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# Truck Bogie Optical Geometry Inspection System Hunting Alert Criteria

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## Summary

As part of the Association of American Railroads' (AAR) Strategic Research Initiatives Program, as directed by the Equipment Health Monitoring Committee, the Transportation Technology Center, Inc. (TTCI) has estimated an alert limit for TBOGI-HD™\* peak hunting comparable to AAR truck hunting detector (THD) limits.

Results of the nonparametric survival analysis show the similar distribution of the dataset of the TBOGI-HD system with the THD dataset.

The similar distributions and traffic of both technologies permit an estimate for the TBOGI-HD peak hunting that corresponds to the THD hunting index as follows:

- 23.4 to 23.5 TBOGI-HD peak hunting corresponds to 0.35 THD hunting index
- 33.8 to 33.9 TBOGI-HD peak hunting corresponds to 0.50 THD hunting index

The analysis provides statistical estimates for corresponding TBOGI-HD peak hunting values to the AAR THD hunting index limits. For future work, trucks will need to be measured for worn conditions to verify the correct alert limits of the TBOGI-HD system corresponding to the THD hunting index limits specified in AAR Rule 46.A.1.e.<sup>1</sup>

This research is a continuation of the original study performed by TTCI and reported in *Technology Digest* titled "Initial Performance Limits: Three Hunting Detector Types," which established correlations between the hunting detectors and an onboard 300-foot root mean square value.<sup>2</sup>

\*TBOGI™, Truck Bogie Optical Geometry Inspection  
TBOGI-HD™, Truck Bogie Optical Geometry Inspection and Hunting Detector



**INTRODUCTION AND BACKGROUND**

This research is a continuation of the original study performed by TTCI and reported in 2007, which established correlations between three hunting detectors that included the Wayside Inspection Devices (WID) TBOGI™ and Salient Hunting Truck Detector (HTD) systems.<sup>2</sup>

From the original study, the correlation coefficient between onboard 300-foot root mean square and each hunting value are reasonably strong.

The TBOGI-HD measures the tracking position, angle of attack of wheelsets on a truck, and provides truck composite metrics that include a hunting metric for lateral instability. The focus of the research is hunting with the TBOGI-HD system.



Figure 1. Two TBOGI-HD Detectors on Double-Track

A vehicle that is hunting exhibits a harmonic motion on the track (Figure 2) and imposes regular lateral and vertical load patterns on the track. The AAR *Field Manual* (Rule 46.A.1.e) provides instructions to request disposition from the car owner for a single Salient THD absolute alert value of at least 0.50, or a two Salient THD absolute alert values of at least 0.35 in the last 12 months. The TBOGI-HD system measures the peak to peak lateral motion of the truck's wheelsets and quantifies this motion in millimeters (or inches), a physical unit. There are 12 active TBOGI-HD detectors and 81 THD detectors in North America.

The goal of the research is to estimate an alert limit for TBOGI-HD peak hunting comparable to AAR THD limits.

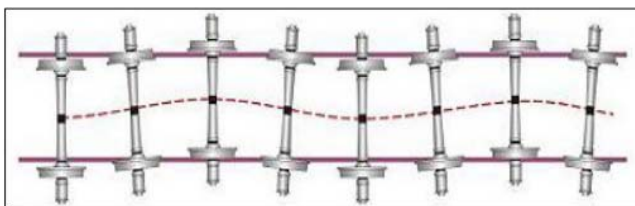


Figure 2. Wheelset Hunting Motion

**ANALYSIS**

The analysis started with a TBOGI-HD dataset with 4,220,552 records from January 2010 through September 2014 and a THD dataset with 52,474,169 records from December 2011 through December 2012. Hunting values greater than zero were used from both datasets for analysis.

TTCI examined traffic patterns across both technologies in revenue service. The top five car types are the same in a different order, as shown in Figures 3 and 4.

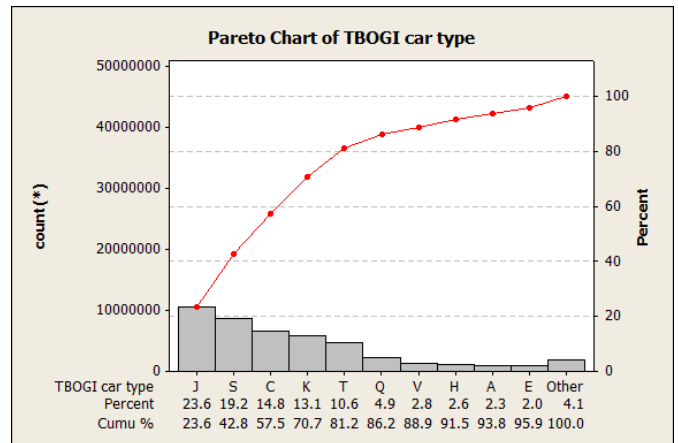


Figure 3. Pareto Chart of TBOGI-HD by Car Type

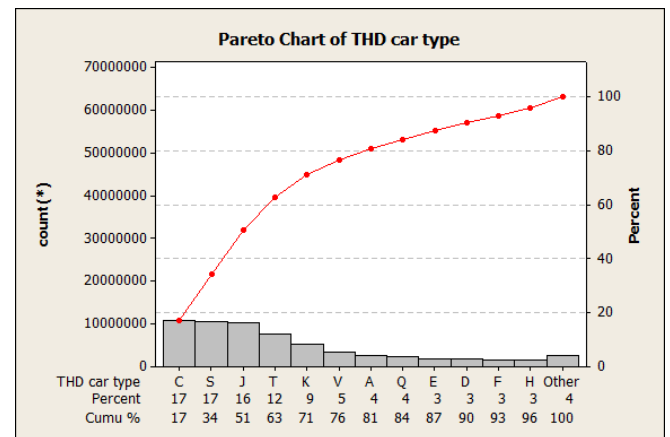


Figure 4. Pareto Chart of THD by Car Type

The statistical method applied in the study is a frequency analysis that measures how often high measured values occur in a dataset. Nonparametric survival (NPS) testing is used to perform the frequency analysis with the right tail of the hunting values. The NPS technique verifies the likelihood that any measure for the TBOGI-HD dataset is comparable to the THD dataset. The right tails of the distributions, the largest 11.3 percent of the data, are selected from the THD dataset where the hunting index is greater or equal to 0.06, and the hunting value for TBOGI-HD must be greater or equal to 3.90. For the NPS tail analysis, the THD dataset is reduced to 7,132,591 records, and the TBOGI-HD dataset is reduced to 516,411 records.

Figure 5 shows an overlay of the TBOGI-HD and THD datasets with two x- and y-axes. The left and bottom axes denote the TBOGI-HD hunting values and frequency (count data). The right and top axes denote the THD index values and frequency (count data). Figure 5 shows that both distributions have a similar shape. This is expected because both datasets represent hunting values for similar traffic.

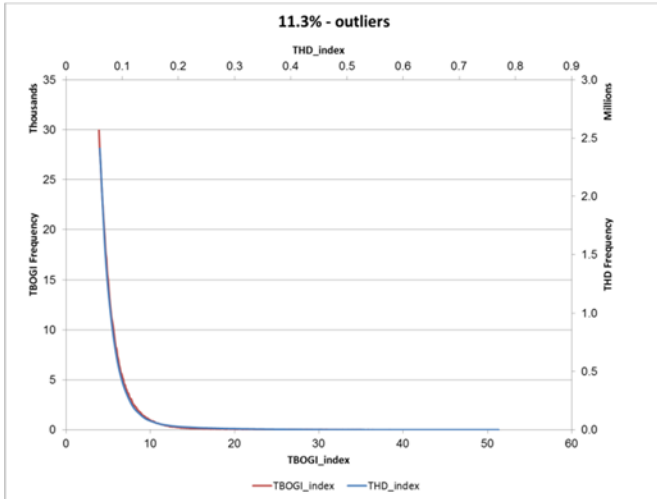


Figure 5. Overlaid Survival Plot of TBOGI-HD and THD for the Tails of the Data

The corresponding values of the TBOGI-HD are estimated from the NPS analysis in Figure 6. The corresponding values of a 0.35 absolute value of THD (yellow) and 0.50 absolute value of THD (green) are estimated as follows:

- Corresponding TBOGI-HD values for 0.35 THD hunting index
  - THD values of 0.35 occur approximately 0.53 percent to 0.54 percent of the time.
  - The THD probabilities, translated to TBOGI-HD, identify the range 23.4 to 23.5 for the TBOGI-HD peak hunting at the same likelihood.
- Corresponding TBOGI-HD values for 0.50 THD hunting index
  - THD values of 0.50 occur approximately 0.04 percent of the time.
  - The THD probabilities, translated to TBOGI-HD, identify the range 33.8 to 33.9 for the TBOGI-HD peak hunting at the same likelihood.

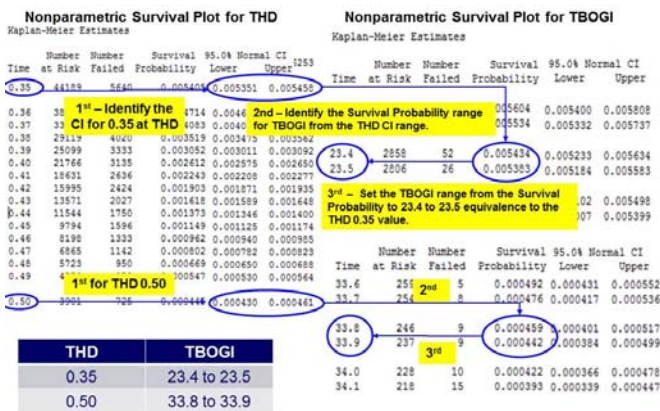


Figure 6. Estimate Comparison between TBOGI-HD and THD

RESULTS

Using the estimated values of about 23 and 33 for TBOGI-HD, the number of additional trucks that may alert in a 12-month period are determined. Three rules are evaluated, two similar rules to the existing THD hunting index (AAR Rule 46.A.1.e) and one composite with THD and TBOGI-HD.

- One single TBOGI-HD peak hunting value of 33 or more
- Two TBOGI-HD peak hunting values of 23 or more in a 12-month period
- One TBOGI-HD peak hunting value of 23 or more and one THD hunting index value of 0.35 or more in a 12-month period

Table 1 shows the number of unique trucks that alerted in a 12-month period for THD detectors per AAR Rule 46.A.1.e.<sup>1</sup> Trucks that alerted multiple times in the 12-month period are only counted for the first alert. For the same 12-month period, about one-third of the THD trucks alerted with single values of 0.50 or more.

Table 1. Trucks Alerting in a 12-month Period with THD Only

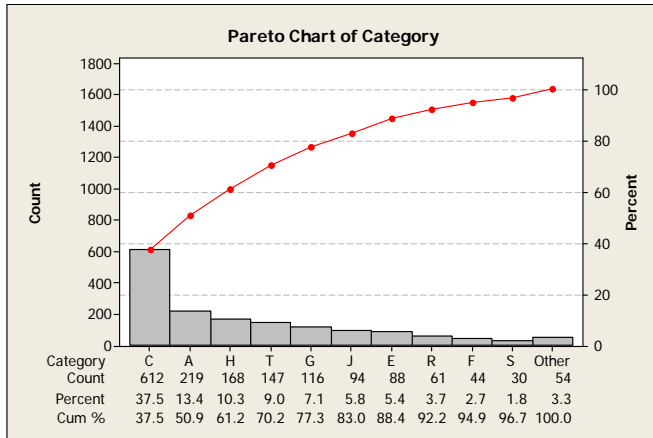
Alert Criteria THD Hits	Count
2 Hits at 0.35+	5,424
1 Hit at 0.5+	3,233
<b>Total:</b>	<b>8,657</b>

For comparison, Table 2 uses the three rules above to determine the number of unique trucks that would alert in the same 12-month period including the TBOGI-HD data. As before, trucks that would alert multiple times in the 12-month period are only counted for the first alert. For the 12-month period, 1,891 additional trucks would have alerted, with about one-third of them with single values of 33 or more.

Table 2. Additional Trucks that would Alert with TBOGI-HD

Alert Criteria TBOGI-HD THD Hits	Count
1 Hit at 23+ and 1 Hit at 0.35+	350
2 Hits at 23+	902
1 Hits at 33+	639
<b>Total:</b>	<b>1,891</b>

Including the TBOGI-HD hunting data with the existing THD hunting detector, some trucks may alert sooner with the additional coverage. For the same 12-month period, only 55 of the 8,657 alerts (0.64%) occurred sooner with the TBOGI-HD hunting data included. Figure 7 represents the additional trucks that would alert by AAR car type. There are 258 trucks excluded with missing car type information.



**Figure 7. Pareto Chart of Additional Trucks that would Alert by Car Type**

## CONCLUSION

Results of the nonparametric survival analysis show the similar distribution of the dataset of the TBOGI-HD system with the THD dataset.

The similar distributions and traffic of both technologies permit an estimate for the TBOGI-HD peak hunting that corresponds to the THD hunting index as follows:

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## FUTURE WORK

The analysis provides statistical estimates for corresponding TBOGI-HD peak hunting values to the AAR THD hunting index limits.

Trucks will need to be measured for worn conditions to verify the correct alert limits of the TBOGI-HD system corresponding to the THD hunting index limits specified in AAR Rule 46.A.1.e.<sup>1</sup>

## REFERENCES

1. Association of American Railroads. 2014. *Field Manual of the AAR Interchange Rules*, Rules 46.A.1.e and 46.B.7.a-e. Washington, DC.
2. Tournay, Harry, et al. October 2007. "Initial Performance Limits: Three Hunting Detector Types." *Technology Digest* TD-07-034, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, CO.