ASSESSMENT OF THE IMPROVEMENT STATEGIES FOR THE N1 CORRIDOR BETWEEN BELLVILLE AND CAPE TOWN

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ABSTRACT

The N1 Corridor has enormous development potential and the development of strategic sites will result in increased travel demand. A vast amount of this travel demand needs to be accommodated by an integrated N1 Corridor transport network, incorporating both private and public transport systems, as well as traffic flow management systems.

Following a critical assessment of the development potential and travel demand, an analysis of the transport system was carried out. Besides the identification of the status-quo, potential improvement options were assessed, including heavy and light rail, Bus Rapid Transit (BRT), Bus/Minibus Taxi (BMT) lanes, High Occupancy Vehicle (HOV) and High Occupancy Toll (HOT) lanes, as well as road pricing.

It was recognised that a traditional Cost-Benefit Analysis (CBA) would not include all the relevant criteria. An extensive analysis of the literature and available data led to the selection of 22 transportation, environmental, social and cost related criteria for assessment purposes. Aspects, such as the accessibility of the CBD and Port, the utilisation of spare capacity, safety and security as well as capital costs and annual subsidies were included.

Multi-Criteria Analysis (MCA) determined that the implementation of a busway (including lane balancing on the highway) has the highest overall benefit. Moreover, if ticket prices for the bus are R3.00 or more per average trip, no operational subsidy will be required.

This paper provides on overview of the identification of alternatives, the selection of criteria, as well as the final results of the assessment.

1. INTRODUCTION

At the largest scale, the portion of the N1 corridor that is the subject of this study forms the southernmost section of the most important land transport connection between Cape Town and the hinterland of South Africa; particularly the economically important Gauteng and the rest of Africa. In addition, the N1 corridor forms a link between the fast growing residential and industrial areas to the northwest of the Cape Town Metropolitan Area (CMA). It contains and provides access to a number of very important ‘brownfield’ sites or new development opportunities, such as the Culemborg/Black River Area, the military land of Ysterplaat and Wingfield and Century City, which are of significance at the metropolitan level (see Figure 1). By the year 2026, the corridor could provide an additional 50 000 job opportunities and an additional 11 000 housing opportunities on these sites alone (HHO Africa Infrastructure Engineers, 2007).

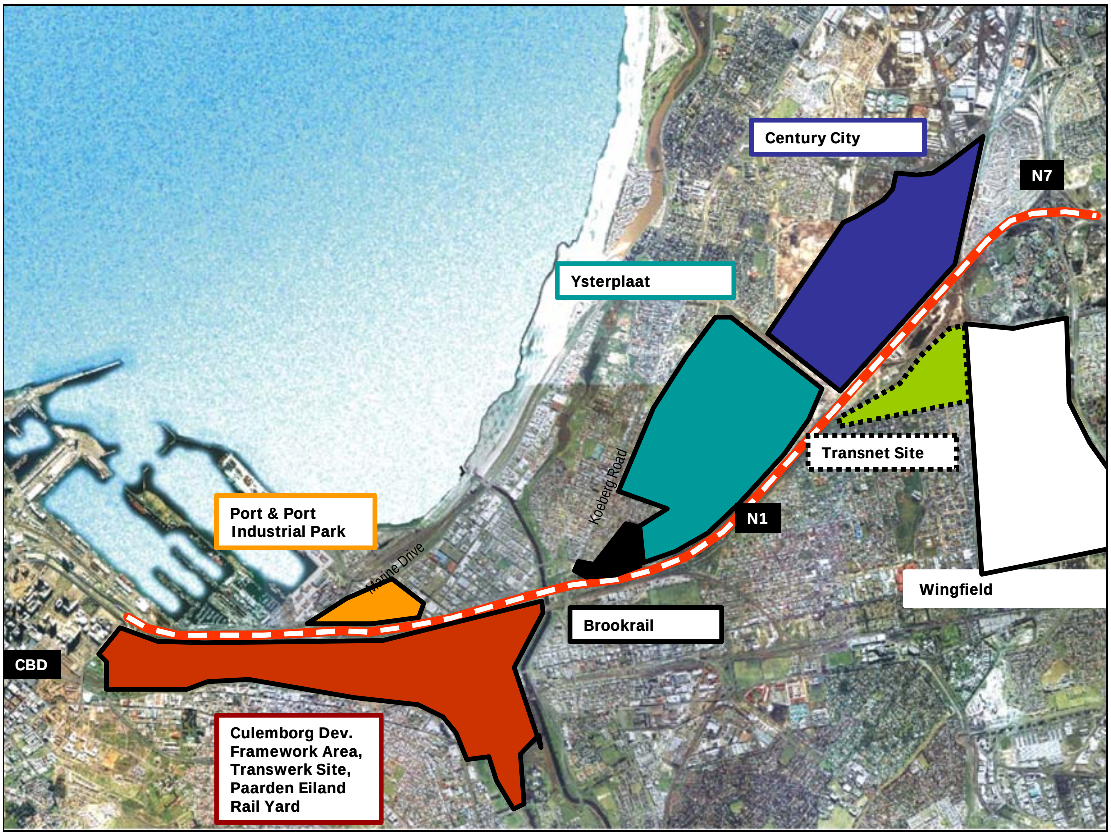

Figure 1 Strategic sites along the N1 corridor

Internationally, transport planners have acknowledged that along congested freeways (and other roads) additional capacity is quickly consumed by latent demand and congestion returns to the routes shortly after the capacity upgrade. Many cities have realised that they will never solve the "congestion problem", but can use it as an effective tool to promote high occupancy alternatives. These strategies incorporate predominantly public transport alternatives and are primarily aimed at "car restraint". A fundamental principle in addressing future congestion is the provision of attractive alternative modes of transport for existing and future car users. As the N1 is one of these congested freeways, a study was conducted into potential alternatives.

2. IDENTIFICATION OF TRANSPORT ALTERNATIVES

A first order assessment of alternative transport strategies that could be considered has brought the following observations to light (see Table 1):

- The existing rail system and service, if upgraded could play a significant role in providing an attractive travel alternative for choice commuters living in close proximity to the existing and planned future rail network.
- The N1 corridor catchment areas are currently poorly served by road based public transport and have limited existing rail network connections. These residential developments are predominantly middle to higher income areas, which translate to high car ownership and dependence. Unless effective and attractive public transport

network and services are planned for these growth areas, the travel demand generated by these areas will be predominantly private car based, which will exacerbate the current commuter congestion problem.

Table 1 Range of transport network strategies for the N1 corridor

Strategies	Description	Additional Lane(s)	Traffic Using New Facility
Heavy Rail	Enhanced commuter rail service with good access & secure park & ride	Existing Rail Corridor	Passengers
Light Rail Transit (LRT)	New strategically located service within the corridor with good access & secure park & ride	In median or alongside the current freeway or on separate alignment	Passengers
Bus Rapid Transit (BRT)	New strategically located service within the corridor, barrier separated two way busway, with good access & secure park & ride	In median or alongside the current freeway or on separate alignment	Road based public transport vehicles only
Bus/Minibus Taxi Lanes (BMT)	Exclusive public transport lanes, but not barrier separated	Typically along freeway median	Road based public transport vehicles only
High Occupancy Vehicle Lanes (HOV)	Barrier separated lanes	Typically along freeway median	Road based public transport vehicles, carpools and HOVs (typically 2 or more occupant cars)
High Occupancy Toll Lanes (HOT)	Barrier separated lanes	Typically along freeway median	Road based public transport vehicles, carpools, HOVs (typically 2 or more occupant cars) & toll paying Single Occupancy Vehicles (SOVs)
Collector Distributor Roads (C-D Roads)	Parallel two/three lane general traffic access roads	Adjacent to the freeway	General traffic
Additional Freeway Lanes	Additional general traffic lanes on the freeway	Widening of existing freeway	General traffic
Bicycle lanes	Separate bicycle path	Alongside freeway or on separate alignment	Cyclists

- It is unlikely that a high proportion of the choice commuters will drive their cars to the closest railway station to park-and-ride to their destination. Public transport services between the above growth areas and the central city may best be accommodated using an intermediate form of public transport, such as either LRT or BRT. Road based feeder services to the LRT or BRT network, could greatly assist in reducing car dependence and capturing choice commuters into public transport.
- The N1 Corridor serves a multiplicity of trips generated by the developments along the route and by the major nodes on either end. As a result, there is currently a relatively low proportion (<40%) of long distance through trips (i.e. trips entering on one end and existing on the other end) on this section of the N1 Freeway. The close spacing of interchanges, which provide access to development on either side of the freeway, confirms the high demand for access along the route. The above

conditions make the operation of median type priority lanes problematic, as median lanes are better suited to long distance trips (getting into and out of the median to access interchanges is problematic). Furthermore, the proportion of through trips is likely to decrease with future development. Therefore, schemes such as HOV and HOT lanes which operate best in freeway medians may prove to be impractical and may favour long distance trips.

- HOT lanes in the USA have been termed “Lexus lanes”, as the excess capacity in the HOT lane is used predominantly by wealthy commuters to buy themselves priority. In the South African context, the applicability of this type of strategy would need to tested, as it favours the wealthy commuter. It could be argued that those able to pay for the priority will be cross subsidising the public transport service operating in the same lane.
- A few examples of BMT lanes exist within the metropolitan area. Unfortunately, due to a lack of ongoing enforcement caused by a lack of financial resources, these lanes do not operate effectively as they suffer a high rate of illegal use. Public transport priority strategies that are self enforcing i.e. barrier separated schemes, will be highly effective while reducing the ongoing financial burden of enforcement.
- The addition of freeway lanes to the N1 Freeway will not eradicate congestion on this route. Latent demand for travel, which is currently absorbed by the rescheduling of peak hour trips (peak spreading), ridesharing and by the public transport system, will quickly result in the consumption of the additional freeway capacity. The side effects will be a reduction on public transport use and a higher proportion of SOV trips.
- Strategic sections of freeway widening may be warranted to provide capacity at critical bottlenecks, in order to achieve lane balance to improve the operational characteristics of weave and merge areas at interchanges.
- Collector-distributor (C-D) roads may be warranted along sections of the N1 Freeway to provide the level of access required by the future land use developments along the route. The purpose of C-D roads are to allow the freeway to maintain its mobility function, while the C-D road fulfils the access function (i.e. accommodates the turning manoeuvres). C-D roads are not intended to fulfil the role of additional freeway lanes.
- A Non-Motorised Transport (NMT) facility will provide another valuable transport alternative to the corridor. As mixed use infill of the various vacant sites along the corridor occurs, cycle and walk trips between residential areas and places of work, recreation and shopping, could significantly reduce the travel demand by other motorised modes.
- Other strategies exist which target the car user (i.e car restraint measures) and have been implemented internationally, examples being the London cordon toll strategy and the Bogotá, Columbia number plate strategy (only cars with number plates ending in specific numbers can access the road system on certain days). Numerous other car restraint strategies have been formulated and operate in other cities. These restraint schemes have had success in reducing car usage, but do have enforcement implications. Furthermore, these schemes can only be implemented once car commuters are afforded attractive travel alternatives i.e. preferably public transport. Without providing such alternatives, car restraint can set off strong decentralisation forces, which result in commuters exchanging places of work, rather than shift to public transport.
- Price elasticity for congestion pricing and HOT lanes varies based on the public transport level of service. Cities with poor public transport have a price elasticity of about -0.1 for urban highways and up to -0.4 in cities with excellent public transport (www.vtpi.org). On the N1, due to the current low level of the public transport

system, this would mean that an increase in variable costs of 10% would reduce the number of vehicles with 1%. It is anticipated that the overall speeds and throughput will increase marginally. Unfortunately, due to a lack of research with regards to pay/HOT lanes in South Africa, it is not really possible to estimate the effects.

The University of Cape Town has been involved in several projects over the last few of years with regards to assessment criteria in the developing world. Recently, a Sustainability Assessment tool was developed, in collaboration with Sustainable Energy Africa, and funded by the British High Commission (Vanderschuren et al, 2006). The Sustainability Assessment tool was used as a starting point for the criteria selection. It was found that not all criteria were applicable to the N1 corridor project. Table 2 provides the criteria included in the evaluation and the way of measuring the impacts. For the final analysis and evaluation of the various alternatives a spreadsheet transport operations model was developed.

Various combinations of the identified alternative transport strategies have been assessed using the selected criteria. The identified combinations are:

- Alternative 0: Do nothing
- Alternative 1: Upgrade Monte Vista rail service only
- Alternative 2: Lane balance to N1 Freeway only
- Alternative 3: Upgrade Monte Vista Rail and lane balance to N1 Freeway
- Alternative 4: Lane balance to N1 Freeway plus BMT lanes
- Alternative 5: Upgrade Monte Vista Rail, lane balance to N1 Freeway plus BMT lanes
- Alternative 6: Lane balance to N1 Freeway plus busway
- Alternative 7: Upgrade Monte Vista Rail, lane balance to N1 Freeway plus busway
- Alternative 8: Upgrade Monte Vista Rail to Tram Train and lane balance to N1 Freeway
- Alternative 9: Road pricing and lane balance to N1 Freeway plus bus service on Freeway

The inputs to the model included weekday peak hour vehicular O-D matrices, with modal split and vehicle occupancy data, existing weekday peak hour rail occupancy data, existing and future geometric data of the N1 freeway (including number of lanes per section and lane capacities), expected shifts to enhanced public transport modes, future (2026) weekday peak hour O-D matrices and future road linkages and interchanges that would affect trip assignment along the network.

Public transport operational attributes, such as the required number of vehicles in circulation, was established using the model developed by Cloete (Cloete and Vanderschuren, 2006). The capital costs of the projects were estimated using current construction rates.

Moreover, descriptions for the scoring of qualitative criteria were provided and accepted by the City of Cape Town and the Provincial Government of the Western Cape.

Table 2 Evaluation criteria

CRITERIA CLUSTER	CRITERIA	MEASURES
Spatial	Impact on land use patterns	Qualitative assessment
	Accessibility of CBD, strategic sites and Port of Cape Town	V/C ratio
	Land requirements for additional transport infrastructure	Qualitative assessment
Transportation	Public transport use	Passengers per hour 2026: AM Peak inbound
	Increase in public transport use per hour	Percentage change in 2026: AM Peak inbound
	Travel speed - General traffic lanes	Km/h
	Travel Speed – Rail	Km/h
	Travel Speed - Road public transport	Km/h
	Enforcement	Qualitative assessment
	Public transport reliability, frequency, etc	Weighted headway in minutes
	Freight transport	Qualitative assessment
	Private car trip reduction	Percentage change in 2026: AM Peak Inbound
	Parking demand	Percentage change in 2026: AM Peak Inbound
	Utilisation of spare rail capacity	Qualitative assessment
	Utilisation of spare freeway capacity	Qualitative assessment
Environmental	Fuel consumption, alternative fuels and pollution	Kg CO reduction in 2026: AM Peak inbound
	Water bodies	Qualitative assessment
	Non-motorized transport	Qualitative assessment
Social Environment	Safety (Accident rates)	Qualitative assessment
	Security	Qualitative assessment
Costs	Capital costs	Million Rand
	Annual subsidy	Million Rand

3. ANALYSIS METHODILOGY

Traditionally, Cape Town used Cost Benefit Analysis (CBA) for the assessment of transportation projects. The First Edition of the Guidelines for Conducting the Economic Evaluation of Urban Transport Projects was issued in June 1992 after input from several stakeholders and practitioners. Since then, two reviews have taken place. In May 2002, the city adopted the Third Edition (CCT, 2002). This version allows for the possibility to assess road and public transport infrastructure investments as well as interchange facilities. Criteria included are: income distribution considerations, regional developmental benefits (economic developments) and environmental considerations (integration of Environmental Impact Assessment (EIA) requirements).

Multi Criteria Analysis (MCA) was developed as a reaction to the limitations posed by a CBA. The main argument against CBA is that not everything can be translated into monetary terms. Many criteria, including safety and security issues, as well as other qualitative issues are excluded in a CBA. MCA unifies different dimensions (qualitative as well as quantitative) of criteria. Different criteria are allocated a weight (adding up to 1.0) to indicate the relative importance.

Different MCA methods have been developed during the last 30 years to support decision makers facing conflicting decision situations. Every method appears to have advantages and disadvantages. The literature has not come to a conclusion with regards to a preferred method. There are two main schools of thought regarding MCA. The first unifies scores across alternatives, applies a weighting and sums the result per alternative. The second school of thought takes the comparison a step further. After the unification of scores, weighted alternatives are compared pair-wise. It is important to note that different assessment methods might lead to different conclusions.

In order to have confidence in the outputs, it was decided to use two significantly different methods in this project: The Weighted Sum method (appealing to the first school of thought) and the EVAMIX method (appealing to the second) (Vermeulen, 1986).

Weighting was applied for the criteria within a cluster, as well as between clusters. Between clusters two different weightings have been used. An initial equal weighting was used along with a proposed weighting (Table 3). The proposed weighting for criteria clusters as well as the weighting of criteria within a cluster was agreed upon by the City of Cape Town and the Provincial Government of the Western Cape.

Table 3 Applied weighting

CRITERIA CLUSTER	INITIAL	PROPOSED
Spatial	20	20
Transportation	20	30
Environmental	20	15
Social Environment	20	20
Costs	20	15

Earlier, a description was given of all alternatives that were considered in this project. Within the assessment calculations, it was decided to vary the ticket price for the busway option (Alternative 6) and the tram train option (Alternative 8). In both cases, the quality of the public transport system will be so much better, that charging a higher ticket price was a likely scenario. The prices used would result in an operational subsidy free alternative.

4. ALTERNATIVE ASSESSMENT

All criteria were included in the Weighted Sum method and EVAMIX method. In both methods, a larger number represents a more attractive alternative. Moreover, if the values are negative, the benefits are smaller than the dis-benefits (costs). Table 4 summarises the results of the assessments. A colour coding has been added to distinguish very negative (dark orange), negative (light orange), neutral (no colour), positive (light green) and very positive (dark green). The results in Table 4 clearly show the difference between the two methods. The maximum value for the Weighted Sum method is 1.0, whereas the EVAMIX method does not have a minimum or maximum value but shows a larger spread.

Both methods indicate that Alternatives 0 to 5, are considerably less attractive than Alternatives 6 to 9. Based on the negative values in the EVAMIX method, implementation of Alternatives 0 to 5 is not recommended. Moreover, the values for the "Do Nothing" alternative (Alternative 0), indicate that changes are required.

As indicated, the conclusions drawn from various methods might differ. Converging results strengthens the argument for the recommendation of a particular alternative. The application of further methods is recommended if diversion occurs. The range of answers between the two applied methods differs significantly. This is attributable to the different ways of applying the weighting.

Irrespective of the weighting and method, and excluding those alternatives with increased fares (Alternatives 6b & 8b), the busway with lane balance alternative (Alternative 6) scores higher than all other alternatives. The next highest scores are Alternatives 7, 8 and 9 with similar scores. Even with slightly elevated fares, Alternative 6b still has better scores than Alternative 8b.

5. CONCLUSIONS AND RECOMMENDATIONS

Cape Town has set itself the goal to become a more liveable city. The N1 corridor is one of the city's development corridors and sustainability has been identified as a must. This has lead to the selection of 22 transportation, environmental, social and cost related attributes for assessment purposes. Moreover, nine different corridor development alternatives were assessed. Two analysis methods and various weightings concluded that a busway with lane balancing is the preferred alternative. If a fare of R3.00 is applied, no subsidy will be required.

Through the use of the MCA Analysis tools, it was possible to determine the most effective transport solution to the N1 Corridor, taking into account more than just the transport costs and benefits as would have been the case using the CBA method. MCA is generally a more holistic approach to project assessment.

Over the last 30 years, various MCA methods have been established. No one method is preferable over all others. Users need to realise that various methods could provide different results. It is recommended to apply multiple methods until the results converge.

For future studies it is recommended to use MCA rather than CBA to assess projects, in order to include a vast amount of qualitative and quantitative criteria. Further research might be needed to align different studies and come to a common set of criteria to be used in South African practice.

Table 4 Summary of the results of the Multi Criteria Analysis

		Alternative											
		0	1	2	3	4	5	6a	6b	7	8a	8b	9
Method	**Weight**	Do nothing	Upgrade rail	Lane Balance to Freeay Lanes	Lane Balance & Rail Upgrading	BMT Lanes & Lane Balance	BMT Lanes, Rail Upgrade & Lane Balance	Busway & Lane Balance	Busway & Lane Balance (ticket R3)	Busway, Rail Upgrade & Lane Balance	Tram Train & Lane Balance	Tram Train & Lane Balance (ticket R3.5)	Road Pricing & Lane Balance
Weighted sum	Proposed	-0.034	-0.007	0.215	0.168	0.225	0.163	0.513	**0.531**	0.436	0.398	0.458	0.394
	Initial	-0.066	-0.031	0.200	0.137	0.197	0.118	0.443	**0.467**	0.343	0.310	0.390	0.337
EVAMIX	Proposed	-4.542	-4.175	-1.005	-1.510	-1.010	-1.757	2.991	**3.201**	2.057	1.781	2.501	2.055
	Initial	-4.257	-3.782	-0.511	-1.222	-0.709	-1.654	2.741	**3.021**	1.539	1.250	2.210	1.781

6. REFERENCES

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