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Une charge élevée par essieu s'avère rentable.

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While the economics of heavy axle load operations has been established in North America and Australia, it has not been proven to date in Europe. Under increasing international competition, those responsible for the movement of iron ore from mines in Northern Sweden to ports in Norway and Sweden, were looking for ways to reduce transportation costs and increase competitiveness. In order to determine if heavy axle load operations was an answer, a two pronged study was undertaken on the effects of increasing axle loads (from the current 25 Tonnes to a proposed level of 30 Tonnes) and increasing train size.

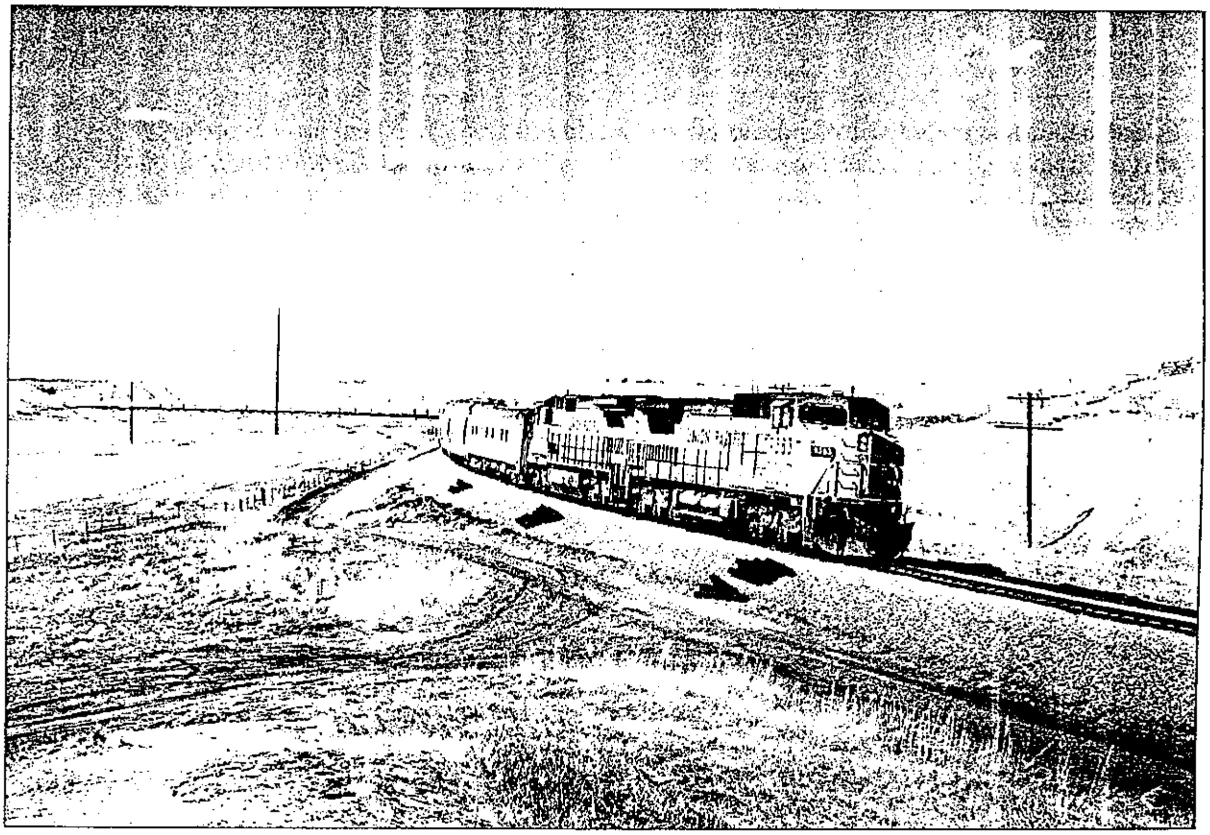
Heavier Axle Loads Prove Economic

By Allan M Zarembski, Zeta-Tech Associates, Inc. & Björn Paulsson, Banverket

A parallel study performed by consultant Zeta-Tech Associates, Inc. of the USA and an internal Banverket/Jernbaneverket team, examined both the effect of the heavy axle loads on track damage (and maintenance costs) and on the overall cost of rail operations. The results, which was supported by both team efforts, was that while track maintenance costs would increase by approximately 13%, overall operating costs (to include track maintenance) would be reduced by almost 30%. Based on the results of this study, orders have been placed for a new generation of 30 Tonne axle load wagons for use on this line.

North American Parallel

The economics of heavy axle loads, particularly for the transport of high volume, high density commodities, has been well established in North America and Australia where 30 Tonne axle loads have been the "norm" for decades. In fact, the economics of these heavier axle loads have been so strong that recent moves have been towards even higher axle



The joint study examined the implications of employing North American

Table 1: Characteristics of Freight Wagons

	Base Wagon	High Capacity Wagon
Length	8,400 mm	10,300 mm
Tare Weight	20 tonne	20 tonne*
Net Capacity	80 tonne	100 tonne*
Gross Weight	100 tonne	120 tonne
Cost (SEK)	600,000	750,000

*The new wagon actually have a tare weight of < 20 tonnes and a capacity > 100 tonnes

load levels of 33 Tonnes and greater[3]. As European railways come under increasing pressure to reduce operating costs, and to even show a profit in their freight (goods) operations, it is only natural that they look at the costs and benefits associated with heavier axle loads and see if the benefits experienced elsewhere can also be realized in the European environment.

This was clearly the case recently, in northern Sweden and Norway, for the large scale movement of iron ore from the LKAB mines in Kiruna and Gällivare, to the ports of Narvik, Norway and Luleå, Sweden. As international competition increased, the mine owners looked at alternative ways to reduce their costs, with one such way being reducing transportation costs by using heavier wagons and longer, heavier trains. Since this movement had relied on 25 Tonne axle load wagons, the lowest axle load of all the major international iron ore movements, it was logical to look at increasing the axle load to 33 tonnes. However, the impact of this increased axle load had to be carefully examined in light of the current track conditions on the Swedish and Norwegian line segments over which this movement took place.

In order to assess the impact of increasing axle loads (and train length), a parallel research approach was adopted. The first part of the study was performed by Zeta-Tech Associates, which used its previously developed heavy axle load methodology to assess the impact of the increased axle loads on track damage, and corresponding levels of track maintenance. It further evaluated the overall economics of the heavier wagon, heavier train options, again using North American based analysis methodology.

The second part of the study was performed by a joint BANVERKET/SJ-Jernbaneverket/NSB-LKAB team that independently examined all of the major track and operating issues associated with the increased axle load operations. These multi-discipline teams used internal studies, external research (to included external university and consultant research), and foreign experience to examine and quantify these effects, independent of the Zeta-Tech team. Here too, the focus was on both the assessment of increased track and structure damage (and maintenance costs) and the impact on overall operating costs.

By allowing these two teams to work independently and in parallel, and by comparing the two sets of results at the end of the studies, a mechanism was set up to provide the information needed to determine if heavier axle loads was right for Europe (and for the Malmbanan operation in particular).

Analysis:

The analysis performed by Zeta-Tech Associates, Inc. consisted of two major efforts:

- An assessment of the increased track and structure damage that would be caused by the operation of heavier wagons
- An assessment of the overall operating costs associated with the heavier wagons and heavier trains.

The effect of increasing axle loads was from the current 25 tonnes to an increased level of 30 tonnes. In addition the effect of introducing new equipment, *with radial trucks (bogies)*, and improved net to tare ratios, was incorporated in the analysis as was the effect of increasing operating speed from the existing 50 km/hr to 60 km/hr.

Track and Structures costs considered in the analysis included:

- Rail
- Sleepers (both wood and concrete)
- Track geometry (to include the effects of ballast and subgrade)
- Turnouts
- Bridges

The analysis addressed both capital costs (for major track and bridge replacement work) and maintenance costs (the day-to-day cost of keeping the railway in safe operating condition). In addition to track costs, the expected increase in maintenance/replace-

Table 2: Operating Scenarios Analyzed

	Base Case	Heavy Axle Load Case	Longer Train Case
Cars per Train	52	68	85
Net Wt.	4,160	6,800	6,800
Tons Ore/Yr.	22,900,000	22,900,000	22,900,000
Cycle Time (Load to Load)	15 hours	15 hours	15 hours
Axle Load	25 tonnes	30 tonnes	25 tonnes

Table 3: Estimate of Costs and Savings Operation of 100-Tonne Wagons on the Kiruna to Narvik Line Cost per Year (All Costs in Million SEK)			
Cost Category	Base Case	HAL Case	Longer Train Case
Locomotives			
Ownership	46.780	34.666	34.666
Maintenance	33.080	12.141	12.141
Cars			
Ownership	26.051	22.964	26.051
Maintenance	32.199	13.462	35.040
Track Cost	35.010	37.860	35.010
Electric Power Cost	10.145	8.681	11.272
Crew Cost	29.430	18.004	18.004
Total	*212.696*	*147.779*	*172.184*
Notes:	In each case, annual volume of ore is 15.9 M tonnes to Narvik.		

ment cost for all bridges (steel, concrete, and stone) was quantified.

The approach used was based on track component behaviour observed on several North American railways, which indicates that, on a per-axle basis, track cost increases can be non-linear with increases in axle loads. In the analysis of the track and its key components, this heavy axle load effect was addressed through the development of a set of damage factors, with separate damage exponents and damage factors calculated for each track component and component failure mechanism.

For the assessment of overall operating costs, only the direct costs of movement were considered. In general, the direct costs of movement are those which vary with the movement of trains and cars; administrative and overhead expenses, and those costs (such as snow removal) that logically do not vary with train size, axle load, or traffic volume, were excluded.

Thus, direct costs of movement considered in the analysis included:

- crew wages
- electric power cost
- equipment maintenance expense (cost of maintenance, plus cost of shop operation and direct supervision)

- equipment ownership expense (purchase price amortized over the economic life of the locomotives and freight wagons
- track maintenance expense
- an annualized cost of required bridge upgrading or replacement to carry the heavier loads (effect of a reduction in bridge life)

As mentioned previously, the study involves the comparison of two different types of wagons at two axle loads. Table 1 shows the characteristics of the 4-axle wagons. Note that the 100 tonne wagon achieves a substantial improvement in net-to-tare over the 80-tonne wagon, carrying 25% more net load with the same tare weight.

The analysis also involved the determination of the benefits of increased train weight. By looking at different combinations of axle load and train weight, it was possible to isolate particular benefits of heavier axle from the more general benefits of increased train weight. Table 2 shows three scenarios for which costs were developed in this analysis.

Taking all these factors into account, Zeta-Tech quantified the expected increase in track and equipment maintenance costs associated with an increase in maximum car weights, as well as the savings available to LKAB from the operation of heavier trains. Note; the current equipment was more than 30 years old, and decisions were being made regarding what type of replacement equipment should be purchased. In addition, the route from Kiruna to Narvik was nearly at the maximum capacity permitted by current operating practices, and investment of some kind (in track, wagons, locomotives, or in all these areas) were required in order to accommodate a plannèd expansion of iron ore production.

Railway Teams

A parallel analysis was conducted by a set of Banverket-Jernbaneverket-LKAB teams, broken up into individual technical areas. Each team addressed a key infrastructure, equipment, or operating issue from both the technical and economic perspective. The analysis teams were divided up into Swedish and Norwegian organizations, with Bjorn Paulsson of Banverket serving as Project Leader for the Swedish organization and Oyvind Brustad of Jernbaneverket serving as Project Leader for the Norwegian organization. Overall program direction was under the supervision of a steering group composed of:

Nils-Erik Bergstrom	*Banverket Borlange*
Bjorn Paulsson	*Banverket Borlange*
Ivar Hagland	*Jernbaneverket Oslo*
Oyvind Brustad	*Jernbaneverket Trondheim*
Birger Norberg	*LKAB Kiruna*
Ake Bostrom	*MTAB Kiruna*
Thomas Nordmark	*MTAB Kiruna*

Results

The result of the two sets of studies was a comprehensive set of 33 reports, dealing with all aspects of the heavy axle load question. What was of particular note was that the two conclusions were the same, that increasing axle loads to 30 Tonnes made economic sense for this line.

The results of both studies showed that while measurable increases in track maintenance costs will occur under the operation of heavier axle load wagons, these costs will be more than offset by reductions in operating costs. Thus, on the Banverket trackage, the expected increase in track maintenance costs was of the order of 13% with heavier axle loads. If grinding and lubrication are carried out to North American standards, this increase would drop significantly.

However, as noted above, this increased track and structure maintenance costs are more than offset by the other operating costs with the result that there is a significant economic benefit to increasing axle loads on the Malmbanan and Ofotbanen beyond the current 25 ton maximum.

Specifically, the analyses showed that:

- Operation of 68-wagon trains with *100 tonne load capacity (30 Tonne axle load)* produced a reduction of approximately 30% in direct operating costs over the base case (52 wagons of 80 tonne capacity), on both routes, taking into account the expected increase in track maintenance costs as a consequence of the increase in axle loads.
- Assuming a *"worst case"* increase in track costs, savings remained in the range of 27%.
- The increase to 30 tonne axle loads reduces costs by about 50% more than simply increasing train length, without increasing axle loads.
- The increase in axle loads also reduces the number of trains that must be operated to carry the current and future volumes of iron ore, freeing up line capacity for other traffic and allowing the more efficient scheduling of maintenance work.

Table 3 presents a summary of the analysis results.

Based on the results of this study, the decision was made to purchase new heavier axle load equipment, with 100 Tonne capacity (30 Tonne axle load) and radial bogies. Prototype orders have already been placed, with 68 trainsets of 68 wagons each, to be ordered upon completion of acceptance tests■

References

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2 *46 243 445620, FAX: 46 243 4456 17*
3 *see ERR article " Economics of Heavy Axle Loads", June 1998.*