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Eastern and Western Mega Sites: HAL Revenue Service Testing

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Summary

Revenue service testing is a key part of the heavy axle load (HAL) research program funded by the Association of American Railroads (AAR) and the Federal Railroad Administration (FRA). Its objective is to complement and supplement the HAL test activity performed at FRA's Facility for Accelerated Service Testing (FAST), with a wider range of curvatures, train speeds, foundation conditions, and climatic conditions than those found at FAST.

In August 2003, the HAL technical advisory group, which consisted of representatives from the railroads, TTCI, and FRA, proposed a mega site concept to consolidate a wide variety of tests to two specific segments 10 to 30 miles long. The consolidation of the experiments would improve experiment design and capabilities, foster cost-efficiency, and simplify the coordination and communication between the host railroad and TTCI. In 2004, two mega sites were established: one in the east on the Norfolk Southern (NS) mainline from Narrows to Bluefield, West Virginia, and the other in the west on the Union Pacific (UP) mainline, South Morrill subdivision, Nebraska. Both sites are in coal routes with predominately loaded 286,000-pound traffic. For comparison, the eastern mega site typically has sharp curves (up to 12 degrees) and steep grade (up to 1.4%), wood ties, open deck steel bridges, 20-40 mph operating speed, and 60 MGT/year tonnage, whereas the western mega site typically has shallow curves (1-2 degrees), concrete ties, ballast deck concrete bridges, 50-60 mph operating speed, and high tonnage of 220 MGT/year.

Listed below are a number of on-going experiments that started in 2004 and 2005. They were designed to test and monitor new technologies and track materials/components in revenue service. The results and findings will be used to mitigate the adverse effects of HAL on track degradation (stress state) as well as to alert the railroad industry to potential problem areas.

Eastern mega site (NS):

- Premium rail performance test
- Plastic tie performance test
- Elastic fastener performance test
- Top of rail friction control test
- Bridge/approach test (open deck steel bridge with wood ties)

Western mega site (UP):

- Insulated joint test
- Premium rail performance test
- Longitudinal rail stress management
- Tie/bridge/approach test (ballast deck, concrete bridge with concrete ties)

These experiments are ongoing and are conducted in conjunction with other AAR research projects. New experiments will be initiated, addressing key issues of the industry. This TD is intended as a general description of the research and testing conducted at the mega sites, as well as the background to future TDs that will be published to summarize the findings from individual experiments under this research program.

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Introduction and Background

The results and findings from the ongoing HAL research program, funded by AAR and FRA, have contributed to the successful implementation of 36-ton axle loads (286,000-pound gross weight vehicles) by North American railroads over the past decade. The HAL research has been carried out primarily at the Facility for Accelerated Service Testing (FAST), Pueblo, Colorado. Additionally, a similar but much smaller HAL test effort was carried out in revenue service in the past.

In 2003, the HAL Research Committee (HALRC), which oversees the HAL research program, and the Railway Technical Working Committee (RTWC), which oversees the entire AAR research program, decided that the existing revenue service testing efforts need to be expanded to meet the industry needs. Under the direction of HALRC and RTWC, a technical advisory group (TAG) consisting of TTCI, railroad, and FRA representatives, was formed in August 2003 to determine future FAST and revenue service test needs. One of the main recommendations from this TAG was the creation of the “mega test site” concept.

In 2004, two mega sites were selected, each 10 to 30 miles long: one in the east on the Norfolk Southern (NS) mainline from Narrows to Bluefield, West Virginia, the other in the west on the Union Pacific (UP) mainline, South Morrill subdivision, Nebraska. Both sites are in coal routes with predominately loaded 286,000-pound traffic.

It was decided that most revenue service experiments should be consolidated to these two mega sites in order to improve experiment design and capabilities, to foster cost-efficiency, and to simplify the coordination and communication between the host railroads and TTCI. The main objectives of the revenue service testing remain the same; i.e.,

- Determine the effects of HAL on track infrastructure and mechanical components by supplementing and complementing the FAST program with a wider range of curvatures, train speeds, foundation conditions, and climatic conditions than those found at FAST.
- Advise stakeholders of potential safety problem areas.
- Provide data for refined economic analysis of HAL operation.

Eastern and Western Mega Sites

Table 1 lists the main characteristics of the two mega sites selected. For comparison, FAST is also listed in this table. The eastern mega site is located from MP N350-360, between Narrows and Bluefield, West Virginia. An additional test site was selected for the fastener test at MP V238.5, near Niagara, Virginia. The western mega site is location from MP 30-60, South Morrill, Subdivision, Nebraska.

As Table 1 shows, the two mega sites have distinctive characteristics in track components, track geometry, and train operation speeds. The eastern site typically has higher lateral wheel loads, while the western site typically has higher vertical wheel loads. Additionally, the eastern mega site is exposed to more rain and lower temperatures than the western mega site.

Table 1. Mega Site Characteristics

	Eastern	Western	FAST
Track Structure	Timber ties and cut spikes, Premium rail, Premium and standard turnouts w/fixed point frogs, Open deck steel bridges, Variable subgrade	Concrete ties, Premium rail, Premium turnouts w/spring or movable point frogs, Ballast deck concrete bridges, Variable ballast and subgrade	Short sections of various experiments
Annual Tonnage	≈ 60 MGT	>200 MGT	>100 MGT
286-k Traffic	50 percent	80 percent	100% 315 k
Speeds	20 – 40 mph	50 – 60 mph	40 mph
Track Geometry	Curvature up to 12^{o}	1-2^{o} curves	5-6^{o} curves
Grade	0.5-1.4% downhill	Less than 0.5%	Less than 0.7%

Experiments

Started in 2004 and continuing in 2005, TTCI engineers have worked closely with the representatives of host railroads (NS and UP), suppliers, and the FRA to plan and coordinate various experiments at these two mega sites. Tables 2 and 3 list a number of experiments that have been started for the eastern and western mega sites. For each individual experiment, future TDs will be published to summarize the results and findings. In general, however, these experiments are intended to test and monitor various new technologies and track materials/components under revenue service condition. Their results and findings will be used to mitigate the adverse effects of HAL on track degradation (stress state) as well as to advise the railroad industry of potential problem areas.

These experiments are ongoing, and new ones will be added, depending on key issues from the industry. In the near future, for example, the following new experiments have been planned: a wide gap weld test and a guard rail (turnout) test at the NS mega site, a rail pad test at the UP mega site, and a slot weld test following its test at FAST.

Table 2. Ongoing Experiments at NS Site

Experiments	Details
Premium rail test	8 premium rails from 4 suppliers, 4 curves from 6-11 degrees
Plastic tie test	Two plastic types with wood tie as control, in a 6.8-degree curve
Elastic fastener test	2 types of elastic fasteners, with cut spike as control, in an 8-degree curve
Top of rail friction control	Monitor performance of 14 TOR units at the mega site
Bridge and approach in curves	Address both excessive alignment and surface maintenance issues (open deck steel bridges)

Table 3. Ongoing Experiments at UP Site

Experiments	Details
Premium rail test	7 premium rails from 6 suppliers, 3 shallow curves (1-2 degrees)
Insulated joint (IJ) test	Performance and load environment of four pairs of IJs
Longitudinal rail stress test	4 IJ locations and one shallow 2-degree curve
Tie-bridge test	Concrete ties on ballast deck concrete bridges

Testing and Monitoring

Planning, coordination, and installation of various test zones at the two mega sites are obviously critical to the success of the experiments. Another critical part of this research is the testing and monitoring required for various experiments. Under this research, a wide variety of measurements are needed to quantify load environments, track conditions, and performance of new components and designs intended to mitigate HAL effects.

Load Environment

Transducers and strain gages are installed on rails at various mega site locations to measure the following parameters:

- Dynamic vertical and lateral wheel loads
- Longitudinal rail force

These measurements are used to quantify the load environments for various experiments such as top of rail (TOR) friction control, performance of insulated joints, longitudinal stress management, and concrete tie-bridge-approach test.

Figure 1 shows an example of vertical wheel loads recorded near an insulated joint at the UP mega site. The train was a loaded coal train operating at 50 mph. On average, the dynamic vertical wheel loads were between 40 and 50 kips. However, this train also had several wheels generating impact load as high as 80 kips, detrimental to degradation of insulated joints.

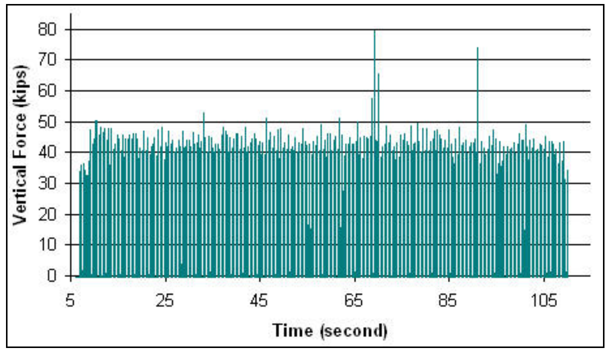

Figure 1. Dynamic Vertical Wheel Loaded Recorded under a Coal Train at UP Mega Site

Figure 2 shows an example of longitudinal force recorded near an IJ test location. Four groups of data are included in the example. The bottom two groups show the total longitudinal forces on two rails, including the components due to temperature change and initial rail pull for welding. As illustrated, the total longitudinal forces between two rails can be quite different. However, the thermal force component is consistent between two rails. The top two groups show the longitudinal forces due only to temperature change with the installation component removed. From the top two groups, it can be seen that thermal force is directly proportional to temperature change, and the neural rail temperature is between 100 and 120 degree F.

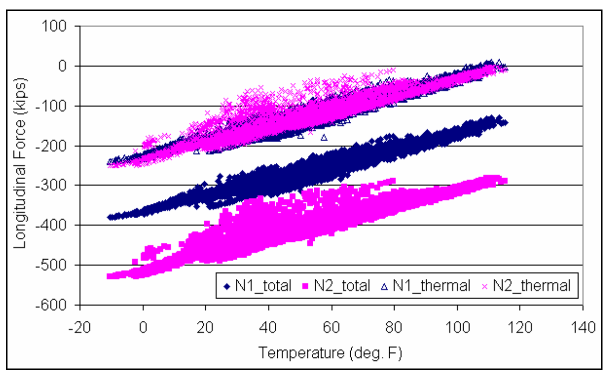

Figure 2. Longitudinal Rail Forces Recorded at UP Site

Deflection Response

Dynamic deflection response is a key performance indicator of track or track components. Figure 3 shows an example of measured lateral deflections of railhead relative to the tie for the plastic tie test zone installed at the NS mega site. As shown, under the same freight train operating through this curve, the control zone (wood ties) showed lower deflections than two types of plastic ties. This is one of the measurements used to quantify the performance of plastic ties under HAL operation.

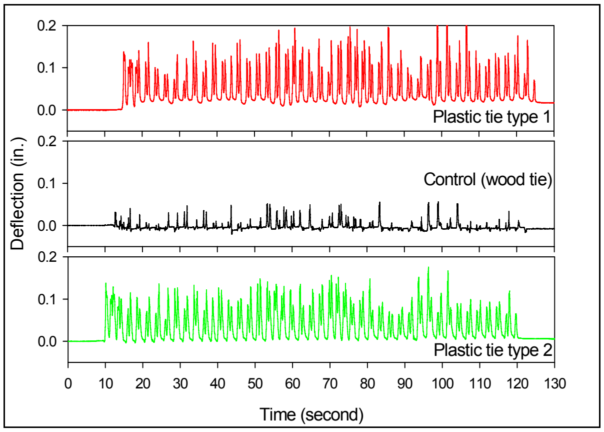

Figure 3. Railhead Lateral Deflection Recorded at Plastic Tie Test Zone at NS Mega Site

Track Strength and Stiffness

The following tests are being conducted to quantify track strength and stiffness characteristics for various experiments at the mega sites:

- Gage strength using FRA's T18 testing vehicle
- Static gage strength using light track loading fixture
- Vertical track strength (track modulus) using TTCI's Track Loading Vehicle also equipped with Cone Penetrating Testing

Figure 4 shows an example of a vertical track modulus profile obtained for one of the open deck steel bridges at the NS mega site, which is associated with significant maintenance problems in both surface and alignment. This is one of a series of investigations planned for the bridges located at this mega site.

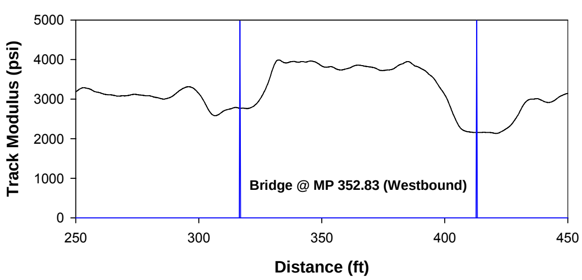

Figure 4. Example of Track Modulus Profile Measured for an Open Deck Steel Bridge at NS Mega Site

Dynamic Stress/Strain Response

Strain gages will be used extensively on various track components to measure dynamic stress and strain responses. For example, strain gages have been or will be applied to the following track components to relate their responses to dynamic wheel/rail forces:

- Bending strain of concrete ties
- Bending stress of joint bars
- Bending stress of concrete beam

Track Geometry

The results of routine track geometry inspections by the host railroads are being analyzed to quantify track performance and track geometry degradation for various test zones at the two mega sites.

Static Measurements

Additional static measurements include:

- Rail profile measurements using MiniProf™ for the test rails every six months
- Field hardness measurements of the test rails at start and end of the test
- Rail and rail pad temperature using thermal couples
- Long-term movement of fixed points of the test tracks relative to the permanent bench marks using survey equipment

Documentation/Maintenance History

In addition to quantitative measurements described above, visual observation, photographing, documentation, and maintenance history is a significant part of the monitoring process.

Summary

The HAL revenue service testing program with the mega site concept started in 2004 and continues today. Consolidating various experiments in the two mega sites allows efficiencies in test performance and simplifies the issue of long distance coordination and communication between the host railroads and TTCI. Under this research, the tests are designed to complement the testing being performed at FAST as much as possible, but remain specific to eastern and western railroad operation conditions. Successful implementation of this research will provide benefits to North American railroads by testing and monitoring the latest technologies and materials in mitigating the effects of HAL on track and mechanical components. In addition, test data obtained under this research will be used to develop, validate, and calibrate track degradation and economic models intended for track maintenance planning and economic analysis of HAL operation.

Acknowledgements

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