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DATA ANALYSIS OF GRADE CROSSING INCIDENTS

SUMMARY

Incidents and fatalities at highway-rail grade crossing in the United States have declined significantly over the past two decades despite a significant increase in both train and vehicle traffic. Therefore, to provide a more realistic comparison of safety performance over the years, it is important to include both train and vehicle traffic when calculating incident rates at highway-rail grade crossings. The U.S. Department of Transportation's (USDOT) Federal Railroad Administration (FRA) tasked the USDOT Research and Innovative Technology Administration's John A. Volpe National Transportation Systems Center (Volpe Center) to review an exposure metric called traffic moment (TM), which is currently used by European nations, and to apply it to U.S. data.

Historically, the highway-rail grade crossing incident rate is calculated in terms of train miles traveled (TMT). Although it is a useful measure of the exposure to the risk of collision between train and motor vehicle, adding vehicle exposure would reflect a more accurate picture. TM is generally calculated as the product of the average value of highway traffic and the average value of the train traffic. Figure 1 graphically displays the TM concept, where AADT stands for average annual daily traffic and TTPD stands for total trains per day.

TM could be defined as the maximum number of encounters between trains and motor vehicles based solely on the average frequency of train

and motor vehicle traffic. The Italian Ministry of Transport and the Italian State Railway defined TM as "a numerical value that is a function of the average value of highway and train traffic through the grade crossing" [1]. The Volpe Center study was conducted in two parts: (1) incidents per TM were calculated for public crossings from 1989 to 2008 to compare safety performance at highway-rail crossings against traditional methods by using TMT; and (2) a comparative analysis of public highway-rail grade crossing safety performance between active and passive crossings for the same period of time.

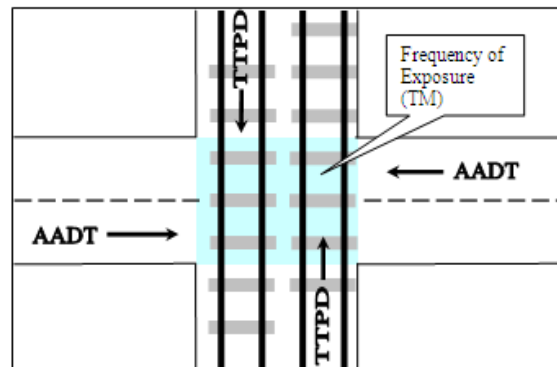


Figure 1. Traffic Moment Concept



BACKGROUND

A highway-rail grade crossing incident is a unique situation in which all three factors—train, motor vehicle, and crossing—must be present for the incident to occur. As such, it is important to include all three factors when calculating incident rate and for comparing highway-rail safety over the years.

Historically, an incident rate per million train miles traveled (TMT) has been used for comparative analysis of highway-rail crossing safety performance. This method is well suited to compare incident rates involving just one mode of transportation such as train-to-train or vehicle-to-vehicle collisions. However, highway-rail grade crossing incidents involve two different modes of transportation. Therefore, a traffic moment (TM), which takes into account exposure of both vehicle and rail, has been reviewed in this research study.

OBJECTIVES

There were two objectives to this research: (1) to review the grade crossing exposure metric used by European nations and to analyze the ability to fit the U.S. data into that method for all U.S. public crossings; and (2) to apply the same exposure metric to public active and passive crossings to compare the trends in incident rate between active and passive crossings.

METHODS

The first step to calculate TM for each year at public crossings was to obtain the average total trains per day (TTPD) and average annual daily traffic (AADT) at public crossings. The average TTPD and AADT was calculated by dividing the sum of TTPD or AADT at public crossings by the number of public crossings for that year. FRA Grade Crossing Inventory database was used to populate AADT and TTPD at public crossings for the calendar year 2008. Since the FRA Grade Crossing History Inventory database only goes back 10 years, the AADT and TTPD

for the calendar years 1989–2007 were extrapolated from 2008 data, based on changes in the number of public crossings, vehicle miles traveled (VMT), and TMT for each year. The following equations were used to calculate AADT and TTPD for the years 1989–2007.

$$AADT_n = AADT_{2008} + AADT_{2008} \times \left[\left(\frac{Xing_n - Xing_{2008}}{Xing_{2008}} \right) + \left(\frac{VMT_n - VMT_{2008}}{VMT_{2008}} \right) \right]$$

$$TTPD_n = TTPD_{2008} + TTPD_{2008} \times \left[\left(\frac{Xing_n - Xing_{2008}}{Xing_{2008}} \right) + \left(\frac{TMT_n - TMT_{2008}}{TMT_{2008}} \right) \right]$$

The TM for public crossings was then calculated by resolving the product of the average TTPD and AADT for each year. For example, in 2008, the average TTPD and AADT at public crossings was 11.03 and 2,323.18, respectively. Therefore, the TM at public crossings in 2008 was calculated to be 25,614.57 (11.03 × 2,323.18).

Finally, incidents per TM at public crossings per year were calculated by dividing the total number of incidents at public crossings by the TM for that year. Incidents per TM for the public crossing are shown below in Figure 2.

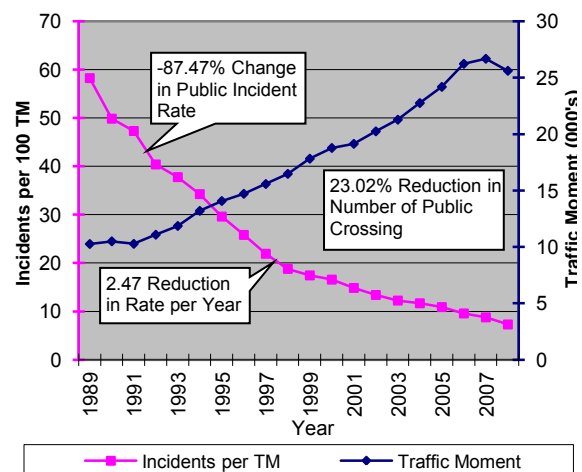


Figure 2. Incidents per TM at Public Crossings



The TM for active and passive crossings was calculated using the same methodology. The only difference was during the extrapolation step of AADT and TTPD. Instead of the changes in overall number of public crossings, changes in the number of each type of crossing were used. The total number of active and passive crossings for each year from 1989 to 2008 was obtained from the *FRA Railroad Safety Statistics – Annual Report*.

An active crossing is defined as a crossing whose warning devices are activated on a train approach to a crossing; these include crossings with the following warning devices: gates; lights; (e.g., highway traffic signal, wig wag, bells); and special warning. All remaining crossings with warning devices such as cross bucks and stop signs are categorized as passive crossings.

RESULTS

Public Crossings

The results of highway-rail grade crossing incidents per TM at public crossings revealed that during the study period, the incidents per TM decreased by 87.5 percent. In comparison, the decrease was 74.8 percent when using an incident rate per TMT, and the decrease was 68.7 percent when using only raw incident data. The largest decrease in incidents per TM was during the early part of the study.

TM at public crossings increased by 149.6 percent from 1989 to 2008. This increase was throughout the study period, except for two minor declines in 1991 and 2008. The drop in 2008 could be attributed to the increase in gas prices and the dwindling economy, which lowered both the AADT and TTPD traffic measures.

Active versus Passive Crossings

Comparative analysis of grade crossing safety between active and passive crossings was conducted to get a better perspective of where the reduction in incidents has occurred and to compare the trend in incident rates between active crossings and passive crossings.

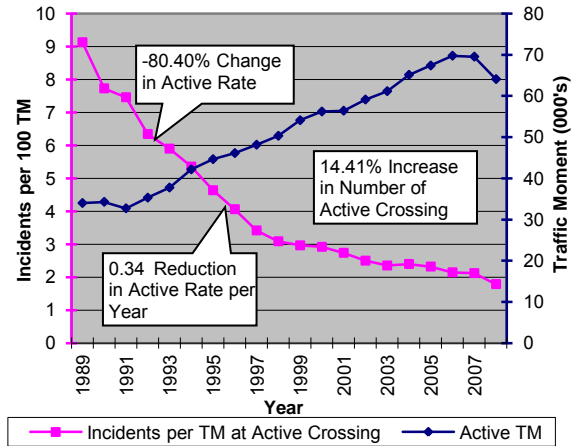


Figure 3. Incidents per TM at Public Active Crossings

Although the reduction in incidents per TM at passive crossings was decreasing much faster than at active crossings, the risk of collision between trains and motor vehicles in 2008 at passive crossings is still almost 10 times greater than at active crossings, as shown in Figures 3 and 4. The greater reduction in incidents per TM at passive crossings could be attributed to the reduction in the number of passive crossings or the theory that most of the risky passive crossings have been upgraded either to active warning devices or selected for consolidation.

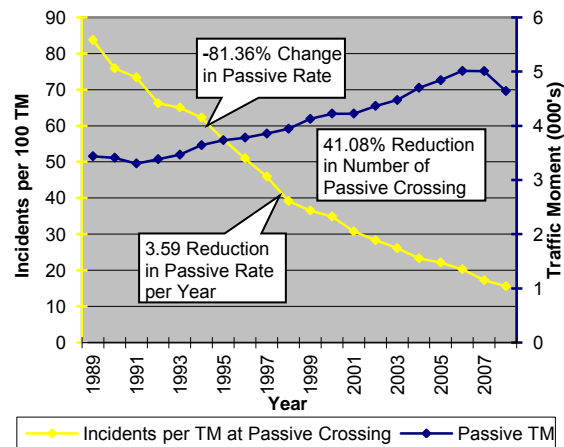


Figure 4. Incidents per TM at Public Passive Crossings



The percent reduction in incidents per TM between active and passive crossings is similar, estimated to be around 80 percent from 1989 to 2008, despite a 41.1 percent reduction in the number of passive crossings and a 14.4 percent increase in the number of active crossings. Incidents per TM at active crossings are shown in Figure 3 for active crossings and Figure 4 for passive crossings.

CONCLUSIONS

Historically, exposure at highway-rail grade crossings is measured by TMT. Although it is a useful measure of the exposure, it does not include the motor vehicle exposure. TM was found to be possibly a more accurate reflection of risk exposure at a crossing that is sensitive to both train and motor vehicle traffic volumes and trends. This new exposure metric was used to calculate incidents per TM at public crossings.

The TM exposure metric was especially useful for comparative analysis between different types of crossings, such as active versus passive, because it effectively normalizes the incident data by both train and vehicle exposure for that particular type of crossing. A comparison of Figures 3 and 4 shows that passive crossings are almost 10 times more risky than active crossings.

TM could also be used as a supplement or alternate method to the USDOT Accident Prediction Formula calculations to determine the types of improvements required for a crossing. Many countries in Europe and Asia have been using TM with other crossing characteristics, such as train speed and number of tracks, to determine appropriate crossing improvements.

REFERENCES

[1] Luedeke, J. F. (1998 Sept.) *Evaluation of highway-railroad grade crossing decision methodologies*. (Unpublished Report).

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Grade crossing, traffic moment, exposure,
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