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NOISE IMPACTS FROM TRAIN WHISTLES AT HIGHWAY/RAIL AT-GRADE CROSSINGS

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ABSTRACT
It has long been the standard procedure in the United States to sound train whistles starting 1/4 mile (400 m) prior to all highway/rail at-grade crossings. US regulations require locomotives be equipped with audible warning devices that generate a minimum sound level of 96 dBA at 100 feet (30.5 m) in front of the locomotives. Most freight and passenger locomotives in the US are fitted with air horns that generate sound levels up to 115 dBA at a distance of 100 ft. There are approximately 2, 500 grade crossings where local communities have declared whistle bans because of the noise impact caused by the whistles. At these crossings, railroad engineers only sound the train whistles when there is potential for pedestrian or vehicular encroachment into the grade crossing danger zone. Recent studies have demonstrated that accident rates are significantly higher at grade crossings with whistle bans, even when the crossings are protected with flashing lights, bells and automatic gates. This has prompted evaluation of new regulation strategies for both whistle bans and for warning whistles on locomotives. This paper reports on the results of studies in support of the new regulations. The studies have shown that eliminating all whistle bans would expose approximately 350, 000 additional people to noise impact and that controlling the location where whistles are mounted on locomotives and modifying the train whistle systems to focus the warning noise at the grade crossings would substantially reduce noise impacts at over 150, 000 grade crossings in the US.

1 - INTRODUCTION
In 1994, the United States Congress passed the Swift Rail Development Act, which directed the Federal Railroad Administration (FRA) to issue a rule requiring all railroads operating in the United States to sound their horns at all grade crossings. In addition, a process was created to establish a national policy for communities to apply for and enact quiet zones. Recommendations were also made to limit the maximum noise level and to change the directivity of the horns. Congress acted to help limit the number of accidents involving trains at grade crossings with quiet zones. Statistics have shown that accident rates are 62% higher at grade crossings where horns are not blown[1].

As a part of the proposed rule, an Environmental Impact Statement (EIS) was undertaken to determine the effects of eliminating all existing quiet zones around the country. There are currently 1,978 grade crossings in the US with quiet zones, out of a total of over 159,000 public grade crossings. Of the 1,978 grade crossings, 1,159 are located in Illinois, Indiana, and Wisconsin; most of the latter are located in the greater Chicago area [1]. Virtually all of the grade crossings with quiet zones are located in urban or dense suburban areas, with high population densities. Because of this, the proposed rule had the potential to affect a large number of people across the country.

Documenting the noise effects of the proposed rule as a part of the EIS process included:

- developing a model based on empirical data to determine the effects of the reintroduced horns at the grade crossings;
- using the noise impact criteria contained in the FRA's High Speed Rail noise and vibration manual[2] to determine the extent of impact at individual grade crossings;

- applying the results to a GIS database referencing census data to catalog the locations and numbers of people effected by the proposed rule; and
- evaluating mitigation options that would help alleviate the noise impact of the proposed rule.

2 - NOISE MODEL

The first step in quantifying the effects of the proposed rule was to develop a noise model. The model needed to be able to accurately determine the existing noise levels without the horns and project the future noise levels after the reintroduction of the horn noise. The Day-Night Average Level (L_{dn}) has been used to characterize existing and future noise levels.

Model Inputs

In addition to the train length, number of cars and locomotives, speed, and number of trains per day, the noise model was based on the following factors:

- Horn Sound Exposure Level (SEL). The model allows the user to select the maximum noise level (L_{max}) of the horn 100 feet (30 m) in front of the locomotive. The model then calculates the SEL of the horn to the side of the train, where the noise sensitive receptors are located. The relationship between the L_{max} to the front of the train and the SEL to the side is based on a large body of measurements of freight trains at grade crossings. For the average fleet of locomotives, the SEL to the side of the trains is 107 dBA from 1/4 mile (400 m) to 1/8 mile (200 m) from the grade crossing, then increasing linearly to 110 dBA at the grade crossing, as shown in Figure 1.
- Horn Location. Measurements have shown that the location of the horn on the locomotive affects noise levels in the communities adjacent to grade crossings (See Figure 2). In the past, the horn was located to the front of the locomotive, over the engineer's cab. However, in an effort to reduce noise inside the locomotive cabs, the recent trend has been to mount the horn in the middle of the locomotive. In this configuration, noise to the front of the locomotive is partially shielded and directed to the side of the train, toward abutting noise sensitive receptors and away from the grade crossing.
- Shielding. The model takes into account the shielding provided by rows of buildings adjacent to the grade crossing. The amount of shielding is based on the density of the buildings, and the distance between the rows of buildings.
- Sounding Pattern. The model assumes the standard sounding pattern for locomotive horns as they approach a grade crossing. The standard pattern is a series of blasts in a long-long-short-long sequence, where the final long blast occurs as the lead locomotive passes through the grade crossing. Data from field measurements was used to model the length of time for each blast, the length of the pauses between the blasts, and the horn rise time.
- Noise Environment. The model allows the user to select the "background" noise level (in L_{dn}), or the ambient noise level without the noise from trains. The background noise level is based on the type of noise environment: urban, suburban or rural, or a user defined background noise level. Without the background noise, the difference between the curves of existing and future noise in Figure 3 would remain a constant value, and the extent to which noise impact penetrates into the community could not be assessed.

The model projects the L_{dn} for the existing and future cases versus distance, until the user selected "background" noise level is reached. The results are the two curves shown in Figure 3. The lower curve is the existing noise level as a function of distance perpendicular to the tracks. The upper curve is the future noise level with the horns, also as a function of distance to the tracks.

3 - NOISE CRITERIA

The noise criteria used to assess impact were taken from the FRA noise and vibration manual[2], and are based on the increase in L_{dn} over the existing noise level. The existing noise was assumed to be dependent on the existing train traffic through the grade crossing, without the contribution of the horns, plus the background level. The increase in noise was based on the addition of the horn noise to the existing train noise. The noise impact criteria used in the assessment are shown in Figure 4.

The noise criteria were applied to the existing noise curve in Figure 3 to create another curve representing the increased noise that would cause impact and severe impact as a function of distance. The point of

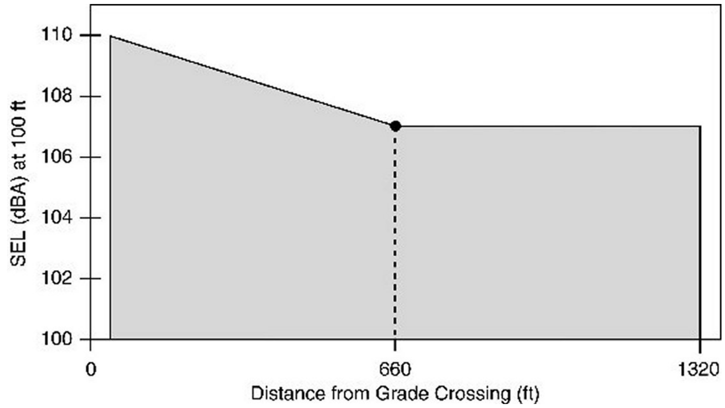

Figure 1: SEL Source Level at Grade Crossings.

Figure 2: Locations of Horns on Locomotives.

intersection between this curve and the future noise curve determines the distance to which impact occurs. Without including the background noise level, impact would occur out to an infinite distance from the tracks. The background noise level forces the two curves to approach each other and reach a point where impact no longer occurs.

4 - APPLICATION

The output of the model was imported into a GIS database. The output consisted of a series of points at each grade crossing, defining polygons in each of the four quadrants of the grade crossing where both impact and severe impact were projected to occur, as shown in Figure 5.

The GIS system was used to overlay the noise impact polygons onto census data based on population density inside each census tract, and estimate the number of people living inside the impact zone at each of the 1,978 grade crossings with quiet zones. The results of the GIS program showed the potential for 365,000 persons across the US to experience noise impact as a result of eliminating the quiet zones, and for 151,000 persons to experience severe impact. Almost 50% of the impacts are in Illinois, and nine of the top 20 most affected cities are in the greater Chicago area.

5 - CONCLUSIONS

In addition to eliminating all existing quiet zones around the country, the proposed rule also details a number of measures meant to provide relief to affected persons where the horns will be blown, and also to the population as a whole living near all 159,000 public grade crossings around the country. The measures include regulation of:

- Creation of Quiet Zones. The proposed rule sets nation-wide standards for the application for, and certification of a quiet zone by a community. The current system allows any community to establish a quiet zone, without any additional safety measures to replace the sounding of the horn.

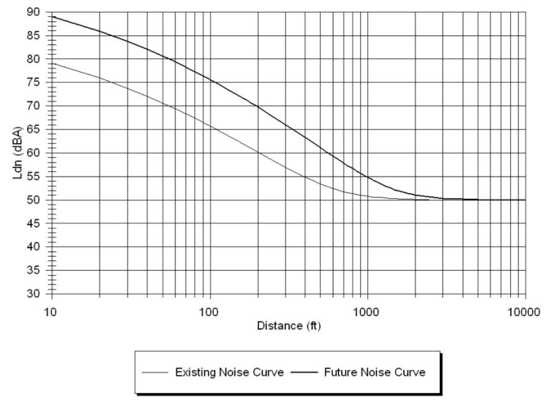

Figure 3: Noise Model Curves of Existing and Future Noise Levels.

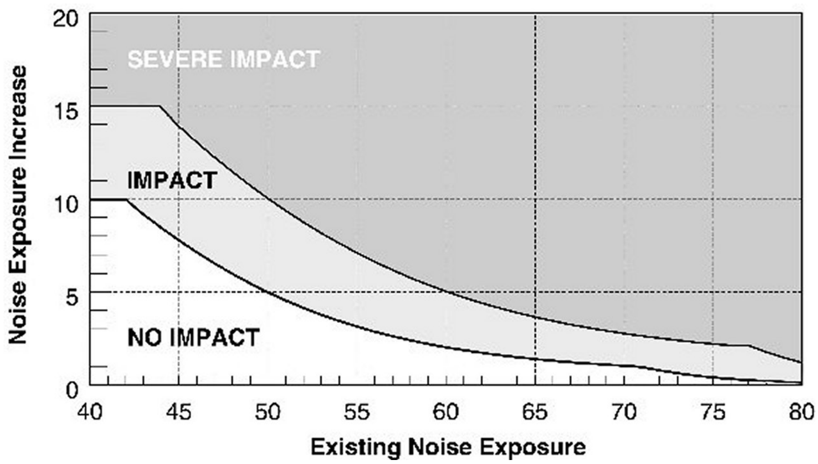

Figure 4: Noise Criteria.

The new measures allow for Supplemental Safety Measures (SSM's) to be used in place of the horns. The SSM's include 4-quadrant gates and median barriers. Communities with existing quiet zones will be given a two to three year grace period in order to qualify for a quiet zone under the new regulations.

- Maximum Sound Levels. Currently the FRA only regulates the minimum sound level for locomotive horns at 96 dBA 100 feet (30 m) in front of the locomotive. Many of the horns currently produce sound levels up to 115 dBA at this distance. The FRA has proposed limiting the maximum sound level at either 111 dBA, 104 dBA, or allowing a variable setting based on these levels for daytime and nighttime use.

- Directionality. The directionality of the horn is dependent on the characteristics of the horn and more importantly, the location of the horn on the locomotive. Many railroads are moving the horns away from the front of the locomotive, which sometimes places the horn behind obstructions. In order for the horn to meet the minimum noise level to the front of the locomotive, the noise level to the side is often significantly higher than to the front, due to the shielding of the obstructions in front of the horn. The FRA has proposed limiting the maximum level at 100 feet (30 m) to the side of the locomotive to be no higher than the level 100 feet (30 m) in front of the locomotive. The FRA gave no guidance to the railroads on how this was to be accomplished, and a study is currently underway to examine this issue.

- Sounding Time. The current horn sounding practice requires locomotives to sound their horns starting 1/4 mile (400 m) from the grade crossing and sound it until the lead locomotive enters the grade crossing. This practice does not take into account the speed of the train. For slower trains, the horns can be blown for a long time, increasing the noise exposure for people next to the tracks.

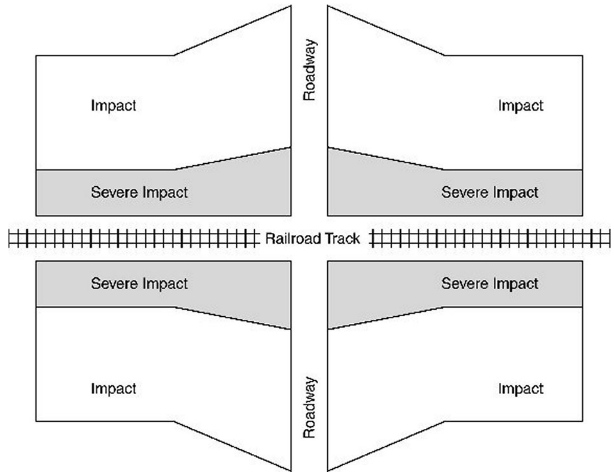

Figure 5: Noise Impact Polygons.

The FRA has proposed changing the rule to state that horns must be blown starting 20 seconds before the grade crossing (based on the maximum allowed speed on that section of track), with a maximum distance of 1/4 mile (400 m) from the grade crossing.

These measures are expected to help mitigate the noise impact of horns at grade crossings with and without quiet zones. A combination of the 104 dBA L_{max}, the prescribed directionality, and the 20-second horn sounding time limit would reduce the number of persons impacted by horn noise, at all 159,000 grade crossings across the country, by 71% as compared with the current practices[1].

REFERENCES

1. **United States Department of Transportation, Federal Railroad Administration**, *Proposed Rule for the Use of Locomotive Horns at Highway-Rail Grade Crossings, Draft Environmental Impact Statement*, 1999

2. **United States Department of Transportation, Federal Railroad Administration**, High Speed Ground Transportation Noise and Vibration Impact Assessment, 1998