# A SAFETY EVALUATION OF THE RCL AUTOMATED HORN SYSTEM
**A Report from the Texas Transportation Institute**

by

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**May, 2000**

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## Background

Safety at highway-rail intersections (HRI's) has been dramatically improved since the 1970's through concerted public and private efforts. According to the Bureau of Transportation Statistics (BTS) accidents, injuries, and fatalities decreased between 1975 and 1995, by 38%, 49%, and 36%, respectively, even in light of increased traffic on both roads and rail. Ton-miles of freight increased by approximately 57% during the same period (BTS). This feat was accomplished through a multi-pronged attack on both grade crossings and drivers. The Federal Highway Administration (FHWA) estimates that between 1974 and 1995, the investment of over $3 billion in grade crossing safety for nearly 30,000 projects helped save almost 9,000 lives and prevent nearly 40,000 accidents. Federal funding, including the Section 130 Program, allowed most states to install active warning devices at high-priority crossings at a fairly steady rate. Coupled with public awareness programs like Operation Lifesaver, this one-two punch has proven that cost-effective safety gains can be made at HRI's.

Importantly, the improved safety record at HRI's has been achieved largely without much innovation in the *presentation* of warning systems themselves. Standard lights and gates remain the front line in safety, augmented by advanced warning signs, pavement markings, and the locomotive horn. This last element in the warning system arsenal, the locomotive horn, has been shown to be effective by its selective omission. In a rather unique and unintended demonstration of warning system efficacy, "whistle bans" in some communities have resulted in increases in accidents. In 1984, Florida imposed a whistle ban between the hours of 10pm and 6am on the Florida East Coast Railroad in cities along its operating corridor. In a subsequent study of the effects of the ban, the Federal Railroad Administration (FRA) reported that accidents increased by 84 percent across the 2,000 impacted intersections. In spite of increased accidents, however, Florida counties choose to maintain the whistle ban.

The central issue regarding whistle bans revolves around the intrusive and very disruptive impact of locomotive horns on the surrounding community. Federal regulations (CFR 49 Part 229.129) ensure that the volume of the horn is sufficient to reach motorists on roadways perpendicular to the trains and well enough in advance of the intersection to be able to respond safely to the train (i.e., stop). Herein lies the dilemma: to reach motorists at the proper angle to the HRI with enough time to provide for adequate stopping distance, the horn has to be loud. The intensity of the horn allows the sound to reach far beyond a desirable range, impacting everyone, whether in a vehicle or not. Community critics suggest that the locomotive horn works too well and alerts everyone, day or night, proximate to the intersection or not. The FRA and the railroads see the locomotive horn as an effective means of alerting motorists to the immediate presence of a train and consider the safety benefits gained worth the intrusive noise.

Federal regulations require the train horn to be 96 db at a centerline point 100 feet in front of the locomotive, and four feet above the track. This intensity is judged to be sufficient enough to reach down intersecting roadways, penetrate any barrier presented by the automobile itself, overcome other internal or external environmental auditory competitors, and alert the driver of the train's approach. Most of the time it seems to work, although as vehicles become better insulated, the challenge of alerting motorists increases. Unfortunately, reaching other people who happen to be in the vicinity seems far easier.

An innovative solution to this problem supported by some is a stationary horn mounted at the grade crossing. The stationary horn or automated horn system (AHS) is sounded in place of the train horn. Activated by the same mechanisms that trigger the active warning system, the AHS is designed to direct sound down the roadway rather than down the track. In this way, horns with less overall intensity may be able to deliver a more effective warning to vehicle operators approaching an HRI.

**The Gering, Nebraska Study**

A recent study of the automated horn system in operation in Gering, Nebraska, suggests that the AHS is effective in warning motorists (Volpe, 1998). In fact, with the AHS in place, motorist violations were shown to initially decrease over the rate seen with standard locomotive horn warnings. The Volpe report also examined the community response to the AHS relative to locomotive horns, performed some acoustic analyses, and observed driver behavior at the intersections where the AHS was installed. The results of the study suggest that the AHS was an effective substitute for the locomotive horn in warning motorists.

The AHS evaluated in Gering in 1995 consisted of a Federal Signal Selectone horn (model 302-GCX), a tone module (Federal Signal Universal Tone Module 13) containing the sound recording of an air horn and a control board which received the signal from the track circuitry and activated the horn. Mounted on the top of the horn case was a Federal Signal strobe light (model 131ST) that provided a visual confirmation for the locomotive engineer that the wayside horn was appropriately sounding. A detector installed inside the horn case activated the strobe light if the horn emitted a signal of at least 80 dB. If the wayside horn was less than 80 dB, the strobe light remained off and the engineer was instructed to manually blow the train horn. The system was subsequently enhanced with a digital recording which more closely resembles the 3-tone sound of a locomotive horn. This enhancement was prior to the data collection period in March and April, 2000.

The activation of the wayside horn was tied to the same circuitry that activated the crossing gates, flashing lights, and crossing bells. Gate descent began approximately two seconds after activation of the flashing lights, bells and wayside horn. When the track circuitry activated the AHS, the system repeated the sequence shown in Table 1 until the train reached the grade crossing. When the train reached the grade crossing the wayside horn sounded for five seconds. The system was designed to produce a sound pressure level of 114 dB at 10 feet and 98.9 dB at 50 feet.

**Table 1. Wayside Horn Temporal Sequence**

| Sequence | Duration On (s) | Duration Off (s) |
|---|---|---|
| 1 | 3.0 | 1.5 |
| 2 | 3.0 | 1.5 |
| 3 | 1.5 | 1.5 |
| 4 | 3.0 | 1.5 |

(from Volpe, 1997)

In the Volpe report, motorist violations at grade crossings were described as Type 1 or Type 2 violations. Type 1 violations were defined as those where the motorist is observed to drive through the grade crossing after gate descent is initiated, but before the gates were completely down. Type 2 violations were those where the driver proceeded through the crossing after the gates were completely down. In Gering, Type 1 violations were reduced by a statistically significant amount with the AHS over the rate observed with a standard locomotive horn. There were no clear differences between the locomotive horn and the AHS relative to Type 2 violations, perhaps in part since motorists are less likely to commit Type 2 violations in any event.

## Problem Statement

“Whistle-bans,” because of the negative safety ramifications, present a problem for railroads and any public agency responsible for the well-being of the traveling public. Currently, the Federal Railroad Administration, through its rule-making process, has plans to recommend five safety measures that “fully” compensate for locomotive horns and may therefore be substituted under whistle-ban conditions.

These supplementary safety measures (SSMs) are:

- four-quadrant gates
- median barriers
- photographic enforcement systems
- 1-way streets

- temporary closure (e.g., nighttime closure)

Further, under the proposed rule, alternative safety measures (ASMs) may be employed in combination with SSMs to "fully compensate for the absence of the audible warning provided by the locomotive horn." The ASMs include:

- variations of SSMs
- long-tern programmatic law enforcement efforts and initiatives, and
- targeted public awareness efforts and initiatives

Thus, under the condition of a local ordinance banning locomotive horns, it is proposed that one or more of these sanctioned measures may be employed to compensate for the loss of the auditory warning. There are no plans to include the AHS as one of these measures due to lingering reservations about the long-term effectiveness of the system. The principal issue, therefore, seems to focus on the credibility of the AHS warning for motorists – do motorists learn that the AHS is just a device and not really a train and thus become more likely to disregard it, with a corresponding increase in the likelihood of accidents?

It is not suggested by proponents of the AHS that it is necessarily superior to the locomotive horn as a warning to motorists, but rather that evidence to date strongly indicates that the system is *as effective* as a locomotive horn system in alerting motorists to the potential hazard at an HRI and therefore should be included among the array of fully compensatory systems listed above.

## Study Objective

The objective of this evaluation is to revisit the AHS installation at the Tenth Street location in Gering to assess the level of driver compliance with the warning system after approximately six years of operation. Initial AHS implementation was in July of 1994. The original posttest period was from May 24, 1995 to October 22, 1995. Data for this follow up evaluation was collected for 16 days from March 25, 2000 to April 9, 2000. TTI was engaged by RCL to examine the data collected at the site and report on the observed rate of driver compliance (Type 1 and Type 2 violations) with the AHS still in place.

## Evaluation of AHS at the Tenth Street Crossing

RCL used equipment provided by Transit Surveillance Systems, Inc. to video traffic in both directions at the Tenth Street crossing. Each activation of the track circuit mechanism controlling the warning system (lights, gates, and AHS) also activated the digital video system and recorded the warning system behavior (lights and gates) as well as the behavior of motorists in both lanes of traffic on the approach to the crossing. The recording system continued in operation until the train had fully occupied the HRI. The collected digital video was stored on a computer for later analysis.

The collected data was delivered to TTI for processing and analysis in early May, 2000. TTI evaluated the behavior of motorists under the condition of extended exposure to the AHS at the Tenth Street crossing in Gering, Nebraska by recording Type 1 and Type 2 violations of the warning systems. The motorists in the vicinity of the Tenth Street crossing have been exposed to the AHS for over five years and thus the question of central importance to this evaluation is,

> "Do motorists, after extended exposure to the AHS, continue to heed the warning systems at the Tenth Street crossing at a rate which is at least as compliant as with the locomotive horn and thus may be considered as a fully compensatory system?"

The collected digital video data was scored by trained observers at TTI's facility in College Station, Texas. Rated violations were verified by both a second and third observer to ensure the accuracy of scoring. Appropriate statistics were used to assess the rate of violations at the target crossing during the post-posttest phase relative to that recorded during pre and post test by Volpe researchers.

## Results

TTI evaluated 826 digital video records from the Tenth Street HRI in Gering, Nebraska. Of these, 815 observations were included in the analysis. Eleven activations of the recording equipment were omitted and scored as "false activations" due to no observed train activity at the intersection. The intersection tallied approximately 50 trains per day throughout the data collection period.

Volpe's 1997 report defines a Type 1 violation as, "vehicle went through the grade crossing during gate descent" and a Type 2 violation as, "vehicle went through the grade crossing after gate descent." These criteria were applied to the current evaluation to ensure consistency and allow meaningful conclusions to be drawn from the results.
The 1997 Volpe study of the AHS in Gering, Nebraska showed that Type 1 violations decreased following the introduction of the system at two roadways. Type 2 violations were not statistically different between the two systems (i.e., locomotive horn and AHS). It should be noted that Volpe pooled the data from two intersections, the Tenth Street crossing and the Country Club Road, to derive the following table (Table 14, page 40, Volpe, 1997), which is reproduced here for comparative purposes. The Volpe report also evaluates "time to collision,"

which measures how far away the train is from the grade crossing when the motor vehicle is in the intersection. They found no significant difference in this measure between the two systems and, therefore, we are not reconsidering this measure in the current evaluation. The Volpe report also examines the frequency of false activations between the two systems, which is a function of track circuitry and not warning system and thus is omitted from the current evaluation as well.

**Table 2. Frequency of False Activations and Violations for Two Warning Devices**

| | Actual Frequency | | Frequency/1000 Trains | | Chi-square Value | Significance Level* |
|---|---|---|---|---|---|---|
| | Train | Wayside | Train | Wayside | | |
| False Activations | 53 | 41 | 21 | 10 | 10.50 | .0012 |
| Type 1 Violations | 48 | 35 | 19 | 9 | 11.22 | .0008 |
| Type 2 Violations | 4 | 18 | 2 | 5 | 3.31 | .0688 |

* Critical Value at 1 degree of freedom = 3.84 (from Volpe, 1997, Table 14, page 40)

The data presented above, specifically for Type 1 violations, shows the effectiveness of the AHS relative to the locomotive horn across a combined 6,481 train events. The differences observed suggest that, at least initially, the AHS may be *more effective* in alerting motorists of oncoming trains. The lack of statistical difference between the two systems for Type 2 violations suggests that the two systems perform equally well.

Table 3, below, presents data from the current post-posttest period relative to the pretest data collected by Volpe. This allows an indirect comparison of the AHS after a lengthy operational period with the baseline violation rate seen at the Tenth Street site in 1995. The results show that, while Type 1 violations with the AHS have risen over the rate seen following system implementation, they remain approximately on par with the rates seen with the locomotive horn. The statistical analysis indicates no significant difference.

**Table 3. Frequency of Violations for AHS in 2000 Relative to Locomotive Horn in 1995**

| | Actual Frequency | | Frequency/1000 Trains | | Chi-square Value | Significance Level* |
|---|---|---|---|---|---|---|
| | Train | Wayside | Train | Wayside | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Type 1 Violations | 48 | 15 | 19 | 18.4 | .0062 | .96 |
| Type 2 Violations | 4 | 0 | 2 | 0 | 1.28 | .27 |

* Critical Value at 1 degree of freedom = 3.84

A comparison of the AHS in 2000 with the same system in 1995 (Table 4) shows that Type 1 violations are higher now than were observed in the original posttest period. It must be reemphasized that this increase in Type 1 violations is an increase in the frequency over the depressed rate observed after system implementation and not an overall increase.

**Table 4. Frequency of Violations for AHS in 2000 Relative to AHS in 2000**

| | Actual Frequency | | Frequency/1000 Trains | | Chi-square Value | Significance Level* |
|---|---|---|---|---|---|---|
| | Wayside 1995 | Wayside 2000 | Wayside 1995 | Wayside 2000 | | |
| Type 1 Violations | 35 | 15 | 9 | 18.4 | 5.83 | .015 |
| Type 2 Violations | 18 | 0 | 5 | 0 | 3.74 | .06 |

* Critical Value at 1 degree of freedom = 3.84

## Conclusions & Discussion

TTI's evaluation of the AHS data at the Tenth Street highway-rail intersection from March and April, 2000 in Gering, Nebraska suggests the following conclusions:

1. The AHS appears to be, after almost 5 years of operation, an effective alternative to the locomotive horn at the Tenth Street crossing in Gering, Nebraska, with a violation rate no greater than that observed during pretest monitoring.

2. The observed reduction in Type 2 violations at this site may even indicate that the AHS is a higher fidelity warning system than the locomotive horn, although examining only one site makes broad generalizations difficult.

Speculation regarding the initial drop in Type 1 violations following system implementation in 1995 cannot be substantiated without further study of the phenomenon, but it may be due to the greater "delivered" decibel level found with the AHS. An understanding of the affects of distance and physical obstructions on auditory intensity may help explain the effect. With distance, the diminished auditory intensity of a locomotive horn is a cue to the motorist, signaling the relative remoteness of the train. For very low intensities at grade crossings, this remoteness translates into time and thus a perceived safety margin for drivers. As the intensity increases, the perception of closeness of the source and "less time" for traversing an HRI heightens motorist vigilance. This intuitively obvious relationship helps explain the effectiveness of the train horn as a warning mechanism.

The distance-intensity effect may also explain why this warning strategy may break down from time to time, not always serving the motorist well, as environmental obstructions alter the locomotive horn intensity and thus may alter the motorist's perception of source distance and safety margin. Better insulated vehicles, loud stereos, buildings, trees, and other obstructions may contribute to the non-linearity of the distance-intensity cue provided by the horn. In Gering, Nebraska, after installation of the AHS, motorists were alerted to train presence by a higher intensity horn, accompanied by an understandable perception of source proximity. The observed behavior, perhaps, indicates that motorist's perception of the closeness of the source led to safer driving at the HRI and a significant reduction in Type 1 violations.

It could be further speculated that as motorists became experienced with the AHS, they learn that the distance-intensity cue is now a different type discriminator; one clearly associated with train presence, but no longer a good indicator of train distance. This uncertainty leads more motorists to stop rather than risk traversing the HRI. In fact, this cue to train distance has been replaced by activation of the warning system itself, which motorists learn precedes the train by a full 20 to 30 seconds. Motorists witnessing system activation may therefore be the only drivers likely to risk a hurried crossing of the HRI — not unlike motorist behavior at most active HRIs.

The fact that Type 1 violations at the Tenth Street crossing rebounded over time to locomotive horn levels is not seen by the author as indicative of a system weakness, but rather as confirmation that the AHS is an effective alternative to locomotive horn systems. Were the Type 1 violations in March and April, 2000 significantly higher than pretest locomotive horn levels in 1995, serious reservations concerning system effectiveness would have to be stated. This is particularly true given the high level of false activations seen at this busy site, both in 1995 and again in the spring of 2000 where motorists could be expected to have questions about the reliability of the warning they receive.

In summary, the AHS at the Tenth Street crossing in Gering continues to be effective as an alternative to the more disruptive locomotive horn. The system has been in place for almost six years at a site that is very heavily traveled (50 trains per day). It appears the measures of effectiveness, i.e., Type 1 and Type 2 violations, employed to assess every other SSM and ASM, indicate that the Automated Horn System is an effective alternative to the locomotive horn in warning motorists of the proximity of a train. Ancillary questions posed by some concerning factors beyond bottom-line system effectiveness, such as Doppler effect cues or horn directionality and intensity, seem to be holding the AHS to a standard different than that applied to other SSMs and thus appears unwarranted given the performance of the system in Gering.