Annex B: Technical Working Paper

East African Railways Masterplan Study

Working Paper on Rail Technical Issues

Prepared for:

East African Community

Prepared by:

CPCS

Project No. 06089

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Executive Summary

Authority for this Study

This project is carried out under the Contract dated 12 July 2007 between the East African Community (EAC) and CPCS Transcom International Limited (“CPCS”) to carry out the East African Railway Masterplan Study (“Masterplan Study”).

Purpose of this Report

The objective of this Working Paper is to review the railways current capacity and establish the gap between this capacity and the requisite railways infrastructure and services that will be required to meet future demand. This Working Paper is designed to provide input into the Master Plan report to be developed as the main output of this study.

In the past 15 years, the railways of East Africa have generally seen their traffic levels and market share drop on an almost annual basis. This has been, in large part, due to insufficient maintenance and capital spending on railway assets. The other significant contributing factor to the railways’ traffic loss has been the growth in competitiveness of the trucking industry.

One of the biggest priorities of the railways will be to increase train-operating speeds. This will provide a needed boost in levels of service and traffic capacities to begin the process of recapturing lost traffic.

This report documents the increases in capacity that can be achieved on the rail lines through the strategy of increasing average operating speeds. With elimination of speed restrictions and achievement of reasonable operating speeds, the present rail network will meet capacity needs for the next 25 years. This will require investment in the track, train control systems and rolling stock. We recommend that the EAC and member countries should consult and, if necessary, negotiate with the Concessionaires, and develop investment plans that meet the future capacity challenges.

There has been much discussion in African and East African railway communities of converting the entire rail network to a unified gauge or constructing a new standard railway to replace the existing networks of cape and meter gauge. We have reviewed the benefits of both of these options. Our findings are that standardization of gauge will not be cost effective. The capital costs relative to benefits ratio will be very high, and change of gauge could not be financed by the private sector. However, we recommend that all extensions to the East African rail network be designed with the formation, bridges and clearance envelope adequate to accommodate future conversion from narrow gauge to standard gauge.

It is our assessment that the existing narrow-gauge rail network can be restored to meet future competition and capacity requirements, at a fraction of the costs needed to change to a different gauge.

Finally, a whole range of rail expansions have been envisaged for East African and surrounding nations. We discuss and compare the developmental options and, in Annex F, provide a framework for detailed financial and economic assessment of each.

1 Background

1.1 Introduction

This project is carried out under the Contract dated 12 July 2007 between the East African Community (EAC) and CPCS Transcom International Limited ("CPCS") to carry out the East African Railway Masterplan Study ("Masterplan Study"). The objectives of the assignment are:

i. Evaluate the current and potential demand for railways infrastructure and services, in the context of the EAC overall Development Strategy and objective to become more competitive, through the reduction of transportation and transactional cost and times of particularly trade.

ii. Review the current railways capacity and planned improvements and establish the gap between this capacity and the requisite railways infrastructure and services that will be able to cater for future demand.

iii. Propose a railways development strategy and action plan (Master Plan) to close the gap and develop the required level of infrastructure and services needed to make a maximum contribution in facilitating and catalyzing more robust regional trade and economic development.

iv. Prepare suitable organizational structure necessary to implement the Master Plan[1].

1.2 Objectives for This Report

The objectives of the technical report are:

- to determine the current physical extent of the railways as well as condition of the infrastructure;
- estimate the capacity of the existing corridors and identify the constraints to future traffic flows; and
- examine all investment possibilities including rehabilitation and upgrading of the existing rail network as well as rail network expansion.

1.3 Organization of This Report

In addition to the Executive Summary and this Introduction, the Report consists of six additional chapters:

- Chapter 2 presents a brief description of the railways of East Africa including operators, extent and reach, and recent operating performance
- Chapter 3 provides condition of the fixed infrastructure and rolling stock of each EAC railway

[1] Project TOR, page 8.

- Chapter 4 addresses the issue of railway capacity including a discussion on factors which influence railway capacity, estimations of capacity of existing routes, and comparisons against current and forecasted traffic levels

- Chapter 5 focuses on the issue of track gauge

- Chapter 6 summarizes the current railway extensions currently being considered and provides a framework for identifying the costs associated with railway development and operation

- Chapter 7 presents a summary of railway investment possibilities with a discussion of the costs and benefits

2 Overview of the East African Railway Network

2.1 Introduction

This chapter summarizes the characteristics of the existing East African Railway network.

2.2 Existing Railway Organisations

The existing railways in the East African region are being privatised. The Kenya Railways Corporation (KRC) and the Uganda Railway Corporation (URC) networks have recently been concessioned to the Rift Valley Railways Consortium (RVR). The Tanzania Railways Corporation (TRC) network has also recently been concessioned to the Tanzania Railways Limited (TRL). With regards to Tanzania Zambian Railway Authority (TAZARA), the governments have decided in principle to award the concession of this railway to a qualified Chinese company, and a due diligence analysis of the railway is underway.

It is intended that private sector operators will bring market-driven principles to the railways that will drive operating efficiency and cost-effectiveness. The concession agreements include investments requirements of the Concessionaires and also provisions for governments to directly invest in the railway infrastructure.

2.3 Size and Extent of Rail Networks

The total length of the rail network in East Africa is 7,363 route-km; of which 6,341 km is currently active, as identified in **Table 2.1**. It should be noted that we have included only the portion of the Tazara network that is within Tanzania.
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Table 2.1: EAC Rail Network (Track Kilometres)

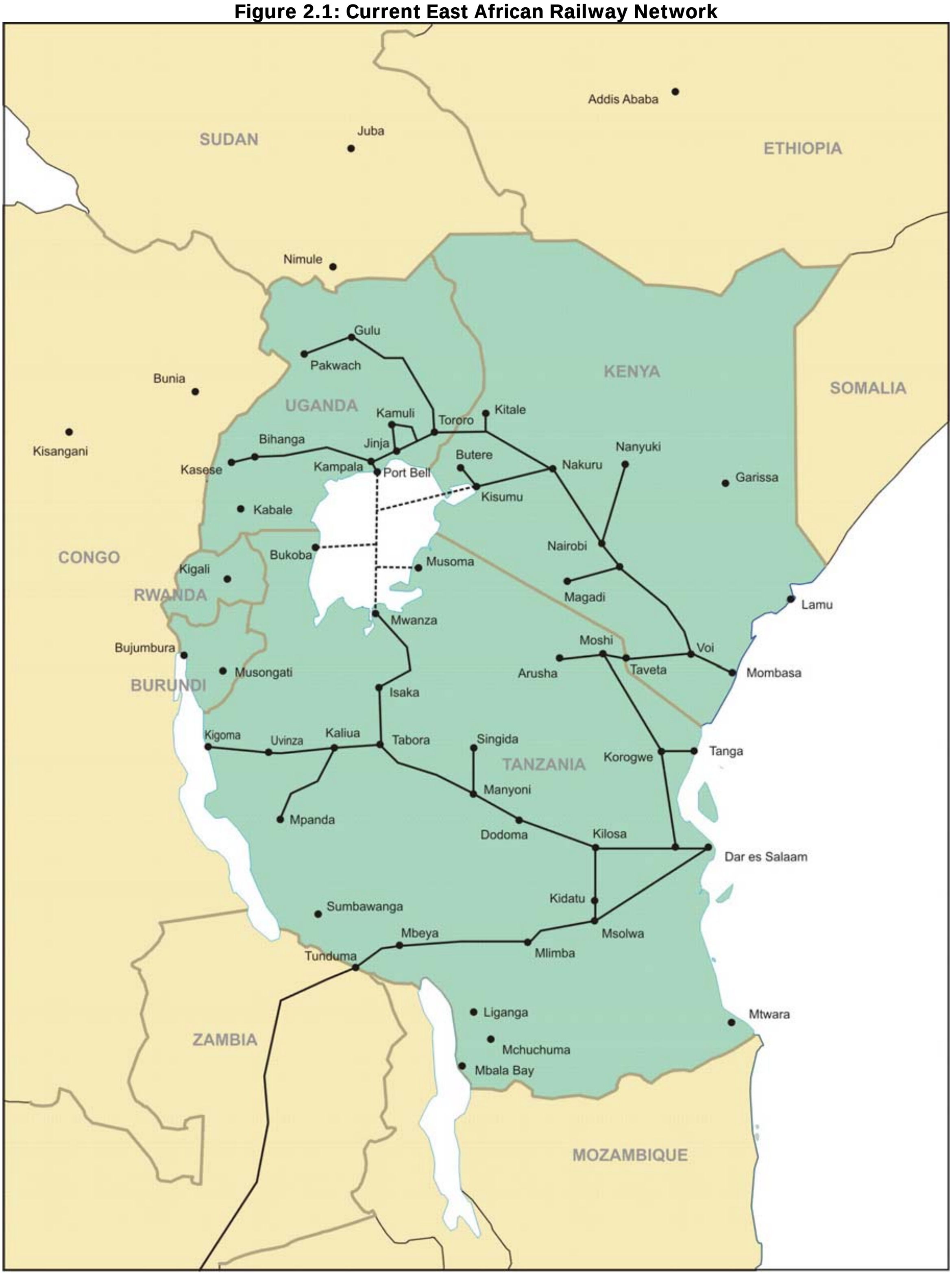
	KRC	URC	TRL	Tazara	Total
Gauge	1000 mm	1000 mm	1000 mm	1067 mm	
Active	2,022	260	3083	976	6,341
Inactive	42	987			1,029

Table 2.2 provides the details of railway coverage by country. The most recent figure for Africa was 2.96 km for 1,000 km^2. With the exception of Uganda, the rail network is slightly denser in East Africa than on the continent as a whole.

Table 2.2: Railway Coverage by Country (km / km^2)

	Kenya	Uganda	Tanzania
Area (km^2)	580,367	241,038	945,087
Coverage–Active Network (km / 1000 $km^{2)}$	3.48	1.08	3.26

Figure 2.1: Current East African Railway Network



Kenya (KRC)

The Kenya Railways Corporation (KRC) is the owner of the entire 2,064 km Kenya rail network. The active KRC network is concessioned to and operated by the Rift Valley Railways (RVR) with exception of the 146 km line between Konza and Magadi that is operated by Magadi Soda. The 42 kilometres that is currently inactive in Kenya is the Solai branch line. In addition, KCR owns one rail ferry on Lake Victoria, which has been concessioned to RVR, bur RVR is currently not operating it on account of difficulties encountered with securing insurance.

The network of trunk and branch lines in Kenya provide very extensive coverage for the south-western portion of the nation, including the port of Mombasa, Nairobi, the Rift Valley and the port of Kisumu on Lake Victoria. The trunk line parallels the border with Tanzania; running from Mombasa through to Nairobi and onwards to Malaba at the Ugandan border where there is an interchange with the URC. Four of the feeder lines branch off to the north and three to the south. The Voi-Kahe Branch leads to an interchange with the TRL network. The most utilized branch is the Kisumu Branch, which leads to the rail-marine terminals at Kisumu on Lake Victoria. Geographically most of the nation is not, nor has ever been, covered by the rail network. However, a number of railway developments are under consideration, including a link of Southern Sudan to the Indian Ocean would open rail development to the northern and eastern regions of Kenya.

Uganda (URC)

Currently, the majority of the 1,247 km Ugandan rail network is out of service. The active network, which is also concessioned to and operated by the RVR, consists of a 251-kilometer trunk leading from the border with Kenya (near Malaba) to the capital of Kampala augmented by a 9-kilometre spur leading to the marine facilities at Port Bell on Lake Victoria. Most operations on the remainder of the network ceased in 1998 or earlier. The Western Railway line extends 335 kilometres from Kampala to Kasese, in the Ugandan Copper Belt near the border with the DRC. Plans to expand the regional network recently have generated renewed interested in the rehabilitation of this line, as has an upswing in the price of copper. The other significant inactive branch line is the Northern Uganda Extension, which runs 507 kilometres from the trunk line at Tororo northwards into the Ugandan hinterland to Packwach, near the border with the DRC. Recent interest in the rehabilitation of this line is on account of focus on development of the mineral potential of the region and an extension of the line to the oil fields of southern Sudan.

The URC owns 2 rail ferries on Lake Victoria, which have been concessioned to RVR. As in the case of KRC, RVR is not currently operating the ferries owing to difficulties encountered with securing insurance.

Tanzania (TRC)

The TRC network consists of two east-west lines from the coast to the hinterland with a connecting link and a number of integral branches. The Central Line runs from Dar es Salaam to Kigoma with a major branch leading from Tabora to Mwanza on Lake Victoria, where there is a marine-rail terminal. Secondary branches from the trunk lead to Mpanda, Singida and Kidatu, where the TRC line meets the Tazara line. The Tanga line originates at the port city of Tanga and runs west to Arusha with a short branch line to north to the Kenyan border where it once connected to the KRC's Voi-Kahe Branch. The connecting 188-kilometer Ruvu Mnyusi Link connects the two east-west trunks in the eastern part of the nation.

The TRC network covers a large portion of Tanzania, especially when augmented with the Tazara railway which covers the south-eastern portion of the county. The entire TRC network was conceded to the railway operator Rites, as the Tanzania Railways Limited (TRL), in 2007. TRL continues to operate the entire network; however, it is speculated that it will choose to discontinue operations on some of the branches in the future.

They also continue to operate one ferry on Lake Victoria.

Tanzania (TAZARA)

The TAZARA Railway was built and financed by the PRC between 1970 and 1975 primarily to serve landlocked Zambia as an alternative to rail lines via Zimbabwe and South Africa. The line starts at the port of Dar-es-Salaam and crosses Tanzania in a south-westerly direction. It has no active branch lines in Tanzania, and the railway's trunk at this time is essentially used for traffic to and from Zambia. There is an interface facility at Kidatu, where the TAZARA line is parallel to TRL to facilitate transhipment of goods from TARARA wagons to TRL and vice versa.

3 Condition Assessment of East African Railways

This chapter assesses the current condition of the existing East Africa railways. The focus is primarily on the railway infrastructure condition. However, as motive power shortages and condition of rolling stock also contribute to the limited capacity of the existing networks, they are also reviewed.

3.1 Infrastructure

The colonial powers started constructing railways in East in Africa in the 1890s and by the 1950s most of the current network of the former East African Railways was constructed. The Tazara network was constructed in the early 1970's with funding and expertise provided by PRC. In general, the railways have lacked the necessary investment and maintenance, particularly in recent years, and this is reflected in the overall condition of the fixed infrastructure. There are, however, portions of the network that are newer, have been recently rehabilitated or have had been better maintained over the years, and as a result they are in an overall superior condition.

Our discussion of the fixed infrastructure will include a general description of the common features of each railway, complemented with descriptions of unique attributes of each railway within the following categories:

- Track Condition
- Bridges and Structures
- Signalling and Telecommunications
- Marine Infrastructure
- Buildings, workshops and depots
- Temporary Speed Restrictions

Our characterizations of the condition of the track and other fixed assets in this report are based on review of recent publicized studies and reports, interviews and data provided at meetings as part of study tour and a very limited physical examination of the physical infrastructure. In some cases, it is clear that we have comprehensive, current information that has been corroborated with multiple sources. Often, the information we have is not complete or it is not current. We have produced the most comprehensive, accurate and current report possible with the information provided. Please provide us with any additional information or corrections, as you may see fit.

The following table provides the details of the allowable axle loadings for trunk and branch lines for the railways of the EAC. Axle loadings are for the most part a function of track construction (rail weight and sleeper type and spacing) and the load ratings of bridges.

Table 3.1: Allowable Axle Loadings (tonnes)

Country Network	Kenya (KRC)	Uganda (URC)	Tanzania (TRL)	Tanzania (Tazara)
Trunk Lines	18	18	16 – 18	20
Active Branch Lines	15	18	12 – 16	N/a

3.1.1 Track

Rail

As per **Table 3.2**, the rail on the core mainline throughout the EAC is in excess of 75 lb / yard with the exception of the TRL where the trunk lines are 56 – 60 lb / yard. The heaviest rail section in the region is on the track with the highest traffic level; the trunk line between Mombasa and Nairobi.

Table 3.2: Rail on Core Lines

Country / Railway	Line	Year Rail Laid	Rail Weight
Uganda / URC	Core - Malaba to Kampala	1931 / 1958	80 lb
Kenya / KRC	Trunk – Mombasa to Nairobi	1896 - 1901 /	95
Kenya / KRC	Trunk - Nairobi to Malaba	1927 /	80 / 75 lb
Tanzania / TRL	Central Line	1907 - 1914 / 1960 - 2002	56 - 60 lb
Tanzania / TRL	Tanga Line	1899 / 1963	60 lb
Tanzania / Tazara	Mainline	1970 - 1975	90 lb

Rails on the core lines are a mix of both CWR and jointed rail. There has been and will need to be in the future rail relay programs on these tracks on account of curve wear. With the current and projected annual tonnages, it is unlikely there will be any need to relay rail on tangent track or on low-degree curves on account of rail wear. In addition, with the relatively light rail axle loadings, there is little expectation for high levels of rail breaks or surface defects that will lead to significant rail change-out requirements.

The KRC between Nairobi and Mombasa will likely require the most aggressive rail relay program on curves on account of relatively high traffic levels and prevalence of curves. The RVR is committed to upgrading to 100 lb rail or greater when undertaking rail relay on the trunk.

Rail on active branch line is of a much lighter weight than on trunk lines, as reflected in **Table 3.3**. For the most part, the rail is 50 lb / yard with some upgrades to heavier steel as part of rehabilitation projects in recent years, usually cascaded from core line rail relay programs. There has been some and will continue to need to be future renewal of this rail on account of curve wear, but it is not expected to be significant on account of the relatively light annual traffic.

Table 3.3: Rail on Branch Lines

Country / Railway	Line	Year Constructed / Rehabilitated	Rail Weight
Uganda / URC	Kampala - Port Bell spur	1915 / 1992	80 lb
Kenya / KRC	Kitale Branch	1926/	50 lb
Kenya / KRC	Butere Branch	1932 /	50 lb
Kenya / KRC	Thompson's Falls Branch	1929 /	50 lb
Kenya / KRC	Nanuuki Branch	1913 & 1930 /	50 lb
Kenya / KRC	Voi-Kahe Branch	1926 /	50 lb
Tanzania / TRL	Ruvu Mnyusi Link	1963 / 1986	50 - 80 lb
Tanzania / TRL	Mpanda Branch	1912 / 2000	45 - 56 lb
Tanzania / TRL	Mwanza Branch	1928 / 1972	60 lb
Tanzania / TRL	Mikumi Branch	1960	50 - 55 lb
Tanzania / TRL	Arusha Branch	1929	45 lb

Table 3.4 displays the rail weights for currently inactive tracks within the EAC.

Table 3.4: Rail on Inactive Lines

Country / Railway	Line	Year Constructed / Rehabilitated	Rail Weight
Uganda / URC	Western Uganda Extension	1956	50 lb
Uganda / URC	Northern Uganda Extension	1929 - 1964/	<= 50 lb
Uganda / URC	Busembatiap-Jinga Loop	1912 / 1928	50 lb
Kenya / KRC	Solai Branch	1926 /	50 lb

Very few of the current temporary speed restrictions are on account of rail wear or defects, and is a very good indication of the relative condition of the component versus sleepers and ballast section. Rail wear and the proliferation of surface defects can be retarded by enhanced maintenance practices and an investment in equipment common elsewhere in the world.

In general, 18 ton axle loadings are permitted on track with 80 lb / yd or heavier rail; and 15 to 16 tons axle loadings on the lighter rail.

Sleepers

With the exception of Tazara, mainline sleepers on all trunk and branch lines in the EAC are, for the most part, steel except at turnouts and some bridges, where they are wood. On Tazara, mainline sleeper are pre-stressed concrete augmented with wood at turnouts and bridges.

On all networks except Tazara, approximately one third of current speed restrictions are on account of damaged sleepers or damaged, loose or missing fasteners. Damages to sleepers or fasteners are on account of corrosion or wear or on account of a previous derailment in the area.

Sleepers in track on Tazara are for the most part the original sleepers laid in 1975. All indications are that the sleepers and fasteners are performing adequately.

Wooden sleepers at turnouts and on bridges are in excessively deteriorated state throughout the EAC, and a major cause of reason for temporary speed restrictions. This seems to be particularly acute on Tazara where temporary speed restrictions on account of sleeper condition on bridges are the second most prevalent cause.

Ballast Section

Ballast sections on most trunk lines in the EAC consist of crushed rock (normally granite) and slag. Where steel sleepers are used, the condition of the ballast section seems to be reasonably good, however, inadequate ballast section appears to be a prominent cause of temporary speed restrictions, behind sleeper / fastener condition and likely bridge related speed restrictions. The ballast section on the Tazara appears to be in the significantly worse condition likely on account of the use of concrete sleepers and the underlying soils, especially the black cotton soil. Inadequate ballast section and the related problems appear to be a major source of temporary speed restrictions on the network.

Branch line ballast most often appears to consist of local dirt, however, there are locations where crushed rock has been used. There are no reports of any significant or widespread problems with the formation on active branch lines, but it is expected that an increase in axle loadings or traffic on any of the lines would require rehabilitation of the ballast section, in some cases part of complete track rehabilitation. In addition to renewing the ballast section, the rehabilitation of inactive lines will require a significant effort to remove vegetation. Formations problems on some inactive branch lines, such as the 344-km Kasese line, are quite severe.

3.1.2 Bridges and Structures

The following table provides a summary of rating applied to bridges on each of the four EAC railways

Table 3.5: Current Bridge Ratings (tons per axle loading)

	KRC	URC	TRL	TAZARA
Trunk Lines	18	15 / 18	16-18	20
Branch Lines	15	13*	11-16	N/A

*not currently in operation

For the most part, bridge ratings are driven by the rating of the track in the vicinity of the track (which is mainly a function of the weight of the rail) and by historic value applied to bridges. It is possible that bridges could have the capacity to handle much higher axle loadings than indicated. On the KRC, as rail is updated to 100 lb rail, the plan is to increase allowable axle loadings greater than 18 tons. On the URC, track is rated for 15 ton per axle and bridges are rated for 18 tons. The maximum allowable axle load on TAZARA bridges is 20 tons. It is recommended that the railways commence with rating programs of bridges, at least on trunk lines.

The current conditions of bridges are major contributors to speed restrictions on EAC railways, in the form of temporary speed restrictions. This seems to be most severe on both the TRL and Tazara, where there is an acute problem with deteriorated bridge timbers. Bridges on the Uganda and Kenyan networks are predominantly ballasted steel deck bridges and are not currently an acute source of temporary speed restrictions.

3.1.3 Signalling and Telecommunications

Each of the four EAC railways has a very rudimentary train control system. Over the years, signalling systems have been installed on, at least, portions of all networks, but for the most part, the systems are effectively no longer used, except in few localized areas. Train control is, for the most part, train order systems used in conjunction with non-interlocked and interlocked signals. The KRC network appears to make the most use of signals (both non-interlocked and interlocked). Signals in use are both semaphore and colour-light systems. Most remaining signals are under localized control. Details of train control system are indicated in the following table.

Table 3.6: Systems of Train Control and Telecommunications

Technology	KRC	URC	TRL	TAZARA
System Of Train Control	Token	Paper Line Clear	Absolute Block Working	Token-less
Telecommunications System	Open pole wire	Microwave communication	Combination: Pole wire, Fibre optic, HF radio	Combination: Digital Microwave, fibre optic, HF radio

As with signalling systems, telecommunication systems are in all cases in a state of disrepair and are unreliable. This contributes to poor productivity as well as a lower level of safety. The deterioration of these systems has been in a large part on account on account of the theft or vandalism of key components of the systems such as pole wire, signal lights, and microwave dishes. For the most part, given the condition and age of the infrastructure, rehabilitation of the systems is not justifiable. Although more study is required, the most logical investment would be in current communication systems and hardware and software to effectively implement an Occupancy Control System (OCS).

3.1.4 Rail Marine Operations and Infrastructure

Up until recent years, four railcar carrying vessels plied the waters of Lake Victoria between the ports of Mwanza, Kisumu and Port Bell. Two of the vessels were owned and operated by the URC, and one each by the TRL and KRC. In 2003, 49% of the URC rail traffic was carried by the Lake Victoria vessels; including 100 % of traffic to and from the Port of Dar es Salaam. As of today, only the TRL vessel is in operation. The KRC and URC vessels are not operated on account of condition and difficulties in acquiring and costs of insurance.

All three terminals continue to be used for rail services, however, based on our cursory review of facilities at Port Bell, it appears rehabilitation is required for continued safe and efficient usage. The track leading from the Port Bell facility to the trunk line is in very good condition and constructed with 80 lb rail. This cannot be said of the track leading to the terminals at Kisumu and Mwanza, which are served by branch lines with rail weight of 60 lb and less. It should be noted that the KRC has the alternative of moving traffic to Uganda through Mbala. Although, it is not clear as to any of the concessionaire's plans for the rail service on Lake Victoria, it is likely that the RVR will focus on rehabilitating its main line to Mbala rather than rehabilitating its Lake Victoria vessel and its Kisumu rail facilities.

3.1.5 Building, Workshops and Depots

Although a detailed review of workshops, depots and other maintenance facilities, and engineering facilities is beyond the scope of this study, it does appears that the overall condition of facilities is poor to adequate. In addition, there does seem to be continued opportunities to rationalize facilities, and consolidate operations. Additional benefits can be made by consolidating rolling stock maintenance and rehabilitation operations across railways to locations and workshops most suitable to the work.

3.1.6 Temporary Speed Restrictions

Temporary speed restrictions are currently prevalent on all EAC railways. Most speed restrictions are currently applied on trunk lines on account of lower speeds on lower track speeds on the branches. As per **Table 3.7**, figures range from 3.6% on Tazara to 23% on the KRC network.

Table 3.7: Temporary Speed Restrictions – Trunk Lines

	KRC	URC	TRL	TAZARA
Number		34	34	13
Kilometres of track	250	45.4	116.3	34.8
% of core track speed restricted	23%	17.5%	7.2%	3.6%

The figure for Kenya is somewhat dated as it is from the *"Information Memorandum – Joint Concessioning of the Railways of Kenya and Uganda".* At the time of our visit, RVR had implemented a 25kph blanket speed restriction on the trunk and was in the process of completing detailed inspections and removing the speed restriction as they deemed fit. We have not yet received an update of the status of speed restrictions. Little detail is known of the nature of these speed restrictions.

The figure for the URC was based on a detailed temporary speed restriction report provided by the RVR at meetings in Kampala. Speed restrictions are on account of damaged sleepers, inadequate ballast section and track geometry. The figures for the TRL were provided by TRL officers at our meeting in Dar es Salaam, and we have included for only the Central and Tanga lines. The 34 restrictions are on account of damaged or deteriorated sleepers (12), inadequate formation or ballast section (12), bridge of culvert issue (7) and geometry (3).

The Tazara figures include for speed restrictions within Tanzania. They have indicated that the main causes for speed restrictions are poor track on account of derailments, decayed wooden sleepers on bridges and bridge approaches, landslides and poor ballast sections on account of fouled ballast, black cotton soil, and formation holes.

3.1.7 Passing Loop Lengths and Spacing

Passing loop lengths on trunk lines are as indicated in the following table. Passing loop lengths provide a limit on the lengths of trains. Passing loop spacing, along with the system of train control, determine the number of trains permissible on a rail corridor at any time, but no information on the spacing was provided by to the Consultant.

Table 3.8: Passing Loop Arrangements by Trunk Line

Railway	Line	Typical Passing Loop Lengths (meters)
KRC	Mombasa – Nairobi	548
KRC	Nairobi – Malaba	514
URC	Malaba – Kampala	514
TRL	Tanga Line	514
TRL	Central Line	514
TAZARA	Core	600

Passing loops on branch lines are approximately 514-meter long.

3.2 Rolling Stock

3.2.1 Rolling Stock Technologies

The following table summarizes the rolling stock technologies used in East Africa.

Table 3.9: Train Coupling and Braking Systems by Railway

Attribute	KRC	URC	TRL	TAZARA
Train Coupling System	Hook & Pin	Hook & pin	Hook & Pin	AAR
Load Capacity of Couplers (max. trailing tons)	1500	1500	1500	1800
Braking System	Air	Air	Air	Dual (air & vacuum)

Train Coupling System

The AAR (Association of American Railways) system of coupling used by TAZARA is far superior to the hook & pin system used on the other three railways in that it allows for bi-directional usage and for significantly higher coupler forces. The Union of African Railways (UAR) has adopted the AAR coupler system as its unified attachment system. The UAR recommends all networks that are yet to use it, to introduce it on their new equipment. However, the adoption of the AAR system by the other railways is an “all or nothing” proposition because the systems are not interoperable.

Air Brakes

The air brake system (which is used in North America) is superior in terms of safety and reliability to vacuum brakes. The UAR advocates the railways “gradually move away from the vacuum brake technology system to the more powerful air-brake system”. The use of vacuum brakes is limited to TAZARA; TAZARA, in both Tanzania and Zambia, uses a duel breaking system (air and vacuum).

3.2.2 Motive Power

Overall, the railways' locomotives are in poor condition and provide utilization, reliability and availability rates that are low relative to international standards. This is likely on account of the advanced age of the locomotives and the lack of necessary investment in maintenance and rehabilitation over the years. Most locomotives, and certainly the more heavily relied upon locomotives, are diesel-electric. The exceptions are the TRL and the URC, where many locomotives are diesel-hydraulic.

The performance of locomotives is sub-par as expected for a fleet of its age. The locomotive performance has been the second most significant contributor to the railways' performance (after fixed infrastructure condition) in recent years.

The following table provides a summary of the number of locomotives in each of the railway's fleets. The KRC figures were as the Information Memorandum, and thus do not indicate the number conceded in the concession agreement. The URC figures were provided by both RVR and URC officials. TRL and Tazara officers provided figures and detail for their respective railways at our meetings held with them in Dar es Salaam.

Table 3.10: Total Locomotive Fleet by Railway

Locomotives	KRC	URC	TRL	TAZARA
Mainline	86*	37	49**	29
NML (Shunters & Branch line)	128	8	43	10
Total	214	43	92	39

* includes 5 ML locomotives leased to Magadi Soda Co.
** Plus 10 leased locomotives

Table 3.11 provides a breakdown of mainline locomotives, and **Table 3.12** provides details of the overall fleet. Mainline locomotives typically provide range between 1000 and 3000 HP. As indicated in **Table 3.12** the mainline locomotives of the KRC are of a higher horsepower, and in addition, however the fleet is 20 years or older.

Table 3.11: Breakdown of Mainline Locomotives

Locomotives	KRC	URC	TRL	TAZARA
Active	54	14		20
Non-active	32	23		19
Total	86	37	49**	39

* includes 5 ML locomotives leased to Magadi Soda Co.
** Plus 10 leased locomotives

Table 3.12: Details on Active Mainline Locomotive Fleet

Attribute	KRC	URC	TRL	TAZARA
Average Horsepower	2476	1174	1577	3000
Average Daily Loco Utilization (km)			272	360.9

It appears that the concessionaires have commenced and will continue programs to rehabilitate a reduced fleet of their best performing locomotives, and shelving or disposing of surplus units. It is likely that as dictated by operational requirements and capital availability, they will eventually implement program of locomotive renewal.

3.2.3 Freight Wagons

The age of freight wagon fleets at EAC railways differs from railway. The KRC fleet is the oldest and has a very high percentage of the fleet inactive. The average age of the fleet transferred to the RVR was 40.9 years old at the time of transfer. Sixty-three percent, or 2179 wagons, were deemed to be life-expired, which for the most part corresponds to the wagons that had not been used in active service in recent years and that were deemed surplus to operations in at least the immediate future. The active fleet as a percentage of the total fleet on the other three railways is 65 to 75%; significantly higher than the KRC likely on account of better rationalization practices in recent years, and newer and better performing equipment than on the KRC. The average age of the total fleet URC wagon in 2004 was 18.9 years, and the average age of the TRL fleet at the time of concession was about 25 years.

Table 3.13: Wagon Fleets by Railway

Wagons	KRC	URC	TRL	TAZARA
Active	2179	1259	1136	1500
Non-Active	3706	574	611	425
Total	**5885**	**1833**	**1747**	**1925**

The maximum gross load of most freight wagons on EAC railways is 15 tonnes per axle, limited in most cases by the bearings and springs. The TRL does have 16 open low gondolas with the capacity for 72.7 gross tonnes weight (18.2 tonnes per axle), however they would have limited usage on account of limitations imposed by tracks and bridges. In addition, the RVR, as a term of their concession agreement, has the option of conveying wagons up to a maximum of 18 tonnes per axle, but must in advance of this perform engineering ratings and required strengthening of existing bridges.

The quantity, capacity and likely performance of the wagon fleets have not and do not appear to impose any limitation on each of the four EAC railways from significantly improving future railway performance, at least on a global network. However, there is and will continue to be requirements for acquiring new or modifying existing wagons to meet market opportunities.

3.2.4 Passenger Equipment

Passenger service is provided on all railways except for the URC. Tazara provides rail service from Dar es Salaam through to Zambia three times weekly. The Kenya concession agreement requires the RVR to operate the following inter-city and commuter services for a period of five years. Inter-city service is offered on the trunk and branch lines with service one to three trains per week. Daily commuter service is between Nairobi and neighbouring suburban areas. On the TRL, passenger services are offered on the Central line from Dar es Salaam to Tabora, Kigoma, and Mwanza. There is also weekly service between Tabora and Mpanda, and between Dodoma and Singida. **Table 3.14** provides the coach fleets on the EAC railways.

Table 3.14: Coach Fleets by Railway

Coaches	KRC	TRL	TAZARA
Active	118	63	68
Non-Active	364	61	52
Total	**482**	**124**	**120**

The figures for the KRC represent the number of coaches conceded to RVR. The age average of the fleet is over 50 years. The average age of the passenger fleet of TRL is currently 27 years.

No review of passenger equipment was undertaken nor was there any information provided on the condition or performance of passenger equipment. However, it is expected that condition of passenger equipment is similar to that of freight wagons.

4 Capacity Assessment and Forecast

4.1 Capacity Assessment

The capacity of a track corridor of track is a function of operating trains permitted within the corridor at any time, the speeds for which trains operate and the traffic tonnage per train. The number of trains within a corridor is for the most part a function of the number of blocks (most often determined by spacing the passing loops) and the train operating system. More advanced systems allow trains in each successive block, whereas older less automated systems allow trains every second block typically.

The speed of the trains is mainly a function of the train characteristics (power-to-tonnage ratio) relative to that required of the terrain, posted track speeds and speed restrictions (normally imposed on account of infrastructure condition). Traffic per train is limited by passing loop lengths in combination with wagon capacity and drawbar strengths, as well as the availability of locomotives and wagons.

Table 4.1 provides an estimate of traffic capacity (expressed in millions of net tonnes of traffic per year in the aggregate of the two directions) as a function of train velocity and freight wagon capacity for the route between Mombasa and Nairobi (the results would be similar for the Dar es Salaam-Mwanza main line). The estimates are constrained by the siding loop lengths (420 meters) and spacings (25 kilometre), and the required power-tonnage ratios (1.2). The capacity estimates are not constrained, for the sake of this analysis, by the availability of motive power and wagons, or by drawbar strength limitations.

Table 4.1: Annual Capacity Projections (Million Net Tonnes) as a function of axle loading and train speed – Mombasa to Nairobi

Train Speed (kph)	Axle Loading per Wagon (tonnes): 12	13	14	15	16	17	18	19	20
20	3.8	4.0	4.1	4.2	4.3	4.4	4.4	4.5	4.6
25	4.9	5.1	5.3	5.4	5.5	5.7	5.6	5.8	5.9
30	5.8	6.0	6.2	6.3	6.4	6.7	6.6	6.8	6.9
35	6.8	7.1	7.4	7.5	7.6	7.9	7.8	8.0	8.2
40	7.9	8.2	8.5	8.7	8.8	9.1	9.1	9.3	9.5
45	9.8	10.3	10.6	10.8	10.9	11.3	11.3	11.6	11.8
50	9.8	10.3	10.6	10.8	10.9	11.3	11.3	11.6	11.8
55	10.9	11.4	11.7	12.0	12.1	12.6	12.5	12.8	13.1
60	11.7	12.3	12.6	12.9	13.1	13.6	13.5	13.8	14.1

* Based on passing loop lengths of 548 meter and spacing of 25 kilometres.

The two points to be garnered from **Table 4.1** are that:

- Capacity of a section track in terms of traffic is directly related to the average speed of trains through the corridor; and
- Capacity of a section of track is less correlated to the average axle loadings of wagons.

Table 4.2 provides our estimate of net tonnage capacity of the trunk between Mombasa and Nairobi with siding loop lengths of 1200 meters, and all else being the same as for **Table 4.1**.

Table 4.2: Annual Capacity Projections (Million Net Tonnes) as a function of axle loading and track speed – Mombasa to Nairobi

Train Speed (kph)	Axle Loading per Wagon (tonnes) 12	13	14	15	16	17	18	19	20
20	8.6	8.8	9.1	9.4	9.5	9.8	9.9	10.1	10.3
25	11.0	11.2	11.6	12.0	12.2	12.5	12.7	12.8	13.1
30	12.9	13.2	13.7	14.0	14.3	14.6	14.9	15.1	15.4
35	15.2	15.6	16.2	16.6	16.9	17.3	17.7	17.9	18.3
40	17.6	18.0	18.7	19.2	19.6	20.1	20.4	20.7	21.1
45	21.9	22.4	23.3	23.9	24.3	24.9	25.4	25.7	26.3
50	21.9	22.4	23.3	23.9	24.3	24.9	25.4	25.7	26.3
55	24.3	24.9	25.8	26.5	27.0	27.6	28.1	28.5	29.2
60	26.2	26.8	27.8	28.6	29.1	29.8	30.4	30.7	31.4

* Based on passing loop lengths of 1200 meter and spacing of 25 kilometres.

The intent of this exercise is not to suggest that, in time, passing loops be increased to provide needed additional capacity, nor is it to provide a roadmap to meeting forecasted traffic. In fact, the same results could be achieved by investing in signal & telecommunications systems and infrastructure and extending some key passing loops over a period of time as required to provide the needed capacity. It should also be noted that the benefits of increased siding loop lengths in terms of traffic capacity can only be realized with the coupler strengths provided by AAR couplers, and of course investment in the required rolling stock. The main conclusion is that considerable increases in capacity are achievable on the existing network.

4.2 Projected Capacity Requirements

Table 4.3 provides our estimation of traffic levels for the existing East African Railways. The rationale for these forecasts is presented in the Traffic Working Paper. The projection is that the railways have the potential to increase their traffic, under the Base Case three- or four-fold between now and 2030. In the case of TRL, where current traffic levels are well below what was carried in the recent past, the projection is for a five-fold increase under the Base Case.

Table 4.3: Forecast Traffic for East African Railways ('000 net tonnes)

Railway	Scenario	2008	2010	2015	2020	2025	2030
KRC	HIGH	2,047	3,767	5,201	6,350	7,646	9,194
	BASE	2,021	3,388	4,503	5,372	6,344	7,509
	LOW	1,994	3,009	3,795	4,430	5,141	6,005
URC	HIGH	719	1,395	1,909	2,345	2,836	3,424
	BASE	710	1,210	1,602	1,932	2,301	2,743
	LOW	700	1,038	1,308	1,549	1,819	2,147
TRL	HIGH	850	1,863	3,456	3,985	4,582	5,296
	BASE	842	1,601	2,799	3,205	3,659	4,203
	LOW	835	1,356	2,152	2,453	2,790	3,200
TAZARA	HIGH	594	719	1,096	1,522	1,980	2,527
	BASE	589	699	1,018	1,368	1,738	2,166
	LOW	583	680	945	1,229	1,524	1,855

With improvements in train velocity and relatively modest investments in capacity (e.g. improved signalling and/or longer sidings), these traffic forecasts can be accommodated on the existing network.

4.3 Port Capacity

The port of Mombasa has seen a 6.3% average annual growth in total tonnage handled from 2001 to 2006, while its average annual growth for container traffic was 10.5% for the same period. Traffic at the port of Dar es Salaam has grown significantly since 2000, at 9.7% annually. Since 2000, rail market share of the Dar es Salaam port traffic for both dry cargo and containers has declined significantly. Although we lack hard data, it is widely understood that this is also the case, although to a lesser extent, at Mombasa.

Currently, the port of Mombasa appears to be experiencing congestion problems, which have some bearing on the rail service of the Rift Valley Railways. Indications are that the problems are being addressed.

Some of the growth of traffic that is being forecasted for the EAC railways will be a shift of road traffic to rail, whereas other growth will be incremental traffic from economic growth. In the case of traffic from new links, much of the traffic will be at the expense of road traffic. This would be especially true to links to Burundi and Rwanda which are well-connected by road to the East Africa and its ports on the Indian Ocean. In the case of some links being proposed, such as to Southern Sudan, the traffic would be incremental transport traffic.

The implications of our forecasted rail traffic growth to traffic at the port is not known, on account a large part of the uncertainty of rail link development plans. However, as development plans are finalized, it will be necessary to look at the implications at the ports to assure that they have the capacity to meet traffic demands.

4.4 Conclusions about Capacity

Key conclusions from the analysis of this section are:

- Train velocity is a key driver of traffic capacity
- The single biggest focus of the railways in coming years should be removal and avoidance of temporary speed restrictions, and other reasonable measures to economically maximize speeds
- Train speeds will never be equal to that of posted track speeds, even without temporary and permanent speed restrictions. Train speeds are inversely related to the number of trains within the corridor.
- A secondary focus will eventually be needed on an increasing axle loadings to meet traffic forecasts
- In about 20 years on the trunk lines, plans will have to be put in place to increase traffic capacity by installing a more effective train control system, upgrading signals & telecommunications systems and infrastructure and / or extending passing loops. This will need to be supported with equipment with AAR couplers and higher carrying capacity.

5 The Gauge Issue

The purpose of this section is to provide some technical context for the discussion of gauge issues.

5.1 Unified Gauge in East Africa

The railway networks of Africa are generally characterized by the lack of connectivity. This was initially on account of independent railway development by colonial powers to extract resource from hinterland. The phenomenon continues today in large part of different track gauges used throughout the continent and even within regions and countries. East Africa is fortunately blessed by a railway network that is of single gauge, the meter gauge, with, of course, the exception of Tazara which was developed in the 1970s as cape gauge on account of its connection to the network of Southern Africa. Most of the existing rail networks in other adjacent countries are also cape gauge including Sudan and the DRC, as well as the nations of Southern Africa.

The Union of African Railways' (UAR) position as of 2006 was that the East African Community (EAC), along with the Southern African Development Community (SADC) and the Arab Maghreb Union (AMU) offer the best integration potential[2]. In addition, in April 2006, they stated that on account of the fact "that the adoption of a unified spacing system for all the continent was unrealistic for obvious reasons of cost conversion, three distinctive gauge systems were retained"[3] including the 1067 mm for the South and East.

Regardless of the UAR's position, discussion continues today of not only unifying the track gauge in East Africa, but also of adoption of standard gauge for both the existing network, as well as for many of the proposed links under consideration. The benefits of converting the entire EAC rail network to cape gauge railways would stem mainly from the additional traffic as a result of the interchange with the rail network of the SADC and possibly in the future, to the railways of other adjacent countries. A secondary benefit would be the availability and lower acquisition cost of rolling stock of cape gauge (mainly from South Africa).

The benefits from the conversion of all or some of the existing or proposed network to standard gauge have mainly to do with the availability and acquisition costs of rolling stock and track maintenance equipment. In addition, it is possible that the EAC rail network may act as a catalyst with other regional railways and new railway developments adopting standard gauge in the future. In section 5.2 we delve deeper into the benefits of standard gauge railway to that of a cape or meter gauge.

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[2] First African Union Conference of African Ministers Responsible for Railway Transport ,
10 – 14 April 2006 Brazzaville, Republic of Congo
"The Overview" document
[3] First African Union Conference of African Ministers Responsible for Railway Transport
10 – 14 April, 2006 Brazzaville Republic of Congo
"Rail Development in Africa: Stakes and Prospects, Objectives and Missions of the African Rail Union (ARU)"

5.2 Standard Gauge Benefits

Based on our research, the main reasons railways have converted to standard gauge from another gauge has been originally on account of equipment availability and in later years to connect with one or more regional standard gauge railways. We have not seen any evidence of projected cost savings or railway capacity increase as being drivers of the conversion to standard gauge. Below we list the benefits of standard gauge versus cape or meter gauge, and provide a brief explanation of each:

1 The potential for better inter-connectivity of railways
2 Better availability and lower acquisition costs of rolling stock and track maintenance equipment
3 Higher traffic-carrying capacity of the railway, and
4 The potential for improved railway operating performance.

1) The potential for better inter-connectivity of railways

The main reason railways around the world have changed to standard gauge from other gauges has been to inter-connect with another regional network. This was the driver in North America as well was and is the impetus behind the movement towards standard gauge in Europe, Asia and Australia. Today, standard gauge is the most prominent gauge in the world, and is used in North America, Europe and much of Asia and Australia. It currently accounts for only 14% of the railway network of Africa, mainly in Egypt.

2) Better availability and lower acquisition costs of rolling stock and track maintenance equipment

Based on our research, there appears to better availability of new and used standard gauge rolling stock and track maintenance equipment versus meter or cape gauge. There is also a cost differential in favour of standard gauge equipment versus narrow gauge equipment. This differential is less than 10% of the equipment capital costs.

3) Higher traffic-carrying capacity of the railway

Standard gauge railways offer the potential of significantly higher traffic-carrying capacity versus meter and cape gauge railways. However, the potential is only achievable with high track quality, especially heavy rail and supported with appropriate train control infrastructure and systems and rolling stock investments. **Table 5.1** provides a comparison of permissible axle loadings of the three gauge tracks across three weights of rail.

Table 5.1: Allowable Axle Loadings (tons)

Gauge	Rail weight (lb / yd)		
	80	100	136
Meter Gauge	16.5	22.5	25.1
Cape Gauge	16.8	24.1	27.3
Standard Gauge	18.5	26.4	37

** Based on 90 kmh track and track construction of concrete sleepers, 60 cm of ballast and 15 cm of sub-ballast*

4) The potential for improved railway operating performance

Standard gauge railways offer the potential for greater operating efficiency than narrow gauge rail networks as measured by fewer carloads required to move the same traffic. The operating savings is not seen to be significant enough for inclusion in analysis of the standard gauge option. However, we have included in further analysis the reduced wagon requirements stemming from the utilizing higher capacity wagons in standard gauge operation.

The operating benefits of standard gauge railway versus meter or cape gauge are only material at high traffic levels; well beyond even the optimistic forecasts for the EAC. This is on account of the higher development costs of a standard track railway, and the fact that the operational benefits and cost savings are only fully achieved when the railway is operating near its track capacity. When one compares the standard gauge alternative against a rehabilitated existing rail network, it becomes less financially attractive, as we will see.

5.3 Standard Gauge Considerations in East Africa

The most immediate benefits that would stem from the development of a standard gauge railway in East Africa would be having new fixed infrastructure and the needed equipment to operate and maintain it, compared to the current fatigued network of railways and equipment. The benefits of inter-connectivity, operating costs improvements and higher traffic levels would not immediately and may never be realized.

However, the decision to develop a standard gauge railway is not one solely of comparing cost and benefits against the current railways of East Africa. A logical alternative would be restoring the current network, including equipment, to a new condition with either uniform cape or meter gauge track. Our discussion below will discuss the alternatives of full rehabilitation and conversion of the existing network to cape or meter gauge, and construction of a new standard gauge railway.

The development of a standard gauge network on the right-of-way of existing rail networks could not likely be cost effectively performed on account of the width of the right-of-way especially at bridges, tunnels and built-up areas, and certainly could not be done without effectively ceasing operations on the lines for a prolonged period of time. Thus development would have to be done remotely from existing tracks, thus allowing train operations to continue to some degree through the construction period. However, given the expected service disruption and the costs associated with developing a railway while trying to operate and maintain an existing one would likely render it prohibitive to operate at all through the construction period.

The rehabilitation of the existing networks to new or nearly new condition can certainly be done without any significant interruption to service.

The conversion of track from cape gauge to meter gauge or vice versa can be done on the same right of way, for the most part, and many of the track components could be re-used. Conversion from cape to meter gauge would pose fewer hurdles than the inverse for obvious reasons. Regardless, service would need to cease for a period of time during the conversion in either case.

Converting to another gauge on any of the EAC railway networks is likely an “all or nothing” proposition. As an example, converting the trunk line of the KRC to either cape or standard gauge without converting the branch lines will likely render a situation that it will not be cost effective to continue to operate the branch lines. It is expected that no railway branch lines would be viable if they are of a different gauge than the trunk line to which they are connected because of the requirement to tranship from one line to the other, thereby losing the competitive edge against trucks.

5.4 Estimate of Costs to Convert Existing EAC Railway Networks to a Unified Gauge

In this section, we provide estimates of the costs to convert the railways in East Africa to a common gauge. For all scenarios, we provide the costs to convert the existing active trunk lines and also the entire active network.

The first scenario is the development of a standard gauge railway on a new right-of-way, separate from (but at times overlapping) the existing cape and mater gauge railways. The second scenario involves a widening of the existing formations and the development a new standard gauge railway. The third and fourth scenarios involve the conversion of the EAC railways into meter and cape gauge railways respectively, with upgrading of the condition to new condition, for fair comparisons against the standard gauge scenarios.

The details of our cost estimates are included in Appendix B1 of this document.

The following table displays the range of development costs for a standard gauge network on a new right-of-way.

Table 5.2: Standard Gauge Network Developmental Costs (New right-of-way), (Millions of USD)

Cost Element	Trunk Lines Only	Current Active Network
Fixed Infrastructure	10,100 to 21,700	13,000 to 27,800
Acquisition of Rolling Stock	250 to 600	400 to 900
Profit Loss during Transfer Period	70 to 250	70 to 250
Total	**10,420 to 22,550**	**13,470 to 28,950**

By comparison, the annual revenue of the East African Railways, under the Base Case, is expected to range from only $200 million to $1 billion over the forecast period.

The following table displays the range of development costs for a standard gauge network on the right-of-way of the existing cape and meter gauge railways in East Africa.

Table 5.3: Standard Gauge Network Developmental Costs (Existing right-of-way), (Millions of USD)

Cost Element	Trunk Lines Only	Current Active Network
Fixed Infrastructure	2,900 to 6,750	3,700 to 8,700
Acquisition of Rolling Stock	250 to 600	400 to 900
Profit Loss during Transfer Period	180 to 620	180 to 620
Total	**3,330 to 7,970**	**4,280 to 10,220**

Table 5.4 and **Table 5.5** provide our estimates of the costs to convert the current network to cape and meter gauge, respectively, and to rehabilitate the track to new condition, and replace the rolling stock fleet with new equipment.

Table 5.4: Cape Gauge Network Developmental Costs (Millions of USD)

Cost Element	Trunk Lines Only	Current Active Network
Fixed Infrastructure	800 to 1,500	1,000 to 1,900
Acquisition of Rolling Stock	300 to 750	470 to 1,100
Profit Loss during Transfer Period	150 to 500	150 to 500
Total	**1,250 to 2,750**	**1,620 to 3,500**

Table 5.5: Meter Gauge Network Developmental Costs (Millions of USD)

Cost Element	Trunk Lines Only	Current Active Network
Fixed Infrastructure	600 to 1,300	750 to 1,600
Acquisition of Rolling Stock	325 to 800	490 to 1,200
Profit Loss during Transfer Period	0 to 100	0 to 100
Total	**925 to 2,200**	**1,240 to 2,900**

Operating Costs Improvements

Given the low capacity of the networks, we cannot forecast with any confidence a significant reduction in operating costs for a new standard gauge railway network in EAC versus a new condition meter or cape gauge railway into the foreseeable future. It would therefore not be financially beneficial to convert all the existing railways in the EAC to either cape gauge (as suggested by UAR) or to convert TAZARA to meter gauge.

Overall, the results of the economic analysis suggest that the KRC/URC/TRL networks should remain with meter gauge and TAZARA should remain with cape gauge.

5.5 New Rail Link Development – Gauge Considerations

Before proceeding with the development of a new link, it is imperative that a decision has been made concerning the standardized gauge for the EAC, and the development is in sync with it. If it is necessary to tranship cargo at the junction point between the existing line and the new line, rail shippers will be forced to pay a financial penalty for using the railway and traffic will be lost to truck.

The differences in Greenfield development costs of fixed infrastructure of railways constructed at differing gauges are relatively small, approximately 2,000,0000 to 4,500,000 USD per kilometre. The difference in rolling stock acquisition costs is estimated to be 10% cheaper per wagon or locomotive for standard gauge equipment and on account of higher wagon capacity requirements, we would estimate 10% fewer wagons would be required. However, in the case of cape gauge or meter line development, there would be opportunities to use existing rolling stock, and this would offset acquisition savings from standard gauge equipment. Most importantly, the acquisition cost of rolling stock required for most, if not all, new links being considered would be significantly less than 10% of the costs of fixed infrastructure development, and as such has no tangible impact on decision analysis.

5.6 Findings of Gauge Issues Analysis

Our findings on the gauge issue can be summarized, as follows:

- Conversion of the entire EAC rail networks to cape gauge would provide very few benefits relative to costs. There is little potential of significant interchange traffic between TRL/KRC/URC with Tazara and the railways of Southern Africa, and there are no operating savings; therefore, there is no justification to convert to cape gauge.

- For the same reasons, a conversion of Tazara to meter gauge makes even less sense as it will only lead to a significant loss of traffic.

- Under the most optimistic scenarios, the current rail networks of the EAC will generate revenues less than 1000 M USD annually by year 2030. Conversion of the trunk lines is forecasted to cost at least $5 B USD. Operating savings (if any) would be insignificant. Given the ratio of capital costs to revenues, it is clear to see that the conversion is cost prohibitive.

- New rail links should be developed consistent with the gauge of the network for which they will connect to. In the event they will not connect to an existing network, consideration should be given to using standard gauge. However, it should be noted that the benefits of standard gauge relative to meter or cape gauge are only appreciable at relatively high traffic levels.

- Although we advocate developing rail links in meter or cape gauge depending on their location, we do recommend that they be developed with a substructure that can accommodate the possible to conversion to standard gauge. This would apply to the width of formation as well as clearances on bridges and tunnels and with adjacent tracks, as well as placement of right-of-way features such as signals, switches, and structures. The incremental costs are relatively minor.

6 Expansion of Railway Network

The purpose of this section is to provide context to current rail expansion under consideration in East Africa. **Table 6.1** below shows details of each proposed link. In section 6.1 we categorize the links and provide a discussion of the drivers for the proposed expansions. In section 6.2, we discuss the capital costs associated with constructing the networks and implementing operations, as well as the operating and maintenance of rail operations on the lines. We follow this with a discussion of links that are for the most part redundant to each other.

6.1 Link Categorization

At least 20 links are currently under consideration in East Africa. The advocacy, status and purpose for the proposed links vary significantly. Some links are well supported and advocated by the relevant state(s), whereas others are driven by private investors. Some are simply ideas bandied around by various stakeholders, whereas others are near the implementation stage. As for purpose, some are purely to access current or proposed mines or mining regions; whereas, are more for the purpose of regional development, and yet others to provide an alternative to trucks.

In this section, we will categorize the proposed links in order to better understand the underlying drivers, and prepare a framework for feasibility analysis of the links. As we will see, some of the links clearly are certainly redundant to each other, as they would provide rail access to fundamentally the same areas.

6.1.1 Links to adjacent countries

As a group, the proposed links will provide access to seven countries beyond Tanzania, Uganda and Network, as follows:

Rwanda – Links 4, 11

Burundi – Link 15

DRC – Links 1, 3

Malawi – Link 8 (via also ferry on Lake Nyasa)

Sudan – Links 2, 5, 21

Ethiopia – Link 6

Somalia – Link 17

Redundancy exists in proposed links to Rwanda, DRC, and Sudan. In section 6.3, we include comparisons of sets of redundant links.

Table 6.1: Links Under Consideration

#	Link	Connection to existing Network	Comment	Kms	Region served	Traffic Base	Key O-D pair	Distance (key O-D pairs)
1	Kasese – Kisangani	URC / Kasese	need to re-activate line between Kampala and Kasese	600	eastern DRC	Resource potential of region	Kisangani / Mombasa	2274
2	Gulu – Nimule – Juba	No connection / independent network	part of ROOLA project	300	southern Sudan	related to the S. Sudan oil fields	Gulu / Lamu	1900
3	Pakwach – Bunia – Kisangani	URC / Pakwach	need to re-activate line between Tororo and Pakwach	900	eastern DRC	Resource potential of region	Kisangani / Mombasa	2494
4	Bihanga – Kabale – Kigali	URC / Bihanga	need to re-activate line between Kampala and Bihanga	300	Rwanda	broadly based	Kigali / Mombasa	1919
5	Lamu – Garissa – Juba	No connection / independent network	part of ROOLA project	1600	S. Sudan & C.Kenya	related to the S. Sudan oil fields	Juba / Lamu	1600
6	Garissa – Addis Ababa	No connection / independent network	part of ROOLA project	1300	Ethiopia	broadly based	Addis Ababa / Lamu	
7	Liganga – Mchuchuma – Mtwara	TAZARA / Mlimba	part of Southern Tanzania project	800	S.Tanzania: nr Lake Nyayasa –Mtwara Port	iron ore / broadly based goods	Liganga / Mtwara	
8	Mchuchuma – Mbamba Bay	Southern Tanzania (to Mbamba Bay Port)	part of Southern Tanzania project	200	S.Tanzania (to Mbamba Bay Port)		Mbala Bay / Mtwara	
9	Liganga – Mlimba	TAZARA / Mlimba	part of Southern Tanzania project	250	Southern Tanzania		Liganga / Dar es Salaam	
10	Dar es Salaam – Mtwara	TAZARA / Mlimba / Dar es Salaam	part of Southern Tanzania project	600	Tanzania (DAR Port to Mtwara Port along coast)		Mtwara / Dar es Salaam	
11	Isaka – Kigal with branch from Keza to Musongati	TRL / Isaka	part of Northern Tanzania - Rwanda project	700	Rwanda, Burundi, Northern Tanzania	Broadly Based	Kigali / Dar es Salaam and Musongati / Dar es Salam	

#	Link	Connection to existing Network	Comment	Kms	Region served	Traffic Base	Key O-D pair	Line Haul Distance (key O-D pairs)
12	Branch from Isaka-Kigali to Kabanga	TRL / Isaka	part of Northern Tanzania - Rwanda project	100	Kabanga, Tanzania (near border with Burundi), link to DRC	nickel ore	Kabanga to Dar es Salaam	
13	Branch from Isaka-Kigali to Biharamulo – Bukoba – Masaka	TRL / Isaka	part of Northern Tanzania - Rwanda project	300	Tanzania & Uganda west of Lake Victoria		Masaka to Dar es Salaam	
14	Tunduma – Sumbawanga – Mpanda - Kigoma	TAZARA / Tunduma & TRL / Kigoma & Mpanda		700 to Kigoma	south-western Tanzania (near border with Zambia & Lake Tanganyika)			
15	Uvinza – Bujumbura	TRL / Uvinza		300	Tanzania – Burundi (link to DRC)		Bujumbura / Dar es Salaam	
16	Arusha – Musoma	Northern Tanzania – south edge of Lake Natron – Lake Victoria		500	Northern-Eastern Tanzania – south edge of Lake Natron – Lake Victoria	soda ash at Lake Natron / mixed products elsewhere	Musoma / Dar Es Salaam	
17	Lamu – Kismayu	No connection / independent network	part of ROOLA project	300	coastal areas of southern Somalia and northern Kenya	iron ore	Kismayu / Lamu	
18	Garissa to Nairobi	No connection / independent network	part of ROOLA project	350	Nairobi / Central Kenya	alternative port for Nairobi traffic	Nairobi / Lamu	
19	Lodwar to Nakuru	No connection / independent network	part of ROOLA project	425	Central Kenya	alternative port for Kampala traffic	Nakuru / Lamu	
20	Gulu - Juba	URC / Gulu	need to re-activate line between Tororo and Gulu (??? Km)	300	southern Sudan	related to the S. Sudan oil fields	Juba / Mombasa	1749
21	Pakwach-Juba-Wau.	URC / Pakwach	connection with the Sudan Railway at Wau	900	southern Sudan	related to the S. Sudan oil fields	Juba / Mombasa	1894

6.1.2 Regional Developments

ROOLA project – Links 2, 5, 6, 17, 18, 19

Southern Tanzania – Links 7, 8, 9, 10

Central Tanzania – Link 14

Arusha – Musoma – 16

N. Tanzania / S. Uganda / Rwanda / Burundi – Links 4, 11, 12, 13, 15

DRC / Uganda – Links 1, 3

N. Uganda / S. Sudan – Links 20, 21

6.1.3 Link to non-EAC Railway

Kisangani, DRC – Links 1, 3

Addis Ababa, Ethiopia – Link 6

Wau, Sudan – Link 21

Malawi (via ferry on Lake Nyasa) – Link 8

In addition, Burundi and Rwanda can be linked to DRC via Links 12 and 15.

6.2 Developmental Costs

The unit cost for construction of a new rail link is between $2 and $4.5 million US per kilometre for all gauges of track. The cost is dependent on many factors including terrain and selected track components and construction, which are a function, in a large part, of the design speed and permissible axle loadings, as well as projected traffic levels.

The second biggest category of costs is rolling stock. In some cases, rolling stock of the existing railways will be adequate to meet the needs of the incremental traffic resulting from the rail link. In other cases, locomotives and / or wagons will need to be purchased. Incremental rolling stock requirements will be dependent on the volume of traffic as well as the linehaul. The axle loadings for new rolling stock will need to be in synch with the permissible axle loading of the new and existing track networks for which the equipment will travel. Similarly, equipment will need to be in line with plans for braking and coupling systems but will also need to be compatible with the equipment for which it will be used with.

Even under the circumstances of a stand-alone rail network development where all rolling stock will need to be purchased, acquisition costs will be insignificant relative to the costs of the construction of the fixed infrastructure. The costs of new wagons will range from

$70,000 to $100,000 US and new locomotives range from $1,500,000 to $2,000,000 US. Used equipment may be available at significantly lower prices.

The third cost category pertains to the cost to rehabilitate lines for which the new links will be connected to. This mainly pertains to new developments from the currently inactive rail networks of western and northern Uganda (links 1, 3, 4, 20, and 21). The cost of rehabilitation would be dependent on the condition of the existing infrastructure and could range from $100,000 to $325,000 US per kilometre. In addition in other cases if incremental traffic is significant enough, it may be necessary to rehabilitate portion of the existing network.

Finally, the operating costs for these railways will be largely dependent on traffic volumes but should range between 3 and 8 cents US per ton-kilometre. Revenues typically will be between 3 and 10 cents US per ton-kilometre, and will be largely dependent on commodity, line-haul length and competition posed by the road sector.

6.3 Comparison of Alternative Links being proposed

6.3.1 Southern Sudan (Juba) – Links 2, 5, 20, 21

Three alternative routes are being considered that would link Juba, the centre of the oil fields of Southern Sudan, to a port on the Indian Ocean. The ROOLA Project is an integrated transportation and communications project focussed mainly on the development of the oil fields of southern Sudan. One of the key components is the development of a rail line (link 5) that will link Juba to the port of Lamu in Kenya. Also as part of the ROOLA project, consideration is being considered to linking Juba to the rail town of Gulu in Northern Uganda (link 2).

Alternatives to the Juba-Lamu link are the extension of the Uganda rail network from Gulu to Juba (link 20) and extension from Packwach to Juba (link 21), and beyond that to Wau, the southern railhead of the Sudan Railway. The following table summarizes the details of each of the proposals.

Table 6.2: Rail Development Alternatives to Link Juba to an Indian Ocean Port

Attribute	Link 5	Link 20	Link 21
New Track to be Constructed	1600	300	370
Track to be Re-Activated / Re-habilitated	-	420	500
Main Lead to Port	Juba - Lamu	Juba-Mombasa	Juba - Mombasa
Lead Distance to Port	1600	1750	1900
Other Cost Considerations	Lamu Port Development	Port Expansion Increase at Mombasa	Port Expansion Increase at Mombasa

It is clear that the extension of the rail network from Gulu to Juba (link 20) would require the least capital investment in fixed infrastructure. In addition, relative to the alternative link to the URC network, it would provide a shorter distance to the Port of Mombasa. Depending on the nature and volume of traffic being generated in the Southern Sudan region, there may be a need to expand or enhance facilities at Mombasa.

The ROOLA alternative will require significantly more investment in the rail infrastructure but also in port facilities at Lamu, and likely rolling stock (most definitely if the network is developed in standard gauge). However, it will also offer the benefit of new infrastructure developed specifically for the objectives of the project. In addition, the project provides the additional benefit of providing rail service to northern Kenya and the potential of alternative rail service to Nairobi, Gulu and Nakuru, communities currently part of the URC / KRC rail network.

6.3.2 Kisangani, DRC (links 1 and 3)

Both proposals being considered to provide rail linkage to Kisangani are from the URC rail network. The first (link 1) is an extension from Kasese on the currently inactive western Uganda rail network. The second (link 3) is an extension from Pakwach on the inactive northern Uganda rail network. The following table summarizes some of the details of these two proposals.

Table 6.3: Rail Development Alternatives to Link Kisangani

Attribute	Link 1	Link 3
New Track to be Constructed	600	900
Track to be Re-Activated / Re-habilitated	335	500
Main Lead to Port	Kisangani-Mombasa	Kisangani-Mombasa
Lead Distance to Port	2274	2494
Other Cost Considerations		

Based on the information in this table, it is clear to see that link to Kasese offers the benefits of significantly lower investment costs and shorter distance to the port of Mombasa than link through Pakwach. However, it is important that the proposed links are not considered in isolation alone. As an example, a decision to develop links 20 or 21 would have impact on analysis on a decision on the routing of a link to Kisangani.

6.3.3 Kigali, Rwanda (links 4 and 11)

The two proposals being considered to link Kigali to the existing EAC rail network would provide two very different routes for Kigali traffic to and from an Indian Ocean port. The first would involve a link from Kigali to Bihanga a terminal on the western Uganda rail network 55 kilometres east of Kasese. This network would require the rehabilitation of the western Uganda network, at least as far as Bihanga. The second is linking Kigali to Isaka, which is north of Tabora on the Mwanza branch line. The details are indicated in the following table.

Table 6.4: Rail Development Alternatives to Link Kigali

Attribute	Link 4	Link 11
New Track to be Constructed	300	500 (excluding the Keza-Musongati branch line)
Track to be Re-Activated / Re-habilitated	280	
Main Lead to Port	Kigali – Mombasa	Kigali – Dar es Salaam
Lead Distance to Port	1919	1482
Other Cost Considerations		

In both alternatives, the link development will provide a much broader purpose of regional development and as such the information provided in the table provides little indication of the superiority of one alternative over the other.

6.3.4 Burundi (links 11 and 15)

The two proposals being considered to link Burundi would connect to the the TRL network, though very differently. The first would involve a branch line from the link being considered for Isaka to Kigal (link 11). The brach line would serve Gitega, Burundi's second largest city. The second is a link from Uvinza to Bujumbura. Uvinza is on the TRL Central line 113 kilometers east of the western terminus at Kigoma. The details are indicated in the following table.

Table 6.5: Rail Development Alternatives to Link Bujumbura

Attribute	Link 11	Link 15
New Track to be Constructed for Link	200 (the branch line from Keza to Musongati)	300
New Track to be Constructed as part of another project	500	
Track to be Re-Activated / Re-habilitated		
Main Lead to Port	Gitega– Dar es Salaam	Bujumbura – Dar es Salaam
Lead Distance to Port	1482	1441
Other Cost Considerations		

Link 15 provides the most direct route from the TRL network and the port of Dar es Salaam and serves the larger of the two Burundi's two largest cities, Bujumbura. However, Link 13 better meets the regional development needs of northern Tanzania, Burundi and Rwanda.

7 Investment Analysis

In this section, we will review all potential investment options that are available within the EAC. However, at the core of railway operations in the EAC are concession agreements and the Concessionaire investment and operations plans. And all potential investment needs to be analysed with full consideration of these Agreements. We start in section 7.1 with a review of the KRC Concession Agreement including a review of its impact on future railway development and investments. The sections that follow provide a breakdown of various classes of future development and investment possibilities:

- Conversion to a Unified Gauge (section 7.2)
- Adoption of Unified Rolling Stock Technology (section 7.3)
- Railway Rehabilitation (section 7.4)
- Increased Track capacity (section 7.5)
- Improved Rolling Stock Carrying Capacity (section 7.6)
- Development of New Railway Lines (section 7.7)

7.1 Concession Agreements

7.1.1 KRC Concession Agreement

The Concession Agreement grants the Concessionaire the right to use the conceded assets to provide freight and passenger services in accordance with the agreement. Freight services are for 25 years and are based on achieving freight volume targets detailed in the Agreement. Passenger services are based on a 5-year obligation as per the provisions in the Agreement.

The Agreement requires the Concessionaire to invest at least five million USD per year in capital expenditures for five years. There are no capital investment requirements beyond the five-year period, and the Agreement does not detail what the investments are to be. The Agreement includes provisions that require the Government of Kenya (GoK) to finance half the cost of refurbishing passenger coaches (to a maximum aggregate of 1 million USD). Other than this, the Agreement includes no requirements for investment by the Government of Kenya but allows provisions for them to do so, at their discretion.

Conceded assets remain the property of the KRC and assets financed by the Concessionaire are deemed to property of the Concessionaire.

The Agreement includes the following key provisions pertaining to track maintenance and standards:

- Stipulations on maximum number of speed restrictions
- Necessity to use 100 lb or equivalent rail to be used on rail renewal programs of 3 kilometres or greater.
- The requirement to perform engineering evaluations of bridge capacities and necessary strengthening programme before increasing allowable axle loadings to 18 tonnes.
- Track work will be performed at the cost of the Concessionaire and the KRC shall not be liable for any residual value at the expiry or termination date.

The Agreement does not appear to include any provisions for changing track gauge on the existing network, or adopting different technological changes such as braking or coupling systems. This can also be said of expanding the existing network or of developing an independent rail network in Kenya that would have some bearing on traffic levels. In fact, Article B.2.3 states that even when the Concessionaire is unable to meet demands for its services, and after all possible upgrades and optimization measures, the GoK or KRC have the right to intercede or invest in railway operations, but only if this does not adversely affect the viability of the Concessionaire's existing business.

It should also be noted that, although, the GoK does have the right to invest in railway infrastructure, and it is most certain that such investment would be welcomed, it must comply with the provisions of the Agreements when making the investments.

7.1.2 URC Concession Agreement

The Concession Agreement grants the Concessionaire the right to use the conceded assets and to provide Rail Transport Services for the 25-year term of the agreement.

In general, all the Uganda railway assets (land, infrastructure & equipment) that were considered essential for the provision of railway freight services ("core assets") were conceded. The remainder ("non-core assets") comprises principally real estate that is (physically) remote from the railway network and not required for railway freight services.

The entire Uganda railway network (including the closed lines) (about 1250km) is included in the concession i.e. "conceded". However, at commencement, only the following lines were "taken over" by the concessionaire for freight operations: (a) the 250km main line (Kampala through Jinja to the border with Kenya at Malaba); (b) the 9km Kampala-Port Bell line; (c) the 6km Kampala-Nalukolongo section (the starting portion of the Kampala-Kasese railway line); and (d) the 55km Tororo-Mbale section of the Tororo-Packwach railway line.

The rest of the rail network comprises the "closed lines". These lines remain in the hands of URC and no depreciation is chargeable to the concessionaire until such time as the concessionaire either commences freight services (whether in terms of a PSO arrangement or otherwise) or the concessionaire enters into an access agreement with a third party operator.

The UCA obligates the concessionaire to operate the Lake Victoria wagon ferry services subject to the two remaining wagon ferries (the third sank in 2005) being refurbished by the Government to an acceptable (Lloyds Register) standard and then handed over (to the concessionaire). The ferry services were deemed essential given Uganda's land locked status and the need to have two alternative routes to the sea (Mombasa and Dar es Salaam). Unfortunately, the refurbishment of the ferries has not taken place yet.

Investment

The UCA stipulates a minimum investment of US$ 5 million by the end of Year 5 of the concession. This investment figure is for "providing freight services" i.e. all capital investment in infrastructure, rolling stock, equipment, ICT, etc. The UCA does not provide for investment by the government.

Maintenance

The main line is to be maintained to at least Concession Class 3 Track Standard (55kph) so that by the end of Year 5, no more than 7% (aggregate track length) is under temporary speed restriction. No later than Year 7, the Port Bell line and the Kasese line (up to Nalukolongo) shall be maintained to at least Concession Class 2 Track Standard (35kph). The rest of the network is to be maintained to at least Concession Class 1 Track Standard (15kph) unless higher standards are agreed with URC to enable the operation of non-profitable freight services.

The concessionaire is to use 100 lb/yd or equivalent rail for all rail renewal on the main line where complete rail renewal is proposed for sections not less than 3km long. Alternate rail sections are acceptable only if they are readily available on the international market and can sustain an axle loading of 22.5 tonne at a speed of 55 kph. The UCA is silent on rail renewal on branch lines.

The condition of the main line track is sufficient for 18 tonne axle loading but the bridges are rated at 15 tonne. Therefore, the concessionaire is required to perform an engineering analysis of the bridges (to URC's satisfaction) to confirm that the bridges can safely handle 18 tonne axle loading before he can operate at 18 tonne.

Financing / Accounting Procedures

Investments in rehabilitation of infrastructure are treated as "Conceded Assets Financed by the Concessionaire" and the approved investment amounts will (at the expiry of the concession term or in the event of premature termination) be offset from the accumulated depreciation of the "Conceded Assets at Commencement".

Standard Gauge Issue

The issue of future conversion to standard gauge is not addressed in the UCA.

7.1.3 TRL Concession Agreement

The Concession Agreement grants the Concessionaire the right to use the conceded assets and to provide Rail Transport Services for the 25-year term of the agreement[4].

The relevant chapter of the Agreement with respect to maintenance and investment is chapter 6 and the related schedules. The maintenance of the concession assets (i.e. the moveable and the immoveable assets) is covered by articles 6-12 to 6-15. The Concessionaire is obligated to prepare separate 5-year Maintenance Plans for the Moveable Assets and the Immoveable Assets. These are to comply with the applicable TRL maintenance standards and are to include: a statement of performance against the previous Maintenance Plan; corrective action plan to address any failure of performance; proposed use of contractors; any other information reasonably required by RAHCO. The Agreement provides for consultation of RAHCO in the preparation of the Plans and a provision for annual updates of the Plans.

[4] With the limitation that it must continue to grant the Trans-Africa Railway Corporation access to portions of the network as per the terms of a pre-existing agreement.

In terms of investments, the Concessionaire is committed to an Investment Plan, to be updated every five years. The initial Investment Plan is attached as Schedule 14 of the Agreement and indicates the Concessionaire's intention of investing $364.47 million over the concession period, of which $78.7 million over the first five years. The amount to be expended on fixed infrastructure is $252.64 million.

Schedule 4 Table 1 of the agreement specifies minimum upgrade requirements for each section of the railway line within five years, within ten years and by handback, in terms of weight of rail to be laid, maximum speed, maximum axle load, etc. It sets out a path for gradual, but significant improvements in the condition of the network prior to handback" "It is the policy of the Government in the very long term to provide for Railway Works that will safely support the use of efficient motive power and optimum capacity wagons so as to deliver the best freight transport efficiency commensurate with commercial demands. This objective will not be achieved in its entirety during the Concession Term, but as a means of ensuring that it is delivered in the longer term, RAHCO and the Concessionaire shall comply with the following standards and minimum requirements when carrying out any Upgrades to the Railway Works"[5].

As in the KRC Agreement, there do not appear to be provisions for changing the gauge on the existing network, or adopting different technological changes such as braking or coupling systems.

7.1.4 Summary

The concession agreements are at the core of rail operations in East Africa. Concessionaires need to be consulted closely in future discussions on railway strategic direction including the adoption of new technology, and future line expansions and line rehabilitations. Investment considerations need to comply with the provisions of the concession agreements, and analyses of the benefits stemming from these investments need to carefully consider these agreements.

7.2 Conversion to a Unified Gauge

By the year 2030, under the most optimistic scenarios, combined railway revenues generated from the current rail networks are forecasted to be less than 1000 M USD. The forecasted cost to convert the trunk lines to standard gauge will likely be over 5 B USD for the core lines, if the right-of-way of the existing railways are used; and significantly higher if new right-of-ways are developed. The cost to convert the entire networks is would be even higher. With no significant operating benefits resulting at the projected traffic levels, and with likely economic and environmental costs of the investment outweighing benefits, conversion of the existing network is not a realistic option even when compared against converting the entire network to either cape or meter gauge and rehabilitate to new condition.

In addition, unless a rail line was being developed remotely from the existing network and was financial and /or economically viable as a stand-alone project, no consideration should be given to standard gauge. It is our belief that with a stand-alone development, standard gauge will be justifiable only with significantly high traffic levels.

[5] Concession Agreement for Tanzania Railways Corporation Concession ..., p. 76.

The conversion of the current EAC, TRL and URC networks in whole or part to a cape gauge can only be justified with significant growth of traffic from the SADC to the EAC network. Given our estimate of conversion cost is at least 6B USD for the entire network, we do not anticipate anywhere near enough to justify the investment. Although not advocated here or elsewhere, preliminary analysis indicates that the conversion of the TAZARA network to meter gauge is clearly not a viable option. In fact, the biggest impact would likely be a significant loss of traffic.

With that said, its is recommend that that the EAC set the course for maintaining meter gauge on the northern networks, and continue with cape gauge on the TAZARA line. We also recommend a policy of maintaining the gauge on any newly constructed connected rail lines. Remote rail developments should be reviewed on a case-by-case basis, with traffic levels likely dictating the most economical option.

It is our assessment a small fraction of the funds that would be required to convert the rail networks to a unified gauge is needed to renew the railways and position them to meet challenges of the future. The remainder of this section discusses many of the investment alternatives.

7.3 Adoption of Unified Rolling Stock Technology

The Union of African Railways (UAR) advocates the adoption of the AAR coupler system as its unified attachment system and the transition of all railways to air braking systems. All trains in the EAC operate with air brakes, and as such this is a non-issue. The AAR coupler technology is superior than the hook and pin type, and advances the objectives of interoperability and best practices across African railways. However, the costs of conversion are significant and certain, which is not the case for the benefits.

7.3.1 Train Coupling System

Currently, the only EAC railway with AAR couplers is TAZARA. The other three railways utilize a hook and pin system. The benefits to converting to the AAR system will stem from higher coupler capacity leading to longer and heavier trains, potentially leading to lower operating costs and higher capacity to move traffic. The benefits will, for the most part, flow to the Concessionaire and as such so should the decision to convert as well as the costs.

We estimate an average conversion cost per wagon or locomotive to be between 2200 and 3300 USD / unit which is based on replacing both the draft gear and couplers at both ends of the Wagon.

Transitioning from one technology to the other can be accomplished with a few tactics and in fact there would be no immediate or even long-term need to convert all wagons in the fleet, although not doing will cause some operational complications. One alternative would be order all new wagons with AAR couplers and possibly converting the newer wagons in the existing fleet to the coupling systems. Having the two systems would require marshalling trains with wagons equipped with the AAR couplers at the head of the train and wagons equipped with the existing coupling system at the rear of the train. In between the two blocks there would need to be a transition wagon; a wagon with an AAR coupler at one end and hook and pin type at the other.

7.4 Electric Traction

Electric railways are widespread throughout the world and there are many different varieties but all are based on either direct current or alternating current supplies. Electric traction is used extensively on higher density railways particularly in Europe and Japan. In North America, it has limited application mainly in urban light rail systems and regional passenger railways, and is not used at all on freight railways.

Electric traction has the potential to provide lower energy costs and emissions. However, a stable cost-effective electrical supply is required. In addition, implementation would require a significant investment in infrastructure and systems for the transmission and distribution of electricity; electric-powered locomotives; and modifications to track and signal systems. As such, high levels of traffic are required to justify the investment in infrastructure.

Table 7.1 displays the diesel consumption (litres per 1000 GTKM's) for typical diesel-electric locomotives in predominantly passenger and predominantly freight service. Also displayed in the table are the electricity utilization (KWH per 1000 GTKM's) rates for both service types with electric traction locomotives. As expected, for both diesel-electric and electric traction locomotives are more efficient in freight services on account of the heavier train weights.

Table 7.1: Fuel Efficiency – Diesel and Electricity

	Consumption of diesel / electricity per 1000 GTKMs	
	Diesel (Litres)	Electricity (KWH)
Mainly passenger traffic	5.29	19.93
Mainly Freight traffic	3.18	8.82

Table 7.2 and **Table 7.3** present the range of unit cost differentials ($ / 1000 GTKM) between electric traction versus diesel-electric operation under a range of electricity and diesel prices.

Table 7.2: Cost Differential ($ / 1000 GTKM) Electric traction versus Diesel-Electric – Mainly Passenger Service

		Electricity - Price per KWH		
		0.1	0.2	0.3
Diesel - Price per litre	1	3.30	1.30	-0.69
	1.25	4.62	**2.63**	0.63
	1.5	5.94	3.95	1.96

Table 7.3: Cost Differential ($ / 1000 GTKM) Electric traction versus Diesel-Electric – Mainly Freight Service

		Electricity - Price per KWH		
		$0.1	$0.2	$0.3
Diesel - Price per litre	$1	2.30	1.42	0.53
	$1.25	3.09	**2.21**	1.33
	$1.5	3.89	3.01	2.12

Based on costs of $1.25 / litre for diesel and $0.20 / KWH for electricity, electricity is less expensive by $2.63 and $2.21 per 1000 GTKM of train operation for predominantly passenger and freight service respectively. In the following tables, we use these figures and a range of Traffic (GTKM per KM) and Investment Costs ($ per KM) to calculate the annual return on investment in electric traction infrastructure.

Table 7.4: Annual return on investment in electric traction infrastructure – Mainly Passenger Service

Annual Return as Percentage of Investment Passenger Service				
		Infrastructure Investment ($/KM)		
		125,000	150,000	175,000
Traffic (GTKM / KM)	500,000	1.1%	0.9%	0.8%
	750,000	1.6%	1.3%	1.1%
	1,000,000	2.1%	1.8%	1.5%
	2,500,000	5.3%	4.4%	3.8%
	5,000,000	10.5%	8.8%	7.5%
	7,500,000	15.8%	13.1%	11.3%
	10,000,000	21.0%	17.5%	15.0%
	20,000,000	42.0%	35.0%	30.0%

Table 7.5: Annual return on investment in electric traction infrastructure – Mainly Passenger Service

Annual Return as Percentage of Investment Freight Service				
		Infrastructure Investment ($/KM)		
		125,000	**150,000**	**175,000**
Traffic (GTKM / KM)	**500,000**	0.9%	0.7%	0.6%
	750,000	1.3%	1.1%	0.9%
	1,000,000	1.8%	1.5%	1.3%
	2,500,000	4.4%	3.7%	3.2%
	5,000,000	8.8%	7.4%	6.3%
	7,500,000	13.3%	11.1%	9.5%
	10,000,000	17.7%	14.7%	12.6%
	20,000,000	35.4%	29.5%	25.3%

Traffic levels on the East African railways in 2008 will average about 1 M GTKM / KM with the highest levels being about 2 M GTKM / KM (on the KRC trunk, as an example). As can be seen in **Table 7.4** and **Table 7.5**, this is certainly insufficient to provide an adequate level of return on the investment in the fixed infrastructure required for electric traction locomotive operation. In addition, we have not included in the analysis, the needed investment infrastructure.

As such, the conversion to electric traction is therefore not recommended for the foreseeable future.

7.5 Railway Rehabilitation

A current focus of the Concession Agreements has been on removal of existing speed restrictions and the necessary track investment to maintain levels in future. This will take investment in rails, ballast and surfacing, and track and bridge sleepers. In our minds, this focus is extremely well directed in that, more than anything else, at this time, the railways need to focus on train velocity as this will provide a much needed boost to railway capacities and service levels.

The EAC should closely monitor the Concessionaire's adherence to their Agreements as they relate to the speed restriction levels and capital spending in the track infrastructure. We see no reason for consideration at this time of direct investment in the fixed infrastructure.

7.6 Increased Track Capacity

We are projecting that within the next 25 to 35 years on some of the trunk lines, traffic will begin to approach the limits posed by the existing infrastructure. In anticipation, we recommend railway and line specific plans be developed to address the capacity constraints. Plans would need to be comprehensive and would include any or all of the following:

- Signals and telecommunications infrastructure
- Train operating software and hardware
- Passing loop extensions or reductions in spacings
- Bridge rating assessments and bridge strengthenings
- Track improvements especially rail weight increases.

A key element of the development will be discussion and possibly negotiation with Concessionaires on how investments will be funded.

Another component of capacity that will need to be evaluated against traffic projections will be the capacity of the ports. At this stage, without a concrete rail link development plan, it is not possible to assess the traffic forecast for the ports, however, the ports do appear to have the needed capacity for the foreseeable future, at least until new rail links are developed and the traffic brought on stream.

7.7 Improved Rolling Stock Carrying Capacity

In conjunction with the assessment of the track capacity, it will be necessary to assess the capacity of the rolling stock and to develop a rolling stock investment plan that supports and is supported by the track investment plan. Investment options include locomotives that are stronger and / or more reliable and wagons with higher carrying capacity and of type that are more suited to operational needs, all in line with the strategic direction set forth for braking and coupling systems.

Again, a key element of this will be how investments will be negotiated with each of the Concessionaires.

7.8 Development of New Railway Lines

A comprehensive rail development plan needs to be developed; addressing not only the links to be developed, but also operating issues (track gauge, as an example), traffic projections, development and ownership arrangements, and project schedules and financing. Each proposed link would ultimately need to be supported by an economic and financial feasibility analysis that meets the requirements of major stakeholders.

APPENDIX B1:
APPENDIX TO ANNEX B: TECHNICAL WORKING PAPER

Estimating the Cost of EAC Railway Network Development

Table of Contents

1 Introduction

In this Appendix, we will estimate and compare the costs to develop:

1. A new standard gauge railway on a right-of-way separate from the existing railways in East Africa, but serving the same regions and rail terminals.

2. A new standard gauge railway gauge railway built on the existing cape and meter gauge railway right-of-ways.

3. A conversion of the existing cape railway gauge railway to a meter gauge railway and an upgrade to nearly condition the existing meter gauge railway.

4. A conversion of the existing meter railway gauge railway to a cape gauge railway and an upgrade to nearly condition the existing cape gauge railway.

For each scenario, we will estimate low and high cost estimates.

2 Fixed Infrastructure

2.1 Current Fixed Infrastructure

The cost estimation and analysis were undertaken for the current amount of active railway track, and the current amount of active trunk track, both as indicated in **Table B1-2.1** and **Table B1-2.2**. The Konza-Magadi subdivision, which is currently operated by Magadi Soda, is excluded from the calculations.

Table B1-2.1: EAC Rail Network (Track Kilometres)

	KRC	URC	TRL	Tazara	Total
Gauge	1000 mm	1000 mm	1000 mm	1067 mm	
Active	1,876*	260	3083	976	6,195
Inactive	42	987			1,029

** Excludes the 146-km Konza - Magadi that is operated by Magadi Soda*

Table B1-2.2: Active EAC Rail Network (Track Kilometres)

	KRC	URC	TRL	Tazara	Total
Trunk	1,083	251	2,515	976	4,825
Branch	793*	9	568		1,370
Total	1,876	260	3,083	976	6,195

** Excludes the 146-km Konza - Magadi that is operated by Magadi Soda*

2.2 Unit Costs of Conversion and Upgrade to New Condition of Fixed Infrastructure

Fixed infrastructure costs are divided into two elements: right-of-way (or formation) construction or modification; and track (and signals) construction or upgrade costs, as detailed in **Table B1-2.3**.

Table B1-2.3: Work required of Right-of-Way and Track & Signals for each development option

Type of Railway	Right-of-Way (Formation)	Track & Signals
Standard Gauge Railway - New Right-of-Way	Construction	New Construction
Standard Gauge Railway - Existing Right-of Way	Widening of Existing	New Construction
Cape Gauge Railway		Convert/Upgrade existing Meter Gauge Track and Upgrade Existing Cape Gauge Track
Meter Gauge Railway		Convert/Upgrade existing Cape Gauge Track and Upgrade Existing Meter Gauge Track

Table B1-2.4 identifies the unit development costs for the standard gauge railway on a new right-of-way. The costs are inclusive of all work and materials to the bottom of the ballast section.

Table B1-2.4: Right-of-Way Construction Costs – Standard Gauge, (New right-of-way)

Cost Element	$ / track-KM Low	$ / track-KM High
Land Acquisition	20,000	60,000
Right of Way Construction	1,680,000	3,340,000
Bridges & Culverts	150,000	700,000
Total	**1,850,000**	**4,100,000**

The following table identifies the unit development costs for the standard gauge railway on the existing right-of-ways. We have assumed that no land would need to be acquired to broaden the formation to accommodate the 317 and 384 mm of track width. The bulk of the costs is associated with broadening the existing formation, and modification and/or replacement of existing bridges.

Table B1-2.5: Right-of-Way Construction Costs – Standard Gauge (Existing right-of-way)

Cost Element	$ / track-KM Low	$ / track-KM High
Land Acquisition	0	0
Right of Way Construction	250,000	500,000
Bridges & Culverts	100,000	500,000
Total	**350,000**	**1,000,000**

Details of the cost of track work are indicated in the following table. **Table B1-2.7** provides the percentage of materials that were sourced from the existing railway.

Table B1-2.6: Details of Standard Gauge Track Construction (for construction on both new and existing right-of-way)

Cost Element	$ / track-KM Low	$ / track-KM High
Track Materials		
Ballast	20,000	35,000
Rail	70,000	120,000
Sleepers	100,000	140,000
Turnouts	5,000	10,000
Subtotal - Track Material	**195,000**	**305,000**
Track Labour	15,000	25,000
Signals	30,000	50,000
Depots	10,000	20,000
Total	**250,000**	**400,000**

Table B1-2.7: Materials generated from existing railway infrastructure

Type of Track	Ballast		Rail		Ties		Turnouts	
	Low	High	Low	High	Low	High	Low	High
Standard Gauge	0%	0%	25%	0%	0%	0%	0%	0%
Conversion of Cape or Meter Gauge	50%	25%	50%	25%	0%	0%	0%	0%
Upgrade of Cape or Meter Gauge	75%	50%	50%	25%	60%	30%	30%	0%

The unit cost differences for track and signals work, as indicated in **Table B1-2.8**, is mainly on account of differences in the utilization of existing railway materials, as indicated in **Table B1-2.7**.

Table B1-2.8: Track Construction & Upgrade Costs (also includes signals and depots)

Type of Track	$ / track-KM	
	Low	High
Standard Gauge	250,000	400,000
Convert Meter Gauge to Cape Gauge	180,000	325,000
Convert Cape Gauge to Meter Gauge	180,000	325,000
Upgrade Meter Gauge or Cape Gauge	110,000	250,000

2.3 Conversion / Upgrade Cost of Fixed Infrastructure

Table B1-2.9 provides the estimated conversion / upgrade costs for currently active trunk lines, and **Table B1-2.10** provides the figures for the entire active network.

Table B1-2.9: Conversion / Upgrade Costs – Current Active Trunk Lines

Type of Track	Unit Cost (USD per KM)		Active Trunk Lines		
	Low	High	KM	Low (M USD)	High (M USD)
Standard Gauge (New right-of-way)	2,100,000	4,500,000	4,825	**10,133**	**21,713**
Standard Gauge (Existing right-of-way)	600,000	1,400,000	4,825	**2,895**	**6,755**
Cape Gauge					
Upgrade Existing	110,000	250,000	976	107	249
From Meter Gauge	180,000	325,000	3,849	693	1,251
				800	**1,495**
Meter Gauge					
Upgrade Existing	110,000	250,000	3,849	423	962
From Cape Gauge	180,000	325,000	976	176	317
				599	**1,279**

Table B1-2.10: Conversion / Upgrade Costs – Current Active Network

	Unit Cost (USD per KM)		Current Active Network		
Type of Track	Low	High	KM	Low (M USD)	High (M USD)
Standard Gauge (new right-of-way)	2,100,000	4,500,000	6,195	**13,010**	**27,878**
Standard Gauge (existing right-of-way)	600,000	1,400,00	6,195	**3,717**	**8,673**
Cape Gauge					
Upgrade Existing	110,000	250,000	976	107	244
from Meter Gauge	180,000	325,000	5,219	939	1,696
				1,047	**1,940**
Meter Gauge					
Upgrade Existing	110,000	250,000	5,219	574	1,305
from Cape Gauge	180,000	325,000	976	176	317
				750	**1,622**

3 Rolling Stock

3.1 Existing Active Fleet

The following table provides an estimate of the active rolling stock fleet.

Table B1-3.1: Existing Fleet Size (approximate)

Equipment	KRC	URC	TRC	TAZARA	TOTAL
Main Line Locos	80	15	40	20	**155**
Wagons	2,200	1,200	600	300	**4,300**

3.2 Rolling Stock Requirements

The following table provides our estimate of wagon requirements under full network operation under a single gauge railway as indicated. The differences are on account of wagon capacity.

Table B1-3.2: Forecast Wagon Requirements

	Trunk Conversion		Full Network Conversion	
Type of Track	Low	High	Low	High
Standard Gauge	1,933	3,200	2,900	4,800
Cape Gauge	2,167	3,600	3,250	5,400
Meter	2,167	3,600	3,250	5,400

The following table provides our estimate of locomotive requirements under full network operation under a single gauge railway as indicated. The differences are on account of locomotive and wagon capacities.

Table B1-3.3: Forecast Locomotive Requirements

	Trunk Conversion		Full Network Conversion	
Type of Track	Low	High	Low	High
Standard Gauge	70	117	105	175
Cape Gauge	80	133	120	200
Meter	80	133	120	200

3.3 Acquisition Costs of Wagons and Locomotives

Unit costs of acquisition of wagons and locomotives are presented in the following two tables.

Table B1-3.4: Projected Wagon Acquisition Costs

Type of Track	Unit Costs (USD) Low	High
Standard Gauge	75,000	100,000
Cape Gauge	80,000	110,000
Meter	85,000	115,000

Table B1-3.5: Projected Locomotive Acquisition Costs

Type of Track	Unit Costs (USD) Low	High
Standard Gauge	1,500,000	2,500,000
Cape Gauge	1,750,000	2,750,000
Meter	1,760,000	2,900,000

3.4 Projected Rolling Stock Acquisition Costs

Based on the preceding forecasts of quantity requirements and unit acquisition costs, the following two tables present our estimates of the required capital investments in rolling stock based on trunk line conversion and complete network conversion.

Table B1-3.6Projected Acquisition Costs of Rolling Stock – Trunk Conversion Only

Type of Track	Trunk Conversion Projected Acquisition Costs (USD) Low	High
Standard Gauge	250,000,000	612,000,000
Cape Gauge	313,000,000	763,000,000
Meter	325,000,000	801,000,000

Table B1-3.7Projected Acquisition Costs of Rolling Stock – Full Network Conversion

Type of Track	Full Network Conversion Projected Acquisition Costs (USD) Low	High
Standard Gauge	375,000,000	917,500,000
Cape Gauge	470,000,000	1,144,000,000
Meter	487,450,000	1,201,000,000

4 Revenue (Profit) Loss During Transfer Period

In addition to the capital costs of gauge conversion, the loss of revenue during the conversion period must also be considered. That is the subject of this chapter.

4.1 2008 Projected Revenue

Table B1-4.1 provides projections of revenue for 2008. For our low estimates of revenue loss, we used the low revenue forecast, and for the high estimates of revenue loss, we used the high revenue forecast.

Table B1-4.1: 2008 Revenue Forecast

Scenario	Forecast of 2008 Revenue (USD ,000)				
	KRC	URC	TRL	Tazara	Total
High	67,407	16,004	43,615	30,603	**157,629**
Base	66,547	15,784	43,215	30,325	**155,871**
Low	65,688	15,563	42,815	30,046	**154,112**

4.2 Forecast Revenue Loss

In the following tables, we have estimated the loss of revenue resulting from the development of the various railway development scenarios.

Table B1-4.2: Forecast Revenue Loss – Low Projection (based on 7% revenue growth), ($ M USD)

Loss of Revenue	Forecast Annual revenue over Life of Project (M USD)	Years	Revenue Loss per year	Projected Revenue Loss (M USD)
Conversion to Standard (new right-of-way)	176,443	4	10%	70,577
Conversion to Standard (existing right-of-way)	176,443	4	25%	176,443
Conversion to Cape Gauge	170,574	3	33%	154,312
Conversion to Meter Gauge	170,574	3	0%	0

Table B1-4.3 Forecast Loss – High Projection (based on 9.5% revenue growth), ($ M USD)

Loss of Revenue	Forecast Annual revenue over Life of Project	Years	Revenue Loss per year	Projected Revenue Loss
Conversion to Standard (new right-of-way)	206,956	6	20%	248,347
Conversion to Standard (new right-of-way)	206,956	6	50%	620,868
Conversion to Cape Gauge	197,775	5	50%	494,437
Conversion to Meter Gauge	197,775	5	10%	98,887

For the sake of conservatism, we have assumed that all railways costs are fixed over the short-term, and as such, revenue loss translates directly into profit loss.

5 Projected Conversion Costs

The following four tables provide the cost estimates for trunk and full network development under the four track gauge scenarios.

Table B1-5.1: Standard Gauge Network Developmental Costs (New right-of-way), (Millions of USD)

Cost Element	Trunk Lines Only	Current Active Network
Fixed Infrastructure	10,100 to 21,700	13,000 to 27,800
Acquisition of Rolling Stock	250 to 600	400 to 900
Profit Loss during Transfer Period	70 to 250	70 to 250
Total	**10,420 to 22,550**	**13,470 to 28,950**

Table B1-5.2: Standard Gauge Network Developmental Costs (Existing right-of-way), (Millions of USD)

Cost Element	Trunk Lines Only	Current Active Network
Fixed Infrastructure	2,900 to 6,750	3,700 to 8,700
Acquisition of Rolling Stock	250 to 600	400 to 900
Profit Loss during Transfer Period	180 to 620	180 to 620
Total	**3,330 to 7,970**	**4,280 to 10,220**

Table B1-5.3: Cape Gauge Network Developmental Costs (Millions of USD)

Cost Element	Trunk Lines Only	Current Active Network
Fixed Infrastructure	800 to 1,500	1,000 to 1,900
Acquisition of Rolling Stock	300 to 750	470 to 1,100
Profit Loss during Transfer Period	150 to 500	150 to 500
Total	**1,250 to 2,750**	**1,620 to 3,500**

Table B1- 5.4: Meter Gauge Network Developmental Costs (Millions of USD)

Cost Element	Trunk Lines Only	Current Active Network
Fixed Infrastructure	600 to 1,300	750 to 1,600
Acquisition of Rolling Stock	325 to 800	490 to 1,200
Profit Loss during Transfer Period	0 to 100	0 to 100
Total	**925 to 2,200**	**1,240 to 2,900**

APPENDIX B2:
APPENDIX TO ANNEX B: TECHNICAL WORKING PAPER

Overview of EAC Railway Network Development Scenarios and Cost Implications

Table of Contents

1 Introduction

This Appendix provides a comparative overview of the costs to re-develop the existing EAC rail network with the following scenarios:

- Develop a new standard gauge railway to replace the existing railway
- Develop the existing railway into a nearly new standard gauge railway
- Rehabilitate the railway into a nearly new cape gauge railway
- Rehabilitate the railway into a nearly new meter gauge railway

Chapter 2 presents the estimated costs for each scenario by railway (i.e. KRC, URC, TRL, and TAZARA networks), for both: 1) the trunk lines only; and 2) the entire existing railway currently in operation.

Chapter 3 provides, in a tabular format, the overall costs (including the rolling stock costs and profit loss during the construction) of developing a unified gauge railway network in EAC using each of the above-listed scenarios.

The ultimate decision as to how to develop the EAC railway system and what gauge to be selected rests in the hands of the EAC Partner States, and this Appendix has been prepared to aid such decision-making by providing an easy-to-read summary of cost implications.

2 Railway Development Cost Estimates by Railway Network – Fixed Infrastructure

Four alternative scenarios were considered to develop a unified EAC railway with a common gauge, as follows:

- Develop a new standard gauge railway to replace the existing railway
- Develop the existing railway into a nearly new standard gauge railway
- Rehabilitate the railway into a nearly new cape gauge railway
- Rehabilitate the railway into a nearly new meter gauge railway

In the first scenario, the cost is estimated based on replacing the existing network with a new standard gauge railway to provide the same level of service. In the second scenario, the estimate is based on constructing a new standard gauge railway on the formation of the existing railways. In the third scenario, the cost is estimated for upgrading the existing cape gauge railway to nearly new condition and also converting the existing meter gauge railways to cape gauge. Finally, in the last scenario, the estimated cost is that of providing a meter gauge railway network of nearly new condition throughout the EAC.

The methodology used to develop the costs displayed in this appendix is described in Appendix B1 to Annex B.

Presented in the following tables are the estimated costs of each of the development scenario for each of the four EAC rail networks showing the range of costs at a prefeasibility level.

Table B2-2.1: Fixed Infrastructure Development Costs (US$M) for KRC Network

Trunk Only		
	Low	High
Standard - new right-of-way	2,411	5,240
Standard - existing right-of-way	832	2,042
Cape - existing right-of-way	411	939
Meter - existing right-of-way	258	654
Entire Active Network		
	Low	High
Standard - new right-of-way	4,130	8,939
Standard - existing right-of-way	1,361	3,282
Cape - existing right-of-way	605	1,308
Meter - existing right-of-way	415	1,023

It is important to note that, in each of the four EAC rail networks, the least costly alternative is to maintain the existing gauge railway and to upgrade to nearly new condition. However, it is equally important to note that these estimates include the cost of upgrading railways to nearly new condition and that this is not an immediate requirement; it is not necessary to upgrade the entire railway network to nearly new condition overnight to meet the immediate traffic demand potential for each of the railways. Investment should be driven by infrastructure condition and traffic projections. Thus, investment required in the immediate term would be much less than that indicated in the tables in this report. Indicative investment requirements of the existing networks are discussed in Section 7.2 of the Final Report. Annex F provides additional discussion and the methodology used to develop the cost estimates.

Table B2-2.2: Fixed Infrastructure Development Costs (US$M) for URC Network

Trunk Only	Low	High
Standard - new right-of-way	560	1,216
Standard - existing right-of-way	194	476
Cape - existing right-of-way	96	221
Meter - existing right-of-way	61	154
Entire Active Network	**Low**	**High**
Standard - new right-of-way	591	1,288
Standard - existing right-of-way	212	519
Cape - existing right-of-way	110	250
Meter - existing right-of-way	78	196

Table B2-2.3: Development Costs (US$M) for TRL Network

Trunk Only	Low	High
Standard - new right-of-way	5,370	11,557
Standard - existing right-of-way	1,627	3,864
Cape - existing right-of-way	592	1,200
Meter - existing right-of-way	367	879
Entire Active Network	**Low**	**High**
Standard - new right-of-way	6,670	14,186
Standard - existing right-of-way	2,030	4,830
Cape - existing right-of-way	755	1,552
Meter - existing right-of-way	507	1,167

Table B2- 2.4: Fixed Infrastructure Development Costs (US$M) for Tazara Network

Trunk Only		
	Low	High
Standard - new right-of-way	2,079	4,537
Standard - existing right-of-way	677	1,589
Cape - existing right-of-way	151	390
Meter - existing right-of-way	240	513
Entire Active Network		
	Low	High
Standard - new right-of-way	2,079	4,537
Standard - existing right-of-way	677	1,589
Cape - existing right-of-way	151	390
Meter - existing right-of-way	240	513

Given the level of projected traffic, the existing meter and cape gauge railways will be able to meet the future traffic demand over the next 10-20 years, as long as they receive sufficient and effective capital investment. It is important to note that this investment would be considerably lower than the investment required for a new standard gauge railway (US$1.2 billion[1] vs. US$4-28 billion[2] for the current active network fixed infrastructure). As well, this investment would be phased in over a number of years of railway operation based on ongoing assessments of infrastructure condition and projections of railway traffic.

[1] Please see Final Report main text and Annex F.
[2] Please see Chapter 3.

3 Total Railway Development Cost Estimates – Entire EAC Railway Network with a Common Gauge

The following tables present the elements of the total cost to develop the EAC railways into a common gauge across the EAC. In all gauge conversion scenarios, the investment in fixed infrastructure is greater than that of the other two classes of development cost (rolling stock and profit loss during construction).

However, it is very important to note that the investment costs in the cases of the meter and gauge railways are based on development into nearly new condition. This was done to compare standardized gauge alternatives of new or nearly new condition across the EAC railways.

Table B2-3.1: Development Costs (US$M) for EAC Trunk Lines Only

Low Estimate	Development Costs			
	Meter - existing right-of-way	Cape - existing right-of-way	Standard - existing right-of-way	Standard - new right-of-way
Fixed Infrastructure	600	800	2,900	10,100
Rolling Stock	325	300	250	250
Profit Loss during Construction	0	150	180	70
Total - Trunk Only (Low Estimate)	**925**	**1,250**	**3,330**	**10,420**
High Estimate	**Development Costs**			
	Meter - existing right-of-way	**Cape - existing right-of-way**	**Standard - existing right-of-way**	**Standard - new right-of-way**
Fixed Infrastructure	1,300	1,500	6,750	21,700
Rolling Stock	800	750	600	600
Profit Loss during Construction	100	500	620	250
Total - Trunk Only (High Estimate)	**2,200**	**2,750**	**7,970**	**22,550**

Table B2-3.2: Development Costs (US$M) for EAC Active Network

Low Estimate	Development Costs			
	Meter - existing right-of-way	Cape - existing right-of-way	Standard - existing right-of-way	Standard - new right-of-way
Fixed Infrastructure	750	1,000	3,700	13,000
Rolling Stock	490	470	400	400
Profit Loss during Construction	0	150	180	70
Total - Current Active Network (Low Estimate)	**1,240**	**1,620**	**4,280**	**13,470**
High Estimate	**Development Costs**			
	Meter - existing right-of-way	**Cape - existing right-of-way**	**Standard - existing right-of-way**	**Standard - new right-of-way**
Fixed Infrastructure	1,600	1,900	8,700	27,800
Rolling Stock	1,200	1,100	900	900
Profit Loss during Construction	100	500	620	250
Total - Current Active Network (High Estimate)	**2,900**	**3,500**	**10,220**	**28,950**