THE WORLD BANK – AFRICA TRANSPORT UNIT

The Economics of Rail Gauge in the East Africa Community

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I. INTRODUCTION

1. A number of recent studies[1] have indicated the significant potential benefits that an efficient and effective railway network could offer trade integration and economic growth in the East African Community (EAC) region.

2. However, the existing railway infrastructure in the region is currently in poor condition. The investment required to return the infrastructure to good condition is significant. There is ongoing discussion about the most appropriate rail gauge, and in some countries appropriate institutional reform is a prerequisite to any intervention.

3. This briefing note focuses primarily on the first issue; the discussion of rail gauge to outline in an objective manner the technical and economic case for investment in a standard gauge railway. It outlines the different options, the technical justification for one gauge over another, and provides an assessment of the costs and benefits of the different alternatives.

4. The note is structured as follows: Section II presents a technical overview of the different rail gauges and the merits and demerits of each; Section III presents the different development alternatives; Section IV presents an evaluation of the costs and benefits of each alternative; and Section V presents the conclusions of the analysis.

II. THE TECHNICAL OVERVIEW

5. Rail (or sometimes Track) gauge is the technical term used to define the physical distance between the inside of one rail to the inside of the other on a railway track.[2] There are multiple railway gauges in use around the world. This briefing note focuses on those gauges found currently in the EAC countries (Metre gauge and Cape gauge) and, what is termed, Standard gauge.

6. ***Metre gauge*** refers to a gauge with a physical distance of 1,000 mm between the inside of one rail to the inside of the other. This is the gauge currently used for the railway network of the EAC countries, with the singular exception of TAZARA (which is Cape gauge, of which more below). This gauge is also used, *inter alia*, in Argentina, Brazil, Chile, Tunisia, Vietnam, and Thailand.

7. ***Cape gauge*** refers to a gauge with a physical distance of 1,067 mm between the inside of one rail to the inside of the other. Cape gauge is used for the TAZARA line that connects Tanzania with Zambia, and the majority of the railways in Southern Africa. This gauge is also used in Japan (for freight and conventional speed passenger services), Indonesia, and Australia (freight, and even high speed passenger services up to 210 km per hour employing tilting train technology).

8. ***Standard gauge*** refers to a gauge with a physical distance of 1,435 mm (4ft 8½ ins.) between the inside of one rail to the inside of the other. It is mostly used in Central and Western Europe, the United States of America, Canada, Morocco, Algeria, and Japan (for high-speed passenger railways).

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[1] See CPCS, 2009; CPCS, 2013; Nathan Associates, 2011 for more detail.

[2] Note Rail gauge is different from Loading gauge, which is defined as the maximum height and width for railway vehicles and their loads to ensure safe passage through bridges, tunnels and other structures. It is entirely possible to have the same Rail gauge and a different Loading Gauge, as between the UK and France.

9. The key question is why one gauge is chosen *vis-à-vis* another, and what are the technical advantages and disadvantages of standard gauge *vis-a-vis* Metre or Cape Gauge. Accordingly to one recent report,[3] there are two main justifications for choosing Standard gauge:

a) To ensure ***better inter-connectivity*** between railways (where neighboring railways are of the same gauge). The move towards the specification of a Standard gauge in both the United Kingdom[4] and the United States[5] in the 19th Century was essentially a response to the commercial demands of the railway companies. There was recognition of the considerable additional costs of transferring freight across lines of different gauges (which in some junction towns, like Erie, provided employment to hundreds of people to assist in the transshipment), and a desire to maximize the commercial potential of the lines. This bottom-up demand is best illustrated by the market ignoring an 1862 edict from President Abraham Lincoln that the standard gauge in the United States should be 5ft.

b) To realize the ***potential for higher speeds*** due to the increased stability offered by the wider footprint. It is no surprise that virtually all the high speed passenger services operating today around the world are on the Standard Gauge of 1,435 mm. However, high speed of up to 210 km per hour are also possible on Metre or Cape gauge, with the use of tilting train technology, as in Queensland, Australia. This requires that the Cape gauge track, in this case, is laid with the same degree of precision as Standard Gauge, which negates some of the cost advantages. Although, the attraction for freight is limited, as most freight tends to have a low value of time, and there is little benefit in running trains at speeds over 60-80 kilometers per hour reliably.

10. One misperception that is often promulgated is that you can carry more freight on Standard Gauge, due to the potential for high axle loads, and longer trains. But the heavy duty Cape gauge railways in Australia (e.g. Queensland), Brazil,[6] South Africa and New Zealand show that if the track is built to a heavy-duty standard, performance almost as good as a standard gauge line is possible. Metre gauge and Cape gauge accommodate freight trains travelling up to 120 km per hour (Japan), with axle loads as high as 25 ton per axle (Australia), pulling more than 200 wagons and 40,000 tons per train.

III. The Development Alternatives

11. There are four main alternatives to upgrade the railway network in the EAC countries: (1) rehabilitate the existing network to the original standard and gauge, (2) refurbish/upgrade the network to a higher standard, with the same gauge; (3) refurbish/upgrade the network to a higher standard, with a different gauge such as Standard Gauge on the same alignment, or (4) construct a new right-of-way:

12. ***Alternative 1: Rehabilitating*** the existing railway network would allow a phased approach to its development, consistent with current and projected demand and the financing envelope available. This would involve necessary investment to achieve reliability and good average operating speeds, with a focus on those sections needing most remediation. This is likely, *a priori*, to represent the most cost-effective option for the development of the railway infrastructure.

13. ***Alternative 2: Refurbishing or Upgrading*** the railway network to the same gauge, would imply a far more substantial

[3] CPCS (2009).

[4] Introduced by the Railway Gauge Act of 1846, after deliberation by a Royal Commission.

[5] Legislation passed by Congress in 1864.

[6] The EFVM railway in Brazil, runs on Metre gauge, and uses over-100-pound rails (100 lb/yd or 49.6 kg/m) and a loading gauge almost as large as US non-excess-height lines. It sees multiple 4,000 hp (3,000 kW) locomotives pulling 200 wagon trains.

intervention, raising the quality and operating speeds along much of the network, where justified by current and projected traffic. This solution is more expensive upfront, as greater investment is required, but also relatively cost-effective since it allows for re-use of materials and existing right-of-way. In addition, the characteristics of the refurbished infrastructure can be equivalent to or surpass the design standard of the existing infrastructure.

14. ***Alternative 3: Upgrading the network to Standard gauge on the same alignment.*** Upgrading a Metre gauge to Standard gauge essentially involves the construction of a new railway, broadly along the same alignment. This solution is more expensive upfront, as greater investment is required, but there are cost savings compared to the construction of a Standard gauge railway on a completely new alignment, through reduction in the amount of new land required, and possibly the scale of some structures.

15. Finally, ***Alternative 4:*** involves the construction of a Standard gauge railway on a ***new right-of-way***. This option requires additional investment in land acquisition and structures, and new right-of-way construction.

IV. EVALUATION OF THE ALTERNATIVES

16. This section presents an indication of the benefits and costs[7] of the alternatives outlined in the previous section:

The Expected Costs

17. It is assumed under ***Alternative 1***[8] that axle loads in the order of 15-18 tons per axles would be realized for the poorest part of the infrastructure, and maximum operating speeds of up to 80km/h. Based on these assumptions, the estimated maximum carrying capacity of the network would be around 5.5 million tons per year.[9] The estimated investment ***cost*** per km of track to implement this alternative is in the order of US$ 0.18 million.[10]

18. ***Alternative 2*** predicates axle loads in the order of 25 tons per axles and a maximum operating speed of up to 120km/h. Based on these assumptions, the estimated maximum carrying capacity of the network would be around 60 million tons per year. The estimated investment ***cost*** per km of track to implement this alternative is in the order of US$ 0.49 million.

19. ***Alternative 3*** predicates axle loads in the order of 25 tons per axles and a maximum operating speed of up to 130 km per hour. Based on these assumptions, the estimated maximum carrying capacity of the network would exceed 60 million tons per year. The estimated investment ***cost*** per km of track to implement this alternative is in the order of US$ 1.50 million.

20. ***Alternative 4*** also predicates axle loads in the order of 25 tons per axles and a maximum operating speed of up to 120 km per hour. Again, based on these assumptions, the estimated maximum carrying capacity of the current network would exceed 60 million tons per year. The estimated investment ***cost*** per km of track to implement this alternative is in the order of US$ 3.25 million

21. All cost estimates exclude additional investment necessary to procure the required locomotives and rolling stock for the projected traffic on the network (see CPCS 2009 for further details).

The Expected Benefits

22. The current freight volume carried in the EAC railway network was 1.6 million tons in 2009,[11] resulting in estimated revenue of US$ 65 million.[12] One recent

[7] Drawing heavily on the EAC railways Masterplan (CPCS, 2009).

[8] Annex A contains a summary of the characteristics of the different Alternatives.

[9] Based on an assumed 40 train services per week, each pulling up to a maximum 40 wagons per train.

[10] All costs and revenues are in 2009 prices (CPCS, 2009).

[11] Nathan Associates (2011).

[12] Assuming an average tariff of $0.05 per t-km and an average haul length of 813 km (CPCS, 2009).

estimate of forecast demand[13] is that freight traffic on the entire EAC rail network will grow to approximately 14.4 million tons per year by 2030.[14] This, based on the same assumptions, would represent annual revenues in the order of US$585 million per year. Using this information, each alternative can be evaluated as follows:

23. ***Alternative 1***: This alternative requires the lowest investment requirements. Without the upgrading of some sections, the maximum amount of traffic that could be accommodated would be 5.5 million tons per year. So based on the traffic projections in the EAC Railway Masterplan, capacity constraints are likely to emerge on the network well before 2030.

24. ***Alternative 2***: This alternative requires slightly higher investment requirements, as above, but would ensure no capacity constraint on the EAC railway network by the end of the forecasting period, 2030. T***he additional investment required for this Alternative vis-à-vis Alternative 1 would be justified if an additional 6.2 million tons per year of freight traffic could be attracted to the network.***

25. ***Alternative 3***: this alternative will also ensure that no capacity constraints emerge before the end of the forecasting period 2030. However, since the investment cost per km of track is US$1.50 million compared to US$0.49 million for ***Alternative 2, the conversion to standard gauge on the same right-of-way is only justified if an additional 20.2 million tons per year of freight traffic could be attracted to the network.***

26. ***Alternative 4***: this alternative can also accommodate the expected traffic. However, the investment cost is considerably higher (US$3.25 million per km of track). Consequently, ***the construction of a standard gauge line in a new right-of-way is only justified if additional traffic attracted to the line amounted to 55.2 million tons per year.***

V. CONCLUSIONS

27. ***Based on these assumptions, there is no economic or financial case for standard gauge in the EAC area at this time.*** A refurbished Metre gauge network (Alternative 2) would appear to be the most appropriate option in economic and financial terms, and could easily accommodate forecast traffic up to 2030, with lower investment requirements.

28. ***Investment in standard gauge appears only to be justified if the new infrastructure could attract additional freight in the order of 20-55 million tons per year.*** Based on the traffic forecasts undertaken for the EAC Railway Masterplan[15] and more recent work[16] undertaken on the central line in Tanzania, these volumes would appear to be unattainable over the medium to longer term.

REFERENCES

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[13] CPCS (2009).
[14] This estimate excludes volumes carried by TAZARA.

[15] CPCS (2009).
[16] World Bank (2013).

ANNEX A – AN ASSESSMENT OF ALTERNATIVES

	Current gauge	Standard gauge
Rehabilitate	**Alternative 1** Max Speed: 80km/h Axle load: 15-18t/axle Cost: $ 0.18m/km Capacity constrained 5.5mt/year	N/A
Refurbished	**Alternative 2** Max Speed: 120km/h Axle load: 25t/axle Cost: $0.49m/km Capacity above 60mt/year	**Alternative 3** Max Speed: 130km/h Axle load: 25t/axle Cost: $1.50m /km[17] Capacity above 60mt/year
New right-of-way	Max Speed: 120km/h Axle load: 25t/axle Cost: $2.60m /km Capacity above 60mt/year	**Alternative 4** Max Speed: 130km/h Axle load: 25t/axle Cost: $3.25m /km Capacity above 60mt/year

Source: CPCS (2009). *East African Railways Master Plan Study*; JICA (2010), *Japan's Experience in Railway Sector: Major Implications to East Africa*

[17] Considering right of way construction costs 40 percent higher than the ones presented in CPCS (2009) to include costs incurred to correct the curvature radios where needed. The total cost presented is 33 percent higher of the cost presented in CPCS (2009).