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1. OVERVIEW AND PROJECT APPRECIATION

1.1 Introduction

1.1.1 Corridor A: Polokwane –Mokopane Commuter Rail Service.

Presently the link between Polokwane and Mokopane stations is made by a rail line of 65 km electrified with 25 kV AC. By road, the distance is about 58 km. The current average travelling time is 1 $^{1/4}$ hours whereas it's approximately ¾ hour by road. The modelling in Phase 1 indicated that 38,181 passengers would travel daily in 2010 for work purposes in the corridor that begins in the residential areas of Mokopane and traverses through the industrial /commercial areas of Polokwane to end at the educational complex of Mankweng. (Refer **Figure 1**)

1.1.2 Corridor D: Polokwane –Moloto Passenger Rail Corridor

The Moloto Corridor (Refer **Figure 2**) project was accepted by Cabinet to link Moloto in Mpumalanga to Tshwane with a standard gauge rail line. The corridor could be extended in future via Jane Furse to Burgersfort.

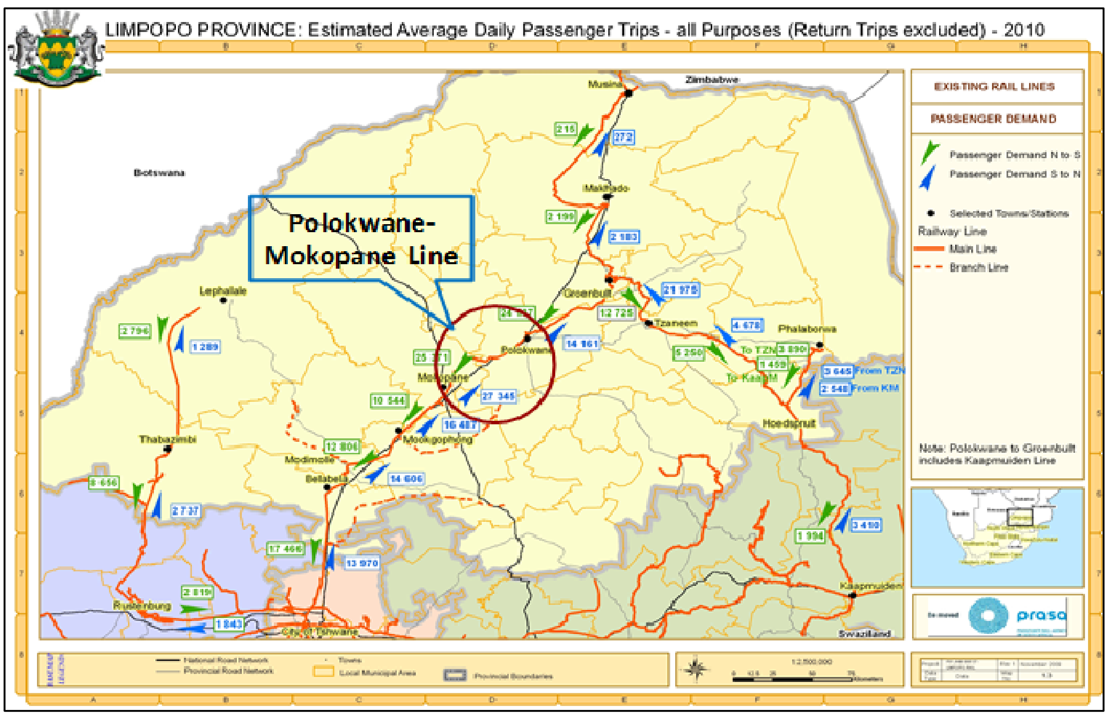


Figure 1: Polokwane-Mokopane line-Estimated Av Daily passenger Trips

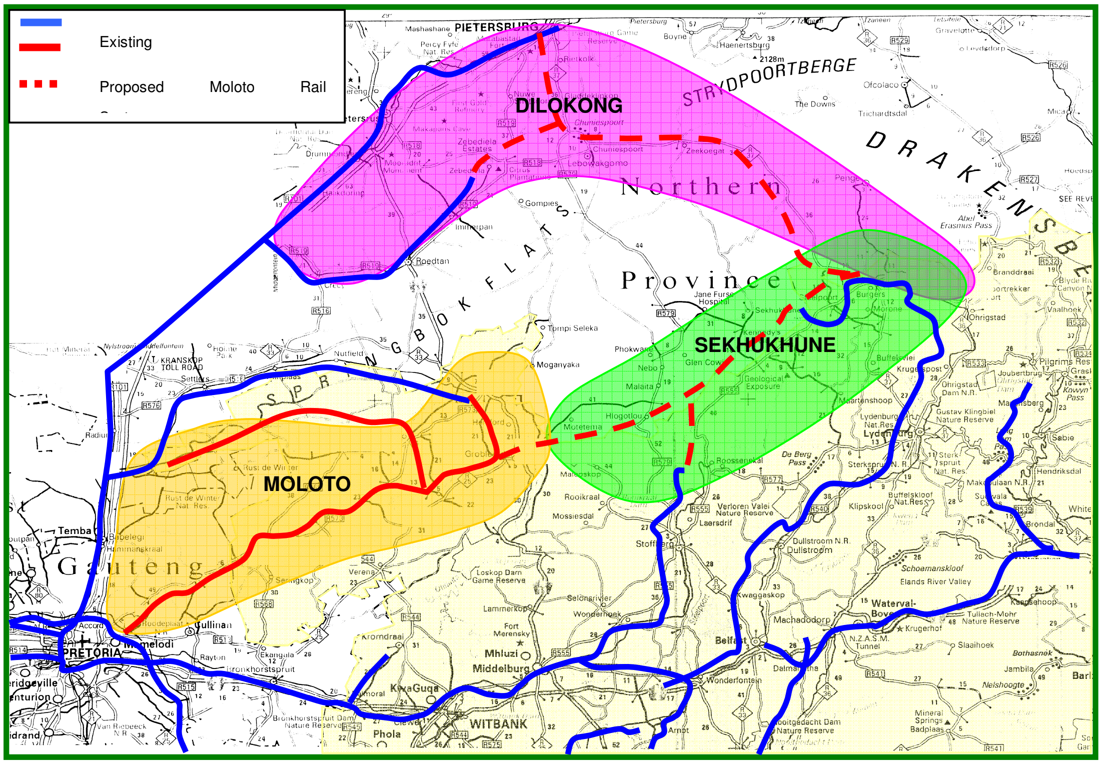


Figure 2: Moloto Development Corridor in Regional Context, Source: NATMAP Phase 4 Report, September 2010

Two options are required to be studied. The first option could be a 36km new rail line could be provided from Polokwane to Zebediela with a possible extension to the Lebowakgomo area. This option would use 19km of the existing mainline between Polokwane and Mokopane. An alternative route to the Lebowakgomo area would be from the Polokwane – Mankweng option. Any one of these options could be extended from the Lebokgomo area to Jane Furse to link with the Moloto Corridor. The total distance from Polokwane to Jane Furse is approximately 150 km (Refer **Figure 3**).

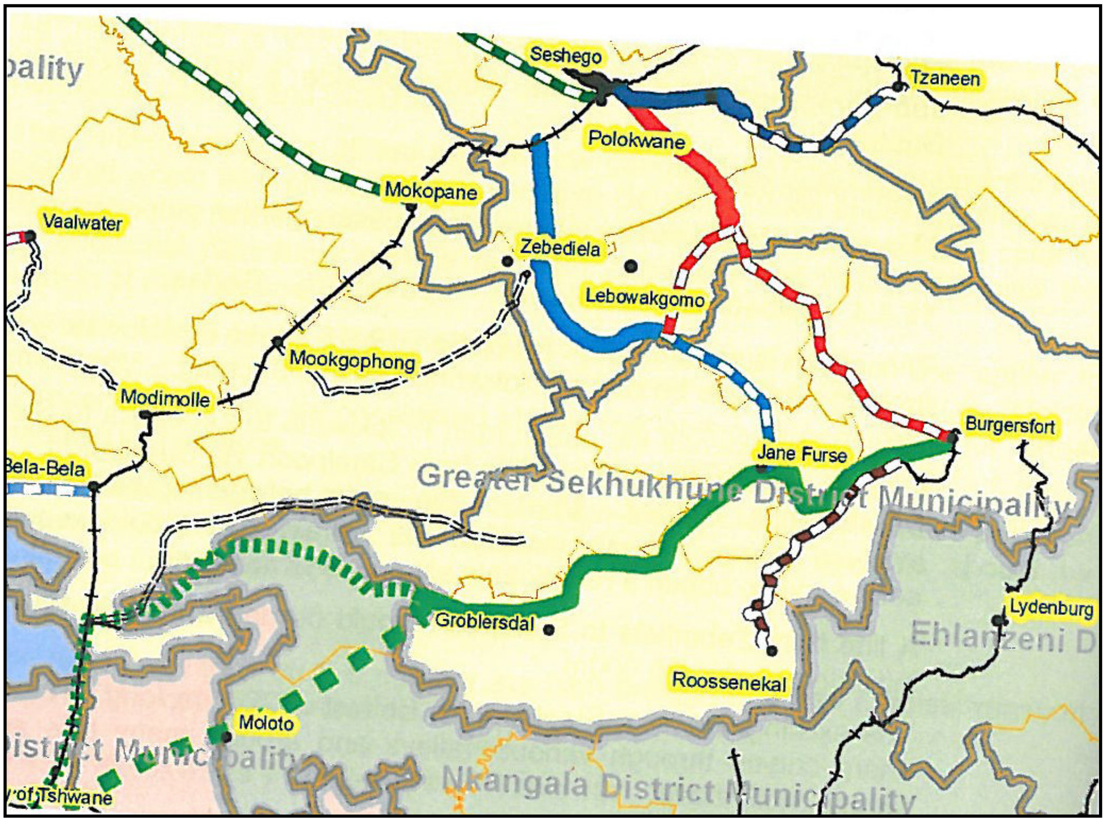


Figure 3: Approximate location of Rail options that could link to the Moloto Corridor

Scope of Study

1.1.3 Corridor A: Polokwane –Mokopane Commuter Rail Service.

The aim of the study is to realize a **business case** and define how a commuter service could be provided between Polokwane and Mokopane stations. This commuter service should be efficient for work and scholar trip and would only be utilized to travel North in the morning and South in the afternoon, as Residences are in Mokopane area and the Industrial and Commercial area are around Polokwane. This report presents the detailed operations proposed for the corridor based on travel demand estimates which are presented in the Market Analysis report for this corridor. The business case is presented separately in the business plan report for this corridor.

1.1.4 Corridor D: Polokwane –Moloto Passenger Rail Corridor

It was recommended in the Phase 1 report that a Conceptual Design be done to link Polokwane with the Moloto corridor which should include the options from Polokwane via Lebowakgomo on the Mankweng route to Jane Furse as well as from Polokwane via Zebediela to Jane Furse where it should link to the possible extension of the Moloto Corridor.

The purpose should be to guide spatial development along this corridor in order that future rail facilities could support the corridor. According to all the previous observations, the aim of the study is to identify the preferred linkage between Polokwane and Jane Furse. The preferred linkage was determined. This was followed by a Conceptual Design and detailing of infrastructure requirements of the preferred alignment with proposition for station location. An operational Assessment based on our experience of similar project was done as well as a Business case. This report presents the results of Operational analysis and detailing of operations for the corridor.

1.2 Option Development

1.2.1 Corridor A: Polokwane –Mokopane Commuter Rail Service

This option (Corridor A) takes Polokwane to Mokopane as the core and adds 8 new stations in between, as depicted below on **Figure 4**.

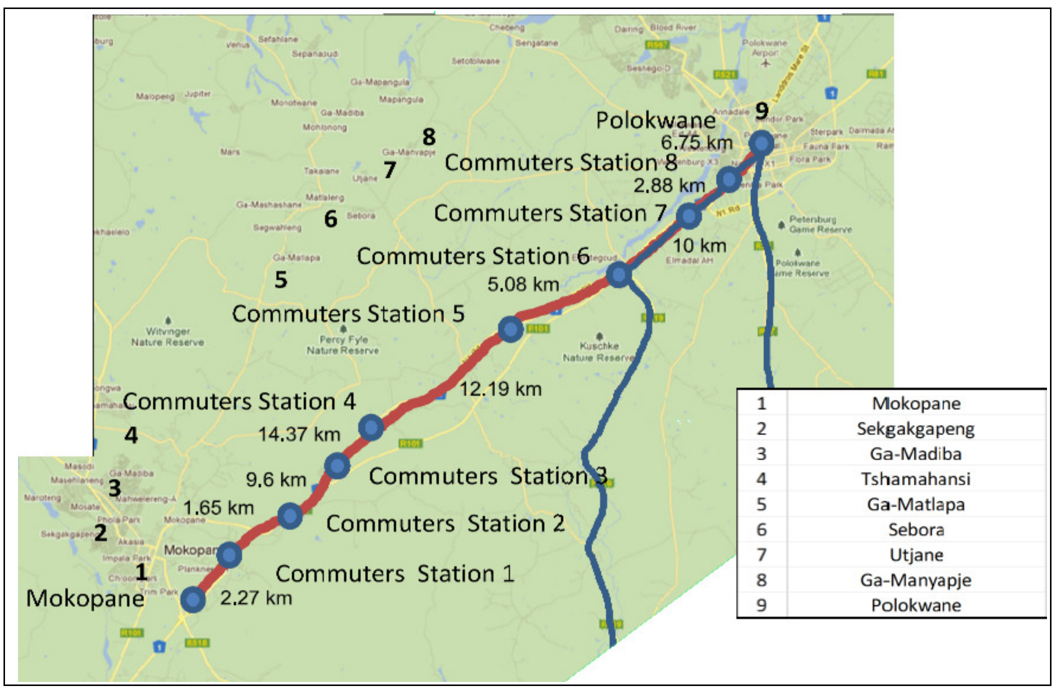


Figure 4: Corridor A – Polokwane to Mokopane

In operational terms, a wholly new line would be relatively simple to plan and operate, and should achieve excellent performance and reliability. If the existing classic line were to be adapted to provide commuter services alongside the current long-distance Shosholoza Meyl service, then there would be considerable operational constraints due to the technological performance characteristics of the classic line (including the one track nature of the line) as well as the complex mix of existing passenger and freight train on this route section. Classic line running also requires that new line rolling stock is compatible with the current classic line infrastructure. The market demand analysis found that in case on Polokwane –Mokopane , the morning peak hour trips towards Polokwane is 62734(2050).

1.2.2 Corridor D: Polokwane –Moloto Passenger Rail Corridor

This option (Corridor D) takes Polokwane to Jane Furse (via Zebediela) as the core and adds 15 stations in between as depicted below on **Figures 5** and **6**.

Figure 5: Corridor D – Polokwane to Lebowakgomo

Figure 6: Corridor D: Lebowakgomo to Jane Furse

1	Lebowakgomo
2	Mmakotse
3	Makhushaneg
5	Motsereng
4	Ga - Madisaleolo
6	Lenting
7	Marulaneng
8	Mamatonya
9	Ga - Phaswana
10	Byldrit
11	Grootklip
12	Malope
13	De Paarl
14	Mahlolaneng
15	Ga - Masemola
17	Sekale
24	Pitsaneng
25	Mashoanyaneng
26	Maraganeng
27	Lewalemolomo
28	Mosehla
29	Good Hope
30	Mgababa
31	Jane Furse
32	Sekhutlong
33	Sekwati
34	Ga-Tisane
35	Diphagane
36	Ga-Taine
37	Mohwelere
38	Ga-Mokalape
39	Ga - Chuene
40	Chuenespoort
41	Schuinsrand
42	Matome
43	Mathibela
44	Ga-Maja
45	Ga - Rakgoatha
46	Makweng
47	Moletlane
48	Mogoto
49	Zebediela
22	Mamaolo
20	Thamagane
19	Morotse

Similar considerations as recorded under 1.2.1 above were factored into the assessment of the Polokwane – Jane Furse line with regard to the track portion from Polokwane to the kilometre 267.8 turn-off, where the route is parallel to the classic line route between Polokwane and Mokopane. The intuitive advantages of utilizing the classic line were far outweighed by the negative operational disadvantages. If the existing classic line were to be adapted to provide commuter services alongside the current long-distance Shosholoza Meyl service, then there would be considerable operational constraints due to the technological performance characteristics of the classic line (including the one track nature of the line) as well as the complex mix of existing passenger and freight train on this route section. Classic line running also requires that new line rolling stock is compatible with the current classic line infrastructure.

In terms of construction, there are a few issues that strongly favoured the Polokwane Jane Furse via Zebediela ahead of via Chuenespoort. The alignment through Zebediela traverses through flatter terrain, hence there is no requirement of tunnels.

Equally, environmental considerations weighed decisively in favour of the via Zebediela option. The option via Chuenespoort traverses through area of high environmental sensitivity viz; Bewaarkloof Nature Reserve, Centres of Endemism, vulnerable and endangered eco-systems, heritage areas, whereas there are no such issues via the Zebediela option. Moreover, the option via Zebediela passes through land capable of arable culture and there will be fewer traffic accidents due to terrain conditions

In case of Polokwane –Moloto Corridor, both the options viz. Option 1 via Chuneesport and Option 2 via were modelled. As the demand estimates are higher for the option via Zebediela, it is recommended for as the preferred linkage from demand side (82,438 morning peak hour trips towards Polokwane via Zebediela vis-a-vis 74872 morning peak hour trips towards Polokwane via Chunespoort)for the cardinal year 2050.

In terms of suitability and, although the principal objective of this study is to provide for passenger transport, the detail feasibility should include freight movement capacity along the corridors of the preferred options.

1.2.3 Recommendations: Corridor A: Polokwane –Mokopane Commuter Rail Service and Corridor D: Polokwane –Moloto Passenger Rail Corridor

The Moloto Corridor project was accepted by Cabinet to link Moloto in Mpumalanga to Tshwane with a standard gauge rail line. The corridor could be extended in future via Jane Furse to Burgersfort. The aim of the study is to identify the preferred linkage between Polokwane and Jane Furse. The options to be studied were 1) Polokwane –Chuenespoort-Lebowakgomo - Jane Furse 2) Polokwane - Zebediela – Lebowakgomo- Jane Furse.

Item	Option A (Chuenespoort)	Option B (Zebediela)
Route Overview	1)Passes through mountainous area	1)Topography is relatively flat with no requirement of long tunnels

Item	Option A (Chuenespoort)	Option B (Zebediela)
	2)Major Settlements on the line: Polokwane, Drop, Plaas, , Ga-Rakgoatha, Mmakotse, Lebowakgomo, Lebowakgomo South, Maruleng , Ga-Masemola, Mashabela, Makadikwe, Ga-Marishane, Difapyae, Jane Furse	2)Major Settlements on the line: Polokwane, Plant, Ga-Tshwene, Lebowakgomo, Lebowakgomo South, Maruleng , Ga-Masemola, Mashabela, Makadikwe, Ga-Marishane, Difapyae, Jane Furse
Time Travel of passenger trains	31 minutes	48 minutes
Passenger Demand forecast (year 2050) high estimate	1947457 morning peak hour trips (Towards Polokwane)	2088477 morning peak hour trips (Towards Polokwane)
	152658 morning peak hour trips (Towards Jane Furse)	265037 morning peak hour trips (Towards Jane Furse)
Route Length	Approx 141 km	Approx 150 km
Social and environmental considerations	1) Traverses through area of high environmental sensitivity viz; Bewaarkloof Nature Reserve, Centres of Endemism, vulnerable and dangered eco=systems, heritage areas	1) No such Issue 2) Passes through land capable of arable culture 3)Fewer Traffic Accidents due to Terrain Conditions
Economic ripple effect (Job Creation-construction)	150000 people/during construction period	136066 people/during construction period
ASSESSMENT		**PREFERRED LINKAGE**

Rail Infrastructure and operational detailing has been done for the preferred option. . For determining the collection and distribution services, the existing bus/taxi routes , flow patterns , frequencies etc were surveyed and analyzed. This fed in to the determination of service description viz. Network, location of ranks, fleet required and frequency of operation from the stations to the settlements.

Employment considerations

Implementation of the two new commuter rail links (Polokwane to Mokopane and Polokwane to Jane Furse – linking to the proposed Molto Corridor) will create an estimated 208406 transient jobs during construction and an additional number of permanent jobs during operation that will be detailed in the detail feasibility assessment. Indeed, operations will see more decent and sustainable jobs created than just those within the rail operations. Public transport integration means that a seamless integrated service provision must be achieved. This, in turn, will norm the feeder systems, integrated ticketing, transparent institutional revenue share arrangements, safety and security arrangements, and the like – all leading to sustainable decent employment opportunities.

Integration and industry transition

Two most prominent benefits of the proposed new rail links are the industry transitional effects on the public transport industry in the area as well as the modernization and improvement in the quality and reliability of service provision to the commuters and general travelers along the corridors.

The industry transition will see the current service providers – both bus and taxi operators – become integrated into the formal sector. This will greatly contribute to the sustainability of the small public transport operators currently rendering services on the 2 routes. An indirect but equally critical value addition from the formalization of the businesses will be the widening of the tax net contributing to mitigating any additional fiscal burden that may be required to support both the creation and operation of the new infrastructure. Social benefits include a time-tabled, reliable, secure and comfortable mass transit service provision along the new corridors.

This assessment recommends that the Polokwane – Mokopane rail commuter service (Corridor A) as well as the regional passenger rail service from Polokwane to Jane Furse (Corridor D) be taken forward for detail feasibility consideration when the appropriate market demand indicators are fulfilled in the medium term.

1.3 Definition of Implementation Phases

It is important to adopt an incremental phase approach. By this approach, the changing situation in the province can be taken care of, in 3 stages of implementation. These are defined as time horizons and explained below:

- **Short Term (5-10 Years)**
  - ✓ Demand on both the corridors would be better served by road based public transport mode like taxi, bus and possibly BRT.
  - ✓ LPDRT shares the findings with affected municipalities and PRASA with a view to ensure that the identified alignment is not compromised by conflicting developments and are preserved for future development of rail corridors as identified in the pre-feasibility study.

- **Medium Term (10-20 Years)**

  - ✓ Demand on both the corridors would be better served by road based public transport mode like taxi, bus and possibly BRT; but
  - ✓ LDRT monitors market developments within the identified corridors and when market viability is reached, the rail option on these corridors be reviewed and confirmed through detailed Feasibility Study.
  - ✓ LPDRT shares the findings with affected municipalities and PRASA with a view to ensure that the identified alignment is not compromised by conflicting developments and are preserved for future development of rail corridors as identified in the pre-feasibility study.

- **Long Term(Beyond 20 years)**
  The long term time frame has been segmented in phases to implement rail option along both the corridors.

  Phase 1
  - ✓ to be started as soon as possible in the long term in order to provide a service level as it was originally planned for.
  - ✓ The time horizon will be "as soon as possible", which can be defined realistically as per the targets

  Phase 2
  - ✓ major improvements in quality and quantity of technology and passenger service are outlined now, which will be supplemented by the future results of the development of the country, in first place the demand-structure.

  Phase 3
  - ✓ this will be the perspective for the final layout of the system, showing the maximum of effort to be understandable under today's knowledge.

1.4 Purpose of this Report

This Technical Report contains technical information required according to the scope of the project and in accordance with PRASA and Limpopo DoRT requirements. The content of this document is based on the understanding of the project's scope of work. Once approved by PRASA and Limpopo DoRT , this Technical Report will form the basis upon which the project will be executed.

1.5 Layout of this Document

In pursuing the objectives and scope of the document the outline of the remaining chapters is as follows:

- Chapter 2 provides a description of the general approach and methodology adopted for the project corridors
- Chapter 3 and 4 present the detailing of potential operations for the rail corridors viz; Corridor A Polokwane Mokopane Commuter Service and Corridor D-Polokwane Jane Furse Rail service.

2. METHODOLOGY

2.1 Introduction

The general requirements of operation for all fields of technology are:

- **Safety**, concerning passengers and the systems, mainly being provided by:
  - ✓ high quality trackwork for avoiding derailments
  - ✓ functioning signalling system assisted by telecommunication
  - ✓ well maintained rolling stock

- **Capacity,** concerning the number of trains, which could be run, mainly being provided by:
  - ✓ trackwork without avoidable speed restrictions
  - ✓ appropriate location and length of passing loops
  - ✓ efficient signaling system
  - ✓ sufficient appropriate rolling stock

- **Schedule,** concerning the planning of train runs, mainly being provided by**:**
  - ✓ appropriate organization of track use (priorities, slots)
  - ✓ optimized use of passing loops
  - ✓ realistic running time calculation including time reserves
  - ✓ establishing an optimized overall timetable (including freight trains)
  - ✓ on time information for railway personnel
  - ✓ reliable information for passengers
  - ✓ establishing of transport chains (including feeder systems)

All technical components have to be oriented to these goals in order to provide a safe reliable and efficient overall system. This is valid especially for mixed traffic systems of single track operation with a high percentage of dispatching work besides the existing proposed timetable. For double track systems, as in the Long Term planning, the situation eases a bit due to the much higher possible capacity against a single track line with passing loops.

2.2 Detailed Methodology

The operational planning of a modern railway system is a complex and sophisticated process, wherein with many aspects have to be considered. There is interdependency between infrastructure, rolling stock and the operational service design. The goal of this chapter is to prepare an **Operation Concept**, which is considered to be a frame for the later investigations, which contains a more detailed Operation Program. The Operation Concept concentrates on the dimensioning of the system and thus deals in first place with the relevant peak services (Refer **Figure 7**). It covers the following:

- Defining service runs during peak hours,
- Estimation of according Rolling Stock fleet,
- Operational requirements for line infrastructure

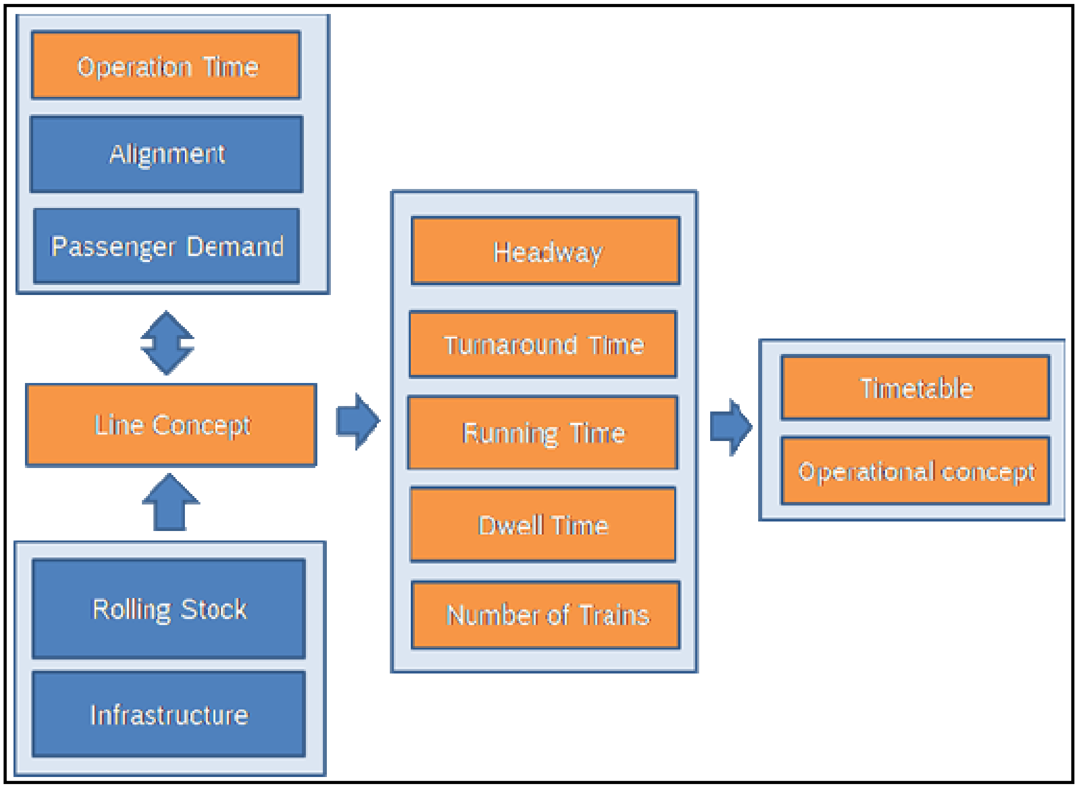


Figure 7: Methodology for Preparation of Operational Concept

The methodology for identification of operational measures for improvement is based on the following:

- **Quality:** necessary for obtaining an attractive and efficient service level,
- **Quantity:** orientating mainly on the demand.

The operational planning procedure at this level covers several consequent steps. A general overview on this procedure is given in **Figure 8.** The main topics are described in detail in the ensuing sections.

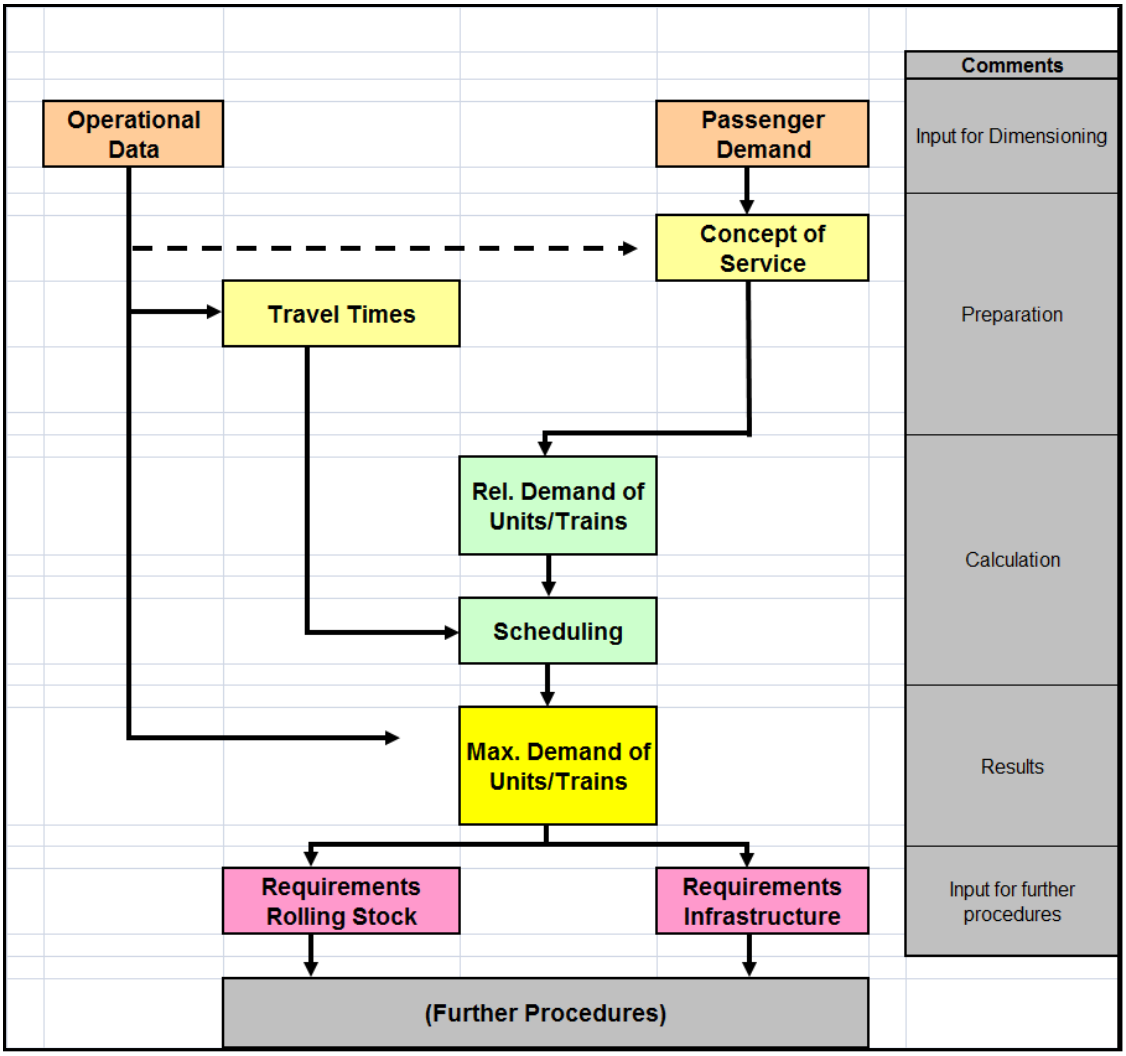


Figure 8: Methodology for dimensioning of Operational System

2.2.1 Demand

3 different time-horizons are looked at, showing the development in demand over the time period until 2050.It has to be clear, that the here given forecast data have to be updated at least every 5 years in order to meet the changes in the actual development of the demand and to cope with the resulting adoptions in the Operation Program, which might cause improvements in Infrastructure and the Rolling Stock fleet.

The analysis of the forecast shows the numbers of embarking and disembarking passengers at each station during peak hours. For defining the **relevant train loads** the numbers of passengers between the stations have to be calculated.

For dimensioning the necessary quantity of Rolling Stock criteria are relevant in first place:

- the direction of the maximum demand at certain times of the day,
- the section of the highest train load during the peak hour.

Regarding both criteria the dimensioning load for the whole line will be defined. Since at the present stage only the demand data of the morning peak and evening are available, all further considerations will be limited to that period of the day.

2.2.2 Rolling Stock Criteria

Since for each of the regarded lines the type of Rolling Stock might be different. For operational purposes the **relevant criteria** are:

- purpose (long distance or commuter service),
- type of vehicles (multiple units of loco hauled trains),
- dynamics-factors (maximum speed, acceleration, deceleration),
- train configuration (composition, length),
- capacity of coaches (seated and standing passengers),
- door access configuration (impact on dwell times).

Valid for all investigations concerning the capacity is the procedure of assigning the critical demand to the proposed Rolling Stock at each line. According to the preconditions, given by PRASA, for dimensioning of the train loads the following criteria are understood:

- Regional service with provision of locomotive hauled trains:
  ✓ 15 coaches per train,
  ✓ capacity: 8.000 passengers per train (crush load),
  ✓ capacity: 533 passengers per coach (crush load),

  ✓ Alternative Approach: multiple unit trains like at Corridor A

2.2.3 Scheduling

At this stage basic **running time estimations** can be made, since neither the accurate dynamics-data of the Rolling Stock nor detailed line and track conditions are given yet. The following procedure of the Iteration Process will cope with these uncertainties.

The **travel time estimations** are based on:

- running time: estimations between terminals, considering the maximum commercial speed,
- time additives: including the additional time for acceleration and deceleration concerning regular stops;
- margin: meant as time tolerance in order to cope with minor delays in service; in general a margin of 5 % of the running time is standard, at the present stage due to the amount of uncertainties a preliminary margin of 10 % is proposed, in order to be on the safe side,
- dwell time: at station in between; important for stations in between, covering disembarking, embarking and technical components like door procedures; a mean value of 1 minute is proposed at the present stage of investigation.

Derived from the maximum load in the peak hour and the proposed capacity of the Rolling Stock the necessary **headway** can be calculated as a theoretical value. It has to be modified (mostly reduced) to become as practical headway a divisible part of an hour.

On this basis a general recommendation will be shown in form of a **graphical schedule** for the peak hour, where the **circulation concept** can be derived from (see below). Since at the present stage only the demand at peak times is available, the considerations will be limited to these periods of the day.

An uneven demand along a line can lead to considerations about the most appropriate **train configuration** for service:

- only long runs between the terminals of a line,
- long runs being supplemented by short runs (at sections of heavy additional demand),
- lengthening / shortening of trains according to individual demand at sections.

2.2.4 Rolling Stock Fleet

The circulation concept in cooperation with the according train configuration leads to dimensioning the **quantity of Rolling Stock** just for service purposes.

Circulation time:

- travel time: see above,
- turn back time: minimum 10 (min),
- circulation time = (travel time + turn back time) x 2,
- should be rounded upwards to plain 10 minutes for the planning process.

Number of trains:

- headways: see above,
- number of trains = circulation time / headway (rounded upwards),

Number of units / coaches:

- number of trains: see above,
- train configuration: see above,
- number of units = number of trains / units per train,
- number of coaches = number of trains / coaches per train.

The joint **reserves** for operation and maintenance have to be added separately (common range: 8 to 10 % of fleet in service), which are here not regarded in the operational dimensioning.

2.2.5 Definition of Speeds

An important distinction has to be made in respect to the definition of the **maximum speed**:

- for the alignment,

- for the Rolling Stock,
- for scheduling and operation.

The latter one is depending on the 2 first ones and is the absolute allowable speed limitation. Since the operation planning for practical purposes usually stays a bit below, the resulting speed is called the “commercial speed”, which means the maximum planning speed for commercial service.

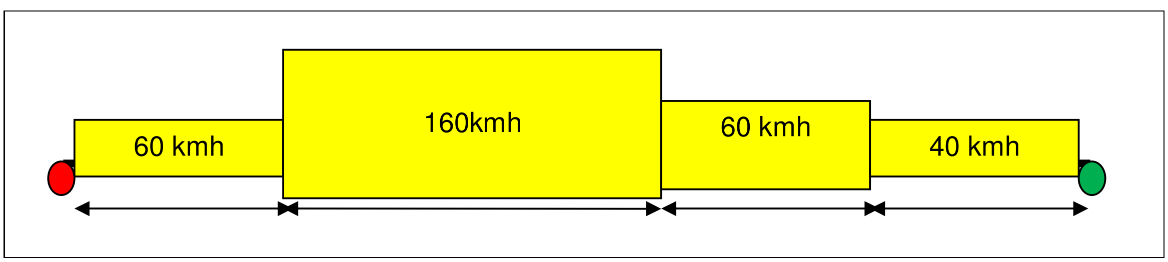
Depending on the distance between station, especially for commuter services with fairly short distances between stations, the commercial speed might be far below the maximum permissible speed due to alignment and the Rolling Stock. In these cases the maximum speed only for operational calculation purposes is reduced to a so called **relevant commercial speed**, which means it is - by rough estimation - the mean value that can be reached between terminals by commercial service.

Figure 9 below shows the line speed profile used to calculate journey times between any 2 stations pairs. Using this profile, journey times between all the station pairs has been calculated using RailSystems and assuming the vehicles have AGV traction and performance characteristics. A notional 2.5% performance allowance was also added to all calculated times.

Assumed speed profile

- 0-15 kilometres from Polokwane: 60kmh
- 15 - 85 kilometres from Polokwane (Express Service):160kmh
- 30 kilometres from destination:60kmh
- 10 kilometres from destination :40kmh

Figure 9: Assumed Speed Profile



2.2.6 Requirements for Infrastructure

Beyond the **speed** requirements, which define the general alignment, the graphical schedule in general shows the necessity for:

- number and location of passing loops (only valid for single track lines),
- sections of double track line.

- Secure Corridor (e.g by fencing) – to increase to at least the design speed of 120km and more, it is necessary to insure that the corridor is fenced to avoid possible incidence.
- All station platforms are assumed to accommodate train lengths varying between 300 -402 m. However in this assessment, the maximum train length is assumed is 402 m

Infrastructural components have to cope with these requirements, in first place the alignment, track layout and the signaling. Where ever it is possible, **level crossings** should be avoided while, it is essential for speeds beyond 120 km/h.

2.3 Definition of Implementation Phases

It is important to adopt an incremental phase approach. By this approach, the changing situation in the province can be taken care of in 3 stages of implementation. These are defined as time horizons and explained below:

- **Short Term (5-10 Years)**

  - Demand on both the corridors would be better served by road based public transport mode like taxi, bus and possibly BRT.
  - LPDRT shares the findings with affected municipalities and PRASA with a view to ensure that the identified alignment is not compromised by conflicting developments and are preserved for future development of rail corridors as identified in the pre-feasibility study.

- **Medium Term (10-20 Years)**

  - Demand on both the corridors would be better served by road based public transport mode like taxi, bus and possibly BRT; but
  - LDRT monitors market developments within the identified corridors and when market viability is reached, the rail option on these corridors be reviewed and confirmed through detailed Feasibility Study.
  - LPDRT shares the findings with affected municipalities and PRASA with a view to ensure that the identified alignment is not compromised by conflicting developments and are preserved for future development of rail corridors as identified in the pre-feasibility study.

- **Long Term(Beyond 20 years)**

  The long term time frame has been segmented in phases to implement rail option along both the corridors.

Phase 1

- to be started as soon as possible in the long term in order to provide a service level as it was originally planned for.
- The time horizon will be "as soon as possible", which can be defined realistically as per the targets

Phase 2

- major improvements in quality and quantity of technology and passenger service are outlined now, which will be supplemented by the future results of the development of the country, in first place the demand-structure.

Phase 3

- this will be the perspective for the final layout of the system, showing the maximum of effort to be understandable under today's knowledge.

3. DETAILING OF OPERATIONS FOR RAIL SERVICES FOR CORRIDOR A- POLOKWANE MOKOPANE COMMUTER SERVICE

3.1 General Characteristics

The existing line (for overview see **Figure 10**) is a **single track line** with some passing loops. Before doing any calculation, originally it was expected, that the line - after an upgrading in respect to its condition - might be able to handle the additional commuter service without major specific improvements. This assumption has to undergo a severe test

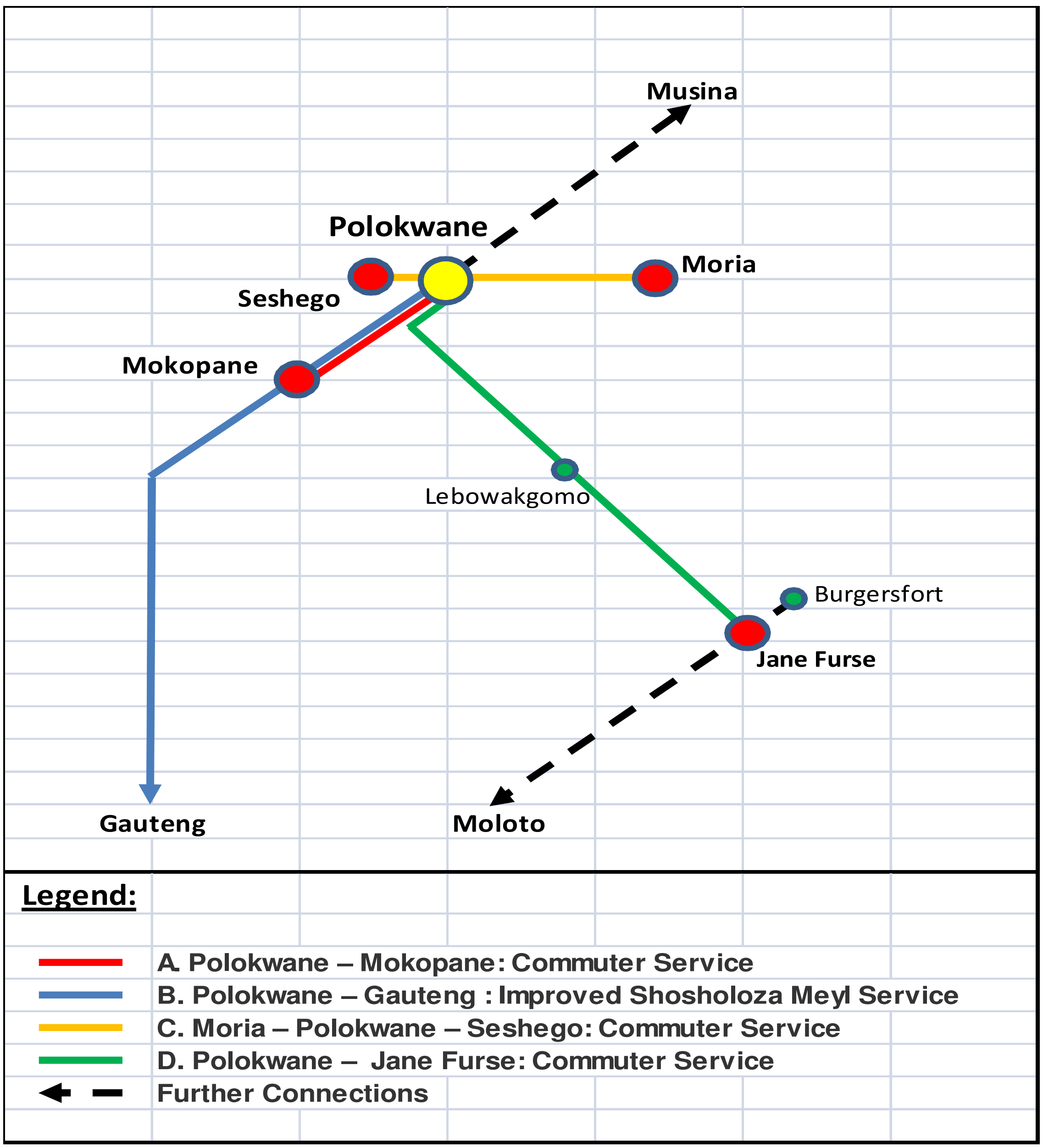


Figure 10: Network Overview

in here.

The type and the capacity of the new **Rolling Stock** for the commuter service is still unknown, so it is understood at present, that it might be of the same type as the commuter-trains presently used for Gautrain (see **Table 1**):

- Multiple units trains consisting of up to 3 units,
- One unit contains 4 coaches,
- Capacity of one coach is assumed to be about 330 passengers (seated and standing, meant as crush load),
- Units powered by 25 % driven axles,
- Maximum commercial speed 160 km/h.

Table 1: Overview of Rolling Stock

Corridor	Criteria	Assumption	Comments
A. Polokwane – Mokopane: Commuter Service			
	Type:	Multiple Unit trains	
	Composition:	3 MU á 4 coaches = 12 coaches	
	Length:	260 m	
	Propulsion:	25 % driven axles	better 50%
	Power:	25 kV AC	
	Capacity:	3965	crush load
	Max. Speed:	160 km/h	minimum: 140 km/h

3.2 Planning Approach

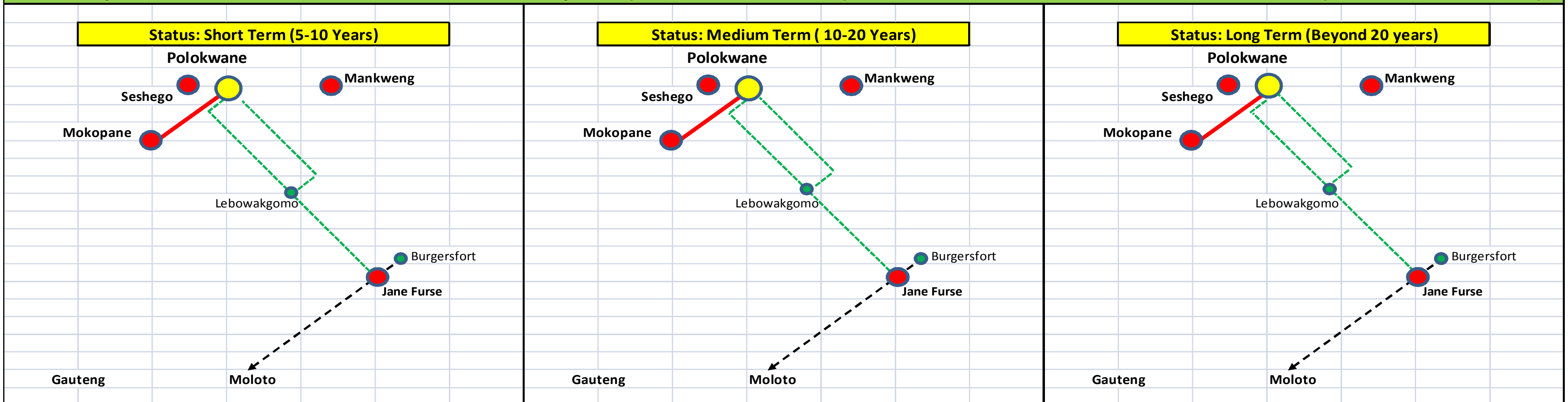
As mentioned above, for dimensioning the demand of the peak hour in maximum load direction is relevant. From the given numbers of embarking and disembarking passengers, the actual load in a train between stations is derived. The section with the heaviest load is **dimensioning section**. As dimensioning value the **morning peak** from Mokopane towards Polokwane is chosen, where the highest data were available.

By assuming the service of trains with maximum length (consisting of 3 units) a **capacity** of 3.965 passengers per train is possible (**Table 1**). The dimensioning load divided by this maximum demand results in the number of **necessary runs** per peak hour and direction.

This result again is leading to the **headways**, where the theoretical value has to be modified to a practical one, which comes close to an even factor of an hour.The possible development of the Corridor A for the various time horizons is shown in **Figure 11.**

Figure 11: Development of Corridor A: Polokwane –Mokopane Commuter Service

Development of Corridor A: Polokwane – Mokopane (Commuter Service) and Corridor D: Polokwane – Jane Furse (Commuter Service)



Legend:	Legend:	Legend:
A. Polokwane – Mokopane: Commuter Service; and D. Polokwane – Jane Furse - demand better served by road based public transport mode like Taxi, Bus and possibly BRT Further Connections	A. Polokwane – Mokopane: Commuter Service: D. Polokwane – Jane Furse - demand better served by road based public transport mode like Taxi, Bus and possibly BRT; but - LDRT monitors market developments within the identified corridors and when market viability is reached , the rail option on these corridors be reviewed and confirmed through detailed Feasibility Study LDRT shares the findings with the affected local authorities and PRASA with a view to ensure that the identified alignment is not compromised by conflicting developments and are preserved for future development of rail corridors as identified in the pre-feasibility study Further Connections	A. Polokwane – Mokopane: Commuter Service: D. Polokwane – Jane Furse Implementation of the following possibly underway: 1) standard gauge single track or doubletrack line after verification of travel demand, 2) Vmax =160 kmph,3) no additional sidings, 4)change of track only at stations Further Connections

3.3 Long Term (Beyond 20 years)-Phase 1

The first step was to integrate the use of the existing single track line into the new commuter service. It has to be checked, if this option might be valid regarding the demand data given by the forecast. Issues of infra ownership and interface with TFR which are a major problem at this stage, should be suggested to be resolved at Medium-term stage during the recommended detailed feasibility.

3.3.1 Joint use of existing single track line

This term is considered to be the starting point of the development process for the corridor by a new commuter service. Various permutations of speed were done for the corridor. From the basic data, given in **Table 2** the travel times and circulation times can be derived:

The **travel time** between the terminals is the sum of the 4 time factors:

- Running time: 43 min (rough estimation for 90 km/h),
- Time additive: 9 min (rough estimation),
- Time margin: 5 min (10 % of running time + time additive),
- Dwell times: 8 min (1 min for each of the 8 stations in between),
- Travel time: 65 min (sum of before).

The **circulation time** is twice the travel time plus turnback:

- Travel time: 65 min (see above),
- Turnback time: 10 min (standard value),
- Circulation time: 150 min (= 2 x the sum of before)

Table 2: Basic Data for Commuter Service

Route		Distance	Run-time (120)	Time additive	Margin	Dwell time	Travel-time
		(km)	(min)	(min)	(min)	(min)	(min)
Maximum Commercial Speed: 90 km/h							
Mokopane	1	0		-		-	
Mokopane - Commuter Station 1	2	6.75		1		1	
Commuter Station 1 - Commuter Station 2	3	2.88		1		1	
Commuter Station 2 - Commuter Station 3	4	10.00		1		1	
Commuter Station 3 - Commuter Station 4	5	5.08		1		1	
Commuter Station 4 - Commuter Station 5	6	12.19		1		1	
Commuter Station 5 - Commuter Station 6	7	14.37		1		1	
Commuter Station 6 - Commuter Station 7	8	9.60		1		1	
Commuter Station 7 - Commuter Station 8	9	1.65		1		1	

Route		Distance	Run-time (120)	Time additive	Margin	Dwell time	Travel-time
Commuter Station 8 - Polokwane	10	2.27		1		-	
Total		**65**	**43**	**9**	**5**	**8**	**65**
Mean Commercial Speed: 120 km/h							
Mokopane	1	0		-		-	
Mokopane - Commuter Station 1	2	6.75		1.5		1	
Commuter Station 1 - Commuter Station 2	3	2.88		1.5		1	
Commuter Station 2 - Commuter Station 3	4	10.00		1.5		1	
Commuter Station 3 - Commuter Station 4	5	5.08		1.5		1	
Commuter Station 4 - Commuter Station 5	6	12.19		1.5		1	
Commuter Station 5 - Commuter Station 6	7	14.37		1.5		1	
Commuter Station 6 - Commuter Station 7	8	9.60		1.5		1	
Commuter Station 7 - Commuter Station 8	9	1.65		1.5		1	
Commuter Station 8 - Polokwane	10	2.27		1.5		-	
Total		**65**	**33**	**14**	**4**	**8**	**59**
Mean Commercial Speed: 140 km/h							
Mokopane	1	0		-		-	
Mokopane - Commuter Station 1	2	6.75		1.7		1	
Commuter Station 1 - Commuter Station 2	3	2.88		1.7		1	
Commuter Station 2 - Commuter Station 3	4	10.00		1.7		1	
Commuter Station 3 - Commuter Station 4	5	5.08		1.7		1	
Commuter Station 4 - Commuter Station 5	6	12.19		1.7		1	
Commuter Station 5 - Commuter Station 6	7	14.37		1.7		1	
Commuter Station 6 - Commuter Station 7	8	9.60		1.7		1	
Commuter Station 7 - Commuter Station 8	9	1.65		1.7		1	
Commuter Station 8 - Polokwane	10	2.27		1.7		-	
Total		**65**	**28**	**16**	**4**	**8**	**56**
Maximum Commercial Speed: 160 km/h							
Mokopane	1	0		-		-	
Mokopane - Commuter Station 1	2	6.75		2		1	
Commuter Station 1 - Commuter Station 2	3	2.88		2		1	
Commuter Station 2 - Commuter Station 3	4	10.00		2		1	
Commuter Station 3 - Commuter Station 4	5	5.08		2		1	
Commuter Station 4 - Commuter Station 5	6	12.19		2		1	
Commuter Station 5 - Commuter Station 6	7	14.37		2		1	
Commuter Station 6 - Commuter Station 7	8	9.60		2		1	
Commuter Station 7 - Commuter Station 8	9	1.65		2		1	
Commuter Station 8 - Polokwane	10	2.27		2		-	
Total		**65**	**24**	**18**	**4**	**8**	**54**

The **relevant data of the demand** are shown in **Table 3**. The operational dimensioning according to the above mentioned description leads to:

- Dimensioning load: 13,600 (passengers),
- Necessary trains: 4 (per peak hour and direction),
- Headway: 7,5 min (per peak hour).

The maximum **number of units** being in service will be derived from the circulation time divided by the headway with 3 units per train:

- Circulation time: 150 min (see above),
- Headway: 7,5 min (see above),
- Number of trains: 10 (in service),
- Number of units: 60 (in service).

For the **unit-kilometres** per day the above mentioned assumption, that the peak hour kilometres are about 10 % of the daily ones, is leading to:

- Trains per peak hour: 8 (both directions),
- Distance: 65 km (one way),
- Train-kilometres: 0.520 km (per peak hour),
- Train-kilometres: 5.200 km (per day),
- Unit-kilometres: 15.600 km (per day).

Table 3: Dimensioning of Operational System (Long Term-Beyond 20 years)-Phase 1

Dimensioning / Peak Hour		
Passengers	**13 600**	maximum load of peak hour
Coaches needed	**41**	capacity of each coach: 330 pass.
Units needed	**10**	1 unit consists of 4 coaches
Trains needed	**1**	1 train consists of 3 units
Headway (min)	**60.00**	minimum (theoretical)
Headway (min)	**7.5**	set (practical)
Trains given	**4**	1 train consists of 3 units
Units given	**12**	1 unit consists of 4 coaches
Coaches given	**48**	capacity of each coach: 330 pass.
Capacity	**15 840**	possible limit
Reserve (pass.)	**2 240**	free capacity
Results:	**- double track line sufficient for all services** **- headway convenient for commuter service**	

For **infrastructure** ,the results lead to the following requirements:

- The existing single track line with passing loops is not sufficient, not even in cooperation with another single track line to be built,

- A continues new single track line required for commuter service only in addition to the existing line, due to short headways during peak service,
- Stable system by operational separation of different services given (no mutual interferences),
- Best solution: separate single track line for commuter service only (already designed for 160 km/h, see below), in addition to existing single track line being used by freight and Shosholoza Meyl services.

3.3.2 Additional single track line

Since it is obvious, that the existing single track line cannot meet the need of the commuter service, the additional single track line is needed only for commuter service and should be planned right away for a **maximum speed of 160 km/h**. However it should be kept in mind, that the maximum speed of the alignment can be reduced in the vicinity of stations.

The comparison of various speeds, base for the travel time calculation, shows in **Table 2**, that the difference between a maximum speed of 160 km/h and a mean commercial speed is not significant. Therefore, to be on the safe side for calculation, the relevant speed will be set to 140 km/h.

Due to the higher commercial speed the running times will be reduced, leading to shorter circulation times and thus to a smaller Rolling Stock fleet.

From the new basic data, given in **Table 2** the travel times and circulation times can be derived:

The **travel time** between the terminals is the sum of the 4 time factors:

- Running time: 28 min (rough estimation for 140 km/h),
- Time additive: 16 min (rough estimation),
- Time margin: 4 min (10 % of running time + time additive),
- Dwell times: 8 min (1 min for each of the 8 stations in between),
- Travel time: 56 min (sum of before).

The **circulation time** is twice the travel time plus turnback:

- Travel time: 56 min (see above),
- Turn back time: 10 min (standard value),
- Circulation time: 130 min (= 2 x the sum of before

The **relevant data of the demand** are shown in **Table 3**. The operational dimensioning according to the above mentioned description leads to:

- Dimensioning load: 16300 (passengers),
- Necessary trains: 4 (per peak hour and direction),
- Headway: 7,5 min (per peak hour).

The maximum **number of units** being in service will be derived from the circulation time divided by the headway with 3 units per train:

- Circulation time: 130 min (see above),
- Headway: 7,5 min (see above),
- Number of trains: 18 (in service),
- Number of units: 54 (in service).

For the **unit-kilometers** per day the above mentioned assumption, that the peak hour kilometers are about 10 % of the daily ones, is leading to:

- Trains per peak hour:8 (both directions),
- Distance: 65 km (one way),
- Train-kilometers: 0.520 km (per peak hour),
- Train-kilometers: 5.200 km (per day),
- Unit-kilometers: 15.600 km (per day).

For **infrastructure** the according results are leading to the following requirements:

- separate single track line for commuter service only (already designed for 160 km/h), in addition to existing single track line being used by freight and Shosholoza Meyl services,
- very stable system by operational separation of different services, no mutual interferences.

3.4 Long Term (Beyond 20 years) –Phase 2

This term is considered to be the next step of the development process for the corridor by extending the commuter service. A joint service for commuters together with freight and Shosholoza Meyl is ruled out due to the high forecast data. The **mean commercial speed is set to 140 km/h,** according to the requirements of PRASA for the maximum speed of 160 km/h..

From the basic data, given in **Table 2** the travel times and circulation times can be derived:

The **travel time** and **circulation time** are the same as in earlier sections for the Short Term:

- Travel time: 56 min,
- Circulation time: 130 min.

The **relevant data of the demand** are shown in **Table 4**. The operational dimensioning according to the above mentioned description leads to:

- Dimensioning load: 34.250 (passengers),

- Necessary trains: 10 (per peak hour and direction),
- Headway: 3,0 min (per peak hour).

The maximum **number of units** being in service will be derived from the circulation time divided by the headway with 3 units per train:

- Circulation time: 130 min (see above),
- Headway: 3,0 min (see above),
- Number of trains:44 (in service),
- Number of units: 132 (in service).

For the **unit-kilometres** per day the above mentioned assumption, that the peak hour kilometres are about 10 % of the daily ones, is leading to:

- Trains per peak hour: 20 (both directions),
- Distance: 65 km (one way),
- Train-kilometres: 1.300 km (per peak hour),
- Train-kilometres: 13.000 km (per day),
- Unit-kilometres: 39.000 km (per day).

For **infrastructure** the according results are leading to the following requirements:

- No changes or adaptations necessary compared to short term.
- Continues double track line for commuter service exclusively, due to very short headways during peak service, not to be used by other services at any time,

Table 4: Dimensioning of Operational System –Long Term (Beyond 20 years)-Phase 2

Dimensioning / Peak Hour		
Passengers	**34 250**	maximum load of peak hour
Coaches needed	**104**	capacity of each coach: 330 pass.
Units needed	**26**	1 unit consists of 4 coaches
Trains needed	**4**	1 train consists of 3 units
Headway (min)	**15.00**	minimum (theoretical)
Headway (min)	**3**	set (practical)
Trains given	**10**	1 train consists of 3 units
Units given	**30**	1 unit consists of 4 coaches
Coaches given	**120**	capacity of each coach: 330 pass.
Capacity	**39 600**	possible limit
Reserve (pass.)	**5 350**	free capacity
Results:	**- single track line for commuter service only**	
	- headway standard	

3.5 Long Term (Beyond 20 years) –Phase 3

This term is considered to be the final step of the development process for the corridor for extending the commuter service. Only a "theoretical" calculation on demand and its operational and infrastructural consequences can be done. It has to be kept in mind, that all results are subject to changes in demand, because of the long time period till 2050!

From the basic data, given in **Table 2** the travel times and circulation times can be derived, which here are identical with the ones of the Medium Term:

- Travel time: 56 min (sum of before).
- Circulation time: 130 min.

The **relevant data of the demand** are shown in **Table 5**. The operational dimensioning according to the above mentioned description leads to:

- Dimensioning load: 61000 (passengers),
- Necessary trains: 30 (per peak hour and direction),
- Headway: 2,0 min (per peak hour),
- Altogether 1 parallel single track lines would be necessary to cope with these demand figures.

The maximum **number of units** being in service will be derived from the circulation time divided by the headway with 3 units per train:

- Circulation time: 130 min (see above),
- Headway: 2,0 min (2 x, see above),
- Number of trains: 130 (in service),
- Number of units: 390 (in service).

For the **unit-kilometres** per day the above mentioned assumption, that the peak hour kilometres are about 10 % of the daily ones, is leading to:

- Trains per peak hour: 60 (both directions),
- Distance: 65 km (one way),
- Train-kilometres: 3.900 km (per peak hour),
- Train-kilometres: 39.000 km (per day),
- Unit-kilometres: 117.000 km (per day).

For **infrastructure** the above mentioned results lead to the following requirements:

- The former single track line, for commuter service exclusively required, is not sufficient Hence,
- due to the demand 1 additional single track line only for the commuter service has to be built, which at best is designed with different routing in order to cover the a larger area.

Table 5: Dimensioning of Operational System –Long Term (Beyond 20 years)-Phase 3

Dimensioning / Peak Hour		
Passengers	**61 000**	maximum load of peak hour
Coaches needed	**185**	capacity of each coach: 330 pass.
Units needed	**46**	1 unit consists of 4 coaches
Trains needed	**30**	1 train consists of 3 units
Headway (min)	**2.00**	minimum (theoretical)
Headway (min)	**2**	set (practical), 2 lines
Trains given	**30**	1 train consists of 3 units
Units given	**90**	1 unit consists of 4 coaches
Coaches given	**360**	capacity of each coach: 330 pass.
Capacity	**118 800**	possible limit
Reserve (pass.)	**57 800**	free capacity
Results:	**- 2,0 min headway close to limit** **- implementation of 1 more line necessary**	

3.6 Overview on Operational Results

The major results of the dimensioning concerning the Operation Concept in all 3 time horizons are summarized in **Table 6,** for giving a better overview on the planning status.

Table 6: Overview of Operations Measures for Improvement

Topic	Dimension	Long Term*-Phase 1	Long Term**-Phase 1	Long Term-Phase 2	Long Term ***-Phase 3	Comments
Demand	phd	13 600	13 600	34 250	61 000	given by Forecast
Peak	-	morning	morning	morning	morning	for dimensioning
Direction	-	M - P	M - P	M - P	M - P	for dimensioning
Distance	km	65	65	65	65	derived from Google
Max. speed	km/h	90	160	160	160	for commercial service
Travel time	min	65	56	56	56	per train
Circulation time	min	150	130	130	130	per train
Headway (th.)	min	8.7	8.7	3.47	0.98	theoretical value
Headway (pr.)	min	8	8	3	2 x 2	practical value
Nr. of trains	in service	10	10	20	60	train of 3 units

Topic	Dimension	Long Term*- Phase 1	Long Term**- Phase 1	Long Term- Phase 2	Long Term ***- Phase 3	Comments
Nr. of units	in service	60	54	132	390	unit of 4 coaches
Train-kilometers	km/day	5 200	5 200	13 000	39 000	rough estimation
Unit-kilometers	km/day	15 600	15 600	39 000	117 000	rough estimation
Number of single tracks	-	1 x -	- 1 x	- 1 x	- 2 x	mixed service, commuter service only
Legend:	phd:	passengers per peak hour and direction				
-	*:	with single track line of joint use: commuter + freight +Shosholoza Meyl				
-	**:	with single track line for commuter service only				
-	***:	only of theoretical interest				

3.6.1 Recommendations for Rolling Stock

With the assumption of Polokwane being a regional pivot, independent of the time horizon it is recommended to consider a higher grade of **propulsion** for the Rolling Stock for the commuter units. It should be raised from 25% to 50%, leading to a configuration for the units of:

- Motor car – Trailer –Trailer –Motor car.

The higher grade of propulsion would lead to a faster and more flexible service with comfortable time tolerances, while keeping the proposed maximum speed of 160 km/h. Thus the schedules could get a higher degree of stability, which is of advantage for both passengers and the operator.

Such a solution also would allow to chip in 1 or 2 additional trailers, being more flexible if new service patterns would arise.

In general it is recommended to procure standard type units for 160 km/h maximum speed. This requires also an alignment for 160 km/h.

In case the alignment has to be limited to 120 km/h due to the structure of the landscape or the available space, tilting trains with a maximum speed of 160 km/h could be an appropriate solution.

3.6.2 Recommendations for Infrastructure from an Operational Perspective

It is obvious, that the present single track line, even in an upgraded and renovated form, will not be able to handle any additional commuter service, not even in the beginning. Since the forecast delivers such high increases in demand for all given time horizons, an enormous effort (organizational and financial) is required in order to cope with these challenges in an appropriate way.

Summarizing the line configuration and its use by the various rail-services for the given 3 time horizons is shown in Figure 5. The following recommendations are based on the previous investigations:

3.6.2.1 Long Term (Beyond 20 Years)-Phase 1

- upgrading of the condition of the existing single track line (Vmax = 90 km/h),
- construction of a new parallel single track line (at minimum) with Vmax = 120 km/h, both lines together for joint use of various services, except peak hours (critical operational conditions),
- Better option:
    - construction of a **new single track** line with Vmax = 160 km/h only for commuter service (optimized operational conditions with mean commercial speed of 140 km/h), being sufficient already for the requirements of 2030.
    - In this case of the new single track line, it already should be built with **Standard Gauge**, being compatible with the intensions for the new line between Polokwane and Jane Furse.

3.6.2.2 Long Term (Beyond 20 Years)-Phase 2

- upgrading of the commercial speed of the old existing single track line (Vmax = 120 km/h),
- upgrading of the new parallel single track line (with Vmax = 120 km/h) to a double track line only for commuter service,
- Better Option:
    - no additional activities necessary if int the Short Term a single track line for commuter service already was implemented (see above).

3.6.2.3 Long Term (Beyond 20 Years)-Phase 3

- in general a major update concerning the forecast is inevitable, which could lead to diverging solutions in respect to the ones given in here:
- upgrading of the old existing single track line (Vmax = 120 km/h) into a double track line for freight and long distance services,
- implementation of 1 additional single track line just for commuter services, since the headways, derived from the given forecast, require this ultimately.
- these new lines should not be run parallel, but finding an alternative routing serving the entire population in a more appropriate way by a better coverage.

4. DETAILING OF OPERATIONS FOR RAIL SERVICES FOR CORRIDOR D- POLOKWANE JANE FURSE

4.1 General Characteristics

The corridor between Polokwane and Jane Furse will be subdivided for the operational investigation into **2 sections**, due to significant different demand and possible alternative routing:

- Polokwane – Lebowakgomo (mainly commuter service),
- Lebowakgomo – Jane Furse (mainly regional service).
- For the section Polokwane – Lebowakgomo , the preferred option is through
- via Ga- Rakgoatha (a bit longer than Chuenespoort).

In terms of construction, there are a few issues that strongly favoured the Polokwane Jane Furse via Zebediela ahead of via Chuenespoort. The alignment through Zebediela traverses through flatter terrain, hence there is no requirement of tunnels.

Equally, environmental considerations weighed decisively in favour of the via Zebediela option. The option via Chuenespoort traverses through area of high environmental sensitivity viz; Bewaarkloof Nature Reserve, Centres of Endemism, vulnerable and endangered eco-systems, heritage areas, whereas there are no such issues via the Zebediela option. Moreover, the option via Zebediela passes through land capable of arable culture and there will be fewer traffic accidents due to terrain conditions

In case of Polokwane –Moloto Corridor, both the options viz. Option 1 via Chuneesport and Option 2 via were modelled. As the demand estimates are higher for the option via Zebediela, it is recommended for as the preferred linkage from demand side (82,438 morning peak hour trips towards Polokwane via Zebediela vis-a-vis 74872 morning peak hour trips towards Polokwane via Chunespoort)for the cardinal year 2050.

In terms of suitability and, although the principal objective of this study is to provide for passenger transport, the detail feasibility should include freight movement capacity along the corridors of the preferred options.

This assessment recommends that the regional passenger rail service from Polokwane to Jane Furse (Corridor D) be taken forward for detail feasibility consideration when the appropriate market demand indicators are fulfilled in the medium term. Part of this investigation is to give recommendations from the operational side in order to find the most appropriate solution.

The type and the capacity of the soon to be acquired new rolling stock are unknown. So the following assumptions are proposed at present **(Table 7):**

- Locomotive hauled trains,
- Trains consisting of up to 15 coaches,

- Capacity of one coach is assumed to be about 533 passengers (seated and standing, meant as crush load),
- Maximum commercial speed 160 km/h,
- Due to connections in Jane Furse to the Moloto Corridor, standard gauge is preferred for this line.

Table 7: Overview of Rolling Stock

Corridor	Criteria	Assumption	Comments
D. Polokwane – Jane Furse: Commuter Service			
	Type:	loco-hauled trains	
	Composition:	15 coaches	double deck coaches
	Length:	320	
	Propulsion:	2	number of locos
	Power:	25 kV AC	
	Capacity:	8000	crush load
	Max. Speed:	160 km/h	minimum: 140 km/h
	Alternativ:		
	Type:	Multiple Unit trains	like Corridor A
Based on these preconditions and the forecast-data, the size of the fleets per Corridor is calculated			

4.2 Planning Approach

As mentioned above for dimensioning only the demand of the peak hour in maximum load direction is relevant. From the given numbers of embarking and disembarking passengers the actual load in a train between stations is derived. The section with the heaviest load is **dimensioning section**. As dimensioning value, the **evening peak** from Polokwane towards Jane Furse is proposed, where the most critical data were available.

By assuming the service of trains with maximum length (consisting of 15 coaches) a **capacity** of 8000 passengers per train (absolute “crush load”) is understood, according to international standard, which are also approved by PRASA. The dimensioning load of the peak hour divided by this maximum capacity results in the number of **necessary runs** per peak hour and direction. This result again is leading to the **headways**, where the theoretical value has to be modified to a practical one, which comes close to an even factor of an hour.

As mentioned above, it is most favourable to divide the investigation in two parts and look at them separately for dimensioning, because the demand differs significantly at both sections:

- Polokwane to Lebowakgomo,
- Lebowakgomo to Jane Furse.

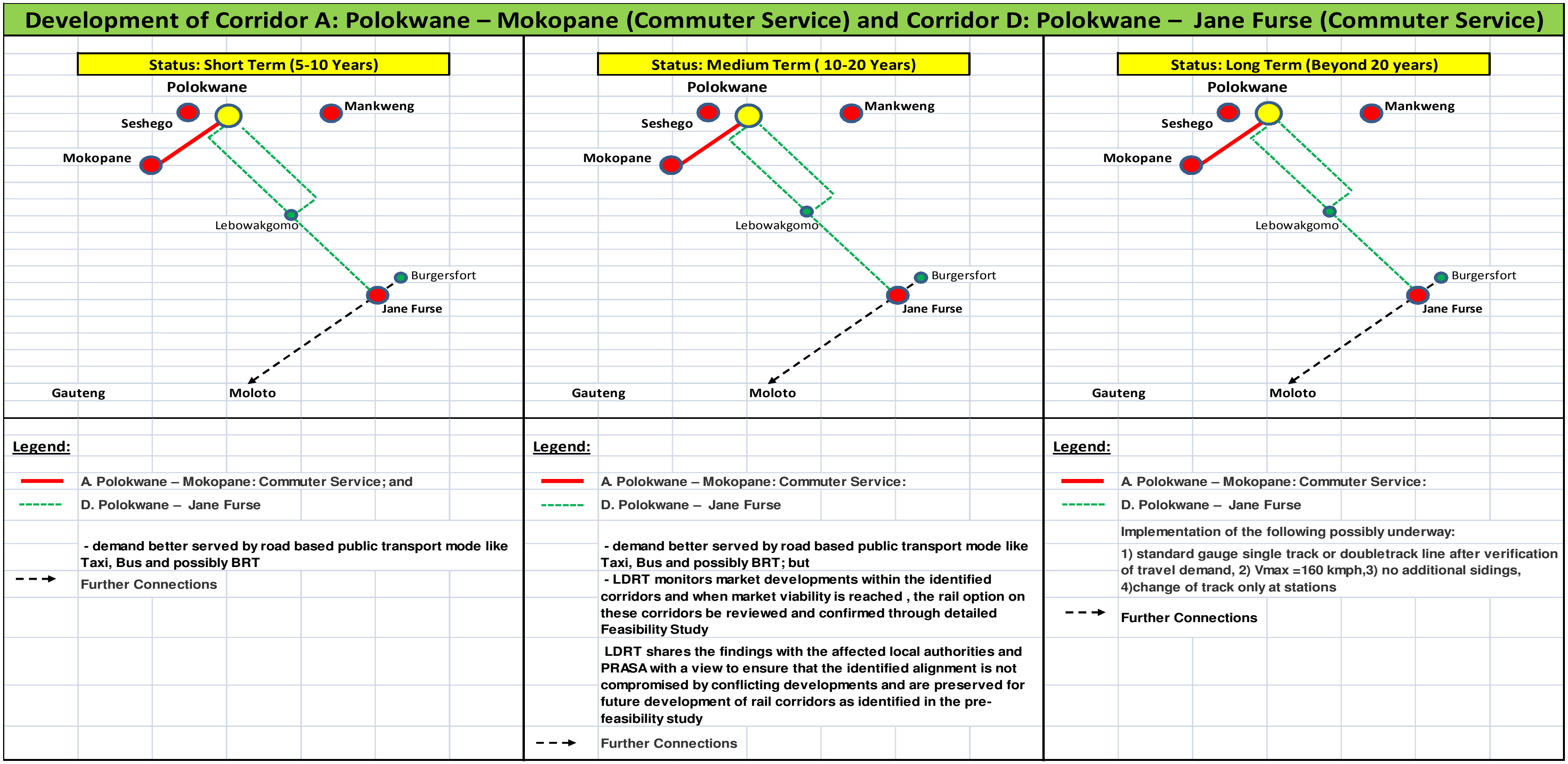
Of course the proposals given on that basis have to be compatible.

For dimensioning the 2 sections are looked at separately, although in later operation the trains serve the whole line:

- All trains run between Polokwane – Lebowakgomo,
- Each second or third train continues to serve Lebowakgomo to Jane Furse.

The headways for both sections have to match. Exceptions can be made, if the headways are very short.

Figure 12: Development of Corridor D: Polokwane –Jane Furse Rail Service



4.3 Long Term (Beyond 20 years)-Phase 1

This term is considered to be the starting point of the development process for the corridor by a new commuter service.

4.3.1 Section: Polokwane - Lebowakgomo

From the basic data, given in **Table 8** the travel times and circulation times can be derived:

The **travel time** between the terminals is the sum of the 4 time factors:

- Running time: 27 min (rough estimation),
- Time additive: 10 min (rough estimation)
- Time margin: 4 min (10 % of running time + time additive),
- Dwell times: 8 min (2 min for each station in between),
- Travel time: 49 min (sum of before).

The **circulation time** is twice the travel time plus turn back:

- Travel time: 49 min (see above),
- Turn back time: 10 min (standard value),
- Circulation time: 120 min.

Table 8: Basic Data for Commuter Service

Vmax = 160 km/h								
Route		**Distance**	**Run-time**	**Time additive**	**Margin**	**Dwell time**	**Travel-time**
		(km)	(min)	(min)	(min)	(min)	(min)
Polokwane to Lebowakgomo via Ga-Chuene							
Polokwane	1	0		-		-	
Polokwane - Ga- Chuene	2	36.06		2		2	
Ga- Chuene - Lebowakgomo	3	13.16		2		2	
Total		**49.22**	**19**	**4**	**2**	**4**	**29**
Polokwane to Lebowakgomo via Ga- Rakgoatha							
Polokwane	1	0.00		-		-	
Polokwane - Commuter Station 8	2	2.27		2		2	
Commuter Station 8 - Commuter Station 7	3	1.65		2		2	
Commuter Station 7 - Ga-Rakgoatha	4	53.63		2		1	
Ga-Rakgoatha - Mmakotse	5	9.16		2		1	
Mmakotse - Lebowakgomo	6	3.30		2		2	

Total		70.01	27	10	4	8	49
Lebowakgomo to Jane Furse							
Lebowakgomo - Lebowakgomo South	7	5.85		2		2	
Lebowakgomo South - Marulaneng	8	11.61		2		1	
Marulaneng - Ga-Masemola	9	14.65		2		1	
Ga-Masemola - Mashabela	10	14.22		2		1	
Mashabela - Makadikwe	11	7.80		2		1	
Makadikwe - Ga-Marishane	12	3.31		2		1	
Ga-Marishane - Difapyae	13	8.18		2		1	
Difapyae - Jane Furse	14	5.42		2		1	
Total		71.04	27	16	5	9	57

The **relevant data of the demand** are shown in **Table 9**. The operational dimensioning according to the above mentioned description leads to:

- Dimensioning load: 26.288 (passengers),
- Necessary trains: 2 (per peak hour and direction),
- Headway: 36.60 minutes (per peak hour).

The maximum **number of trains** being in service will be derived from the circulation time divided by the headway:

- Circulation time: 120 min (see above),
- Headway: 30 min (see above),
- Number of trains: 2 (in service),
- Number of coaches: 30 (in service).

For the **train-kilometres** per day the above mentioned assumption, that the peak hour kilometres are about 10 % of the daily ones, is leading to:

- Trains per peak hour: 8 (both directions),
- Distance: 70 km (one way),
- Train-kilometres: 560 km (per peak hour),
- Train-kilometres: 5.600 km (per day),

For **infrastructure** the according results are leading to the following requirements:

- Continuous single track line required, due to headways during peak service,
- No other use by freight or long distance trains during peak service recommended initially, can be considered in later stages
- During off-peak hours, mixed operation requires sensitive handling of operations with optimized signalling system (essential).

Table 9: Dimensioning of Operational System (LongTerm-Beyond 20 years)-Phase 1

Dimensioning / Peak Hour		
Section: Polokwane - Lebowakgomo		
Passengers	**13 000**	maximum load of peak hour
Coaches needed	**25**	crush load of each coach: 533 pass.
Trains needed	**2**	1 train consists of 15 coaches
Headway (min)	**36.69**	minimum (theoretical)
Headway (min)	**30**	set (practical)
Trains given	**2**	1 train consists of 15 coaches
Coaches given	**30**	crush load of each coach: 533 pass.
Capacity	**15 900**	possible limit
Reserve (pass.)	**2 900**	free capacity
Results:	**- single track line for all services** **- headway comfortable**	

For **infrastructure** the according results are leading to the following requirements:

- Continuous single track line required, due to headways during peak service,
- No other use by freight or long distance trains during peak service recommended,
- At off-peak with possible mixed services sensitive operation handling possible with optimized signalling system (essential).

4.3.2 Section: Lebowakgomo – Jane Furse

From the basic data, given in **Table 8** the travel times and circulation times can be derived:

The **travel time** between the terminals is the sum of the 4 time factors:

- Running time: 36 min (rough estimation),
- Time additive: 8 min (rough estimation)
- Time margin: 4 min (10 % of running time + time additive),
- Dwell times: 9 min (1 min for each of the 8 stations in between),
- Travel time: 57 min (sum of before).

The **circulation time** is twice the travel time plus turn back:

- Travel time: 57 min (see above),
- Turn back time: 10 min (standard value),
- Circulation time: 140 min.

The **relevant data of the demand** are shown in **Table 10**. The operational dimensioning according to the above mentioned description leads to:

- Dimensioning load: 5598 (passengers),
- Necessary trains:1 (per peak hour and direction),
- Headway: 30 min (per peak hour).

The maximum **number of trains** being in service will be derived from the circulation time divided by the headway:

- Circulation time: 140 min (see above),
- Headway: 60 min (see above),
- Number of trains: 1 (in service),
- Number of coaches: 15 (in service).

For the **train-kilometres** per day the above mentioned assumption, that the peak hour kilometres are about 10 % of the daily ones, is leading to:

- Trains per peak hour: 1 (both directions),
- Distance: 71 km (one way),
- Train-kilometres: 71 km (per peak hour),
- Train-kilometres: 0.710 km (per day)

For **infrastructure** the according results are leading to the following requirements:

- Continuous single track line recommended, due to headways during peak service,
- At peak and off-peak mixed services possible: sensitive operation handling with optimized signalling system (essential).

Table 10: Dimensioning of Operational System (Long Term-Beyond 20 Years)-Phase 1

Dimensioning / Peak Hour		
Section: Lebowakgomo - Jane Furse		
Passengers	**5 598**	maximum load of peak hour
Coaches needed	**11**	crush load of each coach: 533 pass.
Trains needed	**1**	1 train consists of 15 coaches
Headway (min)	**85.21**	minimum (theoretical)
Headway (min)	**60**	set (practical)
Trains given	**1**	1 train consists of 15 coaches
Coaches given	**15**	crush load of each coach: 533 pass.

Capacity	**7 950**	possible limit
Reserve (pass.)	**2 352**	free capacity
Results:	**- single track line for all services** **- headway very comfortable**	

4.4 Long Term (Beyond 20 Years) –Phase 2

This term is considered to be the next step of the development process for the corridor by extending the commuter service.

4.4.1 Section: Polokwane - Lebowakgomo

From the basic data, given in **Table 8** the travel times and circulation times can be derived, which here are identical with the ones of the Short Term:

- Travel time: 49 min,
- Circulation time: 120 min.

The **relevant data of the demand** are shown in **Table 11**. The operational dimensioning according to the above mentioned description leads to:

- Dimensioning load: 33,375 (passengers),
- Necessary trains: 4 (per peak hour and direction),
- Headway: 14.29 min (per peak hour).

The maximum **number of trains** being in service will be derived from the circulation time divided by the headway:

- Circulation time: 120 min (see above),
- Headway: 10 min (see above),
- Number of trains: 6 (in service),
- Number of coaches: 90 (in service).

For the **train-kilometres** per day the above mentioned assumption, that the peak hour kilometres are about 10 % of the daily ones, is leading to:

- Trains per peak hour: 10 (both directions),
- Distance: 70 km (one way),
- Train-kilometres: 0.070 km (per peak hour),
- Train-kilometres: 7.000 km (per day),

For **infrastructure** the according results are leading to the following requirements:

- Continuous single track line recommended, due to headways during peak service,
- At peak and off-peak mixed services possible: sensitive operation handling with optimized signalling system (essential).
- Use by freight or long distance trains at any time possible,

Table 11: Dimensioning of Operational System Long Term (Beyond 20 years)-Phase 2

Dimensioning / Peak Hour		
Section: Polokwane - Lebowakgomo		
Passengers	**33 375**	maximum load of peak hour
Coaches needed	**63**	crush load of each coach: 533 pass.
Trains needed	**4**	1 train consists of 15 coaches
Headway (min)	**14.29**	minimum (theoretical)
Headway (min)	**10**	set (practical)
Trains given	**6**	1 train consists of 15 coaches
Coaches given	**90**	crush load of each coach: 533 pass.
Capacity	**47 700**	possible limit
Reserve (pass.)	**14 325**	free capacity
Results:	**- single track line for all services** **- headway close to standard**	

4.4.2 Section: Lebowakgomo – Jane Furse

From the basic data, given in **Table 8** the travel times and circulation times can be derived, which here are identical with the ones of the Short Term:

- Travel time: 57 min (sum of before).
- Circulation time: 140 min.

The **relevant data of the demand** are shown in **Table 12**. The operational dimensioning according to the above mentioned description leads to:

- Dimensioning load: 13350 (passengers),
- Necessary trains: 2 (per peak hour and direction),
- Headway: 30 min (per peak hour).

The maximum **number of trains** being in service will be derived from the circulation time divided by the headway:

- Circulation time: 140 min (see above),
- Headway: 30 min (see above),
- Number of trains: 2 (in service),
- Number of coaches: 30 (in service).

For the **train-kilometres** per day the above mentioned assumption, that the peak hour kilometres are about 10 % of the daily ones, is leading to:

- Trains per peak hour: 10 (both directions),
- Distance: 71 km (one way),
- Train-kilometres: 0.355 km (per peak hour),
- Train-kilometres: 3.500 km (per day).

For **infrastructure** the according results are leading to the following requirements:

- Continuous single track line recommended, due to headways during peak service,
- At peak and off-peak mixed services possible: sensitive operation handling with optimized signalling system (essential).
- Use by freight or long distance trains during peak service possible.

Table 12: Dimensioning of Operational System Long Term (Beyond 20 years)-Phase 2

Dimensioning / Peak Hour		
Section: Lebowakgomo - Jane Furse		
Passengers	**13 350**	maximum load of peak hour
Coaches needed	**25**	crush load of each coach: 533 pass.
Trains needed	**2**	1 train consists of 15 coaches
Headway (min)	**35.73**	minimum (theoretical)
Headway (min)	**30**	set (practical)
Trains given	**2**	1 train consists of 15 coaches
Coaches given	**30**	crush load of each coach: 533 pass.
Capacity	**15 900**	possible limit
Reserve (pass.)	**2 550**	free capacity
Results:	**- single track line for all services** **- headway comfortable**	

4.5 Long Term (Beyond 20 Years) –Phase 3

This term is considered to be the final step of the development process for the corridor for extending the commuter service. Although a “theoretical” calculation on demand and its operational and infrastructural consequences can be done, it has to be kept in mind, that all results are subject to changes in demand over time.

4.5.1 Section: Polokwane - Lebowakgomo

From the basic data, given in **Table 8** the travel times and circulation times can be derived,:

- Travel time: 49 min,
- Circulation time: 120 min.

The **relevant data of the demand** are shown in **Table 13**. The operational dimensioning according to the above mentioned description leads to:

- Dimensioning load: 202750 (passengers),
- Necessary trains: 26 (per peak hour and direction),
- Headway (theoretical): 2.35 min (per peak hour),
- Headway (practical): 2 min (per peak hour, 3 x!),
- Altogether 1 single track lines would be necessary to cope with demand figures

The maximum **number of trains** being in service will be derived from the circulation time divided by the headway:

- Circulation time: 120 min (see above),
- Headway: 2 min (see above),
- Number of trains: 30 (in service),
- Number of coaches: 450 (in service)

For the **train-kilometres** per day the above mentioned assumption, that the peak hour kilometres are about 10 % of the daily ones, is leading to:

- Trains per peak hour: 30 (both directions),
- Distance: 71 km (one way),
- Train-kilometres: 4.260 km (per peak hour),
- Train-kilometres: 42.600 km (per day).

For **infrastructure** the according results are leading to the following requirements:

- Continuous double track line required, due to extremely short headways during peak service,
- Use by freight or long distance trains possible at all hours of operation,
- Fragile operational system due to extremely short headways, absolute limit.

Table 13: Dimensioning of Operational System –Beyond 20 years-Phase 3

Dimensioning / Peak Hour		
Section: Polokwane - Lebowakgomo		
Passengers	**202 750**	maximum load of peak hour
Coaches needed	**383**	crush load of each coach: 533 pass.
Trains needed	**26**	1 train consists of 15 coaches
Headway (min)	**2.35**	minimum (theoretical)
Headway (min)	**2**	set (practical)
Trains given	**30**	1 train consists of 15 coaches
Coaches given	**450**	crush load of each coach: 533 pass.
Capacity	**238 500**	possible limit
Reserve (pass.)	**35 750**	free capacity
Results:	**- line capacity with 3min headway reached** **- implementation of 1 more line possible**	

4.5.2 Section: Lebowakgomo – Jane Furse

From the basic data, given in **Table 8** the travel times and circulation times can be derived, which here are identical with the ones of the Medium Term:

- Travel time: 57 min (sum of before).
- Circulation time: 140 min.

The **relevant data of the demand** are shown in **Table 14**. The operational dimensioning according to the above mentioned description leads to:

- Dimensioning load: 81115 (passengers),
- Necessary trains: 10 (per peak hour and direction),
- Headway (practical): 5 .88 min (per peak hour),

The maximum **number of trains** being in service will be derived from the circulation time divided by the headway:

- Circulation time: 140 min (see above),
- Headway: 5 min (see above),
- Number of trains: 12 (in service),
- Number of coaches: 180 (in service).

For the **train-kilometres** per day the above mentioned assumption, that the peak hour kilometres are about 10 % of the daily ones, is leading to:

- Trains per peak hour: 20 (both directions),
- Distance: 71 km (one way),

- Train- kilometres: 1.400 km (per peak hour),
- Train- kilometres: 14.000 km (per day).

For **infrastructure** the according results are leading to the following requirements:

- Use by freight or long distance trains at off –peak hours possible,
- Second single track line recommended, due to extremely short headways during peak service.

Table 14: Dimensioning of Operational System –Beyond 20 years-Phase 3

Dimensioning / Peak Hour		
Section: Lebowakgomo - Jane Furse		
Passengers	**81 115**	maximum load of peak hour
Coaches needed	**153**	crush load of each coach: 533 pass.
Trains needed	**10**	1 train consists of 15 coaches
Headway (min)	**5.88**	minimum (theoretical)
Headway (min)	**5**	set (practical)
Trains given	**12**	1 train consists of 15 coaches
Coaches given	**180**	crush load of each coach: 533 pass.
Capacity	**95 400**	possible limit
Reserve (pass.)	**14 285**	free capacity
Results:	**- - line capacity with 5 min headway reached - implementation of 1 more line possible**	

4.6 Overview on Operational Results

The major results of the dimensioning concerning the Operation Concept in all 3 time horizons are summarized in **Table 15,** for giving a better overview on the planning status.

Table 15: Overview of Operations Measures for Improvement

Section: Polokwane - Lebowakgomo	Topic	Dimension	Long Term-Phase 1	Long Term-Phase 2	Long Term-Phase 3	Comments
	Demand	pphd	13 000	33 375	202 750	given by Forecast
	Peak	-	evening	evening	evening	for dimensioning
	Direction	-	P - L	P - L	P - L	for

						dimensioning
	Distance	km	70	70	70	derived from Google
	Max. speed	km/h	160	160	160	for commercial service
	Travel time	min	49	49	49	per train
	Circulation time	min	120	120	120	per train
	Headway (th.)	min	36.69	14.29	2.35	theoretical value
	Headway (pr.)	min	30	10	2	practical value
	Nr. of trains	in service	2	6	30	train of 15 coaches
	Nr. of coaches	in service	30	90	450	coach with 530 pass.
	Train-kilometers	km/day	1	7 000	42 600	rough estimation
	Nr. double tracks (by calculation)*	-	0	1	1 x	only used by commuter service recommended
	Nr. double tracks (recommended)**	-	0	1	1 x	only used by commuter service recommended
Section: Lebowakgomo - Jane Fursa	**Topic**	**Dimension**	**Long Term-Phase 1**	**Long Term-Phase 2**	**Long Term-Phase 3**	**Comments**
	Demand	pphd	5 598	13 350	81 115	given by Forecast
	Peak	-	evening	evening	evening	for dimensioning
	Direction	-	L - JF	L - JF	L - JF	for dimensioning
	Distance	km	71	71	71	derived from Google
	Max. speed	km/h	160	160	160	for commercial service
	Travel time	min	57	57	57	per train
	Circulation time	min	140	140	140	per train
	Headway (th.)	min	85.21	35.73	5.88	theoretical value

Headway (pr.)	min	60	30	5	practical value
Nr. of trains	in service	1	2	12	train of 15 coaches
Nr. of coaches	in service	15	30	180	coach with 530 pass.
Train-kilometers	km/day	1	7 000	14 000	rough estimation
Nr. double tracks (by calculation)*	-	0	1	1 x	only used by commuter service recommended
Nr. double tracks (recommended)**	-	0	1	1 x	only used by commuter service recommended

Legend: pphd: per peak hour
*: calculation with unrealistic demand (theoretical)
**: recommendation (practical)

4.6.1 Recommendations for Rolling Stock

The general idea, based on the preconditions of PRASA, is to run the system with locomotive hauled trains, containing 15 **coaches** with crush load of 533 passengers each, which is extremely high. The soon to be acquired rolling stock has to take cognizance of this aspect. Double –decker coaches can be considered as an extra technology in future based on passenger demand.

Independent of the time horizon it is recommended by the Consultant to consider also a more **flexible train configuration**, where 2 shorter trains can be coupled to 1 long one. There at off-peak times the train capacity would be reduced, but the frequency could be kept partly, thus serving the needs of passengers better.

The higher grade of **motorization** in this case also would lead to a faster and more flexible service with comfortable time tolerances, while keeping the proposed maximum speed of 160 km/h. Thus the schedules could get a higher degree of stability, which is of advantage for both passengers and the operator.

Considering the whole system of commuter service in the region of Polokwane, it might be an appropriate solution, to run the Corridor D also with Multiple Unit trains (like proposed for the Corridors A and C). This could assure a highly flexible use of the Rolling Stock in that whole region.

4.6.2 Recommendations for Infrastructure from an Operational Perspective

Since the forecast delivers **increases in demand** for the given time horizons of 2030 and 2050, effort in terms of organizational and financial framework is required in order to cope with these challenges in an appropriate way. The PRASA-proposal of implementing **standard gauge** is understood for all section at any time horizon. All station platforms are assumed to accommodate train lengths varying between 300 -402 m. However in this assessment, the maximum train length is assumed is 402 m . Hence present station platforms (with length of approximately 265m) need to be upgraded.For the **line configuration** and its use by the various rail-services for the given time horizons the following recommendations are given, which are based on the previous investigations:

4.6.2.1 Long Term (Beyond 20 years)-Phase 1

- Section Polokwane – Lebowakgomo,
  - ✓ a high capacity single track line is necessary right from the beginning,
  - ✓ no additional rail services are possible at peak hours,
  - ✓ the section between Polokwane and Commuter Station 7 cannot be operated jointly with the commuter service between Mokopane and Polokwane (even if a decision for the same gauge would be made).

- Section Lebowakgomo - Jane Furse.
  - ✓ a high capacity single track line is necessary right from the beginning,
  - ✓ additional rail services are possible at peak hours.

4.6.2.2 Long Term (Beyond 20 years)-Phase 2

- Section Polokwane – Lebowakgomo,
  - ✓ Continuous single track line required, due to extremely short headways during peak service,
  - ✓ Use by freight or long distance trains at off-peak hours possible,
  - ✓ Fragile operational system due to extremely short headways, absolute limit.

- Section Lebowakgomo - Jane Furse.
  - ✓ Continuous double track line required, due to short headways during peak service,
  - ✓ No other use by freight or long distance trains during peak service possible.

4.6.2.3 Long Term(Beyond 20 years)-Phase 3

- ***Section Polokwane – Lebowakgomo,***
  - ✓ By pure calculation 1 parallel single track lines are required (regarding the total width of the corridor), due to extremely short headways during peak service; this is considered only a theoretical solution,
  - ✓ Practically it should be limited to altogether 1 double track lines (regarding the total width of the corridor)
  - ✓ Use by freight or long distance trains at off peak hours possible,
  - ✓ Fragile operational system due to extremely short headways, absolute limit.

- ***Section Lebowakgomo - Jane Furse.***
  - ✓ By pure calculation 1parallel single track lines required (regarding the total width of the corridor), due to extremely short headways during peak service; this is considered only a theoretical solution,
  - ✓ Practically it should be limited to altogether 1 double track line,
  - ✓ Use by freight or long distance trains at off peak hours possible,
  - ✓ Fragile operational system due to extremely short headways, absolute limit.