TTCI TRANSPORTATION TECHNOLOGY CENTER, INC. TECHNOLOGY DIGEST

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Comparative Examination of FAST Track Geometry and Vehicle/Track Interaction Exceptions

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Key Findings:

- Instrumented freight car short wavelength exceptions from six tests were not always related to the track geometry defects as identified per current regulatory standards
- After six different on-track tests and the accumulation of 87.4 MGT, nearly 80 percent of all recorded track geometry defects consisted of 31- and 62-foot mid-chord offset (MCO) cross level deviations.
- Of the total geometry defects, gage and 31-foot alignment MCO amounted to about 12 percent and 10 percent, respectively.
- No surface anomalies (i.e., bump or dip deviations) were detected during any of the six track geometry tests conducted.

TTCI conducted a study at the Facility for Accelerated Service Testing (FAST) to use a controlled environment to investigatethe difference between assessing the FAST track condition using TTCI's rail-bound Track Geometry Measurement Vehicle (TGMV) and a TTCI-developed Instrumented Freight Car (IFC). The IFC is an autonomous, car-based vehicle-track interaction (V/TI) monitoring technology[1] designed to run with the FAST train for continuous track condition assessment in a heavy axle load environment. The investigation was conducted over the Class 4 track on FAST's High Tonnage Loop (HTL) at the Transportation Technology Center in Pueblo, Colorado.

A total of six TGMV and IFC tests were conducted simultaneously at different time intervals with over 87.4 million gross tons (MGT) accumulated since the first geometry baseline test was conducted. Track geometry standards compliance was determined based on FRA regulatory geometry defects[2] for track Classes 1 through 5. For the IFC, exception track locations were identified when empirically derived, pre-set safety limits were exceeded. For the six tests conducted, GPS-tagged defects generated by both systems were visually assigned to locations over a map of FAST and synchronized and compared. This *Technology Digest* examines and contrasts the testing results of both IFC and TGMV.

BACKGROUND

Track conditions can change rapidly in a revenue service heavy axle load environment. Rolling stock stability and dynamic wheel/rail forces are directly linked to the complex, non-linear vehicle/track interaction. Conventional track assessment methods, such as track geometry measurement, ensure that the track meets safe operation standards. Track geometry deviations are measured and compared with pre-set regulatory limits to determine if safe operation limits are exceeded and whether track maintenance attention may be warranted. Such assessment methodology does not account for vehicle response to track geometry anomalies and cannot promptly relate vehicle dynamic performance to track and operating conditions. IFC autonomous technology is designed to monitor track conditions continuously in near real time, relate adverse dynamic behavior to track geometry and operating conditions, identify track locations with derailment potential and generate automated exception reports for track locations that cause adverse vehicle responses.

TESTS AT FAST

TTCI's railbound TGMV (Figure 1) was operated on the HTL to conduct six different tests measuring track geometry over about 87.4 MGT accumulated after the first baseline test was conducted.

Figure 1. TTCI's rail-bound Track Geometry Measurement Vehicle (TGMV)

The IFC (Figure 2) is deployed with the FAST train's night time operations when operated.

Figure 2. TTCI's Instrumented Freight Car (IFC)

For each geometry test and the accumulated MGT, the research team recorded and analyzed the corresponding IFC response results. IFC responses consisted of carbody vertical and lateral acceleration measurements on both car ends and truck side frame accelerometers on both sides of the lead truck. The lower left picture in Figure 2 shows an example of the A-end carbody accelerometer at the car centerline. The lower right picture in Figure 2 shows an example of a side frame accelerometer above the lead axle of the lead truck.

TRACK GEOMETRY DEFECTS

For all the track geometry tests conducted at FAST, track geometry standards compliance was determined based on FRA regulatory geometry defects for track Classes 1 through 5. FAST Class 4 track geometry regulatory defects were identified for the following main parameters:

- Gage
- Alignment left and right: 31- and 62-foot mid-chord offset (MCO)
- Surface left and right: 31- and 62-foot MCO
- Cross level
- Superelevation

Figure 3 designates all the defects from the six tests after accumulating approximately 87.4 MGT by the final test. Defects were overlaid on the FAST map using corresponding GPS coordinates. A color was assigned to each defect type to render it visually distinguishable. As can be seen, the defects were mostly clustered around HTL Sections 9, 25, 27, and 28. The geometry defects appear to be more repeatable in Section 9 in the vicinity of a crossing, the beginning of Section 25, in Sections 27, and Section 28 by a turnout.

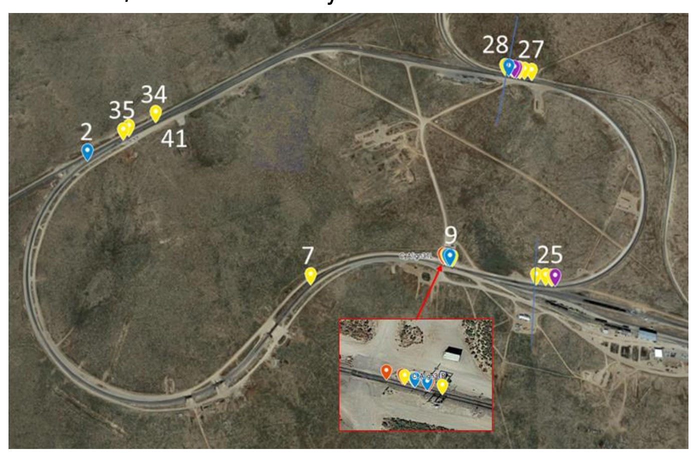

Figure 3. Combined geometry defects from six tests

Nearly 80 percent of recorded track geometry defects consisted of 31- and 62-foot MCO cross level deviations represented by yellow and purple markers, respectively.

Of the total defects, gage and 31-foot left and right alignment, MCO amounted to about 12 and 10 percent, respectively. Gage is represented by the blue markers in Sections 2, 28 and 9 while alignment is represented in red in Section 9. It is noteworthy, however, that no surface anomalies (i.e., bump or dip deviations) were detected during any of the six geometry tests.

Figure 4 shows the distribution of all the defects from the six tests. Figure 5 shows the track geometry defect breakdown for each of the six tests conducted at FAST starting from the baseline test.

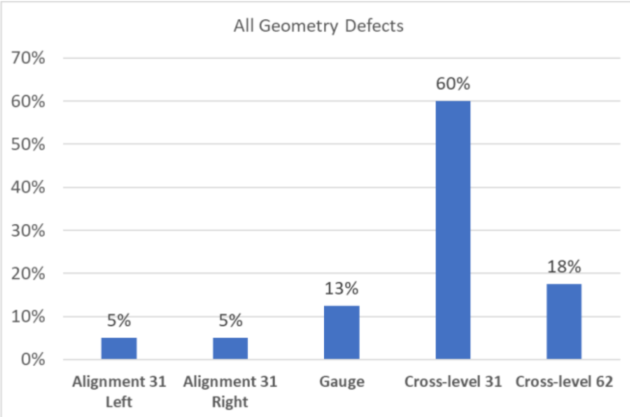

Figure 4. All track geometry defects per current standards

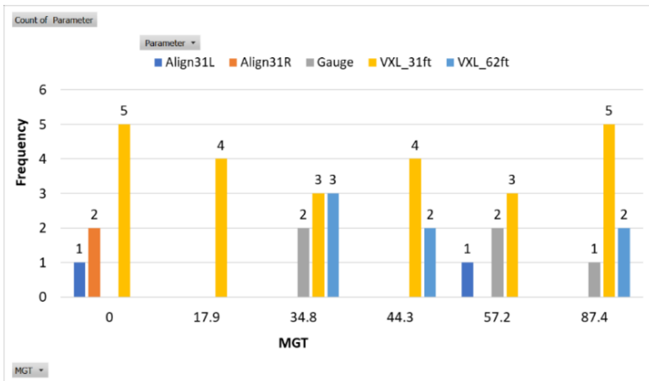

Figure 5. Track geometry defect types for each test

It should be noted that track maintenance activities at FAST, such as track surfacing, are scheduled after every track geometry inspection test has been completed and defect locations have been identified.

IFC EXCEPTIONS

Conducting field verifications of IFC exceptions from the six tests was not emphasized under this investigation because IFC is an established technology permanently deployed with the FAST train for track health monitoring that has shown consistent track inspection results in revenue service[3] and on the HTL.

Exceptions are derived from all the nightly laps the IFC travels while operating with the FAST train. Both shortwave and longwave length exceptions are computed and generated. The former are identified by the lead truck side frame accelerometers, the latter from the carbody vertical and lateral acceleration measurements on both ends of the car body. All IFC-generated exceptions in this study were of the shortwave length type, a type that is frequent and typically generated over misaligned track, battered rail joints, crushed railheads, or cracked welds and rails. Often, the exceptions are also generated over special trackwork components, such as turnouts, crossing diamonds, switches, and frogs due to the structural characteristics that tend to generate high dynamic responses. Longwave length exceptions out of the carbody accelerations occur at FAST as well, although infrequently.

GEOMETRY ANOMALIES VERSUS IFC EXCEPTIONS

Figure 6 shows a summary distribution of exception track locations identified by each technology for every conducted test, as well as the same locations identified by both technologies.

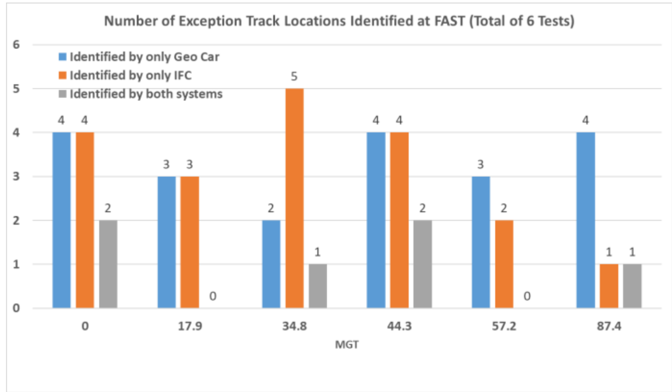

Figure 6. Geometry defects versus IFC for each test

Figures 7 and 8 use GPS information overlaid with the numbered HTL Sections to show examples of geometry defects per current regulatory standards (red markers) contrasted with track locations identified by IFC (blue markers) at two MGT levels— 44.3 MGT and 87.4 MGT, respectively.

In Figure 7, all geometry exceedances consisted of 31- and 62-foot MCO cross level deviations. IFC exceptions coincided with geoemtry deviations in Section 7 and consisted of vertical side frame acceleration exceptions.

Figure 7. Regulatory geometry defects (red) versus IFC exceptions (blue) at 44.3 MGT

Figure 8. Regulatory geometry defects (red) versus IFC (blue), 87.4 MGT

LONGWAVE LENGTH WORST RESPONSES VERSUS GEOMETRY DEFECTS

Since no longwave length exceptions were recorded during the IFC runs, the longwave length worst IFC responses, consisting of carbody maximum and minimum accelerations, were computed at 57.2 MGT for one night's operations with the FAST train and compared with the geometry defects identified at the same MGT level. As presented in Figure 9 over numbered HTL sections, track geometry recorded in red markers point to three distinct locations: 1) over Section 9, 2) the beginning of Section 25 when traveling counterclockwise, and 3) over Section 27.

Figure 9. IFC worst responses (blue) versus geometry defects (red) at 57.2 MGT

Considering that multiple hits indicate locations with repeatable events, the worst IFC responses, however, were recorded in seven distinct locations (blue markers,Figure 9). Out of the seven locations, one track geometry defect location was close to the IFC worst response on Section 28. IFC worst responses do not always appear to correlate with track defect locations at 57.2 MGT. Under the assumption that no maintenance work is performed, some locations with the worst IFC responses can carry the potential to worsen overtime as track accumulates more tonnage.

As the main objective of this effort was to compare the performance exceptions generated from two different technologies, it should be noted that the longwave worst responses analysis was conducted for one test only.

CONCLUSION

Based on six different geometry tests conducted at FAST, Class 4 track locations with geometry defects as defined by current regulatory standards do not appear to be determinant of adverse vehicle dynamic responses in all cases. Likewise, based on six IFC tests, exception track locations that generate unwanted vehicle responses do not always relate to track geometry defects.

After evaluating the geometry defect categories identified at FAST after six tests and 87.4 MGT, it was determined that nearly 80 percent of the combined track geometry defects consisted of 31-foot and 62-foot MCO cross level deviations. Of the total geometry defects, gage, and alignment MCO amounted to about 12 and 10 percent, respectively. However, no surface anomalies (i.e., bump or dip deviations) were detected during any of the track geometry tests.

References

1. Li, D., A. Meddah, and W. Lundberg. July 2008. "Instrumented Freight Car for Performance-based Track Inspection." *Technology Digest* TD08-028 AAR/TTCI Pueblo, Colorado.
2. Code of Federal Regulations, Title 49, "Transportation," Part 213, "Track Safety Standards," Subpart C "Track Geometry." Federal Railroad Administration. Washington, D.C.
3. Meddah, A., D. Li, and S. Roybal. March 2010. "Track Inspection Using an Instrumented Freight Car in Revenue Service." *Technology Digest* TD10-005 AAR/TTCI Pueblo, Colorado.

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