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Initial Performance Limits: Three Hunting Detector Types

Harry Tournay, Sam Chapman, Scott Keegan (NS), and Robert Blank (NS)

Summary

An analysis of truck hunting performance predictions made by three different types of hunting detectors (HD), each using two different algorithms, is presented. Data is sourced from an instrumented test conducted by Norfolk Southern (NS) and the Federal Railroad Administration, using a consist of 10 vehicles across the NS integrated wayside detector site in Flat Rock, Kentucky.

The correlation between lateral accelerations measured on board and each hunting index (HI) provided by each detector is reasonably strong. Equivalence is suggested between a currently proposed performance limit for the Salient Systems' HI and the other five HIs provided during the test. These equivalent performance limits may be used for the initial deployment of alternate HDs. It is suggested, however, that these limits be reviewed and refined once extensive data from alternate HDs deployed in revenue service is available in InteRRIS®. Equivalence can then be re-evaluated by examining the truck hunting performance predictions made by these HD types for the same cars passing at similar speeds and loads in the same direction and orientation.

The introduction and presentation of different HIs from each supplier's HD highlights the fact that correlations and comparisons may only be accurate for the algorithms and site topology used during a given test. Since both algorithms and wayside detector site topology are proprietary, and no configuration control is required, performance limits may change.

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Please contact **Harry Tournay (719) 584-0704** with questions or concerns regarding this *Technology Digest.* E-mail: Harry_Tournay@ttci.aar.com.

INTRODUCTION AND BACKGROUND

In 2005 and 2006, Transportation Technology Center, Inc. (TTCI) was sponsored by the Association of American Railroads (AAR), as part of its Strategic Research Initiatives Program, to:

- Analyze Salient Systems' HD data
- Relate this data to car condition through inspections, tests, and teardowns of cars identified at different levels of performance
- Suggest repair procedures to improve condition and performance
- Verify that these repair procedures improve dynamic performance

This work, conducted jointly with the AAR Advanced Technology Safety Initiative Program, was completed in 2006 and reported in four digests.[1,2,3,4] The work used data from Salient Systems' HDs, because it was the only HD data available in *Inte*RRIS®.

HDs identify poor lateral dynamic performance that results in sinusoidal motion of truck wheelsets (Figure 1). Inspections, tests, and teardowns of poorly performing cars suggest 0.2 as an absolute valued Salient Systems' HI threshold at or above which a truck will likely be found with condemnable defects and poor performance.[1,2,3]

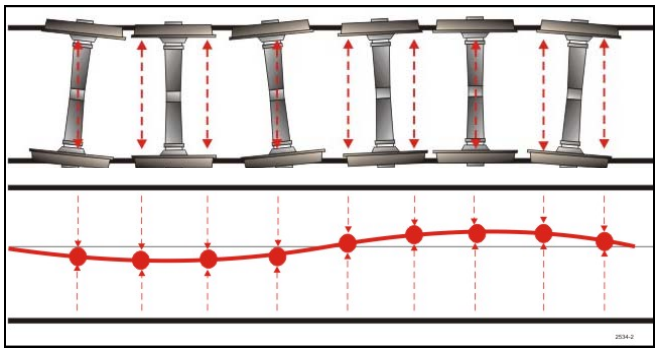

Figure 1. Hunting Motion

Salient Systems' HDs are force-based. Two other HD types have become available in the North American market. These two types, supplied by Lynxrail and Wayside Inspection Devices (WID), detect the motions of wheelsets relative to track. Lynxrail and WID have each, in turn, developed algorithms to translate the motions of a truck's wheelsets into a single truck-level HI. The development of alternate HDs and HIs has necessitated their evaluation.

In July 2004, NS, in conjunction with the Equipment and Operating Practices Research Division of the Office of Research and Development at the Federal Railroad Administration (FRA), conducted a comparative test of HDs as part of its ongoing cooperative agreement for wayside component inspection demonstrations.

NS and FRA used a 10 vehicle test train to compare the performance of three HDs installed at the NS integrated wayside detector site at Flat Rock, Kentucky. The vehicles were one locomotive, one test car, one boxcar, two covered hoppers, one flatcar, three gondolas and an autorack. Five of the vehicles were selected as known "hunters" and were instrumented at each end with accelerometers. The consist passed the site in both directions of travel at speeds between 15 and 55 mph. The onboard instrumentation measured root-mean-square (rms) carbody end lateral accelerations, while the wayside equipment recorded various HIs.

NS supplied TTCI with test data. Onboard rms values over both 300 and 2,000 feet were calculated, and each supplier provided two HIs for its HD:

- Lynxrail: An initial hunting factor as well as a normalized hunting factor
- Salient: The original HI analyzed previously[1,2,4] as well as an adjusted HI
- WID: A peak-to-peak index and an amplitude index

For the purposes of this report, these six HIs will be referred to as HI1 through HI6. However, to ensure objectivity, their above listed order was deliberately mixed prior to assigning the general labels.

It should be noted that the HDs were not located on exactly the same section of track but arranged in sequence over about 300 feet; hence the reason for a 300-foot rms.

TTCI examined the test data:

- Calculating the correlation coefficient between onboard 300-foot rms and each HI
- Suggesting an initial performance limit for each HI that would identify approximately the same number of hunting incidences as were identified using the original Salient HI at or above 0.2 (single pass) and onboard 300-foot rms at or above 0.13

ANALYSIS OF HUNTING INDICES

The correlation coefficient between onboard 300-foot rms and each HI is reasonably strong (Table 1):

Table 1. Correlation Coefficients

Truck-Level Hunting Index	Correlation Coefficient between 300-Foot rms
HI1	0.92
HI2	0.93
HI3	0.89
HI4	0.95
HI5	0.80
HI6	0.91

Figures 2a through 2f display HI versus onboard 300-foot rms for HI1 through HI6, respectively. Scales for HI1 through HI6 have been deliberately omitted.

The rms limits of acceptable performance according to AAR Specification M-1001, Chapter XI[5] and AAR Specification M-976[6] are indicated in the figures. The value 0.13 stipulated in M-976 has been emphasized because it may supercede the Chapter XI limit of 0.26.

A HI threshold is indicated in each figure by a dashed, blue line. Each threshold was chosen to identify approximately the same number of hunting incidences as were identified using the original Salient HI at or above 0.2 (single pass) and onboard 300-foot rms at or above 0.13. This fact can be observed among the figures.

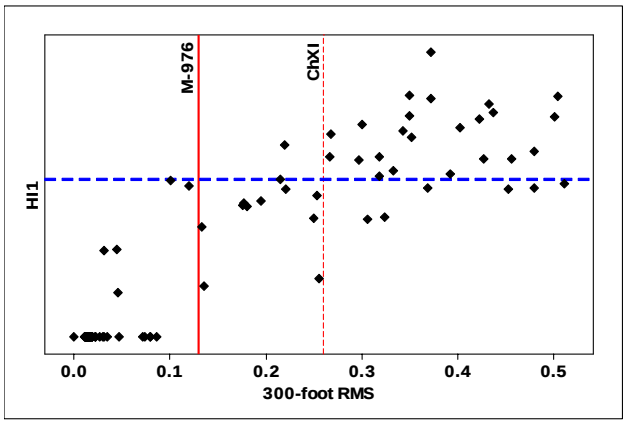

Figure 2a. Scatterplot of HI1 vs. 300-foot rms

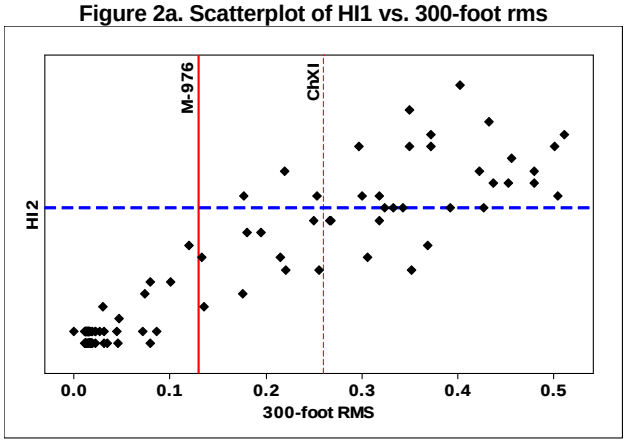

Figure 2b. Scatterplot of HI2 vs. 300-foot rms

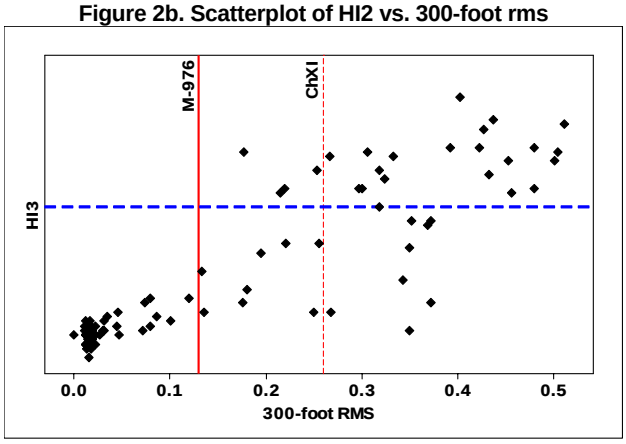

Figure 2c. Scatterplot of HI3 vs. 300-foot rms

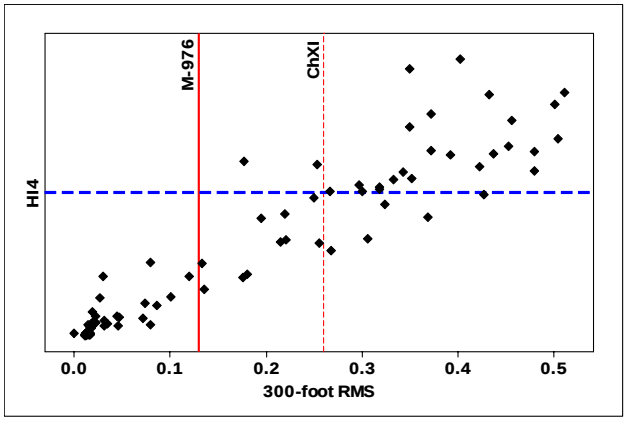

Figure 2d. Scatterplot of HI4 vs. 300-foot rms

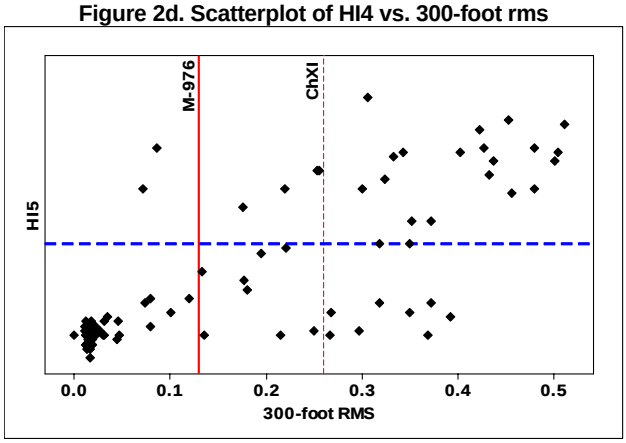

Figure 2e. Scatterplot of HI5 vs. 300-foot rms

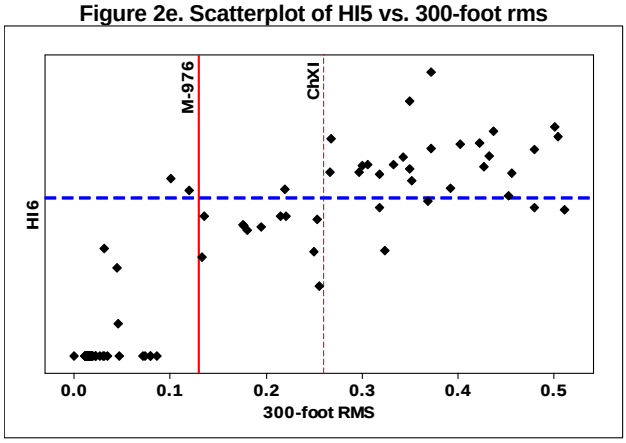

Figure 2f. Scatterplot of HI6 vs. 300-foot rms

Using the limit of 0.13 for onboard 300-foot rms and the abovementioned thresholds, observations may be made regarding each HI (Table 2).

The thresholds indicated in Figures 2a through 2f and described in the above observations are:

- Lynxrail Hunting Factor: 13.0
- Lynxrail normalized Hunting Factor: 12.2
- Salient HI (original): 0.2
- Salient adjusted HI: 0.28
- WID Peak-to-Peak Index: 21.8
- WID Amplitude Index: 12.0

Round-off of these thresholds does not appreciably change the observations made, which suggests that equivalence between HD types and their HIs may be initially established. Consequently, these thresholds are proposed as initial performance limits for the listed HDs, prior to a more detailed equivalence analysis that should be conducted with extensive datasets from alternate HDs deployed in revenue service.

Table 2. HI Observations using Limit of 0.13 for Onboard 300-foot rms and Chosen Thresholds

Observation	HI1	HI2	HI3	HI4	HI5	HI6
Total number of passes with all detectors reporting indices	110	110	110	110	110	110
Number of hunting passes correctly identified by all indices	10	10	10	10	10	10
Number of additional hunting passes correctly identified by index	15	16	15	16	15	15
Number of non-hunting (stable) passes correctly identified by index	69	69	69	69	67	67
Number of "false positive" passes identified by index (indicated as hunting when not actually hunting)	0	0	0	0	2	2
Number of "false negative" passes identified by index (indicated as not hunting when actually hunting)	16	15	16	15	16	16

CONCLUSIONS

The following conclusions are made by TTCI regarding alternate HDs supplied by Lynxrail, Salient, and WID:

- The correlation coefficient between onboard 300-foot rms and each HI is reasonably strong.
- Initial HI performance limits are suggested that identify approximately the same number of hunting incidences as were identified using the original Salient HI at or above 0.2 (single pass) and onboard 300-foot rms at or above 0.13.
- Observations made upon using the initial performance limits suggest that equivalence between HD types and their HIs may be initially established.
- Extensive datasets are needed from alternate HDs deployed in revenue service to conduct a more detailed equivalence analysis and to verify performance limits.

The introduction and presentation of different HIs from each supplier's HD highlights the fact that correlations and comparisons may only be accurate for the algorithms and site topology used during a given test. Since both algorithms and wayside detector site topology are proprietary, and no configuration control is required, performance limits may change.

References

1. Tournay, Harry, Sam Chapman, and Russell Walker. October 2006. "Evaluation of Cars Registering Salient Hunting Indices at or above 0.25." *Technology Digest* TD-06-025, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, CO.
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