UPGRADING OF SOUTH AFRICA'S NATIONAL ROUTE 3 ECONOMIC CORRIDOR BETWEEN DURBAN AND JOHANNESBURG, SOUTH AFRICA

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ABSTRACT

Traffic congestion is an unavoidable phenomenon in most countries worldwide. It necessitates the need for capacity improvements in the road network to accommodate the growth in traffic. Although the need for road infrastructure expansion is necessary, funding is always a constraint that must be managed optimally in order to avoid inefficient expenditure. Engineers are therefore obligated to manage a project in a manner in which the most efficiently engineered solution is selected which ultimately satisfies the financial budget as well as addressing the fundamental road traffic constraints.

National Road N3 between the Port of Durban on the East Coast of South Africa and the City of Johannesburg (South Africa's economic hub) is a national route integral to the economic growth of Southern and East Africa. The route is part maintained by Sanral and part by the N3 Toll Concessionaire. A growing Southern African population, with its commensurate demand for goods, has placed this strategic corridor under severe pressure, requiring substantial upgrading to portions of the corridor. The corridor is South Africa's key infrastructure development project and is one of the SA Governments key strategic integrated projects (SIP2) that forms part of the National Development Plan.

A key portion of the corridor is being upgraded between Durban and Cedara, over a distance of 84km. This section of the N3 carries anything between 40 000 and 120 000 vehicles per day, with a mix of urban commuter traffic, long-distance traffic and a substantial number of heavy vehicles. In addition, it carries in excess of 70 million tonnes of freight per annum, with approximately 9 000 heavy vehicles using the route every day. Add to this the anticipated increase of 12.6 million TEUs from the planned upgrade to the existing Durban port, we can appreciate the strategic and structural importance of the N3. With this kind of traffic, upgrades and ongoing road maintenance will be critical.

In addition to the capacity upgrades, there are sections of the N3 requiring major improvements from a safety consideration due to the high number of vehicle accidents involving heavy vehicles as well as the existing alignment of the N3 presenting many challenges. These sections will require complete realignment. Managing both freight and passenger traffic on this corridor presents many challenges and needs smart and innovative engineering and funding solutions.

KEYWORDS

South African National Roads Agency, Freight traffic, funding constraints, engineering solutions

INTRODUCTION

Africa's Infrastructure Requirements

Two thirds of Africans are expected to live in cities by 2050 according to a latest report, 2017, presented to the United Nations Development programme. According to the African Economic Outlook 2016, released at the African Development Bank Group's annual meeting last year, Africa remained the second-fastest growing economic region in 2015, after East Asia. The continent's average growth was expected to be 3.7 per cent in 2016 and 4.5 per cent in 2017, provided the world economy strengthens and commodity prices gradually recover. However, due to under recovery of commodities, the economic outlook in 2016 was not so great. With Africa's economic outlook being predicted to become one of fastest growing, it places huge pressure on its infrastructure, particularly transport infrastructure, moving people and goods between towns, cities and ports.

According to the recently released 2017 Global Infrastructure Outlook report (Ref 2), South Africa together with Nigeria and Egypt were forecast to meet only 69% of their infrastructure needs by 2040. However South Africa would still need to spend 2,4% of its gross domestic product (GDP) a year to meet these needs until 2030. The report included a study of about 50 countries across the world and across seven industry sectors. The results found that African countries had to spend $174 billion dollars collectively per year until 2040 if the continent was to meet its infrastructure needs under the UN Sustainable Development Goals (SDG). Most African countries has very large infrastructure need relative to the size of the economies. However between South Africa, Morocco, Ethiopia and Egypt, each has contributed between 6 and 11 percent of Africa's infrastructure investment since 2007. (Ref 1)

A World Bank report released earlier this year found that only 35% of sub Saharan Africa's population had access to electricity. Likewise transport infrastructure is lagging being the only region the world where road density has declined over the past 20 years.

South Africa, who was overtaken by Nigeria as Africa's biggest economy, has had major economic setback in 2017, with downgrades from all three rating agencies i.e. Moody's, Standards and Poor's and Fitches. In the first week of April 2017, Standard & Poor (S&P) Global Ratings and Fitch Ratings both downgraded South Africa to sub-investment grade, also known as junk status. GDP Growth Rate in South Africa is expected to be 0.90 percent by the end of this quarter, according to Trading Economics global macro models and analysts' expectations. Looking forward, GDP Growth Rate in South Africa is estimated to stand at 1.10 in 12 months' time. In the long-term, the South Africa GDP Growth Rate is projected to trend around 2.10 percent in 2020.

This year, South Africa's National Treasury has committed to spend more than R50 billion to fund national and provincial economic infrastructure requirements.

South Africa's National Development Plan 2030 and Infrastructure Plan

In May 2010 the South African President appointed the National Planning Commission, an advisory body made up of 26 experts drawn largely from outside the government, to draft a vision and national development plan.

The commission's Diagnostic Report, released in June 2011, set out South Africa's achievements and shortcomings since the beginning of democracy in 1994. It identified a failure to implement policies and an absence of broad partnerships as the main reasons for slow progress, and set out

nine primary challenges and crafted a plan forward. Figure 1 below indicates the problems facing the country and how these could be overcome.

FIGURE 1 Problem and Plan for NDP 2030

Infrastructure – The challenges

Investment spending on infrastructure in South Africa fell from an average of almost 30% of GDP in the early 1980s to about 16% of GDP by the early 2000s. Public infrastructure spending was also at low levels by historic standards.

In effect, South Africa has missed a generation of capital investment in roads, rail, ports, electricity, water, sanitation, public transport and housing.

The country does have a relatively good core network of national economic infrastructure. But the challenge is to maintain and expand it to ensure inclusive economic growth. The economy has already been constrained by inadequate investment and ineffective operation and maintenance of existing infrastructure. Productive investment in historically black communities also continues to face constraints from inadequate logistics, transport, water, waste removal and electricity.

Current investment levels are insufficient and maintenance programmes lagging. Given the government's limited finances, private funding will need to be sourced for some of these investments, and policy planning and decision-making will require trade-offs between competing national goals.

The South African Government had endorsed the NDP in 2012 including the National Infrastructure Plan. It also established a body to integrate and coordinate the long term infrastructure build, namely the Presidential Infrastructure Coordinating Commission (PICC), which goes a long way towards achieving these goals, together with a programme for coordinated and managed infrastructure delivery. The PICC's mandate is to ensure a systematic selection, planning and monitoring of large infrastructure projects. (Ref 3)

The Infrastructure Development Act of 2014 laid the basis for further strengthening coordination of infrastructure provision as well as accelerating implementation. A total of eighteen (18) Strategic Integrated Projects (SIP's) were identified as part of the National Infrastructure Plan.

In terms of transport needs, the intention is to consolidate and selectively expand transport and logistics infrastructure, with key focus areas being:

- Upgrading the Durban-Free State-Gauteng freight corridor, including a new port at the old Durban airport site
- Expanding capacity of the coal, iron ore and manganese lines, with consideration given to concessioning parts of this network
- Building the N2 road through the Eastern Cape
- Public transport infrastructure and systems, including the renewal of the commuter rail fleet, supported by enhanced links with road-based public services.

The Upgrading of the Durban-Free State-Gauteng freight corridor is a Strategic Integrated Project 2 (SIP2). Its objectives is to strengthen the logistics and transport corridor between South Africa's main industrial hubs; improve access to Durban's export and import facilities, raise efficiency along the corridor and integrate the Free State Industrial Strategy activities into the corridor and integrate the currently disconnected industrial and logistics activities as well as marginalised rural production centres surrounding the corridor that are currently isolated from the main logistics.

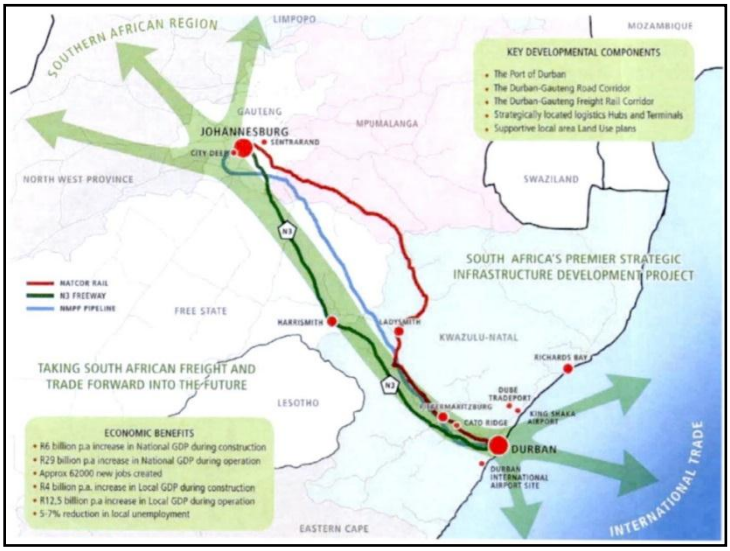

FIGURE 2 The Durban-Free State-Gauteng Corridor (Transnet, 2017)

The National Route 3 (N3) is a key component of the corridor as shown in Figure 2 above**,** between the Port of Durban on the East Coast of South Africa and the City of Johannesburg (South Africa's economic hub) is a national route integral to the economic growth of Southern and East Africa. The route is part maintained by Sanral and part by the N3 Toll Concessionaire.

The Port of Durban is South Africa's busiest port. It handles 60% of South Africa's exports and imports. It is the leading port in the SADC region and the premier trade gateway between South-South, Far East trade, Europe and the USA and the East & West Africa regional trade.

A key portion of the corridor is being upgraded between Durban and Cedara, over a distance of approximately 90km. The N3 corridor is the most important and busiest freight corridor in South Africa. It moves freight destined to be imported or exported in containers through the Port of Durban. It carries a substantial volume of heavy vehicles together with passenger vehicles and in

addition to a challenging topography makes the upgrading complex. In addition, due to the magnitude of funding required, various funding options will need to be considered.

METHODOLOGY

The approach and methodology adopted to obtain an optimum upgrading strategy to the ongoing road congestion, safety concerns, mix of heavy and passenger vehicles and accidents will be discussed under this section of the paper. It should be noted that even though SANRAL was the client and appointed engineering firms to undertake the investigations, SANRAL played a fundamental and key role in the management of the service providers, interpreting the findings and decision making. In this instance SANRAL played the role of the client including client technical input as well as the overall project manager under the various design work packages.

As part of the feasibility and design development SANRAL adopted the following methodology:

a) A full traffic study of the N3 corridor between Durban and Cedara,
   - Freight volumes and projections
   - Interaction with national and local traffic authorities to obtain accident statistics and information.
   - Detailed traffic counts at various locations on the corridor
   - Detailed traffic analysis on the mainline corridor as well as at the various interchanges which provided the status quo of the current levels of congestion as well as the future volumes and capacity constraints.
   - Upgrade proposals

b) A preliminary design of the proposed improvements,
   - Analyse the existing geometry of the road
   - Check compliance in terms of design speed
   - Check compliance in terms of operating speed
   - Check impact of upgrade strategy on the structures
   - Prepare proposals for improvements
   - Check impact on the environment and land requirements

c) An economic assessment and study of the N3 corridor
   - Importance of the corridor
   - Microeconomic analysis
   - Macroeconomic Analysis
   - Funding options
   - Impacts relating to possible tolling

d) A detailed design of the proposed upgrading
   - Finalisation of design packages
   - Proceed with selected design proposals
   - Coordination between design packages
   - Finalize design

RESULTS AND ANALYSIS

Traffic Study – Freight Impact

The importance of the N3 corridor as a freight corridor in relation to the rest of South Africa's road network is shown in Figure 3 below.

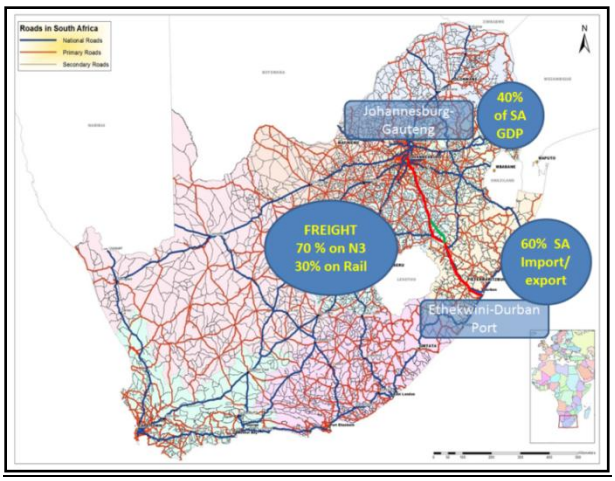

FIGURE 3 N3 Corridor in relation to the rest of South Africa's Road network (SANRAL, 2017)

Historically, rail was the preferred method of moving freight in South Africa, but following the deregulation of the transport sector, the rail market share has progressively decreased. The investment in the rail transport infrastructure also decreased in conjunction with the liberalisation of transport in South Africa. Due to the decreased condition of rail infrastructure, there are significant challenges in promoting the most economically effective movement of freight. There is a modal imbalance between road and rail movements, which leads to an unsustainable use of road infrastructure (Havenga & Pienaar 2012). This has led to strain being put on the national fiscus due to increased capital and maintenance costs of road infrastructure, as well as strain on the private sector who are forced to use more expensive road transport as the mode of choice.

While Transnet has a policy to shift freight from road to rail, it is unlikely to materialise in the short to medium term. Therefore while cognisance needs to be taken that this may be the right decision from a freight perspective, from a road planning perspective freight traffic forecasting has been based on historical trends as well as on estimated GDP growth in South Africa.

Various uniform sections were identified along the corridor consisting of traffic volumes and topography, converting freight volumes to equivalent passenger car units (pcu's) to obtain volumes and compare to capacity to obtain the Level of Service. This was done over various periods over the forecast period of 30 years. The first section between Durban and Cato Ridge is 43km in length and is a 6 lane dual carriageway while the section between Cato Ridge and Cedara is 47 km in length and is a 4 lane dual carriageway. This is shown in Figure 4 below.

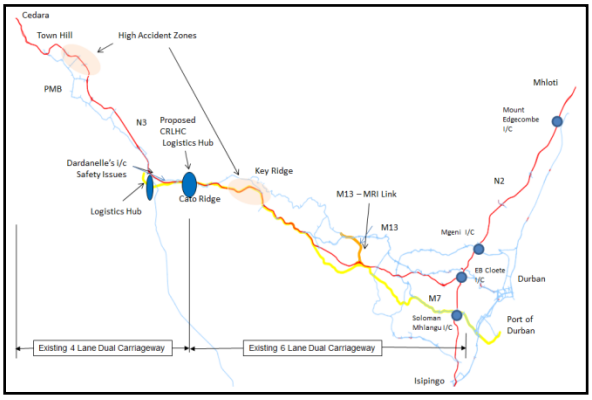

FIGURE 4 Layout of N3 Corridor between Durban and Cedara

Table 1 below shows the 4 lane section traffic analysis over the next 10 years. The traffic analysis shows that the majority of the 4 lane dual carriageway are between Level of Service (LOS) D to F in the year 2017. Sanral's requirements for capacity upgrades is when LOS C is reached in the peak hour period. For reasons to be discussed later in the paper, the upgrades have still not been undertaken.

A total of twenty three interchanges between Durban and Cedara is required to be upgraded in addition to the mainline carriageways. The traffic analysis has been based on projected growth in addition to the Local Area Plans of the municipalities within which the interchanges fall. Key to the plans are current and future developments within the municipalities. There are a few substantial private sector developments planned along the corridor especially at certain key strategic nodes like Cato Ridge, Hammarsdale, Dardanelles, Lynnfield Park and Pietermaritzburg.

TABLE 1 Traffic projects over next 10 years on 4 lane dual carriageway

Existing Lanes		2010			2017			2022			2027		
From Interchange	From Interchange	AADT (PCU)	Existing Lanes PH V/C	Existing Lanes LOS	AADT (PCU)	Existing Lanes PH V/C	Existing Lanes LOS	AADT (PCU)	Existing Lanes PH V/C	Existing Lanes LOS	AADT (PCU)	Existing Lanes PH V/C	Existing Lanes LOS
Hilton	Cedara	52 800	0.43	B	72 400	0.59	C	86 400	0.71	C	100 400	0.82	D
Athlone	Hilton	56 400	0.46	B	77 100	0.63	C	91 800	0.75	D	106 500	0.87	D
Chatterton	Athlone	46 600	0.38	B	63 100	0.52	C	74 800	0.61	C	86 600	0.71	C
Sanctuary Rd	Chatterton	32 300	0.27	A	43 600	0.36	B	51 700	0.42	B	59 700	0.49	B
Chota Motala	Sanctuary Rd	62 200	0.38	B	80 400	0.50	C	93 300	0.57	C	106 300	0.65	C
Ohrtmann Rd	Chota Motala	49 700	0.61	C	64 700	0.80	D	75 500	0.93	E	86 200	1.06	F
New England Rd	Ohrtmann Rd	66 800	0.82	D	86 900	1.07	F	101 300	1.25	F	115 700	1.43	F
Epworth	New England Rd	54 400	0.67	C	72 000	0.89	D	84 600	1.04	F	97 200	1.20	F
Market Rd	Epworth	66 300	0.82	D	86 600	1.07	F	101 000	1.24	F	115 500	1.42	F
Ashburton	Market Rd	56 500	0.70	C	74 100	0.91	D	86 700	1.07	F	99 300	1.22	F
Lynnfield Park	Ashburton	56 800	0.70	C	74 700	0.92	E	87 500	1.08	F	100 300	1.24	F
Dardanelles	Lynnfield Park	59 100	0.73	C	78 000	0.96	E	91 600	1.13	F	105 100	1.30	F
Camperdown	Dardanelles	55 100	0.68	C	72 400	0.90	E	84 700	1.04	F	97 000	1.20	F
Cato Ridge	Camperdown	55 300	0.68	C	71 900	0.90	E	83 800	1.03	F	95 600	1.18	F

Preliminary Design

Subsequent to completing the traffic study and the requirements for the upgrading, Sanral appointed four consulting engineering firms to undertake the preliminary design for sections of the corridor based on the requirements from the traffic study in terms of capacity requirements.

These were defined into two distinct sections as shown in Table 2 below.

TABLE 2 Accident Statistics obtained from RTI

Location	Traffic Volumes (Veh/Day)	Requirements
EB Cloete Interchange to Paradise Valley (8km)	80 000 to 130 000	5 Lanes per direction with auxiliary lanes between interchanges were required
Paradise Valley to Cedara (72km)	40 000 to 80 000	4 Lanes per direction with a climbing and passing lane on steep inclin8/es/declines

The preliminary design was undertaken over a 12 month period. The preliminary design was three fold – to obtain the impact of the additional lanes on the freeway cross section for capacity requirements in terms of the pavements, drainage and interchange bridges, secondly to consider any safety improvements, and thirdly gauge the impact of the land required.

The cross section adopted is shown in Figure 5 below.

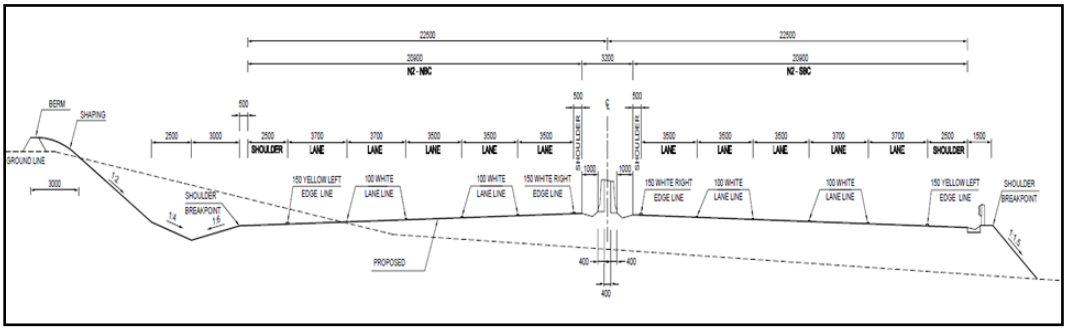

FIGURE 5 Freeway cross section adopted for the N3 corridor

In terms of safety improvements (i.e. high accident areas), two areas were identified and investigated as shown in Figure 4 above. Both the Townhill and Key Ridge areas are notorious for heavy vehicle collisions. The existing N3 at these areas have steep gradients (townhill-8,3% & Key Ridge- >9%) together with a curvilinear alignment results in many heavy vehicle's losing control causing severe accidents and closure of the N3 for lengthy periods of time. At both these locations various options have been investigated in terms of upgrading the existing alignments as well as re-alignments. For the Townhill section, a number of new routes are being investigated which are shown in Figure 6 below.

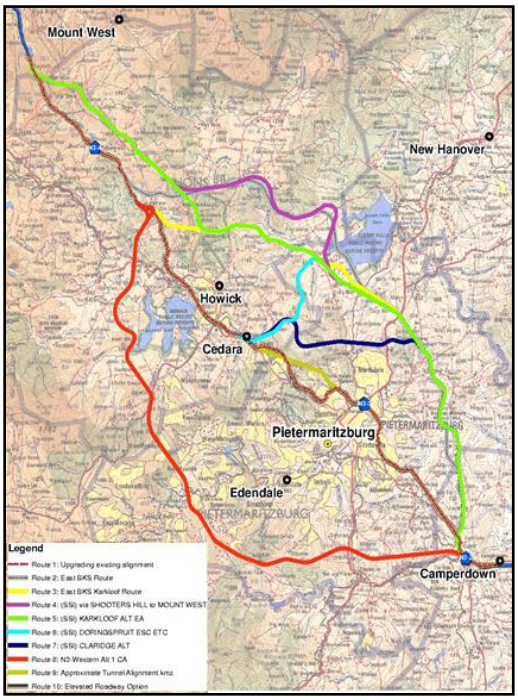

FIGURE 6 New routes considered around Townhill

Each of the routes are being assessed in terms of length, environmental screening, economic benefits, engineering requirements and cost, and a matrix developed to identify the most feasible route. A similar process has been followed for the Key Ridge realignment and the most feasible route identified as shown in Figure 7 below, which is now progressing into detail design.

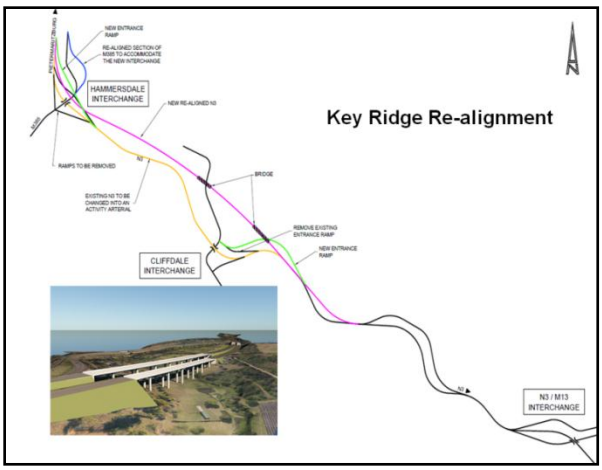

FIGURE 7 Re-aligned portion of N3 at the Key Ridge section

Innovation

In the preliminary design phase Sanral jointly with the engineering firms optimised the design to ensure there would be minimum impact especially in the built up urban areas. In addition, where the interchanges were not required to be upgraded because of local conditions, but the interchange structure was required to be upgraded because of the freeway cross section, Sanral reconsidered the cross section in terms of horizontal clearance requirements. One such structure was the EB Cloete Systems Interchange that connects the National routes 2 and 3 in Durban. The traffic study required that all four levels of the interchange be upgraded to provide at least 2 lanes of traffic. However at the lowest level, the existing A-frame structure support prevented such an arrangement. If the two lanes were to be provided with full horizontal clearance, the entire systems interchange would need to be reconstructed which would costs in the order of R3 billion to R4 billion rand. However an innovative solution was adopted whereby the support was replaced with cables supported off an arch structure across the interchange. Figure 8 below shows the arrangement.

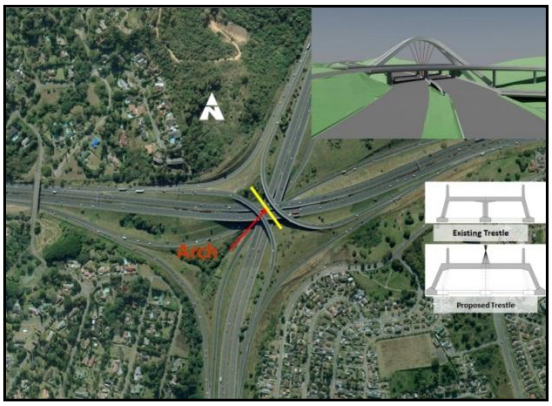

FIGURE 8 Innovative solution adopted for the EB Cloete Interchange

Another innovative solution to limit the interchange upgrades where there were substantial right turn movements was to consider the a Double Crossover Diamond Interchange (DCD) or more commonly known in South Africa, the Diverging Diamond Interchange (DDI) layout was selected at certain interchange locations. The purpose of the DDI was to address the above

mentioned concerns and to create a value engineered solution. A layout plan of the DDI is shown in Figure 9 below.

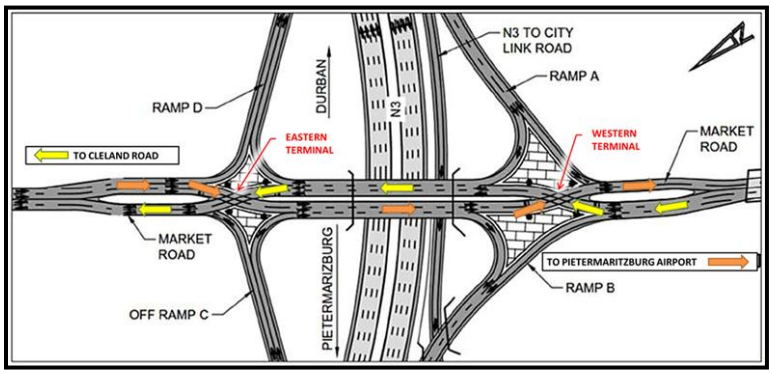

FIGURE 9 Plan view of a Diverging Diamond Interchange (DDI)

Another consideration was given to separation of heavy vehicles from passenger vehicles. An investigation was undertaken including international best practice to check impact of separation in terms of cost benefit as well as practicalities of implementing such a scheme. While dedicated freight routes were supported, it was considered too expensive to undertake if it was to be considered from Durban to Gauteng, a total of about 550km. EThekwini Municipality also considered this as an option at the Durban port access. It was finally agreed to accommodate the heavy vehicles on the N3 cross section. Consideration was then given to separate the heavy and passenger vehicles using a barrier. An economic assessment was done of this option but it was not viable due to periods of the day where the heavy vehicle demand was minimal. It also posed a problem and interchange accesses and would create substantial operational difficulties.

Economic Analysis

As indicated previously, Durban handles 60% of South Africa's exports and imports. The Port of Durban is the leading port in the SADC region. It is the international commercial gateway to South Africa and is strategically positioned on the world shipping routes. Durban ranks within the top fifty for container traffic internationally.

Based on the current traffic volumes and without any of the upgrading taking place, it will cost society R1,1 billion per annum within the next 7 years in time costs. Due to high value of cargo transported on the N3, an accident resulting in closure will cost R340,000/hour.

The four municipalities through which the corridor passes are EThekwini, Mkhambathini, Msunduzi and uMngeni. The unemployment rates vary between 24% to 30% and the upgrading will add huge benefit to the employment reduction levels. The results of the cost benefit analysis is indicated in Table 3 below.

TABLE 3 Results of Cost Benefit Analysis (Rm, 2014 prices)

	Without Tolling	**With Tolling**
Costs (Rm)	19 423	20 201
Benefits (Rm)	70 318	70 166
NPV	50 894	50 065
BCR	3.6	3.5
IRR	22.8%	22.2%

The results indicates that the project is highly viable based on the BCR well above 1.0 as the IRR being well above the discount rate of 8.0%.

In the microeconomic analysis, the impact of tolling of the corridor at specific locations were considered. The following issues were considered: affordability, toll tariff caps, Equity, Impact on Commercial transport, taxi fares and impact on the cost of consumer goods. The outcomes indicated that except for taxi fares, in general tolling will have a positive impact on the issues investigated. Due to mainly low income earners using minibus taxis, tolling will result negatively on them.

In the macroeconomic analysis of the upgraded road, the following was considered: Contribution to Gross Domestic Product, Contribution to KwaZulu-Natal Gross Geographic Product, Direct and Indirect Jobs and other macroeconomic benefits. The corridor upgrade during construction as well as during commissioning indicates positive impacts on all of the issues considered.

Funding availability for the corridor upgrade is however a major risk. While a portion of the corridor is tolled, the major portion requiring upgrading is not tolled, and will require substantial budget allocation from central government. Currently in South Africa, tolling is very sensitive to both the public and to politicians due to a portion of the national road network in Gauteng (GFIP) which currently operates as an open road toll system. Since GFIP commenced, the revenue collected has been diminishing as the public sentiment to tolling diminishes. Options to still be explored as part of the funding considerations are as follows: Fuel levy (national, provincial or local), User Pay (tolling), Shadow tolling (borrowing from private sector and paid back through Treasury). The possibility of mixed funding options are also to be explored further i.e. part government and part private sector i.e. capital works funded through central government and maintenance through tolling, which will place a lesser burden on the road users.

Detail Design.

The N3 corridor was split into various work packages for the detail design and construction phases. Consulting engineering firms have been appointed for each of the packages in 2015. Table 4 below shows the details for each package.

TABLE 4 Detail Design Package information

PACKAGE	DESCRIPTION	LENGTH KM	NO. OF NEW BRIDGES/ WIDENINGS	I/Cs TO BE UPGRADED /NEW
A	EB Cloete (including portion of N2 North and N3 West)	6.3	10	1
B	Westville Viaduct (Km11.8) to Paradise Valley (Km17.5)	5.7	13	2
C	Paradise Valley (Km17.5)-Marianhill Toll Plaza	7.5	5	3
D	Marianhill Toll Plaza (25) to Key Ridge (2.8)	11.1	9	2
E	Hammarsdale I/C upgrade (Km 9.4)	0	1	1
F	Hammarsdale (9.1) to Cato Ridge (20.1)	11.3	3	-
G	Keyridge (Km2.8) to Hammarsdale (Km 8.1)	5.3	4	-
H	Cato Ridge (Km19.4) to Dardenelles I/C (Km26.6)	7.2	6	2
I	Dardenelles I/C (26.6) to Lynnfield Park (Km 30.6)	4	4	1
J	Lynnfield Park (Km 30.6) to Asburton I/C (Km 1.5)	5.3	4	1
K	Asburton I/C (Km 1.5) to Murray Road (Km6.1)	4.6	2	1
L	Murray Road (Km 6.1) to New England Rd I/C	2.9	9	2
M	New England Rd I/C to Twickenham Road (Km16.4)	7.5	8	4
	Townhill Realignment	12.5	10	3
	TOTAL	90,7	88	23

The estimated construction cost is R23 billion (in 2015 Rand), based on the preliminary design. The detail design has been progressing thus far and will be completed during 2018. Various co-ordination meetings have been taking place to ensure that there is uniformity between the work

packages for the design methodology adopted in terms of the various aspects of the project as shown in Figure 10 below.

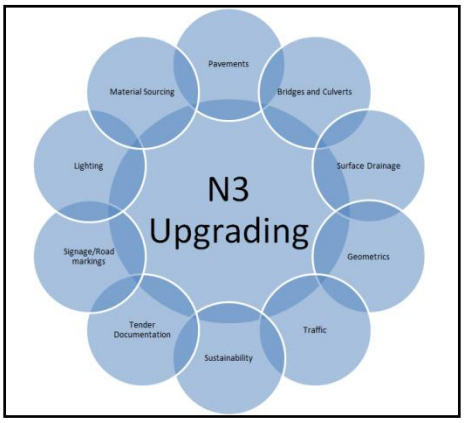

FIGURE 10 Design aspects coordinated between work packages

CONCLUSION

South Africa is a developing country and the National Development Plan adopted by the government is to ensure that it responds to the challenges being faced by the country as a whole.

Investing in economic infrastructure is a key aspect to provide much needed jobs to reduce the high unemployment rate as well as to stimulate opportunities for the small and medium firms. This will in turn will expand the current limited tax base for the South African Government.

The N3 corridor as presented is a key strategic and economic road freight corridor for the country linking both the busiest port in Durban to Johannesburg, the economic hub of South Africa. While innovative design solutions have been adopted to ensure that value engineering strategies have been considered, there is still huge risk facing the project being delivered, mainly because the funding has not been secured.

Road infrastructure funding has become a challenge in South Africa due to the pressure on central government for other social needs and therefore innovative funding strategies needs to be explored both in terms of public-public and public-private partnerships.

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