PRASA: JOINING DEMAND FORECASTING AND THE TECHNOLOGY CHOICE FRAMEWORK

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ABSTRACT

The Passenger Rail Agency of South Africa (PRASA) completed the update and reissue of its National Strategic Plan in 2012. As part of this process PRASA recognised that its classic offering of high capacity heavy rail services was not appropriate for all corridors, and that alternative modes may offer more suitable capability.

Analysis of a large range of comparator systems across the world was undertaken to determine the key characteristics of a range of rail and road based transport modes. The findings adapted to South African conditions and presented in a tabular format. This Technology Choice Framework was used to inform stakeholders as to the options PRASA could offer.

PRASA used this framework to analyse each corridor. Evidence is presented describing this analysis in Kwa-Zulu Natal (KZN), and the conclusion that Light Rail Transport (LRT) would provide a better option for the longer term for the lesser used corridors. Building on this core vision a concept has been developed for a wider network that serves the city centre, and creates urban redevelopment opportunities in the city centre and harbour area following the transfer of port activity further west.

This is an example of PRASA's approach, worked up in conjunction with local stakeholders, to determine future development options appropriate to local needs, and through objective assessment of the most suitable transport technology.

Keywords: Innovation, strategic plan, rail investment, light rail, urban regeneration, technology choice, public perception & stakeholder engagement.

1 INTRODUCTION

PRASA operates all heavy rail passenger services in South Africa, including high volume metro operations in Gauteng, Western and Eastern Cape and KZN. The authors supported PRASA in the development of their National Strategic Plan in 2012, which defines the shape and direction of service provision over the next 40 years. This is in the light of the R80bn of investment in infrastructure, rolling stock and customer facing systems currently under way.

In passenger transport applications, rail offers unparalleled advantages in terms of moving high volumes of people at high frequencies. It is however recognised that at lower volume levels heavy rail may not provide the ideal transport solution. Current provision may be based more on historical reasons than current needs, and other modes may offer advantages.

A key starting point in the creation of the Strategic Plan was a review of whether the service provision on each corridor was consistent with both current levels of demand and future forecasts. Passenger railway provision in South Africa has focussed around high volume operations using rolling stock principles established over 50 years ago. Because of the changes that have occurred in this period it was felt appropriate that such a review should inform the process to determine what services should be provided, and by what technology, for the next 40 years.

To undertake this assessment a review was conducted of public transport technologies which were made use of in other comparable countries. South Africa has specific considerations which needed to be reflected in the analysis, and where appropriate the outputs were customised to suit local conditions.

A key objective was to inform stakeholders (including planning and other decision making authorities and local interest groups) as to the choices available, and the issues which should be considered in selecting the optimum system. Arising from this, a series of proposals has been made regarding possible future options to transform transport provision on certain corridors.

This paper reviews the appraisal matrix used and then discusses the proposals made for the adoption of light rail transport in KZN as a replacement for heavy rail on specific corridors.

2 DEFINING APPROPRIATE TEHCNOLOGY

Differing transport modes have specific attributes, including flexibility, planning and implementation timescales, headways and corridor capacities, technical characteristics, and capital and operational costs (Booz Allen Hamilton with Institute for Transport Studies Leeds and Associated Consultants, 2005). There is no single best answer, and development strategies may require the use of successive technology solutions to keep pace with forecast demand growth.

A useful approach to infrastructure investment was outlined by the World Bank Public Private Infrastructure Advisory Facility – a multi-donor technical assistance facility aimed at facilitating private infrastructure investment (PPIAF, 2014). This highlighted as best practice the need to undertake a comprehensive review of available transport modes prior to committing to specific corridor development work. Figure 1 overleaf illustrates the technology planning process.

PRASA adopted this philosophy in its strategic review. A key component of service provision once corridors are clearly defined is to undertake analysis of the strengths and weaknesses of each potential transport mode, to select which is the most suitable for the circumstances. Only then, should work begin on development of a preferred solution.

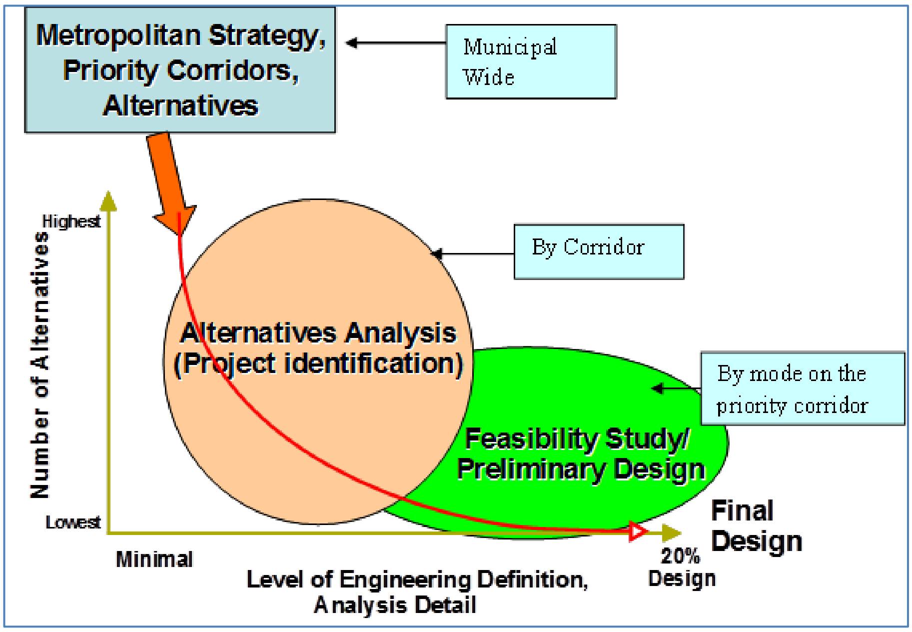

Figure 1: Public Transport Technology Planning Process
Source: PPIAF & World Bank (2008)

As a first step a series of transport modes was defined, based on structured public transport provision, including:

- **Conventional bus:** Normal road based bus services including limited segregation such as bus lanes, access to pedestrian areas or off line bus stops;
- **Bus Rapid Transit (BRT):** Bus based system accessible at dedicated 'stations' 500m or more apart and with road segregation;
- **Guided Bus:** BRT with fixed guidance using bus lanes or segregated busways giving higher speed operation especially in areas with limited clearances.
- **Street Tram:** Rail based street system with lightweight units offering low floor access. Can run in normal traffic, using tight radius curves and steep gradients or on dedicated corridors or pedestrianized areas;
- **Light rail (LRT):** Similar to street trams using lightweight vehicles on segregated railway corridors or street running. Usually with limited station stops. LRT extends to small scale metro train operations
- **Tram train:** LRT units capable of running both on heavy rail and street tracks. Must be separated by a safe distance from classic trains and need high level platform access,
- **Heavy Rail:** Classic electric or diesel passenger trains, capable of 100 km/h running, but requiring fully segregated and protected rights of way. Needs large radius curves and relatively shallow gradients.

By definition privately operated minibus taxis were not considered as part of this provision. The taxi market is only lightly regulated, in most cases service provision is almost completely informal and does not offer desired levels of safety or reliability commensurate to required public transport standards. While the minibus taxi market currently fulfils an important social need, and can be argued to be demand driven, in the longer term it needs to be part of a more efficient method of public transport provision on core corridors.

The UK Commission for Integrated Transport (2005) sets out key differences between the various available transport modes in terms of technical capability, passenger capacity, service frequencies, and capital investment costs and operating costs. The approach advocated by the Commission was adopted by PRASA, as many of the findings apply internationally rather than just to the UK or Europe.

Analysis of urban case studies in South and North America, Europe, East Asia and Australasia was undertaken to examine what modes were used, the typical operating conditions that apply in each case, and the outcomes experienced. Published research, notably from the UK, USA, France and Germany, has been reviewed, notably from Glover and Low (2008), Bennet (2005), Gleeson et al. (2003), Levinson et al. (2003) and Topp (1998) and data held by PRASA's research consultant, Arup, was also incorporated.

Detailed reviews were undertaken of light rail case study systems in:

- Manchester UK (Metrolink);
- Portland USA (Metro Area Express)
- Strasbourg France (CTS);
- Karlsruhe Germany (Karlsruhe Stadtbahn);
- Sydney Australia (Sydney Metro);
- Croydon UK (Croydon Tramlink); and
- Sao Paulo Brazil (Sao Paulo Metro).

Additionally cognisance was taken of the attractiveness of rail modes and their ability to generate ridership because of their perceived attributes of comfort, reliability and convenience. This is best summarised in Table 1, which though applying directly to UK experience illustrates that different modes have differing passenger perceptions.

Table 1 Evidence on Patronage Transfer from Car and Public Transport

Modal shift	**Bus**	**Guided Bus /BRT**	**Light/heavy rail**
% transfer from car	3% - 10%	3%	12.5% - 20%
% transfer from other public transport		6%	48% - 69%

Source: UK Commission for Integrated Transport (2005)

A summary of the characteristics of each mode was then drawn up, and collated into a table reflecting the key transport attributes of each mode – a Technology Choice Framework as shown by Table 2 below. Data from each candidate country was converted into local monetary values, and assessments made of acceptable vehicle loadings, which using PRASA experience are considerably higher than European tolerances and more in line with normal South American and East Asian practice.

Table 2 Technology Choice Framework - Transport Mode Attributes
Source: Arup analysis

Transport mode	Planning time	Peak capacity / hour	Max radius and climb	System life (years)	Unit capacity (pass)	capital cost per route km (R mil)	Passenger operating cost R/km/pass
 Regular Bus	Short	2,500 – 6,000	14m 13%	8 - 14	40 - 120	0.8 - 4	1.06
 Bus Rapid Transit	Short / medium	4,000 – 10,000	14m 13%	8 - 14	40 - 120	35 - 60	1.06
 Guided bus	Short / medium	4,000 – 10,000	14m 13%	8 - 14	300 - 450	35 - 200	1.06
 Street Tram	Medium / long	12,000 – 20,000	18m 10%	25 - 50	400 - 600	67 - 330	1.88
 Light Rapid Transit	Medium / long	12,000 – 20,000	18m 10%	25 - 50	400 - 600	67 - 330	1.88
 Tram Train	Medium / long	6,000 – 12,000	18m 10%	25 - 50	400 - 600	67 - 330	1.88
 Heavy Rail	Long	20,000 – 60,000	80m 3%	25 - 50	2,000 – 3,500	50 – 500	0.5 – 3.0

While the results in the table will always be open to challenge and only provide typical generalised values, they serve to emphasise the differences between modes and their relative suitability for specific corridors. The findings were summarised to stakeholders as follows:

- **Bus** services are flexible, easy and quick to introduce and relatively cheap. Changes can be implemented quickly to respond to demands. The principal weakness is that they are slow (though to some extent this can be helped by the provision of dedicated lane running) and subject to the impact of urban congestion. Bus services cannot carry large numbers of passengers on a route

- **BRT or Guided Bus** services combine the flexibility of bus with a more controlled passenger boarding environment by establishing stations where ticket checks can take place, thus speeding the entrance and exit of passengers, though it does require specialised infrastructure. This adds to the cost, but is still cheaper than rail based solutions. BRT increases the number of passengers that can be moved, but corridor capacity does not reach that of rail modes. There are fewer stops and therefore BRT does not serve local areas as well as bus services. Guided bus services can reduce the width of the corridor needed.

- **Street Trams** have much greater carrying capacities, and when provided with elements of segregated street running can run frequencies as close as buses. Because of the infrastructure required (including overhead electrification equipment) trams are more expensive than BRT, but have a longer life and can move more passengers per hour. Modern street trams can offer step free access at pavement level, which increases urban transport connectivity.

- **LRT** is a development of street trams, offering a combination of urban street running with faster transits on dedicated ROW outside the immediate city centre. This reduces journey times and therefore widens catchment areas. While more expensive than tram LRT can serve a much greater area, and move the same number of passengers. LRT systems are generally not compatible with heavy rail, and often use disused or redundant heavy rail corridors for the longer distance routes.

- **Tram Train** is a variant of LRT that makes use of heavy rail routes still used by conventional passenger and freight trains. This requires physical separation of Tram Train from heavy rail trains, which in turn reduces the overall frequency of services. However this is potentially a cheaper and effective way of using existing corridors, and combining these routes with improved city centre access.

- **Heavy Rail** offers the greatest passenger capacity of all modes, as trains can be longer (up to 280 metres in South Africa) and carry up to 3,000 passengers in one train. They are capable of running faster and with greater safety and reliability than other modes, as they generally operate on fully segregated formations, and have sophisticated train control systems. Heavy rail is the most expensive in terms of capital cost, and takes the longest to establish, but has a long life of up to 50 years, and can provide the best mass transit provision of any mode. It is however relatively inefficient with lower patronage levels. PRASA used the Technology Choice framework and the above conclusions to examine the service provision on each of its urban corridors.

3 APPLYING THE PROCESS IN PRACTICE – KZN

As an example of the application of the Technology Choice Framework, reference is made to the work strategic planning carried out in KZN. PRASA's KZN urban rail network consists of 605km of route serving 101 stations (see Figure 2). There are 8 heavy rail corridors with varying levels of patronage and serving different markets, all operated with 8 – 12 coach trains at frequencies of between 5 minutes and 1 hour in peak periods.

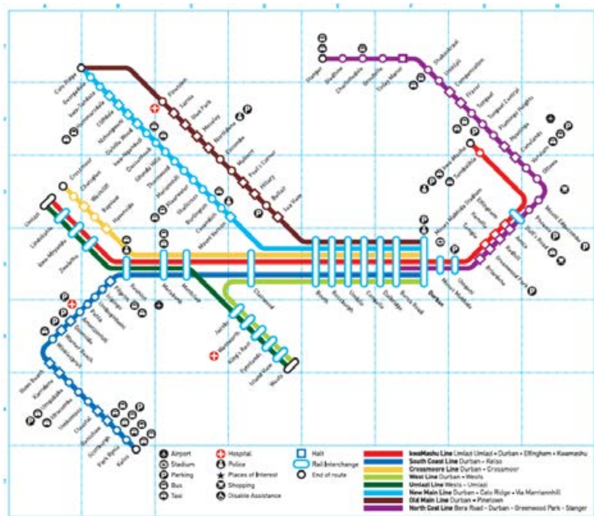

Figure 2: PRASA KZN Route map

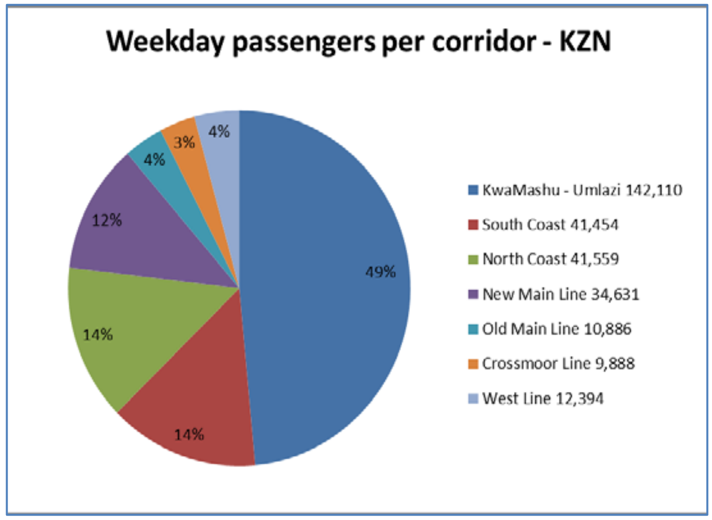

Figure 3: Corridor volumes as a proportion of total carryings (Source: Arup analysis of PRASA data)

The highest priority corridor links Umlazi, Kwa Mashu and Bridge City, with Durban (see Figure 3). Approximately 140,000 passengers use this route daily, and it accounts for about 50% of all journeys made on the network. Two more corridors, to the north and south coast regions, also carry significant, though lower, volumes. By contrast three lines – those serving Chatsworth, Pinetown and Wests (docks area) carry far lower volumes, and have relatively low market shares of total corridor movements.

The eThekwini Transport Authority (ETA) is currently revising its Integrated Rapid Public Transport Network (IRPTN) and is looking to establish new BRT corridors to meet identified demand across the area (see Figure 4). Corridors C5 and C7 are planned to serve the Chatsworth area which is also served by PRASA's Crossmoor branch.

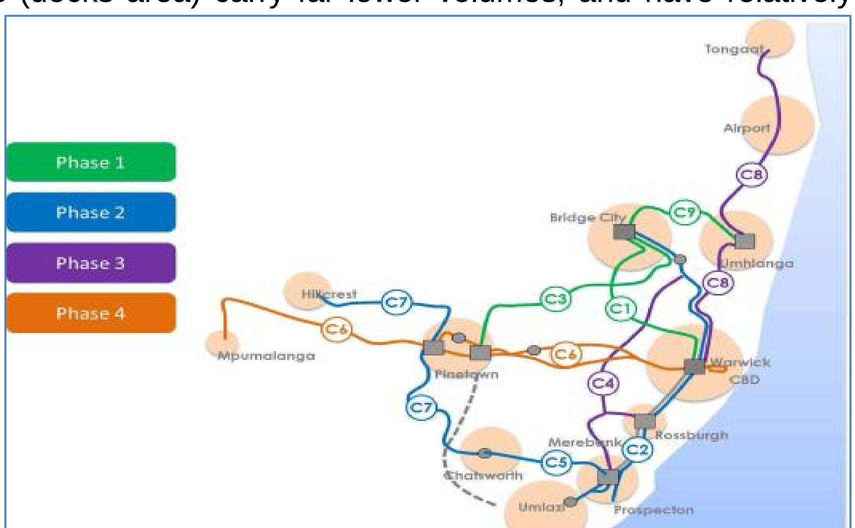

Figure 4: eThekwini IRPTN Corridor identification
Source: eThekwini Transport Authority (2012)

Analysis of the traffic levels on this branch line shows that they fall well short of the volumes required for a frequent heavy rail service, and reference to the Technology Choice Framework suggested that the more appropriate technologies would be BRT or LRT.

Part of the reason for the low traffic levels is the relative inaccessibility of the rail line, which for much of its route runs in the central reservation of the M1 Higginson Highway. Rail currently only has a 7% share of the public transport market as a result. In total 50% of all journeys in the area are by car, with 38% by public transport and 12% by foot or by bicycle.

The strategic review also identified other factors impacting on rail carryings within the region:

- City centre stations at Durban and Berea Road are relatively remote from the CBD
- A key travel demand for over 40,000 passenger journeys between Umlazi and Chatsworth is currently poorly served by any form of public transport
- Key industrial developments such as the new port will change work travel patterns over time, and reduce the industrial role of the current port area

PRASA believes that there is considerable potential for improving the rail share of the Chatsworth – Durban travel market, but that in this instance the Technology Choice Framework was used to demonstrate to stakeholders that heavy rail is not the best mode, as the train size forces services to be relatively infrequent an unattractive. LRT would offer options for creating additional street running sections to improve rail's accessibility, and could provide considerable increases in service frequency for the same number of passengers.

Building on this, extending the LRT on a parallel route into Durban could provide much improved connectivity between Berea Road and the city centre while also better serving the employment areas along the R102. Using proper connectivity between heavy and light rail at key interchanges such as Merebank and Rossburgh could also reduce main line journey times by the elimination of stops. LRT's ability to handle steeper gradients would also offer a means of creating a route between Umlazi and Chatsworth.

Figure 1: Visualisation of LRT operating in Durban city centre and seafront

Figure 6 shows that PRASA sees this as a first stage for an iterative LRT strategy for KZN. Other PRASA lines with low passenger usage are also seen as longer term candidates for conversion to LRT as part of a wider network. The route to Pinetown follows the steep and tightly graded original main line and makes heavy rail services slow and uncompetitive. Conversion to LRT would allow services to be faster, as well as again providing opportunities for street running to better serve local areas.

In the longer term creation of a bridge or tunnelled route across the current harbour entrance could link the city centre to the area served by the current Wests branch, together with Brighton Beach and Bluff. With the anticipated transfer of much of the port activity to the new dugout port, LRT could then act as a catalyst for redevelopment of the former industrial area, and widen the Durban city centre out across the harbour. LRT's ability to generate transfers from other modes, as described above, plays a crucial role in this. Evidence from around the world demonstrates that LRT schemes can have a dramatic impact on boosting property prices and encouraging private sector redevelopment investment (Hess & Almeida, 2007; Forrest & Ward, 1996; Dziauddin et al., 2013).

Figure 5: Concept LRT route network

PRASA's concept route diagram for a Durban LRT network is outlined above (see Figure 6). Looking further ahead the Northern Urban Development Corridor (NUDC) and King Shaka International Airport will both require high quality public transport links, and given the congested road links a new rail corridor will be needed. The current corridor is very nearly at full capacity, and creation of a new corridor using light rather than heavy rail technology would be considerably cheaper, as well as offering much better accessibility.

PRASA continues to develop these proposals in partnership with ETA, to overcome the issues which impact on today's rail transport offering. Development of both BRT and LRT modes in the area is seen as complementary, and it is planned to ensure that a development plan capitalises on their respective benefits as outlined in the Technology Choice Framework

4 CONCLUSIONS

PRASA has recognised that classic heavy rail service provision is not appropriate to all transport requirements, and in many cases other modes are more suitable, practical and cost effective. It has used the lessons offered by international applications to understand the strengths and weaknesses of each transport mode. Building on this PRASA has created a Technology Choice Framework which sets out these attributes in a comparable way. This has been used to help inform stakeholders of the areas where heavy rail is unlikely to compete effectively, either in the short or the longer term.

PRASA has used this process to evaluate its own transport corridors. In Durban it is clear that rail does not compete effectively on certain routes. The framework suggests that in the short term BRT is the best solution, but that in the longer term LRT would be a viable and effective solution, both to enhance the value of the current rail corridor, but also to increase accessibility and to encourage urban development. LRT has been demonstrated as being particularly effective at stimulating mode shift, especially from private cars, and this is seen as key to addressing the long term transport needs of KZN.

An LRT network serving the wider region, integrated with bus, BRT and heavy rail, and running into the city centre and across the harbour, would have a transformational impact on the status and image of Durban as one of South Africa's leading cities.

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