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# Analysis of Potential Track Panel Shift at WILD Sites

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**Summary**

An analysis of the data recorded at three different wheel impact load detector (WILD) sites under 1,590 trains found no occurrences of wheel/rail forces that would be expected to cause lateral track panel shift. There are no officially recognized panel shift criteria for U.S. railroads for FRA Class 1 to 5 Track, though past research in this area has proposed force value relationships for panel shift that were used in this evaluation. The instances of forces that approached the level of concern for track panel shift occurred under unloaded cars traveling at relatively high speeds and were therefore attributed to truck hunting. This work was performed by Transportation Technology Center, Inc. (TTCI) as part of the Association of American Railroads' (AAR) Strategic Research Initiatives Program under the Dynamic Load Environment of Train Equipment project.

This analysis investigated the occurrence of buff loads and coupler angularity in generating forces of interest for lateral track panel shift. As the total tonnage moved by rail increases, railroads have increased train length and have expanded the use of distributed power to meet these needs. These changes have potential to change the characteristics of longitudinal coupler forces between cars. Buff loads combined with coupler angularity can generate net lateral forces on cars, which are reacted at the wheel/rail interface.

Two different track panel shift criteria were considered in evaluating the data. Previous work involving the AAR's Track Loading Vehicle (TLV) was used to establish the critical forces required to shift track laterally and is the most relevant criterion for North American conditions. An older and more conservative criterion often used in Europe was also considered. Instances were found that exceeded the European criterion, but not the TLV-based criterion.

Data from individual cribs of WILD sites provide an easily accessible source of data. However, these detectors are not typically located in heavy undulating terrain where frequent buff run-ins might occur. Thus, the lack of criterion exceedances in this analysis does not rule out the possibility of track panel shift as a result of buff train forces.

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## INTRODUCTION

TTCI is investigating the possibility of train lateral forces as a root cause for track panel shift. A review of wheel/rail vertical and lateral forces at individual cribs from several WILD sites did not show any occurrences of wheel/rail forces that would be expected to cause lateral track panel shift, though slack action (and lateral wheel/rail forces potentially resulting from that slack action) is not typically expected at WILD sites.

## BACKGROUND

Track panel lateral shift is the formation and growth of lateral track misalignments due to repeated high truck sum lateral to vertical (L/V) load ratios and longitudinal forces, often in combination with thermal compressive forces. Track panel shifts are generally long (on the order of 50 feet) and in one direction laterally from the design centerline of the track. Figure 1 shows a lateral track panel shift.

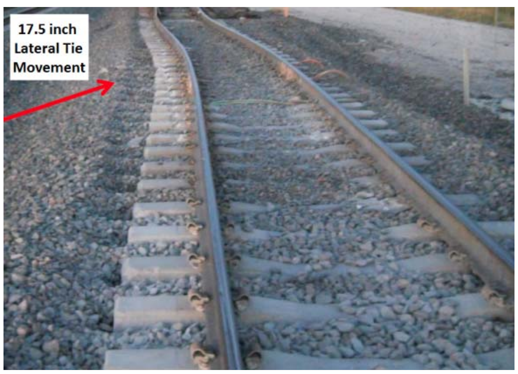


**Figure 1. Track Panel Shift after Multiple Trains**

Prud'homme developed criteria for evaluating the propensity for track panel shift based on the combined vertical and lateral wheel loads of both wheels on the same axle.[1] European railways use the following form of the Prud'homme criterion:

$$L_c = 0.85 * (2.25 + 0.33 * V)$$

Where $L_c$ is the critical axle sum lateral load, and V is the axle sum vertical load. Using the AAR's TLV, Li and Shust were able to apply lateral and vertical loads while in motion and found the Prud'homme criterion to be conservative.[2] Instead, they suggested the following criterion.

$$L_c \sim= 6{,}000 \text{ pounds} + 0.5 * V$$

Figure 2 shows a comparison of these two criteria in terms of the critical axle sum L/V ratio as a function of the axle sum vertical load. Testing with the TLV clearly showed that vertical load has a significant effect on resistance to track panel shift and that longitudinal rail compressive stress (due to thermal effects) has a substantial effect near critical L/V values.

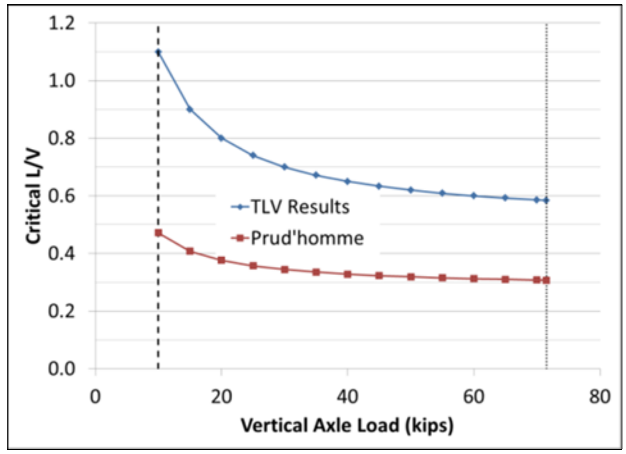


**Figure 2. Relevant Track Panel Shift Criteria**

At least one Class I railroad has experienced lateral track panel shift incidents in recent years on track that would otherwise be considered to have strong lateral track strength and strong buckling strength. By process of elimination, this suggests the suspected root cause may be repeated lateral wheel/rail forces as a result of high buff forces, slack action or truck hunting. Large train run-in events could potentially generate lateral coupler forces in the presence of coupler angularity generating axle sum L/V values of interest for track panel shift. Instability at high speed, also known as truck hunting, could also momentarily produce large axle sum L/V values.

The cause codes available to report lateral track panel shift accidents to the Federal Railroad Administration (FRA) are: M405 Interaction of lateral and vertical forces (a broad category which also includes harmonic rock off); E4TC Truck Hunting; H503 Buffing or slack action excessive, train handling; H504 Buffing or slack action excessive, train make-up; H505 Lateral drawbar force on curve excessive, train handling; H506 Lateral drawbar force on curve excessive, train make-up; and H507 Lateral drawbar force on curve excessive, car geometry. There will be obvious causes of the track panel shifts, but there will also be other causes that are more difficult to identify. In some of these incidents of track panel shifts, railroads were not able to determine what train or car(s) caused the track panel shift. Since the occurrence of this derailment is a function of lateral and vehicle forces, it could potentially be reported under code M405. Track panels shifts should not be closed out as T108 Track alignment irregular (other than buckled/sunkink) or T109 Track alignment irregular (buckled/sunkink). On tangent track, a panel shift is uniformly shifted over a long distance in one direction. On curved track, a panel shift is generally a long lateral shift to the high side of the curve.

Figure 3 shows the history of cause codes that may have a relationship with track panel shift. These categories follow the same general decreasing trend with time seen in nearly all the safety data evaluated.

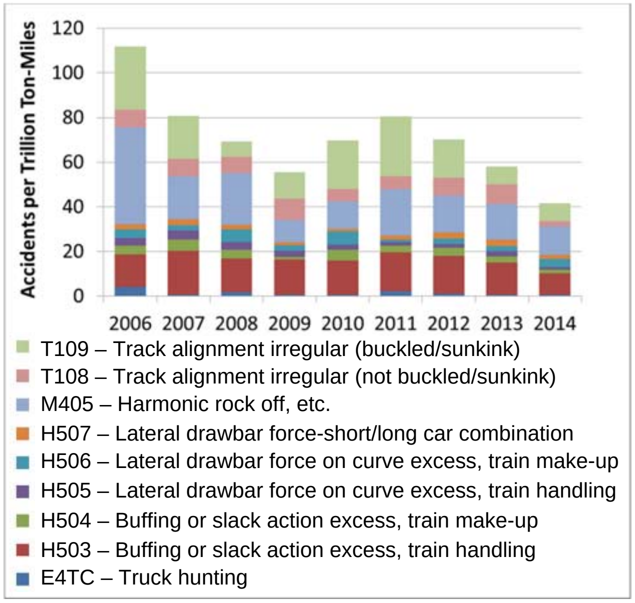


**Figure 3. Historical FRA Safety Data**

## DATA ANALYSIS AND DISCUSSION

To investigate the incidence of wheel/rail forces of interest for track panel shift, TTCI analyzed data from individual cribs at three different WILD sites. Although WILD sites are not typically located in heavy undulating terrain where frequent buff run-ins might occur, they do provide an easily accessible source of data. Many WILD sites include data regarding both the vertical and lateral wheel loads at each crib. The lateral load data is typically used to identify truck hunting using proprietary algorithms. All of the WILD sites from which data was queried for this analysis include the lateral force measurement capability. The characteristics of these sites and the data analyzed from each site are as follows:

**WILD Site A**: steady grade of approximately 0.15 percent in surrounding vicinity and no horizontal curves. A total of 410 trains were analyzed, including 5.31 million records of individual wheel forces by crib (16 per rail). Prominent train types at this site include: unit coal 44 percent, intermodal 25 percent, and manifest 18 percent.

**WILD Site B**: grade of 0.43 percent maximum in the immediate vicinity of the detector and 0.82 percent grade within 2 miles of the detector. There is a 1-degree curve within 1 mile of the detector. A total of 574 trains were analyzed, including 4.76 million individual wheel forces by crib. This site sees the following train type mix: manifest 45 percent, intermodal 40 percent, and grain 10 percent.

**WILD Site C**: flat and tangent in the area surrounding the detector. A total of 606 trains were analyzed, including 9.06 million individual wheel readings by crib. More than 50 percent of the trains at this site are manifest trains followed by 25 percent intermodal.

To begin the analysis, trains of potential interest were selected based on single wheel L/V values. The single wheel L/V was used as an initial evaluation metric for computational simplicity. It was found that the relative position in the train of the highest single wheel L/V values was not consistent between trains. Consistency was also lacking in the location on the track (crib) where large single wheel L/V values were found.

Figure 4 shows two examples of trains with large single wheel L/V values occurring at different locations within the train. Lateral wheel/rail forces are assigned a positive value for gage-spreading force and a negative value in the opposite direction. Because track panel shift relies on repeated loadings near the critical value, the lack of consistency in these initial investigations did not bode well for finding track panel shift events in the WILD data.

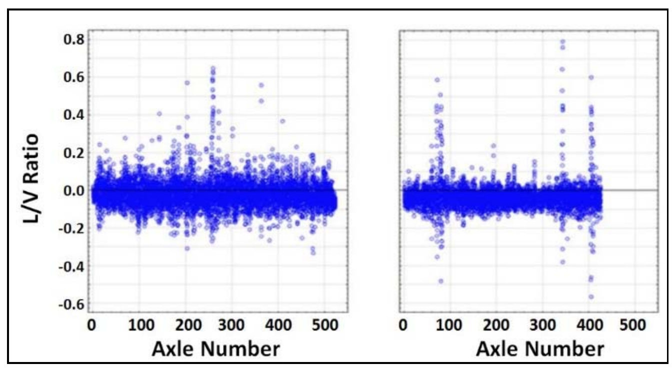


**Figure 4. Single Wheel L/V Ratios at a Single Crib as a Function of Position in Train for Two Different Trains**

Next, the axle sum lateral and vertical loads were calculated for each axle. The axle sum L/V ratio was plotted against the axle sum vertical load and compared to the Prud'homme criterion and the TLV criterion. Figure 5 shows an example from one crib. Because of the sign convention used for lateral wheel/rail forces, the axle sum lateral force is calculated by finding the difference between the reported values on the left and right rails. Net axle lateral forces to one side of the track are positive and net axle lateral forces to the other side of the track are negative. The track panel shift criteria can be applied to positive or negative axle sum L/V values.

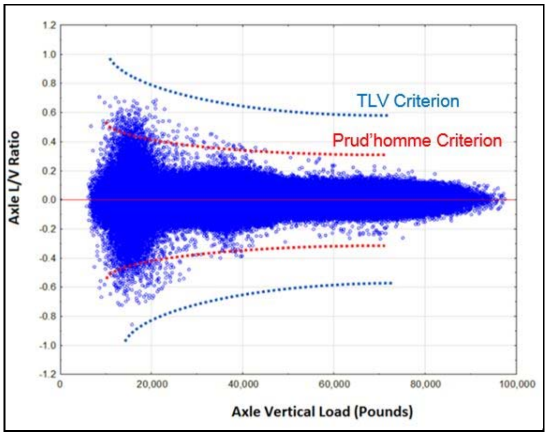


**Figure 5. Axle Sum L/V Ratio Compared to Track Panel Shift Criteria**

Exceptions to the Prud'homme criterion were found for lightly loaded cars, but no exceptions to the TLV criterion were found. The data was subdivided into various categories by train type, car type, and speed. Upon doing this, it became evident that the values of interest in relation to the track panel shift criteria were occurring under boxcars, covered hoppers, and tank cars in manifest trains at speeds above 40 mph and on intermodal trains at speeds above 50 mph. For these combinations of cars, trains, and speeds, truck hunting becomes more of an issue, and in-train forces are generally not as much of a concern. To investigate this possibility, individual wheel/rail forces were tracked through sequential cribs in the WILD site so that a time history of the vehicle passing through the WILD site was created.

Figure 6 shows an example of the lateral forces of four wheels from a single truck passing through each crib. The oscillating nature of the forces is a clear indicator that this truck is hunting rather than experiencing a lateral coupler force induced from slack action. Detailed investigation of other axles with large L/V values showed similar results.

Between the speed of the trains, the light vertical loads, and spot checking a number of individual axle forces through the WILD site, TTCI came to the general conclusion that the larger axle sum L/V values in the data may be due to truck hunting or light car dynamics and not slack action.

## CONCLUSION

No wheel/rail force combinations that would be expected to cause lateral track panel shift were found during an analysis of 1,590 trains that generated more than 19 million individual wheel readings while passing three different WILD sites. Forces that exceeded the Prud'homme track panel shift criterion used in Europe were found, but they were attributed to either truck hunting oscillations or lateral dynamics of lightweight cars at high speeds rather than lateral forces due to longitudinal train dynamics in combination with coupler angularities. The Prud'homme criterion is more conservative than the TLV criterion that was used as the main performance indicator in this analysis.

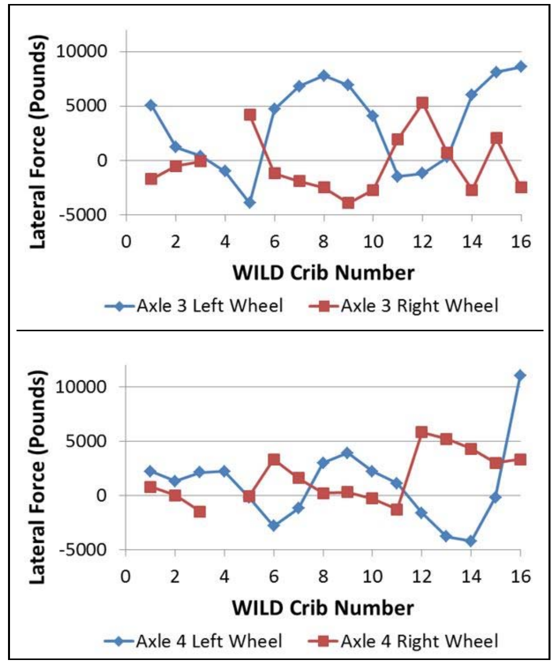


**Figure 6. Example of Truck Hunting**

## FUTURE WORK

Without prior knowledge of where track panel shifts will occur, it is difficult to capture data regarding these events through conventional means such as applying strain gages to the rail to determine vertical and lateral wheel/rail forces. Instead, TTCI intends to conduct simulations using our train dynamics software to determine what longitudinal train action on tangents, spirals, and curves would be needed to produce a track panel shift and whether wheel climb would be expected to occur before the forces reached a level of concern for track panel shift.

## REFERENCES

1. Prud'homme, A. "The resistance of the permanent way to the transversal stresses exerted by the rolling stock." In *Bulletin International Railway Congress Association*. 1967, pp. 731-766.
2. Li, D. and W. Shust. "Investigation of Lateral Track Strength and Track Panel Shift Using AAR's Track Loading Vehicle." Research Report R-917, AAR/TTC, Pueblo, CO. 1997.