with the train horn.

In public, the train horn noise interfered with services at a nearby church. In contrast to the concern about noise pollution voiced by many residents, several school officials voiced more concern with the safety impact of the train horn in warning schoolchildren to keep off the tracks. Interestingly, the horns did not disrupt class at the elementary school, although it is located near one of the grade crossings.

The range of opinions about the noise from the train horn varies from those that have adjusted to the noise and think others are making much ado about nothing to the more frequently offered comment that the tracks should be blown up. The following two quotes illustrate the extremes of opinions.

> *Personally I think they're just a bunch of cranks. I live about 150 yards from the tracks. When the trains go by it rattles the windows. Some of 'em even broke and we had to replace our storms with Plexiglas. But I don't even wake up anymore. You just get used to it.*

More frequent, was the following type of comment:

Figure 4. Map of Gering, Nebraska.

My husband thought of blowing up the tracks. I'm glad he's not a demolition expert. You know, I've heard as many as 32 blasts from those trains going through town. Some of those engineers just don't know when to quit.

The last comment also reflects the opinion by some residents that some engineers blow their horn to purposely disturb residents. Associated with this belief is a desire for retribution which is captured in the following quote:

I've lived next to the tracks my whole life. You never get used to the noise. You can't sleep. Its the engineers. Some guys just really lay on the horn like they're out to get you or something. Sometimes I'd like to get a dummy and set it in the middle of the track so they'd run into it and think they hit somebody. You, know get them back for all this crap. I'd never do it, but I think about it sometimes.

The feeling that engineers purposely blow their horns in a way that disturbs the residents may result from the variability in the way the horns are blown and from the belief that engineers' can control the sound level and duration of the horn. Older locomotives like the SD-40 allow the engineer to manually control both the volume and the duration of the sound. Discussions with engineers who pass through Gering indicate that they differ in the duration and loudness levels at which they sound the horn (Coplen, 1994). Some engineers consistently blow their horn at the highest volume. Others vary the duration and loudness level as a function of time of day or environmental conditions (i.e., visibility).

Newer locomotives give the engineer less flexibility to modify the horn sound level. Locomotives like the SD-60 possess horns with an automatic sequencer. When the engineer activates the horn, it automatically sounds the required sequence, all at the same decibel level (Coplen, 1994). Residents perceive these horns as being significantly louder than the horns on the older locomotives over which the engineer has control. Tests performed by Union Pacific confirm that noise from the SD-60 locomotive is louder than from the SD-40 locomotive, although they both use the same horn.

From the engineer's perspective, the train horn is the only grade crossing warning device over which he or she has some control (Merklin, 1989). In avoiding accidents where the train cannot stop in time at the grade crossing, blowing the train horn provides the only means for the engineer to warn motorists and trespassers of the approaching train.

Wayside Horn Operation

In July 1994, the wayside horns were installed at the three grade crossings and testing began to make sure they operate properly. The video recording equipment was also installed at two of the grade crossings, Tenth Street and Country Club Road. The first video recording period during which the train horn will blow as the train approaches the grade crossing is expected to begin soon (October 1994).

Following installation of the wayside horns at three grade crossings in July, several residents reported hearing both the train horn and the wayside horn. Several factors contributed to this outcome. They included equipment failures, misunderstandings of when the train horn was to be sounded, and liability concerns on the part of the engineers. A lightening strike blew a circuit board controlling the wayside horn at the Country Club Road crossing shortly after installation. Although the circuit board was replaced in the first week of operation, the engineers blew the train horns at this grade crossing until it was repaired.

Many engineers were unclear about how the system worked, were uncertain that the wayside horn would operate as intended, and in particular were concerned over their liability in the event of an accident at crossings where the wayside horn was installed. Initially, not all engineers were aware of the General Order instructing them to avoid blowing their horn when the wayside horn was operating, as signaled by the activation of the strobe light. Many engineers did not understand that the strobe light signaled that the wayside horn was sounding at the grade crossing. Since they could not hear the wayside horn in the cab, they blew their horn. Adding to their concern was the issue of their liability in an accident. Some engineers expressed concern that they might be sued if they failed to blow their horn. Some engineers suggested installing event recorders at the grade crossing to record whether or not the wayside horn sounds (Coplen, 1994) .

During the shake-down period, some engineers reported difficulty seeing the strobe light in low visibility conditions, where fog impaired the engineer's vision. This problem suggests that a more effective method of conveying information about the operation of the wayside horn may be needed. Tail ring was also observed, in which the wayside horn sounded after the train passed over the grade crossing, as the gates were ascending.

At this time, very little information is available about the community noise impact of the wayside horn. During the times when the wayside horn is activated in place of the engineer sounding the train horn, comments from city officials and local residents suggest that fewer residents outside of the path of the wayside horn are annoyed. Comments received by local officials have been overwhelmingly positive. However, one resident living directly in the path of the wayside horn complained to city officials about the wayside horn. How representative that complaint is of the residents living in the path of the wayside horn is unknown. Although, it is reasonable to expect more complaints from residents living in the direct path of the noise than from those who do not, we still do not know the number of people who are affected. The results of the second survey addressing the community noise impact of wayside horn should answer this question.

Conclusion

To summarize, the collection of survey and video data will continue into the Summer of 1995 when data collection will be complete. The results of the shake down period identified a number of problems that need to be corrected. The most important issue revolves around the feedback mechanism for telling the engineer whether the wayside horn is working properly.

The use of a visual signal located at the grade crossing to convey information to the engineer about the status of the wayside horn operation is problematic. Difficulties in communicating how the feedback system works and assuring the engineer that the system is in fact operating properly also suggest that a better mechanism is needed to convey information about the working order of the wayside horn. One solution might be to locate the visual signal closer to the whistle post. However, this solution presents problems if the wayside horn stops working after the train has passed the visual signal. Another method sends a signal to the engineer in the locomotive cab. This approach is being considered by the Los Angeles Metro for the Blue Line Grade Crossing Demonstration Program in California.

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