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Predicted and Actual Benefits of Heavy Axle Loading Operations

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Summary

Increasing the capacity and gross weight of North American freight cars above the current 263,000-pound car is one way to improve the productivity of rail freight operations. An increase in expenditures on track and bridge maintenance is normally essential if axle load increases are to provide promised benefits. If more net tons of bulk commodity can be carried safely by each train, then productivity savings will be achieved by reducing the number of train crews required to haul a given tonnage. If the ratio of net-to-gross tons can be increased, additional savings can be achieved in fuel, track costs, and equipment costs. With fewer trains to move any given tonnage, there will be an improvement in capacity and a reduction in meet-pass delays.

Total track costs were predicted to rise 5 to 10 percent under 286,000-pound cars and 15 to 18 percent under 315,000-pound cars. Bridge costs, which were included as their own separate category, were predicted to rise faster than track costs. While the predicted increases for bridges were extremely high, bridge costs were only 10 to 15 percent of track costs in the base case, so they did not dominate the analysis.

Over the past 15 years, Transportation Technology Center, Inc., a subsidiary of the Association of American Railroads (AAR), has devoted a lot of research to safety, technical, and economic issues related to increasing axle loads. Much of the research has been based upon the five phases of the Heavy Axle Load (HAL) test program, in which more than 1,200 million gross tons (MGT) of HAL traffic was accumulated at the Facility for Accelerated Service Testing (FAST). The HAL program is jointly funded by the Association of American Railroads (AAR) and the United States Federal Railroad Administration (FRA) with significant cooperation from railroads and suppliers.

Following the completion of each test phase, an economic analysis compared the costs and benefits of going to heavier cars. The effects of HAL operations on track costs were estimated through the use of deterioration models calibrated to the FAST results, information from other research, and experience.

Results show that, in general, heavier axle loads will increase track and facility costs, but decrease operating and equipment costs. Since track costs are much smaller than combined operating and equipment costs, HAL operations can be economically beneficial even if the percentage increase in track costs is far greater than the percentage decrease in operating plus equipment costs. However, it should be emphasized again that, where track and bridges need upgrading for heavier axle loads, investment in track and bridges needs to be made first in order to realize the operating benefits from HAL operations.

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Suggested Distribution:

- ❑ Mechanical Operations
- ❑ Planning & Analysis
- ❑ Track Maintenance
- ❑ Safety

Work performed by TTCI Transportation Technology Center, Inc.
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HEAVY AXLE LOAD IMPLEMENTATION

Background

Over the past decade or more, the continuing shift in rail freight traffic mix toward bulk commodity, unit train operations (coal, grain) has raised a question of whether North American railroads should increase the gross weight limits from the present 286,000 pounds on four axles to as much as 315,000 pounds (39-ton axle loads).

In 1988, the FAST program replaced a train of 263,000-pound cars (33-ton axle loads) with cars of 315,000-pound gross weight to conduct controlled tests and evaluations of heavy axle load traffic. A fleet of high side gondolas, covered hopper cars, and tank cars was loaded to a gross weight of 315,000 pounds per car. Normally, the consist includes about 75 such heavy axle load (HAL) cars. Four or five four-axle locomotives are used to power the train at a steady 40 mph over the 2.7-mile High Tonnage Loop (HTL) at the Transportation Technology Center. A typical day of track operation produces approximately 1 million gross tons (MGT) of accumulated tonnage and 270 miles on the cars. The train operates in both directions on the loop and car orientation is reversed periodically to equalize wheel wear.

The performance of conventional track materials under HAL traffic was measured between 1988 and 1990 during Phase I of the test program. Phase I, during which 160 MGT of traffic was accumulated, quantified the effects of 39-ton axle loads on standard track components and provided a comparison with track performance previously measured under 263,000-pound vehicles. Phase I confirmed the feasibility of operating safely with 315,000-pound cars, but it also identified various technical problems that were exacerbated by the heavier cars.

In Phase II, additional tests were conducted using premium track components and improved maintenance techniques. Phase II analysis showed that the effects from HAL on the track structure were lower than predicted in Phase I because of the better track components and a better understanding of deterioration rates. The analysis pointed out the importance of having good components and, especially on poorer quality track, the necessity of budgeting for increased maintenance activities on lines with significant amounts of HAL traffic.

In Phase III, another series of tests was completed using 315,000-pound cars equipped with improved suspension trucks under lubricated rail conditions. The HAL Phase III economic analysis concluded that the extra costs associated with improved-suspension trucks could indeed be justified by reductions in expenditures for track, equipment maintenance, and fuel when compared to the same cars with conventional trucks.

In Phase IV, effects of dry rail operations with improved suspension trucks were quantified on track performance and fuel consumption. During the current Phase V, a number of tests are under way to determine the HAL effects on new track components under the newer generation of three-piece trucks available to North American railroads.

ECONOMIC ANALYSIS METHODOLOGY

The ultimate objective of the HAL research program is to provide guidance to the North American railroad industry on how to and whether to operate with heavier axle loads as well as to develop economically optimum and safe axle loads. This can only be done if the physical test results can be translated into the costs of operating cars with heavier axle loads. In order to evaluate the economics of heavy axle load operations, life cycle costing techniques were used to relate the physical data obtained from FAST tests to costs.

The effects of HAL operations on track costs were estimated through the use of deterioration models calibrated to the FAST results, information from other research, and experience. The track models were used to estimate track costs for 263,000-pound base case cars, 286,000-pound cars, and 315,000-pound cars.

Operating costs were estimated by identifying specific consists that could be used for unit coal train operations on a typical 30-MGT line in the east and a typical 80-MGT line in the west.

For track and bridges, there are four main areas where rising costs act as a constraint to axle loads:

- Age, type and condition of bridges
- Type and condition of rail
- Characteristics and condition of ballast and subgrade
- Other areas requiring extensive routine maintenance, such as welds, turnouts, other special track work

Premium track components, improved maintenance procedures, and improved suspension trucks tend to reduce the effects of HAL traffic on track maintenance costs. Hence, implementation of innovative technologies, along with continued upgrading of the infrastructure (especially the strengthening and replacement of older bridges), can make HAL operations more attractive.

Improved track and structures will benefit all traffic. Improvements in the track structure that reduce the costs of HAL operations also tend to reduce the costs of the base case (263,000-pound gross vehicle weight) operations. As the HAL studies progressed from Phase I to Phase III, considerable improvements in track and vehicle components reduced the costs of the base case as well as the HAL options. Exhibit 1 lists the base case track costs for the eastern and western coal lines for the three phases. Using better components in Phase II provided a 7 to 8 percent reduction in base case costs for track, with most of the improvements coming in maintenance rather than capital costs. In Phase III, the use of improved suspension trucks provided another 8 to 10 percent improvement in track costs, with equivalent cost savings in both maintenance and capital costs.

HAL OPERATIONS WILL INCREASE TRACK AND BRIDGE COSTS.

Results from Phase II are the best to use in estimating the costs and savings from implementing HAL operations. These results consider HAL loads in cars with standard trucks. Although the savings in Phase III appear to justify the use of cars with improved suspension trucks, they have yet to be introduced in significant quantities for coal transportation. Results from Phase II (Exhibit 2) show that the use of HAL operations has a much greater effect on maintenance than on capital costs, which are much more important in terms of life-cycle cost. Total track costs were predicted to rise 5 to 10 percent under 286,000-pound cars and 15 to 18 percent under 315,000-pound cars. Bridge costs, which were included as their own separate category, were predicted to rise faster than track costs. While the predicted increases for bridges were extremely high, bridge costs were only 10 to 15 percent of track costs in the base case, so they did not dominate the analysis.

HAL OPERATIONS CAN REDUCE CREW, FUEL, AND EQUIPMENT COSTS

For operations, the key source of benefits from HAL loads is the ability to operate with more net tons per train. Therefore operating benefits tend to increase with improvements in the ratio of net-to-gross train tonnage and the ability to increase net tonnage on length constrained trains.

Exhibit 3 lists the basic HAL economics. Although the infrastructure costs rise substantially, operating costs decline. Since operating costs are so much greater than infrastructure costs, total costs decline. In these examples, the operating costs actually decline more for the 286,000-pound car case than for the 315,000-pound car case, primarily because of the net-to-tare benefits of the particular 286,000-pound car that was used. In other cases, the differences were somewhat different, but in every case, the 286,000-pound car was found to be superior to the 315,000-pound car.

Both costs and benefits are highly route and site specific. The most promising opportunities are for high density, bulk unit train operations over good track, especially where train lengths and line capacity are limited. The situations that are least likely to be justified on a benefit/cost basis are HAL operations over light density lines where the track structure is weak and there are no problems with train length or line capacity.

HAL IMPLEMENTATION IN NORTH AMERICA

The magnitude of benefits from HAL operations depends upon the extent to which HAL loads have been implemented and the extent to which the predicted effects have taken place. A recent retrospective industry analysis suggests that the railroads have in fact followed the recommendations of the HAL economic studies:

- The North American industry adopted the 286,000-pound car as the HAL standard, as was recommended after Phases I, II, and III. When room was available in existing equipment, car owner increased loading limits very soon after the Phase I study. Car owners then upgraded their fleets through attrition, replacing older cars with 286,000-pound cars.

	West I	West II	West III	East I	East II	East III
Maintenance	100%	92.4%	75.7%	100%	82.2%	75.1%
Capital	100%	91.4%	88.6%	100%	97.2%	86.3%
Total	100%	91.7%	85.1%	100%	93.2%	83.3%

Exhibit 1. Comparison of Base Case Track Costs for HAL Phases I, II, and III

- The extensive studies of possible HAL effects on track were critical in identifying and avoiding potential problems associated with weak elements in the track structure.

CONCLUSIONS

The annual operating benefits of operating HAL traffic can be substantial, if investment in track and bridges are made in a timely manner. The annual net benefit from HAL operations (286,000-pound cars) is estimated in the hundreds of millions of dollars per year if all of the traffic were moved in 286,000-pound cars.

In fact, the transition to 286,000-pound cars is still under way, with one-quarter to one-half of the traffic on high-density lines moving in HAL cars. Using aggregate data for coal tonnage and car-loadings, we find that the average car load of coal has increased from 96.3 tons in 1987 to 106.6 tons in 1998. This increase includes the effects of the shift to lighter aluminum cars as well as the increase in axle loads.

To isolate the axle load effects, data was collected from three wayside load stations to estimate the percentage of loaded cars with HAL loads. At a typical detector on a coal line in the west, 38 percent of the cars were HAL loads; this figure is the percentage of cars for which the wheel loads indicated a gross vehicle weight of more than 278,000 pounds. Since the HAL loads carry more traffic, the percentage of tonnage was somewhat higher at 42 percent. At two typical detectors in the east, an average of 11 percent of the cars and 13 percent of tons were estimated to be HAL loads. However, there is some of each level of traffic density in the east and in the west. Therefore, the average rate of implementation was 38.7 percent in the west (9,500 miles of track modeled as the 80 MGT line, and 24,200 miles as the 30 MGT line) and 27.1 percent in the east (with 1,000 miles modeled as the 80 MGT line, and 22,000 miles as the 30 MGT line).

For this level of implementation, the annual net benefits are estimated to be in the range of $250 to 500 million.

Note: Please contact Semih Kalay at (719) 584-0717 with questions or comments about this document.

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	West 263	West 286	West 315	East 263	East 286	East 315
Track Maintenance	100%	111.3%	132.7%	100%	122.6%	147.5%
Track Capital	100%	102.6%	108.6%	100%	106.5%	110.0%
Track Total	100%	105.0%	115.1%	100%	110.3%	118.8%
Bridges	100%	112.7%	156.9%	100%	114.0%	137.7%

Exhibit 2. Infrastructure Costs Under HAL Operations, Phase II Results

	West 263	West 286	West 315	East 263	East 286	East 315
Track	100%	105.0%	115.1%	100%	110.3%	118.8%
Bridges	100%	112.7%	156.9%	100%	114.0%	137.7%
Operations	100%	90.4%	93.8%	100%	91.1%	95.3%
Total:	100%	92.6%	97.5%	100%	94.0%	99.6%

Exhibit 3. Operating Costs with HAL Equipment, Phase II Results

A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, MAY BE AVAILABLE AT A LATER DATE THROUGH AAR/TTCI, PUBLICATIONS, P.O. Box 79780, BALTIMORE, MD, 21279-0780 <www.aarstore.org>