HOW MIGHT THE RAILWAY RENAISSANCE EVOLVE IN SOUTH AFRICA?

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ABSTRACT

Globally, railways are in renaissance. In South Africa, freight rail is positioned precariously, urban rail is positioned ambivalently, while high-speed or very high speed rail is absent. The research question inquired how railway renaissance might evolve in South Africa. The author applied a SWOT analysis, and observed that low axle load and -speed, and constricted vehicle profile, had led stakeholders to confuse apparent underutilization with obsolescence. The study found that concentrated traffic flows could support a much smaller, higher performance, standard gauge network: A suggestion for freight oriented-, passenger oriented-, and very high speed intercity routes, totaling some 6000km, are shown on a map. In conclusion, the study collated principles for migration to standard gauge, and recommended a track gauge migration master plan to optimize the contribution of standard gauge track to South Africa's railway renaissance.

FOUNDATIONS OF GLOBAL RAILWAY RENAISSANCE

Relevance to South Africa

While renaissance pervades the global railway industry, South African public- and user attitudes towards railways have hardened—many assets are considered underutilized at best and, sadly, worthy of burning at worst. Narrow-gauge railways are changing course—witness industry upheavals in New Zealand, Queensland, and Tasmania. Those in South Africa cannot indefinitely pursue their own direction in isolation. Ultimately and inevitably, they must align with global best solutions, if for no other reason than that their local- and global competitors do so. Institutional arrangements are already metamorphosing—think Gautrain, Kei Rail, branch line concessions, public private partnerships, and railway economic regulation. In that milieu, Transnet's projected sizable capital expenditure could provide a notable opportunity to kick-start a local railway renaissance.

Effective railway positioning

Positioning basics. Railways rest on three genetic technologies, namely Bearing (the ability to carry heavy axle loads), Guiding (the ability to run at high speeds), and Coupling (the ability to couple vehicles into trains). They distinguish railways from all other transport modes, and give them distinctive competitive strengths. Representing these technologies as three mutually orthogonal axes, defines four market spaces, in which railways are inherently competitive. First, Bearing and Coupling support heavy haul railways. Second, Guiding and Coupling support high-speed intercity and regional passenger railways. Third, Bearing, Guiding, and Coupling support heavy intermodal railways that convey double-stacked containers. Fourth, Coupling on its own supports urban railways. Relations among these genetic technologies and railway positioning, in three fundamental settings, are introduced below.

Positioning freight rail. Competitive and sustainable freight rail depends on scoring high on the variables Heavy Intermodal Presence, Distributed Power Presence, Heavy Haul Presence, Private Infrastructure Ownership, Relative Maximum Axle Load, and Infrastructure Operator Diversity (Van der Meulen & Möller, 2008a). Elements of good freight rail positioning are present in South Africa, namely Distributed Power and Heavy Haul. However, variables that promote competitiveness, namely Heavy Intermodal Presence, Private Infrastructure Ownership, High Maximum Axle Load, and Infrastructure Operator Diversity, are weak or absent. Research findings thus confirmed what is intuitively obvious to informed observers—freight rail in South Africa is positioned precariously.

Positioning intercity- and regional passenger rail. Competitive and sustainable line-haul passenger rail depends on scoring high on the variables Relative Maximum Speed, Gross National Income, Motorways Percentage, Information Technology Leverage, High-speed Intercity Presence, Economic Freedom, Paved Roads Percentage, R&D Level, and Electric Traction (Van der Meulen & Möller, 2008a). While IT Leverage and Electric Traction scored high in South Africa, most of the remaining variables were average, while Motorways- and Paved Roads Percentages, two variables that stimulate high-speed rail, were low and, of course, high-speed- or very high speed rail was absent altogether.

Positioning urban railways. People as payload do not achieve high axle load, even in double deck coaches, while physical laws optimize rail line capacity at ≈80km/h maximum speed. Hence, unlike line haul applications, urban rail cannot exploit rail's Bearing and Guiding genetic technologies. Notwithstanding that weakness, combining vehicles into trains by exploiting the Coupling genetic technology allows urban rail to maintain short average headways that enable it to outclass the capacity of rival passenger transport modes. In research on positioning urban rail, Van der Meulen & Möller (2008b) found two factors relevant to this paper, namely *Pitching Urban Rail at Developing Economies* and *Pitching Urban Rail at Developed Economies*. The essential difference between them is that in developing economies urban rail must compete against buses and motorcycles, while in developed economies it must compete against private cars. South Africa's urban rail legacy reflects the many expediencies of the past: The country has not yet moved in either of the above directions. Meanwhile, minibus taxis have garnered a large share of the commuter market and, more recently, bus rapid transit has joined the fray.

Significant clusters. Research has found that the world's railways reside in one of the Fortuitous, Insecure, Enlightened, Progressive, or Assertive clusters, so named by Van der Meulen & Möller (2008a). South Africa's railway positioning is ambivalent: While its heavy haul railways are a redeeming feature, its general freight and passenger railways would reside in the Insecure cluster. From a positioning perspective, railways in the Fortuitous and Insecure clusters should strive to migrate to one of the Enlightened, Progressive, or Assertive clusters, to ensure competitiveness and sustainability. South Africa's challenge is clear.

RAILWAY RENAISSANCE IN SOUTH AFRICA?

The research questions

As primary research question, can one start to map out how the railway renaissance might evolve in South Africa? As secondary research question, what are some of the key drivers that might promote or impede renaissance? The outcome would inform long-term stakeholder aspirations and plans, and provide a basis for optimizing relationships with other transport functions and -modes.

Methodology

This paper applies a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis to railways in South Africa: It integrates previously published statistically based research by the author and a co-author, with review of Transnet (2009) public domain plans, to develop a view on drivers of likely rail renaissance scenarios. Note that Transnet projects a freight perspective only: Since the transfer of Shosholoza Meyl to PRASA, an equivalent projection of passenger rail perspectives has not yet appeared in the public domain. The value of a scenario approach is that it facilitates lay- or popular appreciation of what specific futures may look like, and by what interventions people can influence them.

Obsolescence and underutilization

Many stakeholders have alleged that rail in South Africa is underutilized. If the allegation is true, the way forward will take a particular course: If false, it will take a different course. The distinction is clearly critical. The author argues that the allegation is false, for the following reasons.

First, South Africa celebrates 150 years of railways in 2010, and much has remained as is from fifty or more years ago. Indeed, Van Lingen (1960) mentioned most of the rail infrastructure that currently exists, and observed then that *the improvements to the main line from Cape Town to Johannesburg have not been as spectacular as those in Natal*. Significant new infrastructure investments during the last half century have been the Sentrarand marshalling yard and the Ermelo-Richards Bay and Sishen-Saldanha heavy haul lines in the 1970s; and upgrading Ermelo-Richards Bay, the Newcastle-Volksrust section of the Natal Corridor, and the Hex River tunnel on the Cape Corridor in the 1980s. However, setting aside the two heavy haul lines, one could argue that the other investments have not materially enhanced the railway status quo.

Second, and by contrast, South Africa has substantially upgraded most other national transport infrastructure, e.g. airports, ports and its road network, during the last half century, most of it beyond recognition. That infrastructure would likely now also allegedly be underutilized, had it not been regularly expanded and upgraded.

Third, rail infrastructure is not generic, like roads for example—freight- and passenger rail positioning requirements differ, as is evident from the discussion of genetic technologies. With the exception of the heavy haul lines, the remaining main lines are either too curvy for high-speed passenger trains, or too light for heavy freight, or both. There are other constraints as well, such as the shape and size of the vehicle profile. The author addresses underutilization of branch lines under the heading *Residual routes* below.

Fourth, it is fallacious to assume narrow gauge rail to be competitive with good road transport—this paper mentions many reasons why rail is inherently uncompetitive. In a contest between global best practice on road, and narrow gauge rail, road will unquestionably win. Much existing rail infrastructure is therefore inappropriate to contemporary business requirements. Seemingly, underutilized capacity may not be utilizable at all—it would therefore be correct to consider it obsolete rather than underutilized.

Noting that first-generation infrastructure originated at a time when a one-size-fits-all railway offered superior solutions to any other mode of transport, it is evident that differentiation among applications would now be required to achieve meaningful repositioning. This implies that light axle load, low speed, constricted profile rolling stock, specified for the legacy infrastructure, is also obsolete from a competitiveness perspective.

A SWOT ANALYSIS

Strengths

South Africa possesses a sound heavy haul railway foundation. With ongoing expansion on Sishen-Saldanha, and similar prospects on the Coal Line, rising traffic should ensure a stable revenue stream. Government is sympathetic to passenger services, and citizens are correspondingly expectant. A national railway right-of-way network exists: Given upgrading to competitive norms, it represents a valuable asset. With concentrated traffic flows (Transnet, 2009, Slide 14), a more compact national rail network could emerge. In cities, core urban rail networks already provide access to city centres: Add contemporary rolling stock and signaling, and they could deliver substantially higher capacity than at present.

Weaknesses

Three critical handicaps burden line haul railways in South Africa, namely narrow track gauge, comparatively low axle load, and constricted vehicle profile. To some extent, the latter two result from the first. They impede competitiveness of both freight- and passenger rail, particularly against road transport. Furthermore, the South African rolling stock market is a small fraction of the global market, obliging operators to acquire non-industry standard narrow gauge rolling stock that attracts a price premium despite its performance being inferior to comparable standard gauge equipment sold in its native environment. As example, 194.6-tonne standard gauge US diesel locomotives are priced at USD ≈2.3 million, or R17.25 million, apiece: TFR's 100 new 126-tonne diesel locomotives were priced at R 24 million apiece (Creamer, 2010). For the same adhesion level, narrow gauge locomotives cost more than twice standard gauge locomotives per unit tractive effort (kN).

Opportunities

Noting that much existing rail infrastructure is competitively obsolete, those corridors that offer sufficient traffic to support high performance contemporary rail infrastructure re-present an opportunity for modal shift from road to rail. Congestion and road maintenance challenges have overextended road transport in South Africa, so modal shift to rail could rebalance the national transport task. Climate change considerations could give further impetus—competitive railways consume fewer resources and generate lower external costs than airplanes, buses, cars, and trucks, to perform the same transport task.

Threats

Increasingly, other modes are substituting for rail in South Africa. Minibus taxis now provide a substantial portion of urban- and long haul commuter transport, while trucks have encroached on the bulk commodity market space. These substitutes are entrenching themselves ever deeper, rendering it more challenging for rail to recover lost ground.

For those that seek comfort in respite from globalization in the emerging new world order, will railway drivers change? If so, in what way? The fundamental strengths endowed by rail's genetic technologies will remain, because they inhere in the mode. Newly dominant countries are aligning their railways around standard (or wide) track gauge, heavy axle load, high speed, and large vehicle profile. So, as the world order changes, the railway renaissance will advance, not recede. Unless South Africa aligns its railways with global best practice, it can only drift further from the mainstream, whatever the outcome.

KEY INSIGHTS FOR THE FUTURE

Urban rail

High-capacity single-deck urban rail is sustainable on narrow gauge track. Speed per se is not critical, because journey distance and -duration are short. High acceleration and retardation require many motored axles. The small traction motors required fit easily between the wheels. Technically, narrow gauge urban rail thus sacrifices nothing, although economically it may sacrifice the price advantages of standard gauge rolling stock. Expect traditional urban rail routes to continue to anchor mobility in the societies they now serve, and to provide a foundation for further network expansion. Of course, stations and rolling stock influence passengers' perceptions: Expect to see upgrades of all assets with which passengers interact.

Regional rail

Some existing Metrorail journey distances approach what the rest of the world commonly terms regional rail, although low speed on narrow gauge cannot justify the appellation. High speed, in the 160-200km/h range, and high capacity, using double deck coaches, characterize regional rail. It serves outer urban areas and intermediate intercity journeys to around 400km. Moloto Rail would be an example. Standard gauge track is required for high speed: In South Africa, this requirement of regional rail would contend for right of way with Transnet Freight Rail (TFR).

Very high speed intercity

Traditional long distance passenger rail is moribund—long distances at low speed fail to meet contemporary expectations. Rail cannot compete with low-cost air travel on price, let alone on convenience. Therefore, one should expect traditional Shosholoza Meyl services to wane over time. It is not likely to be worthwhile to renew rolling stock, and their demise will allow TFR to exploit fully a network that is more suitable for freight- than for passenger trains. Very high speed intercity, in the 270-360km/h range, does not exist in South Africa: Van der Meulen & Möller (2010) address this special case in a companion paper, therefore this paper does not mention it further, except that Gauteng-Durban is a candidate.

Heavy freight

Heavy haul has been staple rail traffic for the last two decades, and may be moderately sustainable even on narrow gauge track. However, heavy Intermodal or double stacking of containers is a sustainable growth area that does not exist in South Africa, and that is not accessible on narrow gauge track. The key impediments of low axle load, low traction motor rating, and constricted vehicle profile, preclude narrow gauge railways from rising to the competitive strengths of their standard gauge counterparts. Uncompetitive freight rail burdens society by over spilling its natural traffic onto roads, with concomitant congestion and pollution. Liberalization of the rail industry might help, but only in eliminating the natural inefficiency of state owned enterprises, as in Europe's former vertically integrated national railways. A new take on freight railways is indicated.

A basis for development

Railways in South Africa need to leverage rail's inherent strengths—heavy axle load, high speed, and high capacity. While this requires standard gauge, no case to convert the entire network has been forthcoming: Evidently, such a huge intervention will be unaffordable. Yet rail is inherently uncompetitive as is, so an unsustainable state of stress prevails. The track gauge issue is unlikely to go away: On the contrary, it is set to become more pressing. If not standard gauge, then what? If not now, then when? Changing the nucleus of the national rail network, which carries the bulk of the traffic, to standard gauge could well be affordable and thereby stimulate railway renaissance.

In this context, Kenya provided a provocative example. It intended to enhance transport sector capacity to improve efficiency, cost effectiveness and competitiveness, to facilitate rapid economic growth. It planned to build a new, high capacity, standard gauge railway between Mombasa and Malaba, with a branch to Kisumu, and extension to Uganda and the Great Lakes. An international tender for the provision of transaction advisory and preliminary design services closed recently (Africatenders, 2009). While history will be the final judge of the outcome, Kenya sought to initiate disruptive change by abandoning its moribund railway legacy, and setting out to build a new competitive, sustainable, railway. Regrettably, the tender was subsequently cancelled.

The Gauteng-Durban corridor

Does one need to fix it? How does one raise freight rail competitiveness? Increase axle load and vertical clearance? Both could be expensive considering the bridges and tunnels involved, not to mention the existing electrification. As alternative, the right of way, with extensive adaptation, might serve as basis for a very high speed route: Minimize environmental impact by recycling as much right of way as possible, and change to AC electrification. Access to Newcastle? Perhaps a link from Vryheid via Utrecht. It might make sense to shift containers onto the Coal Line in double-stacked trains: This could be a third line, which would also offer an opportunity to provide symmetrical gradients for bi-directional non-coal traffic. South Africa's prime non-heavy-haul corridor bears incisive analysis.

Durban-Richards Bay

This could develop into a heavyweight corridor. Depending on the end state of the Gauteng-Durban corridor, it could convey double-stacked containers destined for Gauteng via the Coal Line, extend Gauteng-Durban very high speed intercity services to Richards Bay, and serve as part of a narrow gauge port-hinterland linkage to the North.

Ngqura-Northern Cape and Gauteng

Connecting Ngqura to a sizeable hinterland might be politically attractive. Northern Cape mineral deposits could be such a destination. Postmasburg to De Aar has either double track or at least double formation, so running parallel single lines, one narrow gauge and one standard gauge, could be an entry point. If that route were upgraded to standard gauge, a line from Noupoort to Bloemfontein, to move double stacked containers to Gauteng, might be an attractive marginal increment. Such a solution would however need to make peace with the iron- and manganese mining industry's preference to export all product through Saldanha, as well as the longer distance to Ngqura. Indeed, if Ngqura positioned itself as an entrepot industrial development zone, it might ultimately not need rail linkage to a hinterland at all.

The Gauteng-Cape Town corridor

From a passenger perspective, the ≈1500km existing Gauteng-Cape Town route includes ≈500km that might support 160km/h maximum speed if standard gauged. However, a journey in excess of 14½ hours is unlikely to attract passengers. Interestingly, China Railways offers overnight sleeper services between Beijing and Shanghai, using 200+ km/h multiple units that complete the 1323km trip in 10h 4 min for an average speed of 131km/h (Hughes, 2009). On the slightly longer Gauteng-Cape Town route, 240km/h maximum speed could achieve overnight service: It would require a dedicated line, probably double tracked, an investment that is unlikely to be justifiable.

Excluding coal and ore, demand for rail freight becomes insignificant at distances over 500km (Transnet, 2009, Slide 100). The author recently informally observed many covered rigs, presumably carrying high-value freight, on the N1 road. Simultaneously, there was little visible evidence of rail-friendly freight, either on the N1, or on TFR's parallel route. One must therefore question whether this corridor should be part of a future essential rail network. Slide 107, which shows only moderate traffic by 2037, seems to confirm this perspective. One must therefore question whether a Gauteng-Cape Town standard gauge railway is likely to be viable at all. At this time, it looks like a non-starter.

Urban rail networks

The Cape Town, Durban, and Gauteng urban passenger rail networks could serve as foundation for the foreseeable future. Any incremental expansions could remain on narrow gauge, while any new routes should consider standard gauge, to set the future direction.

Retained narrow gauge routes

Sishen-Saldanha. In recent times, TFR has upgraded its Class 9E locomotives, commissioned new Class 15E locomotives, enlarged its ore wagon fleet, and expanded crossing facilities. It is now heading for 60Mtpa and beyond. From a track gauge perspective, one can consider the Sishen-Saldanha railway to have passed the point of no return: It could retain its present development trajectory until Northern Cape ore reserves become depleted.

A rail linkage to the North. Retaining the Durban-Richards Bay-Swaziland-Groenbult-Beit Bridge route would support narrow gauge traffic to the North. However meager that traffic might be, it would likely be politically untenable to sever linkage with landlocked Southern African Development Community states.

A future South African railway network

South Africa's essential railway network would comprise contiguous routes with dense traffic potential that could justify conversion to standard gauge, plus retained narrow gauge routes that could not or should not be converted. It would be smaller than the present one, but contribute more to the national transport task and the wellbeing of South Africa's citizens, through being competitive and sustainable. It would require three classes of line:

- Freight oriented lines: Maximum speed 120km/h, minimum axle load 32.4 tonnes, easy gradients, tight curves where unavoidable and sufficient vertical clearance for double stacked containers;
- Passenger oriented lines: Maximum speed 200-220km/h, wide curves, moderate axle load and steep gradients where unavoidable; and
- Very high speed lines: Maximum speed 270-360km/h, very large radius curves, light axle load and steep gradients as required.

Figure 1 shows such a network. If a shared ring within or around Gauteng makes sense, it would need to compromise the minimum requirements of all three classes of line.

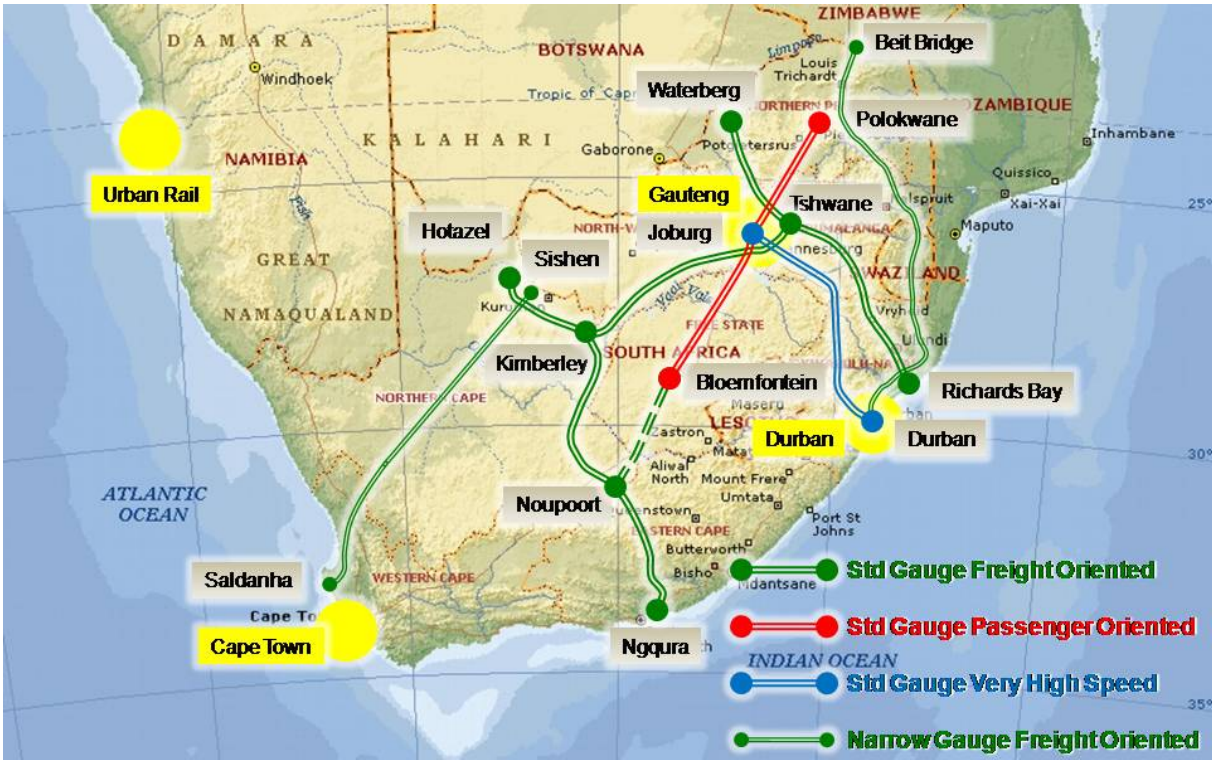

Figure 1 An essential South African railway network

The following links appear justified by Transnet (2009) traffic projections or national development objectives. The distances approximate existing routes: Actual distances would vary to the extent that new construction proves economically feasible, while routes could be shortened and straightened at sites where century-old technology dictated bypassing natural obstacles rather than passing over or through them.

Richards Bay-Gauteng-Waterberg, freight oriented	910km
Durban-Richards Bay, freight and passenger oriented	170
Hotazel-Gauteng, freight oriented	850
Bloemfontein-Gauteng-Polokwane, passenger oriented	750
Gauteng-Durban, very high speed	620
Kimberley-Ngqura, freight oriented	745
Noupoort-Bloemfontein, freight oriented	290
Sub-total	4335km
Allowance for connecting linkages, 20%	865
Grand total	**5200km**

One could thus envisage a standard gauge network of some 6000km, constructed to aggressively competitive standards, to position rail formidably in its catchment area.

Residual routes

Branch lines. Transnet's strategy provides for concessioning branch lines to private operators, and the company is working on a sustainability plan for them (Transnet, 2009, Slide 88). Branch lines are generally in poor economic condition for several reasons, primarily low axle load, and meandering routes and low speed. The former renders them uncompetitive against road, and imposes capacity- and cost burdens on mainlines to which they connect, while the latter increases transit time. Private sector efficiency and initiative cannot conjure returns from inherently uncompetitive situations: In other countries, good intentions in combination with inadequate inherent competitiveness have lead to frustrating outcomes or to stripped assets. From a future rail network perspective, expect many branch lines to languish, or to close in the absence of financial support.

Marginal lines. It may be advantageous to retain a few existing narrow gauge lines for low volume, high value freight only—Gauteng-Cape Town comes to mind. It may also be advisable or necessary to avoid isolating particular destinations. Where traffic is sufficient to keep a narrow gauge line open, it could be appropriate to acquire a modest fleet of wagons with variable-gauge bogies. The cost of maintaining such routes could of course become a decisive determinant of their sustainability.

CONCLUSIONS

An answer to the research questions

Yes, one can start to map out how the railway renaissance might evolve in South Africa. The author has identified several drivers, but their outcome will likely differ from what many stakeholders might have imagined. Noting that politics is the art of the possible, Bismarck (1867) might have added the corollary that the more a proposal deviates from the possible, the less the probability of its success. Recognizing what is possible would thus be a good place to start South Africa's railway renaissance. The industry's present lethargy suggests that unduly prolonging the status quo is not a possible outcome,

Fundamental principles

One can collate the following gauge migration principles from the foregoing examples. They offer a way for South Africa progressively to rejoin the global railway mainstream.

- Standard gauge can increase axle load and/or speed, while narrow gauge lines are "underutilized:" Convert double lines to two single lines of different gauge.
- Focus on the dominant traffic on each route: Separate heavy freight and high speed where possible, but recognize that some overlaps will be unavoidable.
- Convert and/or build an essential core network to standard gauge, and access remaining narrow gauge "branches" by means of gauge changing rolling stock.
- Some narrow gauge lines could or should be retained as is: Identify them and let them be.

- Recycle right of way: Steep lines typically only support low axle load, and are unsuitable for heavy freight—convert them to passenger-only if horizontal and vertical curvature can be eased sufficiently.
- Acquire a modest fleet of gauge-changing wagons—perhaps for containers or special payloads—to access narrow gauge destinations off the core network.

Institutional arrangements

The question of how rail infrastructure ought to be apportioned in the national interest remains open. At present PRASA and TFR each have their share, but the foregoing material indicates that contending requirements will likely compound in future. The track gauge issue is a confounding factor—the necessary accommodation is less complicated on standard gauge, which can lean toward heavy axle load or high speed in corridors where rail is desirable but there is insufficient traffic to justify separate freight- and passenger infrastructure. Is there need for a national railway infrastructure operator, or even a competitive infrastructure dispensation?

A track gauge migration master plan for South Africa

The foregoing discussion, examples, and principles only portray a broad-brush landscape. The seismic nature of actual gauge migration would require attention to many details, among them critical sequencing to ensure faultless execution. As recommendation, South Africa needs a track gauge migration master plan to guide its railways to renaissance.

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