MINISTRY OF WORKS AND TRANSPORT

STANDARD GAUGE RAILWAY PROJECT

DRIVING SOCIAL ECONOMIC TRANSFORMATION THROUGH DEVELOPMENT OF STANDARD GAUGE RAILWAY

1.0 INTRODUCTION

The Government of Uganda has put emphasis on infrastructure development in order to achieve the aspirations of Ugandans as enshrined in the Uganda Vision 2040. The target is to obtain a GDP per capita of USD 9500 by 2040. Infrastructure development is primarily meant to provide a conducive investment climate thus attracting large foreign direct investment especially in heavy industries and services. Since we have limited market size and capacity, it is important that investors who are attracted primarily produce goods for export to high-end markets in Europe, North America, Asia and other developed countries. It is important to know that there is worldwide competition of attracting investors by different countries, it is imperative that our investment climate is competitive at global stage. These investors must be assured of reliable, cheap and adequate transport services to the high end markets. Review of world trade and countries' economic growth trends depict that participating in global value chains is imperative for growth.

Noting the above need, the Head of State of Kenya, Uganda, Rwanda and South Sudan under the auspices of Northern Corridor Integration Projects (NCIP) agreed to develop a seamless high capacity, modern, reliable and safe SGR system across the four countries.

Standard Gauge Railway as a back bone of transport infrastructure must provide a transport service for export and import that is comparable to other services in other countries in terms of quality, cost and reliability.

These countries and their neighbors are at different stages of developing their respective railway systems in order to fully participate in international global trade and production.

Although different political agenda have been set especially on the development timelines, the countries are faced with challenges of raising the necessary resources either internally or through external borrowing. External borrowing is largely dependent on the country's GDP, Debt to GDP ratio, Revenue to GDP Ratio, and the country's risk as assessed by international credit rating agencies.

The table below provides some information on the key macro parameters for the respective countries.

Indicator	**Uganda**	**Kenya**	**Tanzania**	**Ethiopia**
Population (Million)	38.32	46.79	52.48	99.47
GDP USD(Bn)	25.61	69.17	46.70	69.22
Per Capita Income	668.3	1,478.3	889.9	695.9
Credit Rating*****	B	B+	NA	B

Source: The World Factbook- Central Intelligence Agency (2015 figures)

** http://www.tradingeconomics.com-list/rating*

Note: The Debt to GDP ratio for all the above countries is above 30% implying that they all have limited room for additional borrowing.

2.0 WHY UGANDA IS PRIORITIZING THE NORTHERN CORRIDOR AS THE PRIMARY ROUTE

Uganda's strategic geographical positioning, puts it at the heart of the East and Central Africa logistics chain and can evacuate its products through the ports of Djibouti, Mombasa and Dar Es Salaam among others.

However, due to many factors, the port of Mombasa in Kenya and the port of Dar As Salaam in Tanzania are anchor points for two transport routes—the Northern Corridor and the Central Corridor—both crucial for the domestic, regional, and international trade of five Eastern African countries.

Northern Corridor is the busiest and most important transport route in East and Central Africa, providing a gateway through Kenya to the landlocked economies of Uganda, Rwanda, Burundi and Eastern DR Congo. It also serves Southern Sudan.

The less busy alternative transport network serving the landlocked Great Lakes Region is through Tanzania, called the Central Corridor linked to Dar Es Salaam. This uses Tanzania's Central Line.

Table 2: Provides some of the advantages of the Northern corridor over the Central Corridor even if the SGR is developed as planned in the three countries.

ITEM	**THE NORTHERN CORRIDOR (Mombasa – Kampala)**	**THE CENTRAL CORRIDOR (Dar Es Salaam-Morogoro-Tabora-Mwanza-Kampala)**
Distance	1,250KM	1548KM (1228Km on land and 320km on water)
Capacity per day	8640 containers (if 40 SGR trains per day, each train carrying 216 containers)	216 containers (due to limitations on the berth, vessels and loading and offloading time). Each wagon ferry/vessel carries 44 containers.
Transit time	One day (24hours)	Three days per train (72 hours- optimistic)
Restrictions	No restrictions	Some freight like oil and other chemical products cannot be carried on fresh water
Major trans-shipment	None	Two- At Mwanza and Port bell. Each vessel carries 44 containers. Thus for a train carrying 215 containers will require 5 vessels to evacuate the freight on the lake
Capacity of Port	Mombasa port is nearly 3 times bigger than Dar Es Salaam Port. Planned expansion in the port underway	Dar Es Salaam, A third of Mombasa Port
Current freight to and through Uganda	10 Million tonnes of cargo per year	0.5 Million tonnes of cargo per year
Access to higher end markets	Nearer the Suez Canal the major shipping way	Further from Suez canal and will require dedicated Vessels

Expected completion time	Around 2020 -Kenya has nearly completed Mombasa-Nairobi SGR section (472KM) and is already constructing the Nairobi-Naivasha SGR Route (120KM). Already sourcing for financing for Naivasha-Malaba section (369KM)). Thus already nearing the Ugandan Boarder	Tanzania has not commenced development of the 1219km route from Dar Es Salaam to Mwanza. Only contract for Dar Es Salaam-Morogoro (205KM) signed. Mwanza and Port Bell inland ports will need to be redeveloped. New water vessels will be required to be built and building a vessel takes about three years.
Other Infrastructure requirements	Railway infrastructure	Mwanza Port, Bukasa Port, Railway infrastructure and Vessels

The importance of the Northern route is further augmented by the already much bigger trade between Kenya and Uganda which is over USD 1bn.

Despite development of the railway, cargo capacity on the central corridor will be severely limited by the constraints on Lake Victoria, notably, each wagon ferry/vessel carries 44 containers whereas a train can carry up to 216 containers. Therefore, each train can only be offloaded onto five vessels requiring about 15 hours to load and offload the vessels on either side of the lake thus significantly increasing the transit time and cost.

This cargo capacity limitation, distance from the port, size and depth of the port and lake, and restrictions on carrying oils and chemicals on fresh water, makes it important that the central corridor is planned as an alternative to the northern corridor which should be taken as a primary route.

For the Malaba-Kampala SGR, up to 40 trains can be operated in a day transporting 8460 containers. If such amount of Cargo was going to be transported on the lake, assuming that a massive of five wagon ferries are purchased, we would require 40 days to evacuate cargo of one train. This means that the route not be viable. This coupled with the fact that oil products cannot be transported on fresh water make the Dar Es Salaam Mwanza Kampala Route can only be a minor alternative to the Mombasa-Kampala Route which should be looked at as the bark born of the railway network to the sea.

In order to appreciate the similarities and the differences of the proposed Standard Gauge Railways being built in Ethiopia, Kenya, Uganda and Tanzania, we have in a tabular form outlined the key elements of each country's proposed system. There are general issues to note include:

1. The Ministry of Works and Transport carried out a study conducted by an international German consultant **Gauff Ingenieure** who provided the preliminary Engineering and feasibility study for the Malaba-Kampala SGR based on AREMA (American Railway Engineering and Maintenance of way Association) standards. The consultant estimate **WITHOUT** locomotives and rolling stock was **USD2.4 billion** for an electrified railway system and **USD2.0 billion** for diesel system. The contract price for the same electrified route based on the Chinese standards was negotiated to **USD 2.04 billion** without rolling stock and locomotives. The price of USD2.3 billion usually quoted includes locomotives, rolling stock and provisional sums. It's important to note that Chinese standards are an improvement of AREMA standards and are safer, robust and durable. This is explained further in this paper as we analyse the Dar Es Salaam Morogoro and the Malaba-Kampala proposed systems.
2. The contract price and negotiations for the EPC turnkey contract for Malaba-Kampala SGR was based on the Employers requirements derived from the Gauff design, and NCIP agreements which were then provided the contractor. Therefore it is not true there was no basis for negotiations of this contract. The team benchmarked from Ethiopia and Kenya and learnt from their similarities and differences in terms of technical designs and contracting modes.
3. It is important to note that the railway systems can all be Standard Gauge but designed to different standards e.g. AREMA or Chinese or any other standards.
4. The Northern Corridor countries agreed on China Class 1 Railway standard to ensure a seamless transport network while Tanzania is basing on AREMA standard while Ethiopia is China Class 2 Standard. Kenya has built China Class 1 railway system which Uganda must build for purposes of seamlessness.
5. The AREMA standard is not a national standard but a standard of an association of some railways in North America while the Chinese Standard is a national standard approved and followed by the Government of China which today is building more lengths of railways in China than any other country in the world. More research and development has been done on these standards in the last 30 years because of the heavy investment in the railway by the Chinese Government.
6. The Chinese Standards were engineered from AREMA and other standards and are much safer, robust, and durable. As illustrated later in this paper, the formation width of the Chinese

standards is 7.7 Metres compared to 6.6 Metres of AREMA, the minimum height of embankment is 2.5 Metres high for Chinese standards while AREMA is 0.64 Metres. The requirements for protection of the embankments in Chinese is strictly by concrete hellingbone structure and stone masonry and even the construction of the embankments and the soil treatment mechanisms are more stringent with the Chinese standard than AREMA. This is simply because the Chinese standard targets low operation and maintenance costs than AREMA over the life of the project. Overall, the life ***cycle-costs*** of the Chinese standard is lower than railways built to AREMA.

7. The railways in the four countries are dominantly freight but will have passenger services. All the major design parameters are based on freight railway system. Passenger trains can move on these railways at a faster speed compared to freight trains because they are shorter and lighter while the freight trains are longer and heavier. It is important to differentiate the attainable speeds of passenger and freight trains when analyzing the capabilities of the railway systems. Therefore the speed of passenger trains is largely inconsequential to the design parameters and therefore the change in the speed of the passenger trains will not affect the cost of development of the railway.
8. It's important to note that in railway development, the highest cost is in **bridges,** followed by the **earthwork**s (embankment), followed by truck, stations electrification, signaling etc. For example, on Malaba- Kampala, 35% of the route is in bridges, 25% is in earth works and 10% in track, 10% stations, 5% electrification, 5 % signaling and 10% others. The bridges and earth works are a result of hydrology (Rivers, swamps, and amount of rainfall), terrain and geology of the respective routes. These parameters vary significantly among the various project sites in the different countries. Even on road projects in Uganda, variances in project costs can be seen in wet and hilly areas like Kanungu, Kisoro, Kabaale, Kapchorwa and Mbale, compared to the flat areas in Teso and Karomoja region.
9. Strictly from professional Engineering perspective, the cost of a civil engineering structure is built up using the engineers build up cost estimate method whereby the cost of various inputs, (material, labour, technology, equipment) and the quantities are computed to come up with engineer's estimates. The cost comparison should be made on this basis. From the limited information obtained from the respective countries, an analysis on the key parameters and costs has been done between the various projects in the different countries. A good detailed analysis can only be done using detailed designs and understanding the environmental and macroeconomic parameters of each country.

Table 3: Comparison of Major Characteristics of the Malaba-Kampala and Mombasa-Nairobi SGR Projects

Item	**Uganda**	**Kenya**
Route Length	273KM	472KM
Track length	338KM	609KM
Standard	**China Class 1**	**China Class 1**
System	SGR	SGR
Traction	**Electric**	**Diesel**
welding	Continuous	Jointed
Curvatures	1200/800	1200/800
Gradient	1.2%	1.2%
Trailing Load	4000/5000 metric tonne	4000/5000 metric tonne
Structure Gauge	Double Stack	Double Stack
Signaling	Fully Automatic	Fully Automatic
Percentage of Bridges along the route	**8.8 % of the route**	**5.9% of the route**
Super Bridge	**1KM Bridge over river Nile**	**None**
Cost per route Km (excluding locomotives)	7.32m/Km	7.288M/Km
Total costs excluding locomotives	USD2.04 Billion	USD3.44 Billion

Note:

a) *Given that the Ugandan System is electric (at additional cost of 0.54m/km), with a major super bridge over the Nile, and with 53KM in a swamp. Malaba-Kampala SGR cost is comparable to the Mombasa-Nairobi SGR section in Kenya. It is important to note that the cost in Kenya includes the developments at Mombasa port of connecting all the berths, and dredging among others.*

b) *Uganda deliberately took a decision to invest in an electric system due to the lower operation and maintenance requirements (atleast 40%) compared to the diesel system. This will significantly reduce the project life time cost. A report signed by Uganda and Kenya attesting to this is available.*

c) *To demonstrate the impact of terrain on the cost, is to look at the Naivasha-Kisumu section that passes through the rift valley and for 262KM, the cost is estimated at USD 3.6bn roughly translating into USD13.7M per route- KM. In this section, major bridges will be required due to the unique terrain.*

Table 4: Comparison of Major Characteristics of the Malaba-Kampala and Addis Ababa – Djibouti SGR Projects

Item	**Uganda**	**Ethiopia**
Route Length	273KM	656KM
Track length	338KM	765KM
Standard	**China Class 1**	**China Class 2**
System	SGR	SGR
Traction	Electric	Electric
Tonnage per year	**Designed for 20-35m tonnes per year**	**Designed for 10-20m tonnes per year**
welding	Continuous	Jointed every 300 metres
Curvatures	1200/800 m radius	800/600 m radius
Gradient	1.2%	1.85%-2.65%
Trailing Load	4000/5000 tonnes	3500/4000 tonnes
Level Crossings	No level crossings	Several Level crossings
Structure Gauge	**Double Stack container system**	**Single Stack container system**
Signaling	Fully Automatic	Semi-automatic
Percentage of Bridges	**8.8 % of the route**	**3% of the route**
Super Bridge	**1KM Bridge over river Nile**	**Maximum bridge 155 metres**
Earth Fill	**51,620 m^3/KM (365% higher than Ethiopia)**	**11,110 m^3/KM**
Soil cut	30,510 m^3/KM (116% higher than Ethiopia)	26,210 m^3/KM
Higher Embankments	3634 m^3/KM (185% higher than Ethiopia)	1,961 m^3/KM
Geo-synthetics	19,803 m^2/KM (966% higher than Ethiopia due to swamps)	2,050 m^2/KM

Rock fill	19,640 m^3/KM (161% higher than Ethiopia)	12,210 m^3/KM
Cost of cement	**USD180/tonne**	**USD125/tonne**
Cost of steel	USD680/tonne	USD480/tonne
Cost of Diesel	USD0.76/Litre	USD0.62/Litre
Royalties on materials and buying out licenses	Land, royalties and licenses	Land only
Distance from the coast	1,170KM	350KM
Cost of financing	85% borrowed/ 15% domestic	55% borrowed/ 45% domestic
Cost per route Km (excluding locomotives)	USD7.32m/KM	USD5.213M/KM
Total costs excluding locomotives	USD2 Billion	USD3.42 Billion

Note:

a) The Ethiopian system is designed for much lower tonnage and therefore would require additional lines in the near future of the freight increases drastically.

b) There are major differences as illustrated above in the terrain, topography and hydrology of the two project sites thus resulting in higher amounts of rock fill, soil cut, embankments, bridges, geo-synthetics that are major cost centres of railway development.

c) The Class II system looks cheaper at investment stage but will be more expensive in operation and maintenance. Because of the construction standard requirement.

d) It is important for railways designed for 100 years to look at life cycle costs rather than investment costs.

e) For the Uganda project one of the major cost centres is the bridge over the River Nile which is 1KM long whereas in Ethiopia the bridge over Awash is significantly narrow.

f) The design of the Ethiopian route was limited by the capacity of Djibouti Port

Table 5: Comparison of Major Characteristics of the of Malaba-Kampala SGR with the Dar Es Salaam-Morogoro SGR Projects

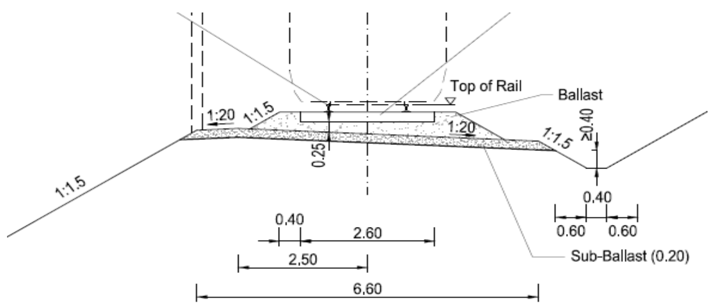
Item	**Uganda**	**Tanzania**
Route Length	273KM	205KM
Track length	338KM	300KM
Contracting mode**	EPC Turnkey (System approach)**	Design and Build (Element approach)*
Standard	China Class 1	AREMA
System	SGR	SGR
Traction	Electric	Electric
Welding	Continuous	Continuous
Curvatures	1200/800 mR	1000 mR
Gradient	1.2%	1.8%/ 2%
Level Crossings	No level crossings	No Level crossings
Structure Gauge	**Double Stack container system**	**Single Stack container system**
Signaling	Fully Automated	Fully automated
Percentage of Bridges	**8.8 % of the route**	**1.8% of the route**
Super Bridge	**1KM Bridge over river Nile**	**Small bridge over River Ruvu**
Swamps	53KM	No major swamp
Formation width	7.7 metres	6.6 metres
Minimum embankment height	2.5 metres	0.64 metres
Cost of cement (Normal grade)	USD180/tonne	USD110/tonne
Cost of steel	USD680/tonne	USD680/tonne
Transportation capacity	20-35 million tonnes per annum	18 million tonnes per annum
Royalties on materials and buying out licenses	Land, royalties and licenses	Only pay for land
Distance from the coast	1,170KM	100KM
Cost of financing	85% borrowed/ 15% domestic	50% borrowed/ 50% domestic
Cost per route Km (excluding locomotives)	USD7.3m/KM	USD5M/KM

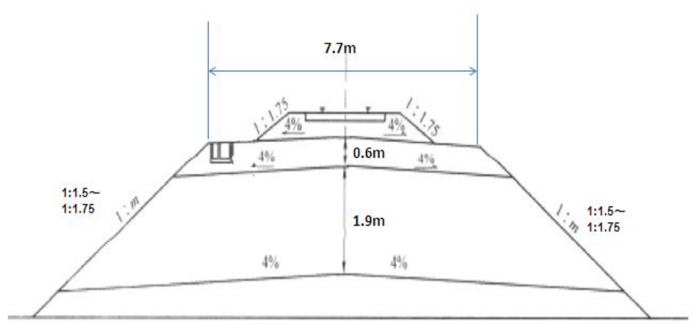
Total costs excluding locomotives	USD2.04 Billion	USD1.029 Billion

As it can be seen, the major differences in the standard as Tanzania opted for AREMA and the NCIP countries including Uganda opted for Chinese standards. From the information obtained and understanding of the Dar Es Salaam Morogoro route, there are major differences in the hydrology, (rivers, swamps and the amount of rainfall), geology, and topography. The percentage of bridges for the different projects and gradients vary greatly.

The major differences between the Chinese standard and the AREMA standard are:

a) The formation width (top width of embankment) is 7.7 meters for Chinese standards while AREMA is 6.6 meters. *See details in attachment*. See illustration below:





b) The height, design and construction of the embankment which is limited to a minimum of 2.5 meters high for Chinese standard and 0.64 meters for AREMA. These high embankments in the Chinese standards require slope protection.

c) The Chinese classification requires the herringbone concrete structure for protection of embankments and concrete masonry for higher embankments of 6 meters while this is not a requirement for the AREMA standards require only benching and grassing. See illustration below:

d) The safety factor in the concrete structures is higher in Chinese standards than the AREMA standards.

e) The utilisation of engineering materials especially the geo-synthetics (geogrid and geotextile) for treatment of soft ground, the backfilling material and soft ground treatments are different in both Chinese and AREMA standards. The general design and construction standard differences in the two standards would therefore make a railway designed and constructed to Chinese standards more expensive than the one designed and constructed to AREMA standards. However, this is only looking at investment cost and not life cycle costs which are much lower in the case of the Chinese standards due to lower operations and maintenance requirements as explained earlier.

f) Nevertheless for Uganda, the Engineering cost estimate provided by Gauff Ingenieure which was based on AREMA standards, is higher than the negotiated contract price of Malaba-Kampala SGR bsased on the Chinese standard. This was due to meticulous negotiations that were carried out.

g) There is no super bridge along the route but on Uganda route there is a 1KM bridge over the River Nile.

h) The Dar Es Salaam-Morogoro contracting mode is design-and-build, whereby the contract only stipulates the development of infrastructure while in Uganda it is EPC/Turnkey mode which does not only look at the infrastructure but also equipping it for operations with locomotives and rolling stock. The design-and-build places major risks to the employer in case any design inadequacies and or construction defects affect the operations and the performance of the trains, while in EPC/Turnkey, the contractor takes all risks associated with the construction and testing the train system operations.

3.0 CONLUSION

From the analysis above, it is important to not the following:

- That both the Northern and the central corridor are important for the land locked east African countries but the northern corridor is a more viable route for Uganda as it has a higher potential to spur growth in the country.
- That the construction cost of railways majorly depends on the unique characteristics of the specific project as determined by the design standard, the geology, terrain and hydrology of the project site.