Evaluation of an Automated Horn Warning System at Three Highway-Railroad Grade Crossings in Ames, Iowa

By Steve J. Gent, Scott Logan and David Evans

Executive Summary

In September of 1998, the city of Ames, Iowa (population 48,000) began operation of three automated horn warning systems. These systems were installed after nearby residents repeatedly expressed their concerns over the disturbance created by the loud train horns.

Traditionally, locomotive engineers begin sounding the train horn approximately 1/4 mile from the crossing to warn motorists and pedestrians approaching the intersection. To be heard over this distance, the train horn must be very loud. This combination of loud horns, and the length along the tracks that the horn is sounded, creates a large area adversely impacted by the horn noise. Unfortunately, in urban areas, this area likely includes many nearby residents.

The automated horn system provides a similar audible warning to motorists and pedestrians by using two stationary horns mounted at the crossing. Each horn directs its sound toward the approaching roadway. The horn system is activated using the same track signal circuitry as the gate arms and bells located at the crossing. Once the horn is activated, a strobe light begins flashing to inform the locomotive engineer that the horn is working. If the strobe light is not flashing, or the locomotive engineer has a reason for concern regarding safety at the crossing, the engineer simply sounds the train horn.

The purpose of this research was twofold: 1.) determine the effectiveness of the automated horn system in reducing the annoyance level for nearby residents; and 2.) determine the overall safety at the crossings with the new automated horn warning system. The research included collecting horn volume data to develop noise level contour maps, using before-and-after surveys to document opinions of nearby residents and motorists, and a survey of locomotive engineers to document their perception of the new systems. The following paragraphs summarize the information collected during the study.

Horn volume readings were collected on a grid pattern and noise level contour maps were developed for the train horns and automated horn system. Use of the automated horn system reduced the area with noise levels greater than 80 dBA by 97 percent, from 171 acres using the train horns to less than six acres using the automated horn system. (For reference, a person shouting from a distance of three feet would produce a decibel reading of approximately 78 dBA.) The contour maps (shown on page 6) give a visual representation of the land areas impacted by the two warning systems. When reviewing the contour maps, note that a typical person would perceive a 10 dBA increase as a doubling of "loudness."

The residents overwhelmingly accepted the automated horn system and appreciated the city staff for attending to their needs. In the before condition, 77 percent of the residents indicated the train horns had either a "negative" or "very negative" impact on their quality of life, compared to only 3 percent in the after condition. Regarding horn volume, 76 percent felt the train horn volume was "too loud" as compared to the after condition where 82 percent indicated that the automated horn volume was "no problem".

When the motorists were asked which system they preferred, 78 percent preferred the automated horn system, 8 percent preferred the train horns and 14 percent had no opinion. Their responses also indicated that each of the warning devices (gates, flashing lights and train/automated horns) located at the crossings provide a value-added safety benefit.

Ninety-two percent of the train engineers rated the overall safety at the crossings with the automated warning system to be "about the same" or "safer," compared to the before (train horn) condition. Seventy three percent of the engineers admitted to blowing the train horn at least once at the subject crossings after the automated

horns had been installed. The two primary reasons stated for blowing the train horns were: 1.) concern related to motorist or pedestrian behavior at the crossing; and 2.) old habits are hard to break.

In summary: 1.) for nearby residents, the automated horn system greatly reduces the negative impacts resulting from the loud train horns; 2.) the automated horns are well accepted by both motorists and locomotive engineers; and 3.) the automated system appears to provide an equivalent level of safety at the crossings.

Introduction

In September of 1998, the city of Ames, Iowa (population 48,000) began operation of three automated horn warning systems located at the North Dakota Avenue, Scholl Road and Hazel Avenue crossings. The systems were installed at three crossings in the western and central parts of the city. Each of these crossings was already equipped with automatic flashing light signals with gate arms and constant warning time circuitry. By installing the new warning systems the city was hoping to improve the quality of life for the residents living near the crossings by reducing the volume of the train warning. Many residents had complained about the loud train horns and how adversely they had affected their lives. Currently about 60 trains per day pass through Ames, and this number is expected to increase to around 100 trains per day within five years.

The purpose of this research was twofold: 1.) determine the effectiveness of the automated horn system in reducing the annoyance level for nearby residents; and 2.) determine the overall safety at the crossings with the new automated horn warning system. The research included the following four initiatives.

Horn Volume Data - Noise level readings were collected before and after the automated horn systems were installed. This data was used to develop noise contour maps showing the maximum noise levels at various locations near a crossing.

Resident Survey - A written public opinion survey was developed and distributed to approximately 1000 residents living near the crossings. The residents were given the surveys before and after the automated horn system were installed.

Motorist Survey - Motorists waiting for stopped trains were asked several questions to determine their opinions regarding the train horn and the automated horn system.

Locomotive Engineer Survey - Twenty-six locomotive engineers completed a written questionnaire regarding the automated horn system.

The city of Ames was only the third community to install an automated horn warning system, with the other locations being Gering, Nebraska and Parsons, Kansas. All of the systems were designed by, and purchased from, Merrill Anderson of Railroad Consulting Services Inc. The city is currently negotiating with the Union Pacific Railroad on outfitting other crossings with the new automated horn systems. In its current agreement with the Union Pacific, the city is responsible for the purchase, installation, maintenance, and electrical power needed for the automated horn system. The agreement also states that the city is liable if an accident can be traced to one of the horns. Each system costs approximately $20,000 per crossing, not including installation.

Horn Volume Data Collection

As illustrated by the noise decibel contour maps (Figures 1 & 2) on the next page, the land area affected by the two types of audible warning systems at the same crossing is vastly different. The automated horn system not only reduces the land area adversely affected by the louder train horns, it also reduces the maximum decibel reading (horn volume) at all locations including properties in-line with, or in the path of the automated horn system. Table 1 shows quantitatively the land areas affected by the two types of audible warning systems.

Sound Level	Train Horn	AHS Horn	Reduction
(dBA)	Area (acres)	Area (acres)	
> 70	265	37	86%
> 80	171	5	97%
> 90	31	< 1	98%

Table 1

The contour maps represent the maximum volume obtained by the audible systems during the warning period. Figure 1 shows the noise contours for a train using the traditional train horn system and travelling in the westbound (right to left) direction. Figure 2 shows the maximum automated horn system volumes are being detected off the roadway, which would indicate that the automated horns need to be realigned.

After conducting this part of the study, it became apparent that two additional issues related to horn volume should be addressed through a future research project. The issues are: 1.) what horn decibel volume is required to adequately warn an approaching motorist; and 2.) at what distance from the crossing does that volume need to be provided? To give a reference to the first question, some typical decibel readings are listed below.

Food blender at 3 feet 87 dBA
Person shouting at 3 feet 78 dBA
Gas lawn Mower at 100 feet 70 dBA
Normal speech at 3 feet 65 dBA

When assessing the relative loudness of a given decibel level, it is helpful to understand the relationship between these two terms. The above typical decibel levels, and the following excerpt, were taken from the 1987 AASHTO Guide on Evaluation and Attenuation of Traffic Noise publication. It states, "An increase of 10 dBA in sound level will nearly double the loudness as rated subjectively by typical observers…A decrease of 10 dBA will appear to an observer to be a halving of the apparent loudness. For example, a noise of 70 dBA will sound only half as loud as 80 dBA, assuming the same frequency composition and other things being equal."

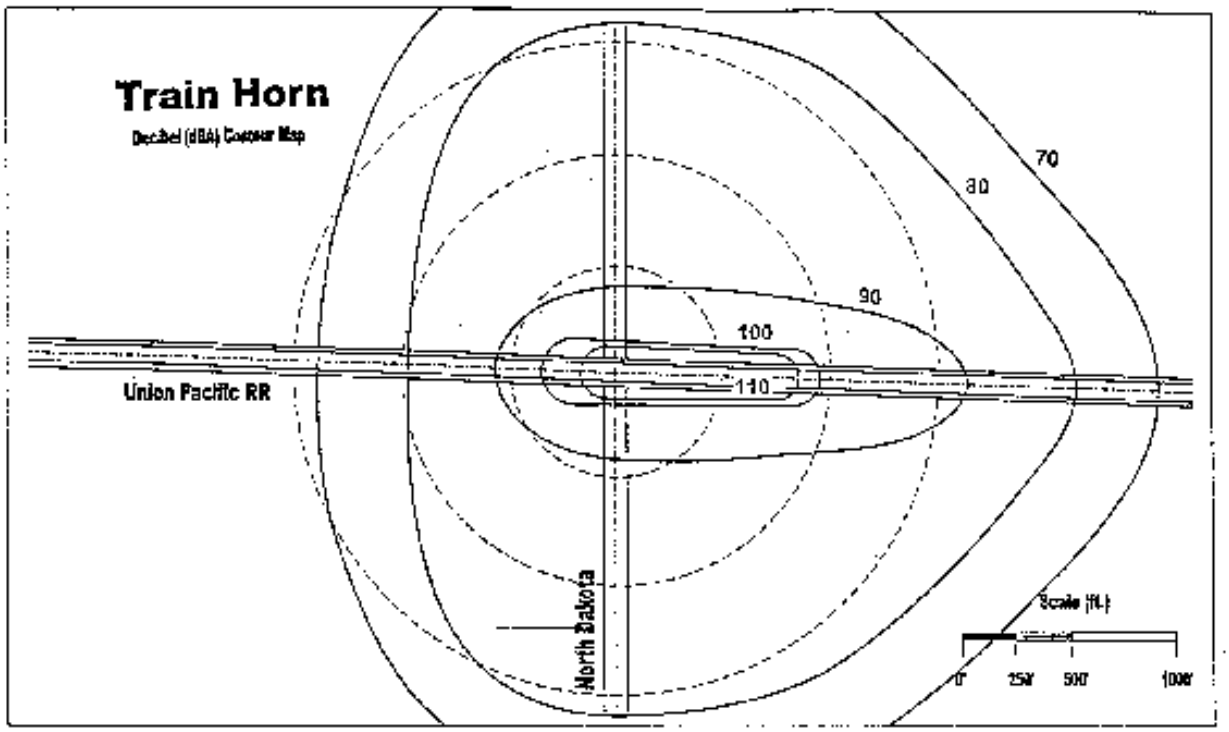


Figure 1

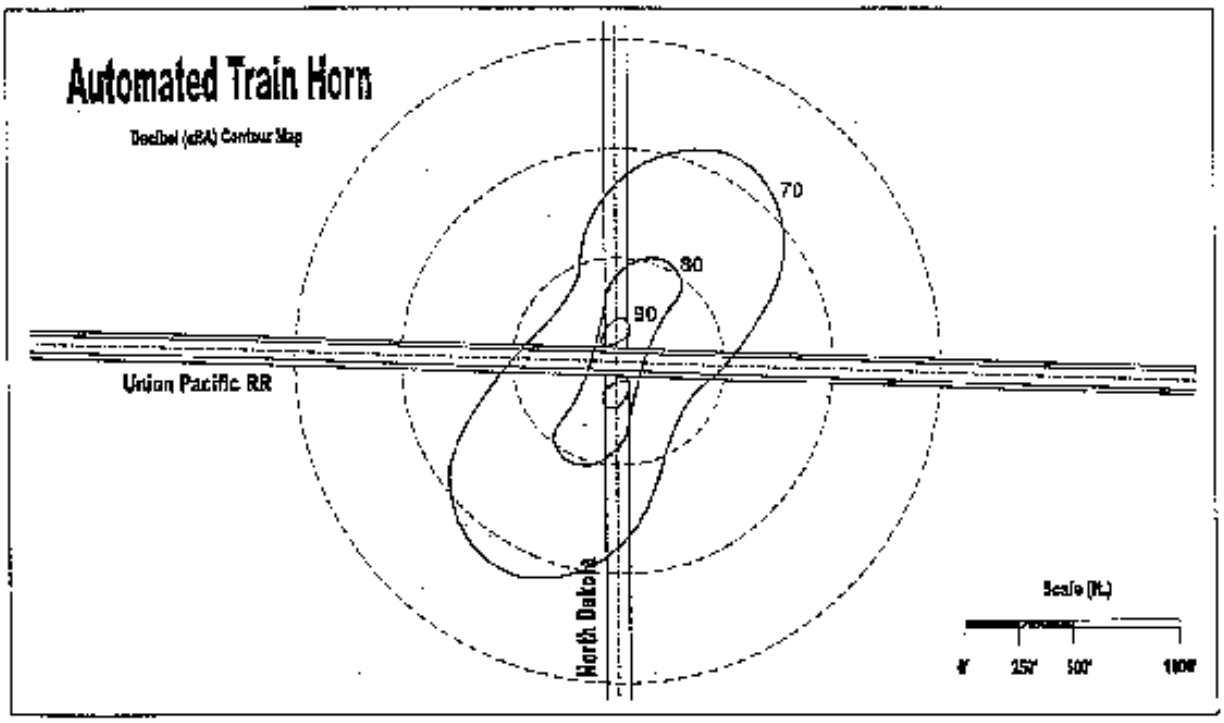


Figure 2

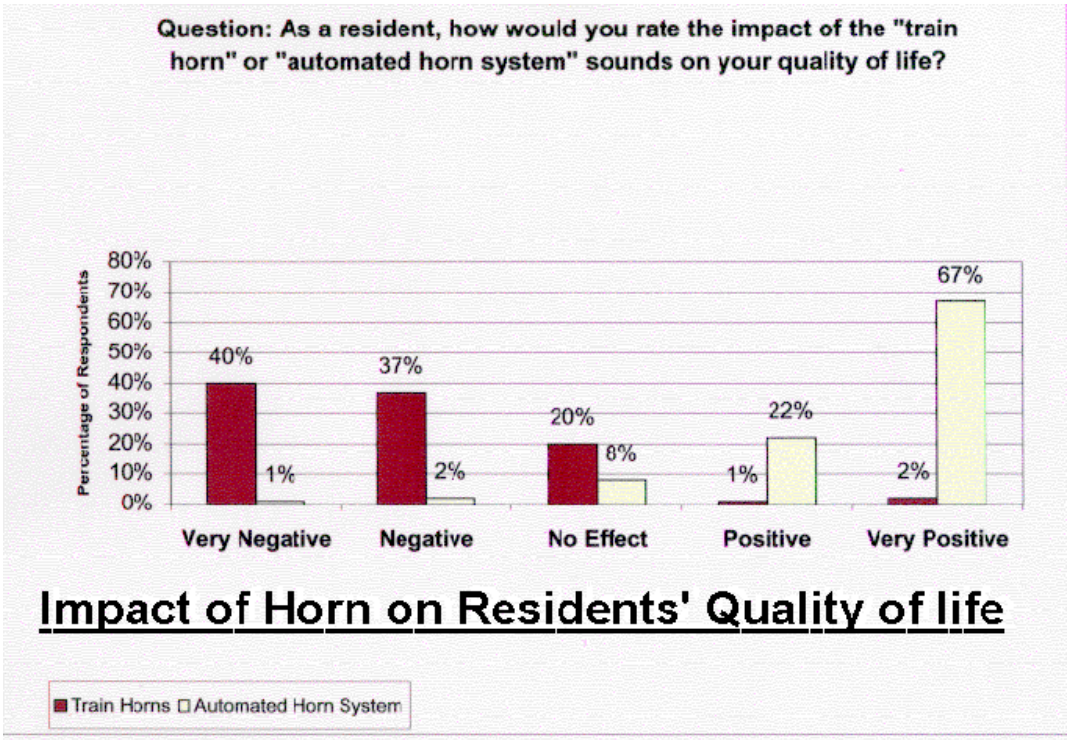
The issue related to distance may be approached by looking at Table II-1, A Guide for Advance Warning Sign Placement Distances found in the Manual on Uniform Traffic Control Devices. This table gives a minimum sign placement distance of 450 feet for a "STOP AHEAD" sign on a 55 mph roadway. The distance is 300 feet for 45 mph roadways and 150 feet for 35 mph roadways. These distances provide adequate time for the driver to perceive, identify, decide and perform the necessary maneuver. For highway-railroad intersections, these minimum distances present a reasonable starting point for the establishment of a requirement for an audible warning distance.

The noise level readings were taken using a Bruel & Kjaer, Model 2231, Type 1 Sound Level Meter. All readings were taken in the northeast quadrant of the North Dakota Avenue crossing and transferred to other quadrants to develop the contour maps. This quadrant provided a reasonably flat and open terrain with the approaching tracks being perpendicular to North Dakota Avenue. Two noise decibel readings were taken at the data collection stations in the before (train horns) and after (automated horn system) conditions. For the train horns, one reading was taken for an eastbound train and one reading was taken for a westbound train.

To look at the variability in train horn volumes, from one train to another, 12 readings were collected on North Dakota Avenue 250 feet from the tracks. The twelve readings averaged 95.5 dBA, with a low of 90.6 dBA, a high of 102.8 dBA and a standard deviation of 3.63.

Resident Survey

Survey questionnaires were distributed to all residents living within an area located 1,000 feet perpendicular to the tracks and 1500 feet longitudinal (each way) from the crossings. Surveys were distributed approximately two months before and two months after the automated horn systems were installed. The responses were overwhelmingly positive regarding the automated horn system. Graph 1 shows the before condition where 77 percent of the residents indicated the train horns had either a "negative" or "very negative" impact on their quality of life, compared to only 3 percent in the after condition.



Graph 1

At the end of each survey, the residents were solicited to write additional comments on the back of the form. Over half of the 550 returned surveys (approximately 1000 total surveys distributed) provided comments. The following examples provide a good cross-section of the issues and observations listed by the residents.

Before condition (train horns):

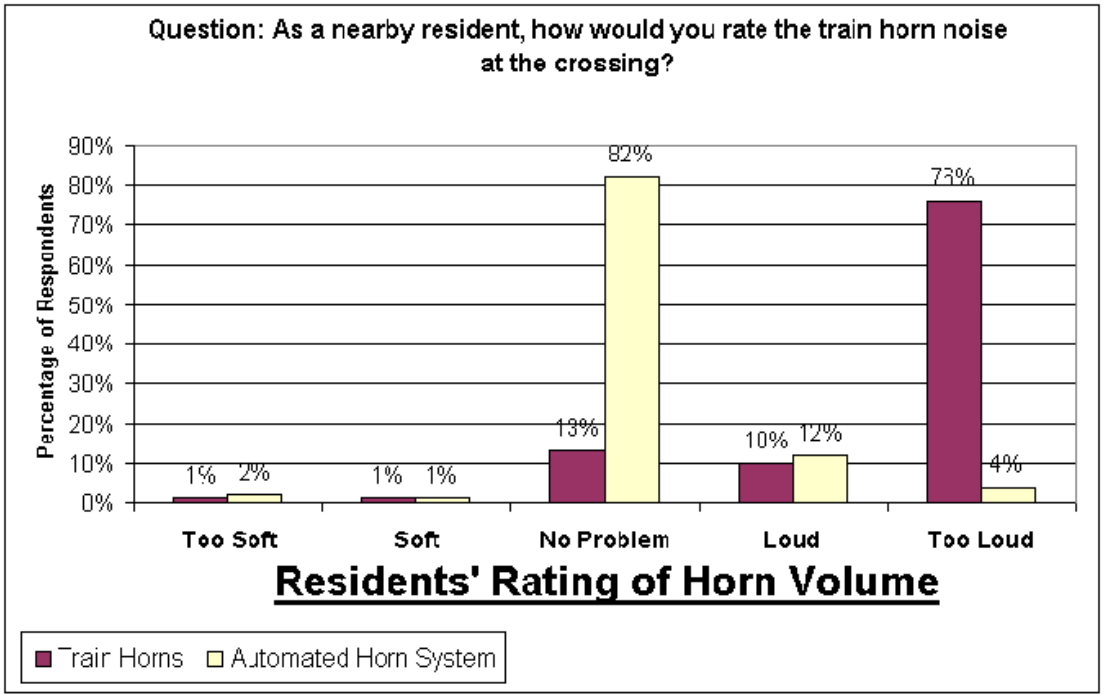
> *I understand the need for trains to make noise at intersections – to make their presence known to avoid accidents – but I don't appreciate the engineers who feel the need to blow the horn for the entire length of their trip. I feel that is unneeded, especially at 3 a.m. when there is nobody out on the roads anyway!*
>
> *The train whistles are way too loud and long in my estimation. If I'm on the phone or listening to the TV, the loud whistles are especially annoying. Also my sleep is often interrupted many times during the night because of the loud whistles. It would be very much appreciated if the noise could be greatly softened and still keep the crossing safe.*
>
> *It is essential to have adequate warning of approaching trains, however, the existing train whistles seem unnecessarily long and loud. I think a town the size of Ames with so many railroad crossings should be looking at building more overpasses, which would provide for more safety, convenience, and would allow the trains to be more quiet.*

After condition (automated horn system):

> *Installation of the automated horn system was a very positive step. There is an occasional train operator that still uses the train-mounted horn to make a statement as he/she passes through our neighborhood. This just reminds us of how much better the noise level is a majority of the time. Thank you for continuing to support our neighborhood in its efforts to improve the quality of life of the residents.*
>
> *I have lived in this neighborhood nearly my entire life. I thought I was used to the train noise. However, with the many trains that go through now, and with the noisy horns, it was affecting my lifestyle. These new automated horns are great and I really appreciate their installation. I used to worry when I had overnight company that they would be kept awake by the noise, and often they were. Now they aren't, thank you.*
>
> *Thank you very much for your work on this. It has been a great improvement. I am reluctant to say it is 100% solved since it is winter and our house windows are all closed. I don't know how it will feel in the summer. I live about 150 yards from the crossing at an angle, and can just hear the horns inside the house with the windows closed. But I can now choose to ignore them and continue my phone conversations. This is a major improvement.*

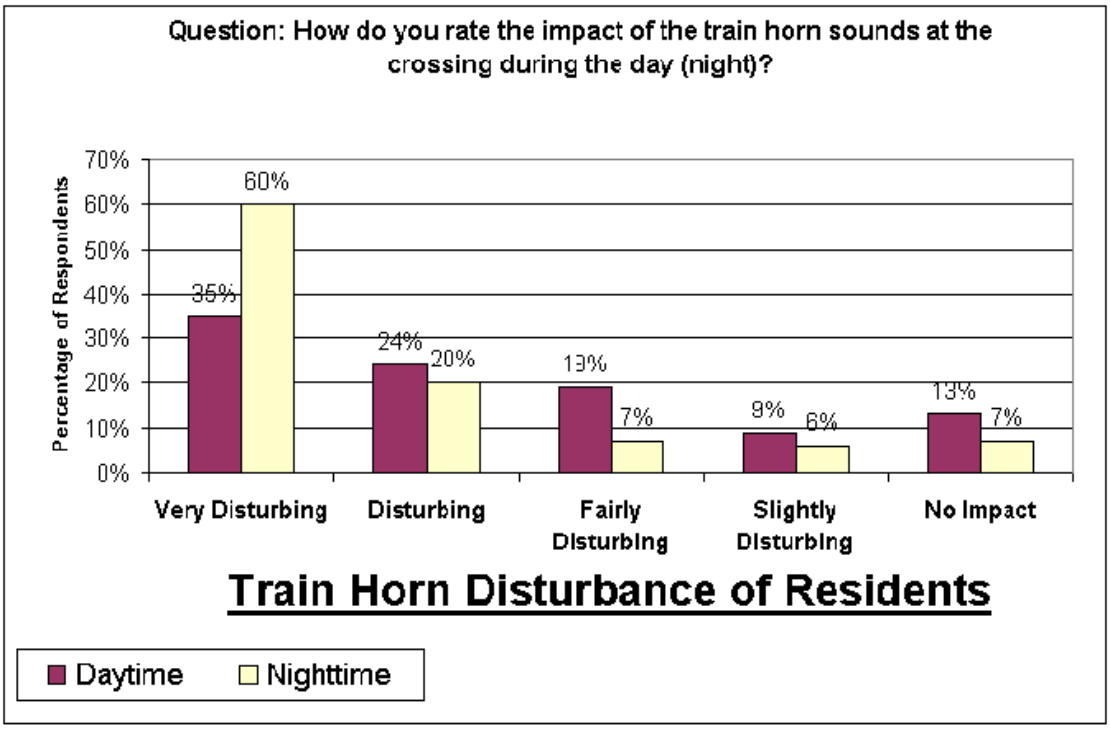
The comments received leave little question as to how appreciative the residents were of the automated horn system. To determine if the perpendicular distance from the tracks affected the survey responses, the distributed surveys were differentiated between the residents living within 500 feet of the tracks, and the residents living between 500 and 1,000 feet of the tracks. The residents living closer to the tracks were slightly more "extreme" in their survey responses. However, the residents living further from the tracks shared the same concerns regarding the train horns and shared the same positive responses regarding the automated horns. Residents living further than 1,000 feet were not included in the survey.

Graph 2 shows the resident's rating of the before and after horn volume. In general, they felt the train horns were too loud, and the automated horns were not a problem.

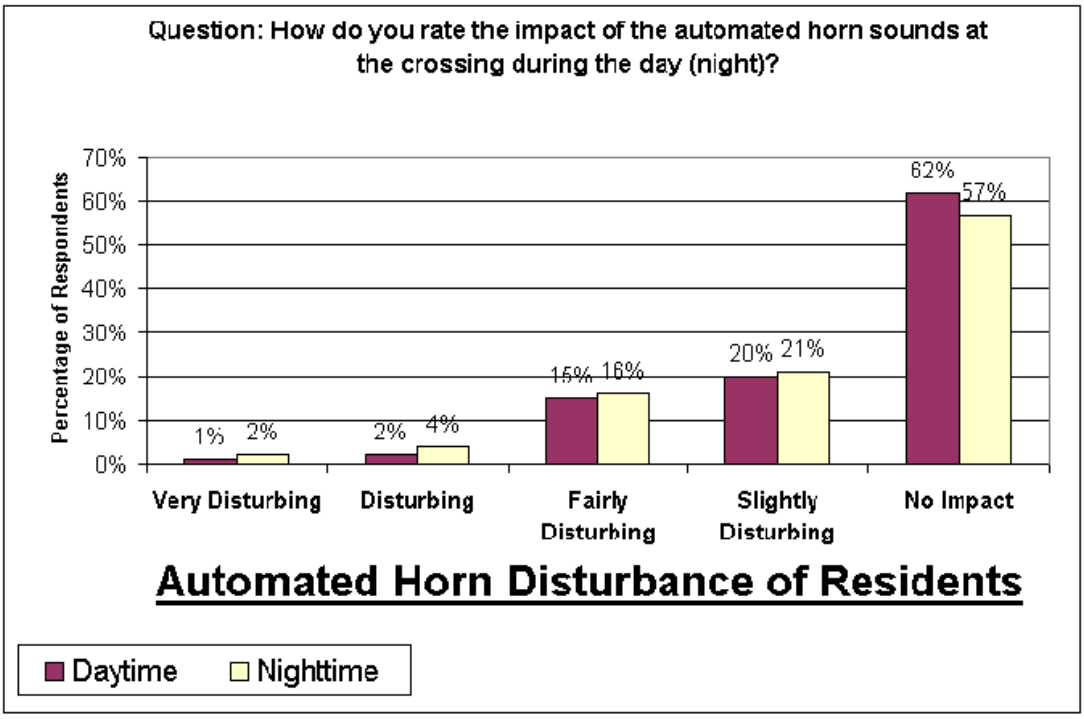


Graph 2

The survey also showed that residents were more disturbed by the train horns at night, compared to the daytime condition. Graph 3 shows the daytime vs. nighttime impact during the before condition. Graph 4 shows the daytime vs. nighttime impact during the after condition. These graphs also reconfirm the acceptance of the new system by the residents.



Graph 3

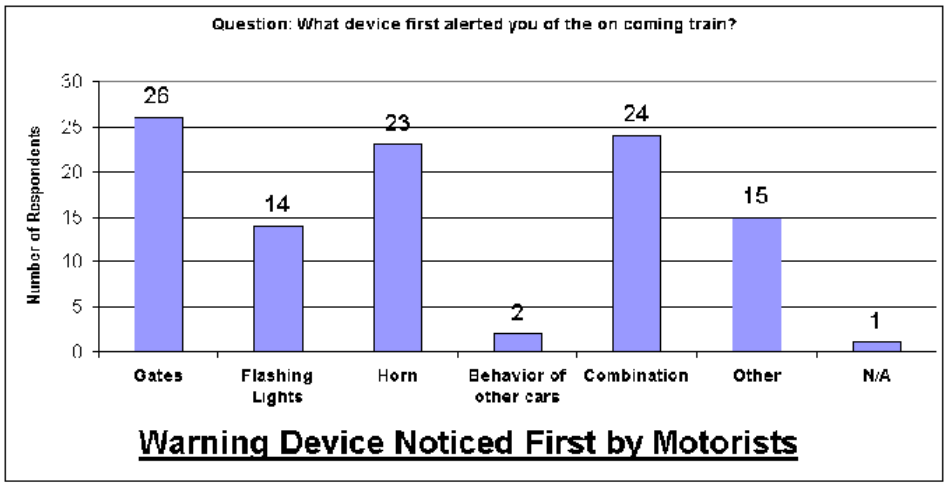


Graph 4

Motorist Survey

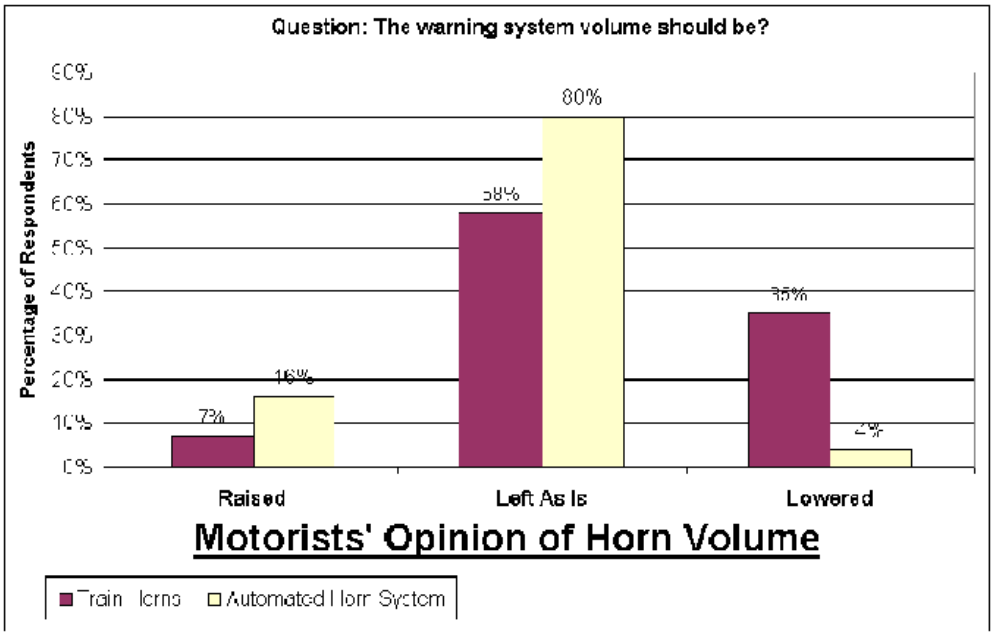
The motorists surveyed at the crossings generally liked the automated horn system and preferred this new system over the train horns. However, they did not feel as strong as the residents about the need to reduce the volume of the train horns.

Graph 5 shows the results of the question, "What device first alerted you of the on coming train?" The mix of responses indicates that each of the various warning devices (gates, flashing lights, horn, etc.) located at the crossings provides a value-added safety benefit.



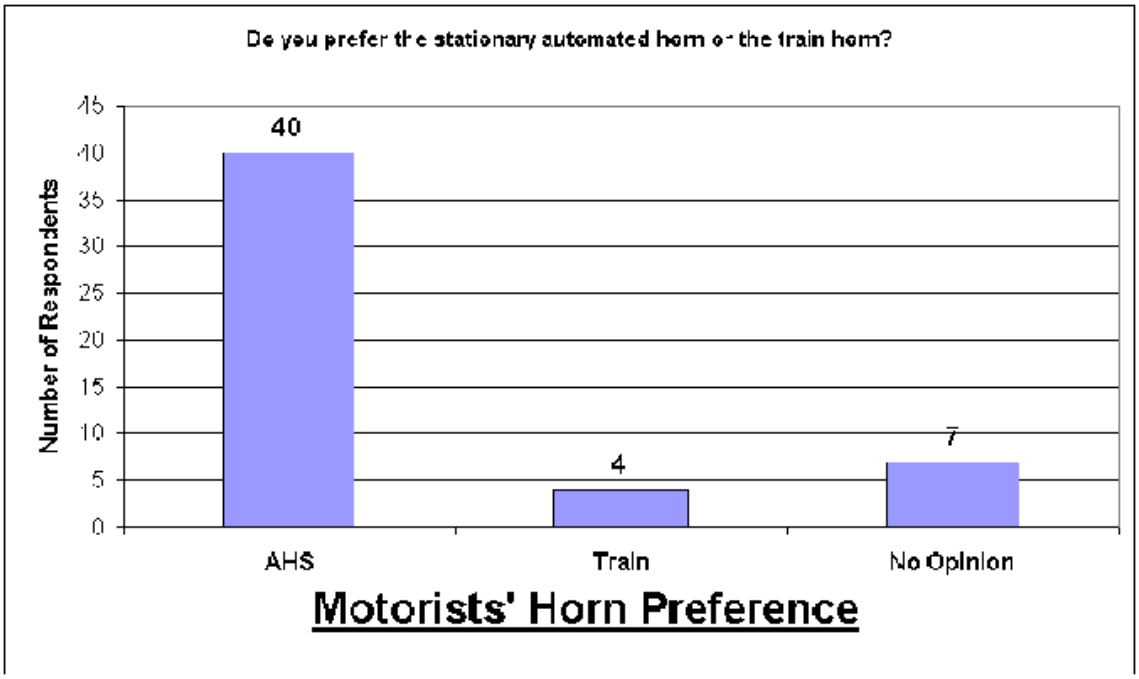
Graph 5

Graph 6 shows the motorist opinion of the horn volume in the before (train horn) and after (automated horn warning system) situations. In both cases the majority of motorist felt the volume should be left as is. It should be noted that some of the surveyed motorists were also residents living near the crossing. The number of residents was not determined during the survey.



Graph 6

One hundred and five motorists were surveyed in the before condition and fifty-one motorists were surveyed in the after condition. The after survey was conducted approximately one month after the automated warning system was installed. Seventy five percent of the respondents indicated that they were aware that the automated horn system had been installed. Graph 7 shows that 78 percent of the motorists preferred the automated horn system over the train horns.



Graph 7

Locomotive Engineer Survey

In general, the locomotive engineer survey provided positive responses regarding the automated horn warning system. The engineers completed the surveys in April of 1999, which was seven months after the installation of the automated horns. A total of 26 surveys were completed.

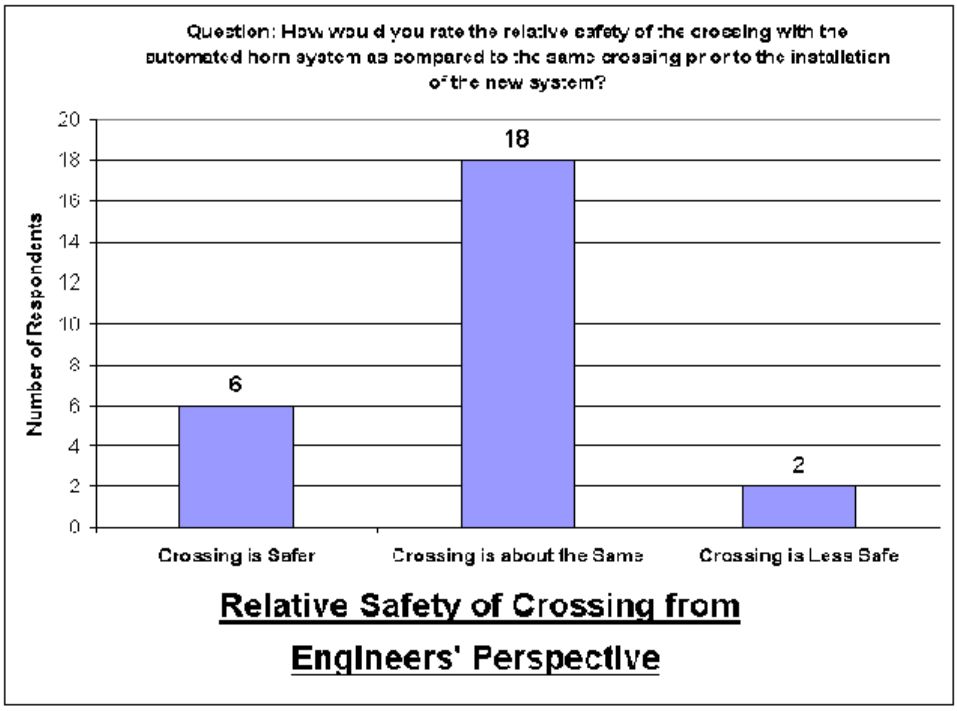
Some highlights from the surveys include:

- Ninety-two percent of the locomotive engineers rated the overall safety at the crossings with the automated warning system to be "about the same" or "safer" as compared to the before (train horn) condition

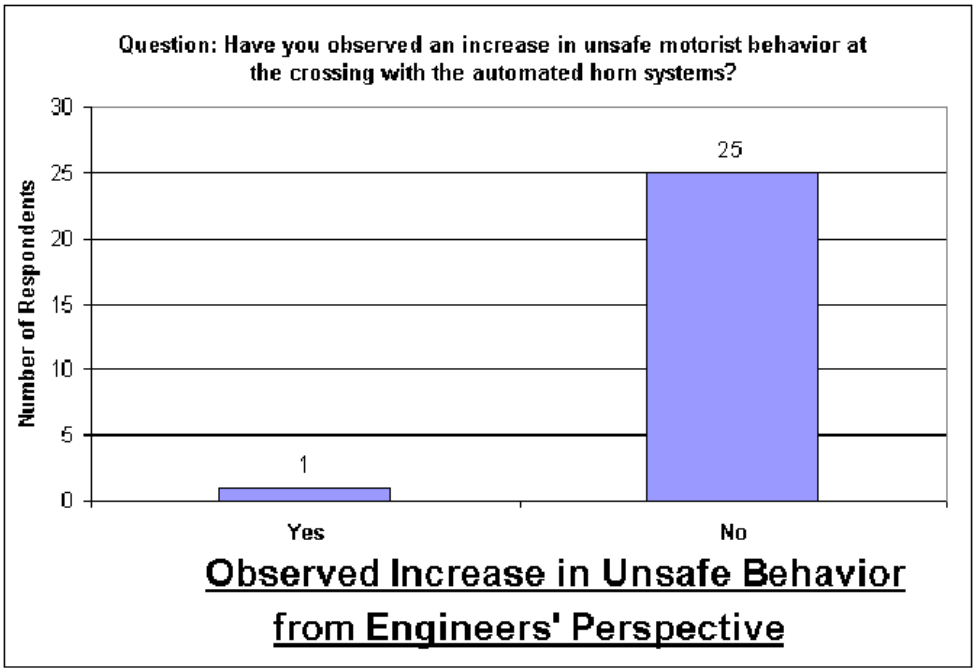
- Only one locomotive engineer noted an increase in unsafe motorist behavior. The other 25 (96 percent) did not observe an increase.

- Seventy-three percent of the engineers admitted to blowing the train horn at least once at the subject crossings. There were two primary reasons stated for blowing the train horns: 1.) concern related to motorist or pedestrian behavior at the crossing; and 2.) old habits are hard to break. Several engineers also noted, "another train passing through the intersection" (double tracks) as a reason for sounding the train horn. This latter reason occurs because the automated horn warning system is activated using the same circuitry as the flashing light signals and gate arms. Therefore it does not reactivate the horn (or strobe light) when the other warning systems are active. The engineers are responsible for ensuring that an audible warning occurs (either with the automated horn system or with the train horn) every time they approach a crossing. Because of this responsibility, they are forced to sound the train horn in this situation. Consideration should be given to redesigning the automated horn system so it can independently detect approaching trains on each set of tracks.

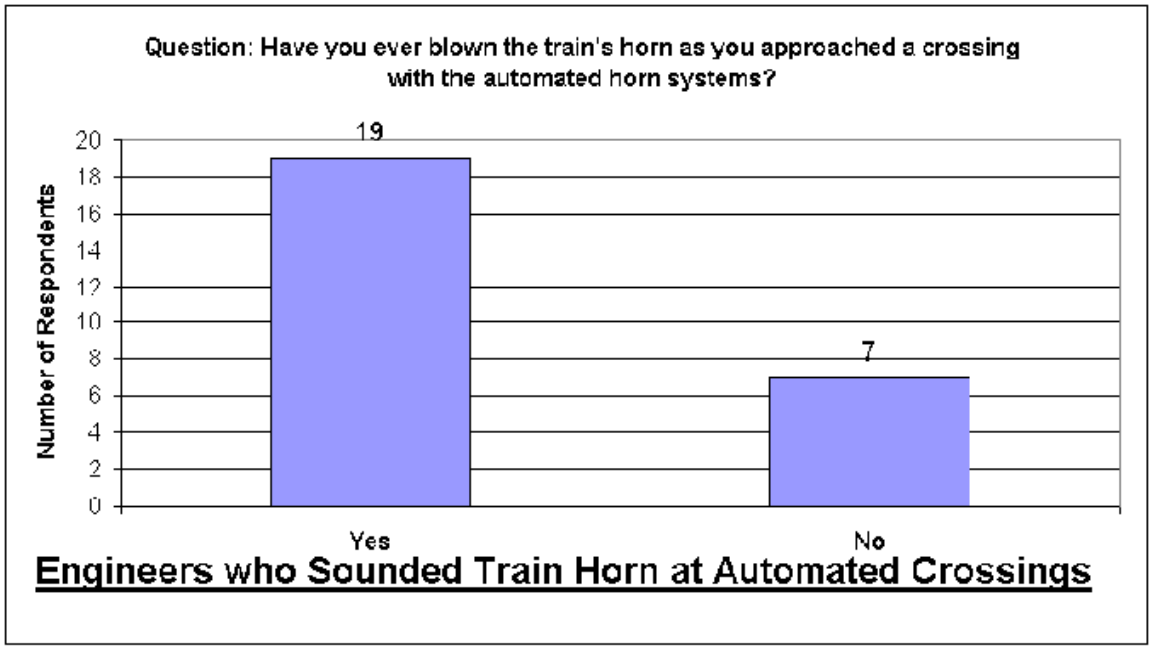
Following are Graphs 8, 9, 10 and 11 showing the responses to the locomotive engineer survey questions.



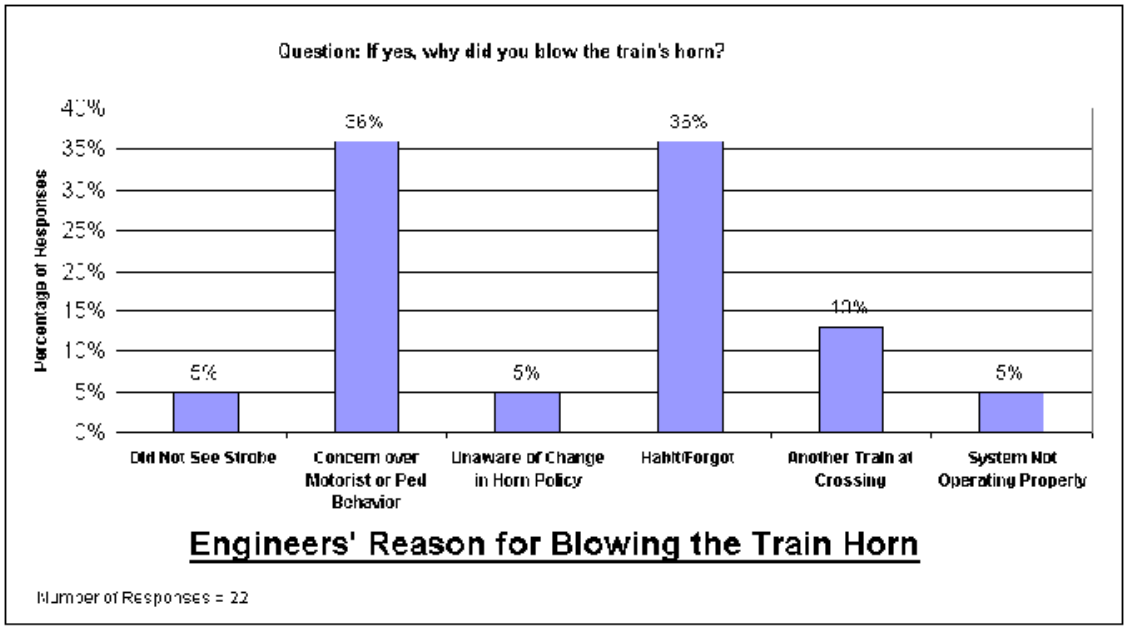
Graph 8



Graph 9



Graph 10



Graph 11

Summary

This research project was initiated for the purpose of evaluating the effectiveness of the automated horn warning systems. This purpose was twofold: 1.) to determine the effectiveness of the new system in reducing the annoyance level for nearby residents; and 2.) to determine the overall safety at the crossings with the automated systems.

The effectiveness of the automated horn in reducing the annoyance level for nearby residents was addressed through the field collection of horn noise levels and through the surveys of residents. The horn volume data that was collected near the crossings clearly demonstrates the significant reduction of land area negatively impacted by using the automated horns. In fact, the automated horn system reduced the area with noise levels greater than 80 dBA by 97 percent, from 171 acres using the train horns to less than six acres using the automated horn system. (For reference, a person shouting from a distance of three feet would produce a decibel reading of approximately 78 dBA.) The residents overwhelmingly accepted the automated horn system and appreciated the city staff for attending to their needs. In the before condition, 77 percent of the residents indicated the train horns had either a "negative" or "very negative" impact on their quality of life as compared to only 3 percent in the after condition. Regarding horn volume, 76 percent felt the train horn volume was "too loud" as compared to the after condition where 82 percent indicated that the automated horn volume was "no problem".

Because the city of Ames is only the third community to install automated horns, it is impossible to accurately determine the overall safety of the crossings. Only after more systems are installed can a study be conducted comparing the collision rates of crossings with similar exposures. Nonetheless, the motorist and locomotive engineer surveys provided valuable input into this issue. When the motorists were asked which system they preferred, 78 percent preferred the automated horn system, 8 percent preferred the train horns, and 14 percent had no opinion. Their responses also indicated that each of the warning devices (gates, flashing lights and train/automated horns) located at the crossings provides a value-added safety benefit. Twenty-three percent of the locomotive engineers rated the crossings "safer," 69 percent rated them "about the same," and only 8 percent rated the crossings with the automated warning systems to be "less safe" as compared to the before (train horn) condition.

In summary, the project found no evidence to suggest that the automated horns are less safe than the current practice of using train-mounted horns. The automated horn system provides the locomotive engineer with the option of sounding the train’s horn if unsafe behavior at the crossing is observed. This option may enhance the safety at the crossing because it provides an additional level of warning. For pedestrians and bicyclists, the automated horns appear to provide a better audible warning because of the intense nature of the horn volume during the early stages of the warning time. However, the automated horns do not provide an indication as to the direction of the approaching train, which is one of the reasons why these systems should only be considered at locations already equipped with automatic flashing light signals with gate arms and constant warning time circuitry. Other jurisdictions considering these systems may also want to use other supplementary safety measures, such as median barriers.

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