TECHNOLOGY DIGEST

Timely Technology Transfer — 98-010

The Potential for Reconfiguring Freight Cars to Optimize Efficiency in Heavy-Haul Operations

by Thomas S. Guins and Jeffrey D. Chapman*, William E. Robert*, and Carl D. Martland*

Summary

A recent Association of American Railroads study of bulk-commodity unit-train operations has led to the suggestion that redesigning freight cars to maximize net weight per unit of train length could result in significant gains in efficiency. This might be accomplished by maximizing the cross section of the car. Higher, shorter cars might raise net capacity per train by 17 percent, and reduce total direct cost by 3 to 5 percent without increasing axle loads for the two sample coal networks in the study.

For this study, operating and maintenance costs were determined for representative East and West coal-distribution networks for a base case of operations using 53-foot aluminum cars with improved-suspension trucks and 33-ton axle loads. This base case was compared to cases with high-capacity cars with two-axle trucks and axle loads of 33 to 45 tons, and with high-capacity cars with three-axle trucks and axle loads of 30 to 39 tons. In all of these alternatives, the height of the car was the same as the 125-ton cars that have been tested at the Facility for Accelerated Service Testing at the Federal Railroad Administration's Transportation Technology Center.

The different axle loads were obtained by adjusting the theoretical length of the cars. For example, by increasing the height of the car, the length of the car with 33-ton axle loads could be reduced from 53 to 45 feet.

* *Massachusetts Institute of Technology*

Suggested Distribution:
- ❑ Planning & Analysis
- ❑ Maintenance Planning
- ❑ Car Department
- ❑ Equipment/Rolling Stock

Work managed by TTCI Transportation Technology Center, Inc.
a subsidiary of the Association of American Railroads

April 1998

INTRODUCTION AND CONCLUSIONS

A recent Association of American Railroads (AAR) study indicates that significant potential for savings in unit-train operations could be realized if freight cars could be redesigned to achieve maximum cross section, and thus maximize net weight per foot of train length. As part of the AAR's Heavy Axle Load (HAL) research program, this study sought to identify the factors that influence optimal axle loads on typical East and West coal-distribution networks. The current study extends the prior AAR HAL economic analyses[1,2,3] by considering:

- A broader range of axle loads
- Alternative car designs (higher capacity, varying length, different trucks)
- Effects of heavier trains on line capacity and equipment utilization
- Network operations, rather than operations on a single high-density coal line

A broader range of axle loads needs to be considered for two reasons. First, it is possible that axle loads above 39 tons could provide extra benefits that would outweigh the added track or bridge costs. Just as the 286,000-pound car is a standard 100-ton car filled to capacity, a standard 125-ton car filled to volumetric capacity could carry as much as 335,000 pounds of relatively dense materials.

Alternative car designs allow greater flexibility in meeting capacity requirements. If car length can be varied, then train capacity can be increased with higher, wider, and shorter cars without increasing axle loads. Once height or width limits are reached, larger car capacity and heavier axle loads can be achieved by lengthening the car.

If a network is near capacity, then operating fewer, heavier trains can have a compound effect on the number of trains required in length-limited operations. First, with more net tons per train, fewer trains will be needed, assuming cycle time remains constant. Second, with fewer trains operating on the network, delays will diminish at bottlenecks so that cycle times will decline, leading to a further reduction in the number of trains.

Finally, coal trains operate over a network that includes low-density lines serving mines and utilities as well as the high-density coal lines. The average track costs on the low-density lines will be higher than on the high-density lines, and the HAL effects will also be different. Analyzing the track costs over a representative network will therefore provide a better estimate of the effects of HAL loads on track costs.

FAST/HAL tests to date have documented the effects of 263,000- and 315,000-pound cars (100-ton and 125-ton cars) on the various elements of the track structure.[1,2,3] The previous HAL economic analyses have estimated the costs of operating both of these cars, as well as the costs of an intermediate option, the 286,000-pound car (a 100-ton car filled to volumetric capacity). All of these cars were assumed to be the standard length, approximately 53 feet, required for rotary dump unloading. The 286,000-pound car, resulting in axle loads of 36 tons, was found to be the lowest cost option in several case studies of a generic 30-million-gross-ton (MGT) eastern coal line and a generic 80-MGT western coal line.

RESULT SUMMARY

In total, 22 cases were analyzed. For typical East and West coal-distribution networks, the following cases were considered:

- Base case: 33-ton axle loads
- Two-axle trucks, 36-inch wheels: 33-, 36- and 39-ton axle loads
- Two-axle trucks, 38-inch wheels: 39-, 42-, and 45-ton axle loads
- Three-axle trucks, 36-inch wheels: 30-, 33- 36-, and 39-ton axle loads

For all cases, cars were assumed to have aluminum boxes and improved-suspension trucks. The base case represents operations with the standard 53-foot-long, 100-ton car. All other cases are based on cars of varying length, but the same height and width as the 125-ton car. The HAL Phase III cases used steel cars with improved-suspension trucks.[3] The 39-ton axle load HAL Phase III case used 38-inch diameter wheels, as opposed to the 36-inch wheels for the two lower axle loads

Both the East and West networks were assumed to be length-limited. Demand was held constant for each network across all cases. Much of the projected savings results from predicted improvements in cycle times. For networks not operating near capacity there would still be cost savings from HAL operations, but the savings would be more modest because there would not be a significant improvement in cycle time. In some cases premium track components would have to be used; for instance, premium rail (340 hardness Brinell) may be necessary on high-density lines in order to control defects. Bridge-maintenance costs were not included in the calculations of this study. Also, a number of assumptions were made concerning equipment design and costs; the assumptions made concerning three-axle trucks are based on very limited data. Many of these simplifying assumptions could be eliminated or improved upon as part of a more-detailed subsequent investigation. A future investigation could involve explicit case studies of real-life coal-distribution networks.

For the new East and West base cases, operating costs (measured in dollars per 1,000 net ton-miles) are approximately 27 percent lower than the costs projected for the preliminary HAL Phase III economic analysis. This is primarily a result of the assumption that aluminum cars would be used.[3] Track costs (excluding bridges) for the East and West base cases are approximately 27 percent higher. This is predominantly due to the presence of low-density spurs and branch lines leading from the coal mines and into the electric utilities. Overall, costs for the East and West base cases are approximately 20 percent lower than the costs projected in the HAL Phase III analysis.

The results indicate that, compared to the base case, all other cases considered result in increased net train capacity and decreased cycle time. Together these effects result in reduced operating costs. However, heavy axle loads result in increased track maintenance that tends to offset the savings in operating costs. Exhibit 2 summarizes the percentage savings for each case relative to the new base case.

Overall, the optimal axle load for the cases analyzed is 36 tons. For the East network, given the assumptions made concerning equipment design, the greatest cost savings could be achieved using cars with three-axle trucks operating at axle loads of 39 tons. However, such cars would be extremely long (more than 70 feet) and may not be feasible. If long cars with three-axle trucks are feasible, then their use could result in savings of approximately 5 percent relative to the base. The maximum savings using shorter cars with two-axle trucks (49 feet rather than the standard 53 feet) is comparable but lower. For two-axle trucks operating with axle loads of 36 tons, the cost savings is 4 percent relative to the base.

For the West network, using cars with three-axle trucks and axle loads of 36 tons would result in cost savings of a little more than 5 percent. However, as for the East network, the three-axle cars would be very long (approximately 70 feet), and may not be feasible. Using shorter cars with two-axle trucks and axle loads of 36 tons would result in cost savings of 5 percent.

Extending the analysis from coal lines to networks tends to reduce the axle-load effects on track-maintenance costs. Fixed maintenance costs for ties and routine maintenance tend to dominate on light-density lines, while increases in deterioration rates for rail and

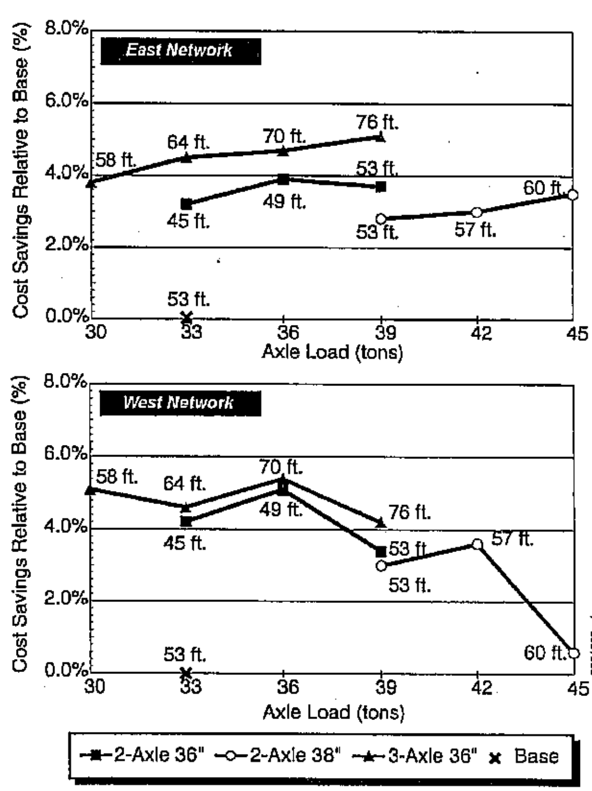

Exhibit 1. Summary of Cost Savings Relative to the Base Case

turnouts are relatively less important because these components will still last for many years. The net effect is that track costs (excluding bridges) per 1,000-net-ton miles vary roughly linearly over a wide range of axle loads (from 30 to 45 tons).

The results suggest that net train capacity is the critical parameter in achieving cost savings for unit-train operations. Holding axle loads at 33 tons, moving from cars with the cross-section of the 100-ton car, to cars with the cross-section of the 125-ton car, increases net train capacity by 17 percent, and results in cost savings of 3 to 4 percent. In the latter case, the cars are shorter (45 feet rather than the standard 53 feet) but there are more cars per train, assuming length-limited trains. Lengthening cars can further increase the net train capacity. Longer cars result in heavier axle loads, but better utilize the limited train length by reducing the number of "empty" gaps over the couplers between the fewer number of cars. However, the extra savings from adjusting car length and axle load are much less than the initial savings from increasing the cross-section of the car.

CONCLUSIONS AND RECOMMENDATIONS

Future HAL research should be expanded to include car design considerations in addition to axle loads. The optimal car may be a short, high car, or a longer car with three-axle trucks. If car lengths are constrained to 53 feet, the optimal car may have axle loads greater than 39 tons, if a higher capacity box than the current 125-ton car design may be safely and feasibly implemented.

The HAL economic research should be enlarged from track costs to equipment and operating costs. FAST/HAL research has shown that the track structure can indeed handle heavier axle loads; a better understanding of equipment costs and operating benefits is required to make the best strategic decisions concerning equipment acquisition, line-capacity investment, and operating-cost reductions. Specifically, railroads attempting to cut costs or facing line-capacity constraints should consider a range of equipment options, including but certainly not limited to the 315,000-pound aluminum car. Continued research is needed to address the primary areas of uncertainty:

- How does car length affect car structure/tare weight?
- Can a practical three-axle truck perform as well as an improved-suspension two-axle truck?
- What are the costs of changing coal unloading facilities to handle longer or shorter cars?

REFERENCES

1. M.B. Hargrove, "Economic Assessment of Increased Axle Loads Based on Heavy Axle Load Tests at the AAR Transportation Test Center – Pueblo," American Railway Engineering Association, Bulletin No. 732, Vol. 92, October 1991.
2. M.B. Hargrove, T.S. Guins, D.E. Otter, S. Clark, and C. D. Martland, "Economics of Increased Axle Loads: FAST/HAL Phase II Results," A World of Change: First Annual AAR Research Review, Vol. 1, 1995.
3. T.S. Guins, "Minutes of the HAL Economic Evaluation Technical Advisory Group: September 27, 1996," technical memorandum prepared for the HAL Phase III Technical Advisory Group, Association of American Railroads, October 24, 1996.

Note: Contact Tom Guins at (202) 639-2259 with questions or comments about this document.
E-mail: **tom_guins@ttci.aar.com**
Web site: **www.ttci.aar.com**

A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, MAY BE AVAILABLE AT A LATER DATE THROUGH THE AAR, PUBLICATION ORDER PROCESSING, 50 F STREET, NW, 5TH FLOOR, COG, WASHINGTON D.C., 20001