Global railway renaissance and its influences on logistics and mobility in Africa

Dr. Dave van der Meulen
Railway Corporate Strategy CC, Pretoria, South Africa
dave@railcorpstrat.com

1 Introduction

1.1 The railway renaissance

1.1.1 The rail mode's genetic technologies

From its origin in the Industrial Revolution, first-generation rail grew to dominate land transport, ultimately peaking in the late 1940s. Thereafter it declined in the face of disruptive competition from other transport modes that had flourished on the momentum of the World War II technology boom. Why did rail not get onto the same bandwagon? By then most countries had either nationalised or regulated their railways, to restrain their monopolistic power, and railways had become too unresponsive to technology and market opportunities to get in on the action.

By comparison with other transport modes, such as air which offers three degrees of freedom of movement (longitudinal, lateral and vertical) but at relatively high cost, and road which offers two degrees of freedom of movement (longitudinal and lateral) at more modest cost, rail is constrained to a single degree of freedom of movement (longitudinal) by its guideway, back and forth on a predetermined, inflexible route. To compete effectively against transport modes that take advantage of more degrees of freedom of movement to get closer to the goal of ubiquitous access, railways must offer compensating advantages. Fortunately guidance endows railways with three genetic technologies that at once distinguish them from, and offer advantages over, all other transport modes. Rail's inherent competitiveness resides in its genetic technologies, and it must look to them for competiveness and sustainability in the aggressive logistics and mobility global markets.

A pair of flanged wheels on an axle running on a pair of rails fixed to ground precisely defines the spatial relation between them. The three genetic technologies that stem from this relation are first, the Supporting genetic technology, or the ability to carry heavy loads. The path of application of the wheel load to the rail is precisely known and it is therefore possible to design the wheel-rail system to carry much heavier axle loads than can road vehicles. The highest railway axle load in current operation is 40 tonnes on heavy haul railways in the Australian Pilbara, with aspirations to 42 tonnes. By contrast, road vehicles, rail's major land transport competitor, are driven autonomously. Hence one cannot precisely define the path of application of the wheel load to the road, and one must therefore design the entire road surface to accept the applied axle load. Consideration of economic relations among the amount of traffic and the amounts of capital and maintenance expenditure has converged permissible road vehicle axle loads on the 8-9 tonne range around the world. Interestingly, where one can define the vehicle path more precisely and design the road structure accordingly, higher axle loads are possible. Thus bus rapid transit axle loads can go as high as 12½ tonnes per axle on specially designed runways.

What about maritime transport, also a form of surface transport that can carry heavy loads? Vessels displace their own mass of water, increasing their draught the heavier they are until the buoyancy force and mass of the vessel are in equilibrium. Thus while the load they can carry might arguably be limitless, hull drag in a medium more viscous than air incurs higher energy consumption than rail or road except at very low speeds, but more on this in the next section.

Second, the Guiding genetic technology, or the ability to travel at high speed. Once again, in contrast to rail's major land transport competitor, rail vehicles are precisely guided by wheel-rail forces, and can therefore safely attain much higher speeds than road vehicles that are still generally guided by human beings. Freight- and passenger vehicles are generally limited to no more than 120km/h on public roads, whereas entry level on standard gauge track is 160km/h with the ultimate maximum in commercial service currently at 380 km/h. Rail can therefore generally service destinations faster and further than road, and at medium distances also offer credible competition to aviation.

Third, the Coupling genetic technology, to deliver high freight- and/or passenger throughput capacity. This genetic technology enables the rail mode to scale capacity to match demand within wide limits. Thus while road trailers are well known, even the number of trailers in Australia's commercial road trains is expressed by a single digit; the number of barges in a single tow on the Mississippi river may be expressed by two digits; but no other transport mode measures its combination vehicles by three digits, as for example South Africa's Sishen-Saldanha iron ore trains at 342 wagons, currently the longest in the world, and many other heavy hauls around the world where train lengths are expressed by three digits. For passenger traffic, coupling rail vehicles together essentially reduces the headway between them to zero. Thus, for example, a railway car carrying say 200 passengers at two-minute headway would carry 6000 passengers per hour per direction. Coupling ten of them together in a multiple unit train increases throughput to nearly[1] 60 000 passengers per hour per direction on the same infrastructure. Other modes do not support capacity scalability of this magnitude, while some instances do not scale at all, for example aviation.

After a pessimistic interlude during which the rail mode's future was in doubt and many stakeholders lost faith in it, optimism returned when the foregoing genetic technologies stimulated vigorous new growth curves, in high-speed intercity from a 1964 start in Japan; heavy haul when North American heavy freight standards spread to mineral railways around

[1] Increasing the number of cars on a train increases its length, and hence the time it takes to clear signals for a following train. Capacity therefore scales at slightly less than in direct proportion to the number of cars.

the world from 1972; heavy intermodal or double stacking when railroad deregulation in the US released pent-up competitive forces from 1980, and contemporary urban rail spontaneously around the world from the start of economic globalisation in 1989. These events have amassed recognition as having triggered global railway renaissance that would render the rail mode inherently competitive in high volume corridors.

Appreciate that the new growth curves of the railway renaissance originated on standard gauge railways. Many broad gauge railways have also participated in renaissance because, other than the obvious issues of interoperability in the context of wide area networking and lower prices associated with a larger market, broad gauge is technically as capable as standard gauge of supporting renaissance. However, narrow gauge railways are not so fortunate. Consideration of track maintenance tolerances and centre of gravity height has held commercial operation of narrow gauge trains to 130km/h. Several key genetic technology parameters scale in proportion to track gauge, for example 1067mm/1435mm ≈ ¾. Thus maximum heavy haul axle load for narrow gauge is 30 tonnes compared to 40 tonnes on standard gauge. Track gauge does not limit the Coupling genetic technology, so narrow gauge heavy haul railways such as South Africa's Sishen-Saldanha and Brazil's Vitória a Minas operate 300+ wagon trains to offset other constraints. Double stacked containers have also not been practicable on narrow gauge. Thus narrow gauge railways are excluded from two renaissance growth curves, and cannot reach full strength on a third. The only renaissance growth curve open to narrow gauge railways is urban rail, where single deck vehicles are appropriate, speed is constrained by headway considerations, and sufficiently powerful traction motors can fit between the wheels.

1.1.2 Energy efficiency

Rail is known to be an energy efficient transport mode. It is nevertheless valuable to contextualise this attribute so as to develop an appreciation of what role railways should fulfil in an energy scarce future.

Rail's energy efficiency essentially spins off from its genetic technologies. The Supporting genetic technology requires a strong interface between wheel and guideway to sustain heavy axle loads, and rail's steel-on-steel system provides just that. The deflection of the wheel and rail to develop a small contact patch between them is very small, and steel-wheel-on-steel rail rolling resistance is therefore very low. By contrast, the contact patch of a rubber wheel on the road is much larger, requiring greater deflection particularly of the tyre, and this increases rolling resistance and hence energy consumption. The Guiding genetic technology supports high speed that in turn allows more potential energy to be converted to kinetic energy and vice versa over undulating gradients, thereby reducing both traction energy consumption and energy dissipated in braking. High speed also reduces journey times, and hence reduces the period of time over which auxiliary equipment such as heating, ventilation, air conditioning and lighting must operate. Consequently high speed passenger trains actually consume less energy per passenger for a given journey than conventional passenger trains (Garcia, 2010). The Coupling genetic technology averages gradients under a long train and therefore requires less traction energy input and less braking energy dissipation, particularly for heavy freight trains that travel at comparatively low speed. It also reduces wind resistance because the frontal area of a train in relation to its length is small compared to any other transport mode—for example the ratio of frontal area to vehicle length for a TGV Duplex train is one tenth of that for an Airbus 380 aircraft, both double decked vehicles.

Rail therefore occupies an energy consumption sweet spot that other transport modes cannot match. All other things being equal, resistance to motion directly influences propulsion energy consumption. Rail essentially undercuts the resistance to motion, expressed in Newtons per tonne, of all other transport modes. Relative to pipeline, rail has lower resistance from speeds higher than ≈3km/h. Relative to maritime in displacement mode where resistance rises exponentially with speed, rail has lower resistance from speeds higher than ≈20 knots (≈40km/h). In addition to being slower, maritime routes can also be longer, for example Beijing to Piraeus (Athens) is 16000km by sea but 8500km overland. Relative to road trucks, rail always has lower resistance, ≈50% at low speed, increasing to ≈80% at 100km/h. Relative to aviation, resistance is also always lower although rail cannot match its top speed. Nevertheless, rail can be competitive on centre-city to centre-city journey times, e.g. the fastest current Beijing to Wuhan schedule averages 285km/h over 1229km, a performance that aviation would be hard put to beat when taking account of time to commute to the airport, check in, check security, reclaim baggage, and commute to destination in addition to the scheduled flying time.

Recall that rail's rolling resistance is very low, and its power and braking requirements are therefore largely determined by undulating gradients. This results in wide swings in propulsion and braking demand, and it is therefore desirable to interchange energy in both directions with its environment. Railways and renewable energy are thus natural allies, particularly when railways are linked to a large grid that can also store instantaneously surplus energy when necessary. Railways can then both consume and regenerate energy without restraint. For scale, locomotives and wind-turbines are of similar size, in the range 2½-6MW. While railway electrification infrastructure is expensive, one advantage of guided transport is that electrification need be confined only to the route defined by the track.

1.1.3 Urbanisation

Urban rail has been around since the early days of railways, so the reason for urban rail's renaissance growth curve may not be as intuitively obvious as the other three growth curves, namely in respect of rail's aggressive positioning in the high speed intercity, heavy haul, and heavy intermodal market spaces. Rapid urbanisation is one of the current global megatrends and, although rail's genetic technologies well support urban applications, urban rail's position within that trend has less to do with technology than with supply industry rationalisation as a consequence of globalisation. The combination of a growing market and increased competition proved to be a compelling driver.

The urban aspect of rail renaissance is manifested by the rapidly growing number of cities with urban railways. Consider the following two examples that illustrate its scale. Over the past ten years, the number of Chinese cities with urban rail has grown from nine to 39; during the same period, the number of Indian cities with urban rail has grown from three to nine (Railway Directory, 2005, 2015). These examples do not include cities that have substantially expanded their networks, nor do they list the many examples from elsewhere in the world. Never before in the history of railways has such rapid growth been experienced.

1.2 The railway enlightenment

1.2.1 Introduction

The 14^{th}-17^{th} century Renaissance, or rebirth, is an apt archetype of the 1964-1989 quarter-century railway renaissance. Looking back to 1989, it is evident that the next quarter century to 2014 has been a period of settling railways into their four inherently competitive sub-modes high speed intercity, heavy haul, heavy intermodal and contemporary urban rail. The heading of this section has been inspired by The Enlightenment, the period that followed The Renaissance and exploited the intellectual freedom that it had let loose.

The know-how of the railway renaissance has been captured in myriad publications and railway industry institutional knowledge. Now freely available, it is being used to position railways for the future. Global consensus seems to be building around the year 2050 as the date by which the shift from a fossil-fuelled economy to a renewables powered economy should be largely in place. The timing recognises the need to wear out the present fleet of transport vehicles--planes, ships and trains, and to adapt, construct or renew infrastructure and rolling stock. The exact year is not important. What is important is the form that transport systems will take at that time. The European Commission's (2011) Transport White Paper for example provides useful insights. It envisions:

> An efficient core network for multimodal intercity travel and transport with greater use of buses and coaches, rail and air transport for passengers and, for freight, multimodal solutions relying on waterborne and rail modes for long-hauls.
>
> New transport patterns emerging, according to which larger volumes of freight and greater numbers of travellers are carried jointly to their destination by the most efficient (combination of) modes.
>
> A global level-playing field for long-distance travel and intercontinental freight in which (high speed) rail should absorb much medium distance traffic.
>
> Clean urban transport and commuting where a higher share of travel is by collective transport, and the interface between long distance and last-mile freight transport is organised more efficiently.

The realisation of integrated, optimised hub-and-spoke networks featuring urban rail within densely populated, commercialised and industrialised areas, and regional rail within larger agglomerations, is already visible in several countries. Consider the example of Verkehrsverbund[2] Rhein-Ruhr (VRR) in Germany, serving a conurbation with 8 million inhabitants in a 7300km^2 area[3]: Former isolated light rail networks of individual local authorities have been linked to one another, going so far as to regauge some from meter

[2] A public transport association.
[3] Compare to Gauteng Province in South Africa with 13 million inhabitants in a 18200km^2 area.

gauge to standard gauge to promote networkability, to create a large network. Recently, VRR acquired new 160km/h regional trains to reduce journey times over longer distances. At national and international scale, long distance high-speed passenger- and heavy freight trains are common in respectively Europe and North America. Dedicated freight- and passenger corridors, where traffic volume is sufficient to separate freight and passenger trains, have been realised in China and India. So the building blocks of the Railway Enlightenment exist: What should now follow is to expand application of the solutions to countries that are earnest about road-to-rail shift to reduce congestion and the accompanying dependence on fossil fuels and the pollution that accompanies the emissions.

1.2.2 Networking

Consolidation of rail's strengths in the four renaissance market spaces presages even greater future rail significance in sub-national-, national-, international- and intercontinental transport. The author's earlier research has already identified networking as factor in railway competitiveness and sustainability (Van der Meulen & Möller, 2006). Per Metcalfe's Law that network value increases as the square of the number of nodes, several international initiatives have been driving global railway networking. Examples are the UN-led Trans-Asian Railway, mooted pre-renaissance in 1960, and the EU-led multilateral development of the Transport Corridor Europe-Caucasus-Asia in 1998. Smaller-scale examples are Russian Railways' extensions eastward to North Korea (implemented) and westward to Vienna (planned), and the Bosphorus rail tunnel completed in 2009, Asia-Europe's first standard gauge connection.

Many large scale railway networking efforts have progressed slowly until recently, due primarily to track gauge incompatibilities. However, China's bold railway diplomacy has been addressing that challenge, with Premier Li promoting Chinese high-speed rail technologies around the world as advanced, secure and reliable as well as cost-competitive (Wang, 2014). Noting how China performs its railway diplomacy in the Balkans, and with similar deals expected to follow elsewhere, the Jamestown Foundation (2014) recommended the world should pay attention as it may be a telling sign of things to come on a global scale. See also §2.2 on African networking.

It is also axiomatic that political differences need to be separated from traffic flows. Even the European Union has experienced difficulty since publishing its first Council Directive on the development of the Community's railways in 1991. Similar challenges have been experienced in consigning containers by rail from China through Kazakhstan, Russia, and Belarus into the European Union. Although they seem eventually all to be resolved, they time it takes allows other modes to entrench themselves at the expense of rail.

Great circle overland rail routes can be shorter and faster than maritime passages. In far-reaching initiatives, China has constructed railways from Kunming and Nanning to its Southeast Asian border, and is promoting standard gauge extensions into Cambodia, Laos, Myanmar, Vietnam and Thailand, while the latter and Malaysia envision onward high-speed service to Singapore. It is also working with Russia to connect north-eastern China with Russian seaports. Ready and able to build a 150km undersea tunnel between Dalian and Yantai across the Yellow Sea, which makes several other key straits crossable, Chinese bigger-and-better rail aspirations have morphed earlier plans by others into wider strategic horizons, including freight services into Europe, a 7000km Beijing-Moscow high-speed line, and connection to North America under the Bering Strait.

For context, by weighting their latitude and longitude coordinates by their GDP, and calculating the weighted average, the author found the economic centre of Earth's top-100 cities by GDP to be in western Iran. All Europe, most of Asia, and much of Africa, lie within some 7000km radius thereof, less than the Trans-Siberian railway's 9288km benchmark. Note that this exercise excluded Australia, because it is more than 1200km from the nearest land that could conceivably link into a global railway network (Java).

Recall from §1.1.1 that high speed and heavy intermodal (double-stacked containers) are not possible on narrow gauge, and that heavy haul needs standard gauge to maximise its performance. Yet high speed and heavy intermodal are eminently suited to the long distance component of the 2050 vision, but they cannot perform this function on narrow gauge or over breaks of gauge.

1.2.3 Rail's new developmental role

Interestingly, the railway renaissance emerged in developed countries, but nowadays railways are underpinning development in developing countries and making an important contribution to their respective national transport tasks. Developed countries have the challenge of well established infrastructure and strong vested interests, although given good alignment in terms of curvature and gradient, railways can be progressively upgraded over many decades before they are no longer competitive. Developing countries are usually not bound by such impediments, and it is interesting to see dedicated corridors for either freight or passenger emerging in countries such as China and India. Compare this with Europe, where rail freight is not performing to expectation despite the best-intentioned policy interventions. When benchmarked against the four inherently competitive railway renaissance market spaces, Europe's railways are substantially biased to optimising passenger traffic, while at the same time sub-optimising freight traffic. Freight and passenger railways differ sufficiently that as soon as traffic is sufficient to justify the investment, dedicated corridors should be considered.

1.3 Methodology

Railways have proven to be one of the most durable industries to have emerged from the Industrial Revolution, measuring their history in centuries, now two centuries on from their early 1800s origins. The last half century of that period saw the railway renaissance take root, blossom, and consolidate rail's aggressive positioning in four competitive market spaces. The global railway industry is now passing an important way station to its further Enlightenment contribution to society. The paper set out to examine the complex interrelations among drivers and outcomes and provides insights on economic, political, social and technical factors that are shaping rail's global contribution to logistics and mobility, and then to apply them to develop perspectives on how they will pan out in Africa. In this sense the paper is a review of learning from the railway renaissance, followed by description and exploration of events that portend the future, for later quantification and statistical analysis.

The paper recognises two significant groups of marker events. The first group represents the theoretical framework that underlies the rollout of the railway renaissance as previously developed and published by Van der Meulen & Möller (2012). The second group reflects the consolidation of rail's strengths into the foundation to position railways for 2050, or 35 years hence. To achieve a consistent source of data over time, they have been drawn from the trade press, primarily Railway Directory and Railway Gazette. However, there are editorial limits to what content ultimately makes the press, and Internet sources have been used liberally to fill in gaps. The author has been assessed as working in the theme of corporate citizenship, in which decision-making may be based on patterns and trends indicating future possibilities. Some of the material herein has been deduced in this way with the intent of subjecting it to statistical analysis later.

2 Africa's response

2.1 Africa in perspective

Against the foregoing backdrop, how could railway renaissance influence African logistics and mobility? The first new railway renaissance growth curves touched Africa only lightly, new investment gravitating mainly to heavy haul and urban rail. The former contribute most of Africa's freight tonne-km, although currently only 2000 heavy haul route-km carry some 50% thereof.

In the freight field, West African heavy haul railways have in recent years started contributing to global iron ore output. SNIM in Mauretania has expanded production. Simandou in Guinea could become a major global player. Tonkolili in Sierra Leone has good potential. ArcelorMitall in Liberia has resuscitated a railway and is considering expansion. However, at time of writing much of West Africa's iron ore activities had been laid low by a depressed iron ore market and an outbreak of Ebola virus. In South Africa, Transnet Freight rail is acquiring upward of 1000 new diesel- and electric locomotives to support its Market Demand Strategy.

In the passenger field, Morocco is en route to the continent's first high-speed intercity railway, although the project appears suspended at time of writing. Passenger Rail Agency of South Africa's 3600-car electric multiple unit contract to recapitalise its old fleet is currently the world's largest. It is also acquiring a fleet of new locomotives for long distance passenger trains.

With every second African projected to live in a city by 2035, how can the continent’s urban hubs drive sustainable and inclusive growth (World Economic, 2014)? To contextualise §1.1.3, of the world's 300 fastest growing cities, 37 are in Africa[4], with an average annual growth rate of 2.84%. This narrowly exceeds that of India at 2.79%, but substantially exceeds 1.96% for the rest of the world and China at 1.58%. The point is that Africa's urban

[4] Bamako, Lagos, Dar es Salaam, Lubumbashi, Kampala, Luanda, Kinshasa, Nairobi, Antananarivo, Conakry, Maputo, Mogadishu, Addis Ababa, Brazzaville, Dakar, Accra, Ekurhuleni, Yaoundé, Algiers, Douala, Abidjan, Rabat, Khartoum, Kaduna, Kano, Johannesburg, Ibadan, Lusaka, Casablanca, Pretoria, Tripoli, Harare, Alexandria, Cairo, Tunis, Cape Town, and Durban, in descending order of growth rate.

population growth rate is comparable to countries that are rapidly advancing their urban rail infrastructure.

However, many remaining railways are inherently uncompetitive and reside in what the author has named the Insecure Cluster (Van der Meulen & Möller, 2008). It is therefore encouraging that Chinese Premier Li considers that Africa's rise will make the world more stable, more democratic, and more robust (Nsehe, 2014).

2.2 African networkability

Recalling that network value increases as the square of the number of nodes, it is unsurprising that Africa's many gauge breaks and missing links impair the value of its railways. What are the essential elements of networkability?

Obviously uniform track gauge, without which time-consuming transloading becomes imperative at each gauge break. The modalities of dealing with loads are the same whether changing mode or changing gauge, so gauge breaks should be considered tantamount to changes of mode. Hence transloading attracts the risk that once a load, usually a container, has been lifted off a rail vehicle, it may not be placed on another rail vehicle, but could well find its way to a road vehicle.

Next is energy source, diesel or electric. At present many of Africa's railways use diesel traction, while electrification has traditionally associated with high volume corridors. However, expect the equilibrium point to rebalance as fossil fuels become scarcer and renewables become comparatively cheaper. Changes between diesel and electric traction incur delays, so uniformity is valuable. The proposed Inga III and Grand Inga hydroelectric schemes could among other provide stable power to a substantial railway network. Railways behave as renewable sources by having variable energy demand and regeneration as track gradients undulate. A robust electric grid would therefore complement electric traction by providing alternative use for regenerated energy.

Africa is a huge continent. The surface areas of the US, China, and habitable Russia, which accommodate the world's three largest railway networks, fit into Africa's surface area: Adding India and its fourth largest railway network overspills by less than 7%. These four countries account for 38% of total world rail network and 86% of freight traffic exceeding 10 billion tonne-km per year per country. Who would endorse narrow gauge for that task? Africa's population is already over the billion mark, and economic growth rates in many of its countries are doing well. Four are predicted to be among the world's top 50 economies in 2050, Egypt 20th, Algeria 34th, South Africa 35th and Nigeria 37th (Platt, 2012). The current state of many of its railways does not support playing in that league.

Chinese Premier Li has depicted a dream that all African capitals are connected with high-speed rail, so as to boost pan-African communication and development and said that China was ready to work with Africa to make this dream come true (Li pledges, 2014).

Inland water transport is little used in Africa despite the fact that it is an excellent way of opening up remote areas. Africa has this cheap energy and environment friendly mode of transport but its development and exploitation have been slow at a time when its importance in other regions of the world has increased. This is because Africa has only a few internationally navigable inland waterways in the Congo, the Nile and Zambezi basins while the greater part of its rivers have remained undeveloped with depths that vary seasonally and remain unpredictable. Lakes offer the best options for inland water transport, particularly in East and Central Africa (United Nations, 2009). It therefore appears that the task of inland transport will largely fall to rail.

2.3 Africa's railway challenges

2.3.1 General

Africa has a lot going for it. Its huge area almost equals the four largest railway countries, US, China, Russia and India combined, its population is more than a billion strong, and economic growth is generally high. However, track gauge is a major challenge. Narrow gauge impedes achievement of renaissance, except for urban rail, and gauge diversity obstructs networking. Three strategic positions are evident.

2.3.2 North

The North's standard gauge track supports renaissance, as is currently evident in Egypt regarding rail and metro expansion to take traffic off roads. Egypt is also currently examining the prospect of high speed in the future. Morocco is implementing a high-speed intercity service, although at time of writing the project was suspended. However, the Morocco-Algeria-Tunisia standard gauge network, the second-largest in Africa at 6300km, is hardly sufficient to sustain significant networking opportunities, and could benefit from completion of the ≈2100km Libyan railway, currently suspended, as well as connection with the standard gauge network in Algeria and/or Tunisia, to link up with Egypt's 5195km network. This would create a network of some 13500km, which in networking terms should have more value than the sum of the parts.

2.3.3 Equatorial

Equatorial and Sahel are making news: Cameroon, Chad, Djibouti, Ethiopia, Kenya, Mali, Nigeria, Senegal, South Sudan and Tanzania reportedly all have standard gauge aspirations or initiatives, with Chinese involvement and potential linkage to the abovementioned Iran-centred network. The Kenya-Tanzania-Uganda meter-gauge network is the third largest in Africa, at some 6000km. Next are the Sudans at ≈4500km, actually a unitary railway that was separated by political change, and Senegal-Mali at 1230km which is operated as a single concession. All are small in comparison with global railway network sizes.

The remainder comprises isolated railways totalling 7430km of standard gauge, 7424km of meter gauge, 5821km of Cape gauge, and 1090km of 1055mm gauge. Their average lengths are respectively 1061km, 825km, 1164km, and 1090km. These distances are at the upper bound of pit-to-port mineral service. Unless this is what they provide, it is improbable that they will be competitive with road. One of the most serious problems for the rail mode in Africa is its limited networkability.

2.3.4 South

The South It has the most extensive railway network in Africa, totalling some 44 000km of Cape gauge, of which that in working order might be somewhat less. However, the traffic density of contiguous railways outside South Africa is only some 0.5 million tonne-km per route km, which is low by global standards. The networking value is therefore not evident, but it is possible that the inherent uncompetitiveness of narrow gauge is the dominant causal factor. The South seems averse to standard gauge, so this phenomenon could be a topic for further research.

3 Findings

The following findings bring the foregoing material together as a foundation for the conclusions:

Freight logistics and passenger mobility have become a fast-paced contest.

Renaissance and Enlightenment rail inherently competitive and therefore well positioned to take a leading position in high-volume high-performance corridors.

Africa has generally missed the railway renaissance. Nevertheless, it should be possible to go straight to the top of the class by going for the Enlightenment.

Where local funding is insufficient, governments, such as India's, are opening railway funding opportunities to foreign direct investment to uplift their railways in time to make a timeous contribution to their development.

The extent of strategic horizon has expanded from national railways to continental and intercontinental railways for both freight and passenger.

Lighter freight and passenger traffic consume a disproportionate amount of expensive line capacity if they are coerced onto dedicated heavy haul lines.

Rail is not well adapted to low volume traffic, and unless containers are double-stacked, also not well adapted to low density freight.

Branch lines with light axle loads, steep gradients, and tight curvature cannot leverage the strengths of rail's genetic technologies. The challenge is compounded when mainline axle load is higher than branchline axle load, and exacerbated if the mainline axle load is to be increased, rendering the difference between mainline and branchline even greater.

Passenger service needs low speed and frequent stops within cities, but as distance from the centre increases, speed should become higher and stops less frequent. Trains need to be of graded performance matched to journey distance.

There is no reason to believe that defunct or disused or obsolete narrow gauge railways will be restored to their former glory. To be inherently competitive a railway needs to have standard gauge track. Broad gauge as in the Community of Independent states, India and Brazil, is as competent from a genetic technology perspective, but it does constrain networkability.

4 Conclusions

Renaissance has progressed well beyond knowing how to design and construct Heavy Haul, Heavy Intermodal, High Speed and contemporary Urban Rail. The industry has now moved on to how one positions railways to take their place in the global logistics and mobility market. The know-how and hardware can be bought in a large market: The real challenge is how to leverage rail's strengths for competitiveness and sustainability.

The future of railways is not to be found in the past. Recall that after World War II they were feared to be in terminal decline. Had the railway renaissance not emerged, that terminal decline would by now have run its course. Where renaissance has not taken root, for whatever reasons, there should be no great expectations of revitalisation by simply trying to restore a railway to its former glory. Competing modes have long taken away that possibility.

Although broad scenarios and objectives for 2050 are crystallizing, the outcome remains a long-term prediction. Rail will therefore need to rest its case on what it does best relative to other transport modes, namely exploit the inherent competitiveness that its genetic technologies support in the High Speed, Heavy Haul, Heavy Intermodal and Urban Rail market spaces.

United Nations' Law of the Sea states that ships of all States, whether coastal or land-locked, enjoy the right of innocent passage through the territorial sea of others. Effective continental and intercontinental railway networking requires similar protection. Do railways need a similar law of the sea?

This paper has raised issues pertinent to global railway renaissance and its influences on logistics and mobility in Africa. It is evident that a large number of those issues still remain open, and that there is hard work ahead to develop railways in Africa to the best they can be. It is also evident that an Enlightenment perspective on that task could accelerate progress and lead to a world class solution for Africa rising.

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