DEVELOPMENT OF A LEAST COST STRATEGY FOR DURBAN'S PUBLIC TRANSPORT SYSTEM

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1. INTRODUCTION

Urban multi-modal public transport systems in South Africa evolved in a political and institutional environment where individual modes developed their patronage base in competition with other modes, some with the benefit of subsidy support and some without.

Uncontrolled competition for passengers on the same routes, over-trading resulting in poor utilisation of service, poor service standards and total lack of co-ordination characterise the supply-driven systems that have grown out of that environment.

The consequence has been escalating financial support for inefficient public transport systems, often focussed on those modes within the system that have been experiencing declining market share.

It is against this background of rapidly escalating transport subsidies, supporting a system of deteriorating public transport service to the public, that the government prepared the White Paper on National Transport Policy in 1996, followed by the Moving South Africa - Action Agenda (1997 - 1999), and the National Land Transport Transition Act which was promulgated in 2000.

In 1999, the National Department of Transport (NDOT) initiated "Fundamental Re-structuring of Durban's Public Transport System" as a flagship project. This paper describes a project within that process called "A least Cost Public Transport System Strategy for Durban".

The overall objective of the Least Cost System investigation was to determine a preferred public transport system at a strategic level which:-

* firstly; was defined in terms of a least cost system of routes and public transport modes;
* secondly; operated at a minimum agreed level of service, based on current service levels, and;
* thirdly; recognised and responded to the preferred land use/transportation framework defined in the first task of the Fundamental Restructuring Project.

In terms of the original brief, the focus was on the formulation of least cost strategies taking account of capital and operating cost, without consideration of revenue and subsidy. During the course of the study however, it became apparent that meaningful comparisons between different strategies could not be drawn without some recognition of the "bottom line" financial implications. At that point "least cost" was redefined to account for the difference between system costs and fare revenue that would determine the subsidy requirements as the primary factor for evaluating the impact of each alternative.

This paper sets out:-

* Study objectives and methodology
* Input requirements from prior investigations
* Alternative system strategies developed and tested
* Performance evaluation
* Key findings
* Conclusion

The study was undertaken by the joint venture of De Leuw Cather Emtateni and Stewart Scott. The project was a National Department of Transport initiative jointly managed and funded by the Durban Metropolitan Council's Traffic and Transportation Department and the National and Provincial Departments of Transport, with Durban's Traffic and Transportation Department acting as the project manager.

2. THE STUDY PROCESS

The figure on the following page sets out the study process.

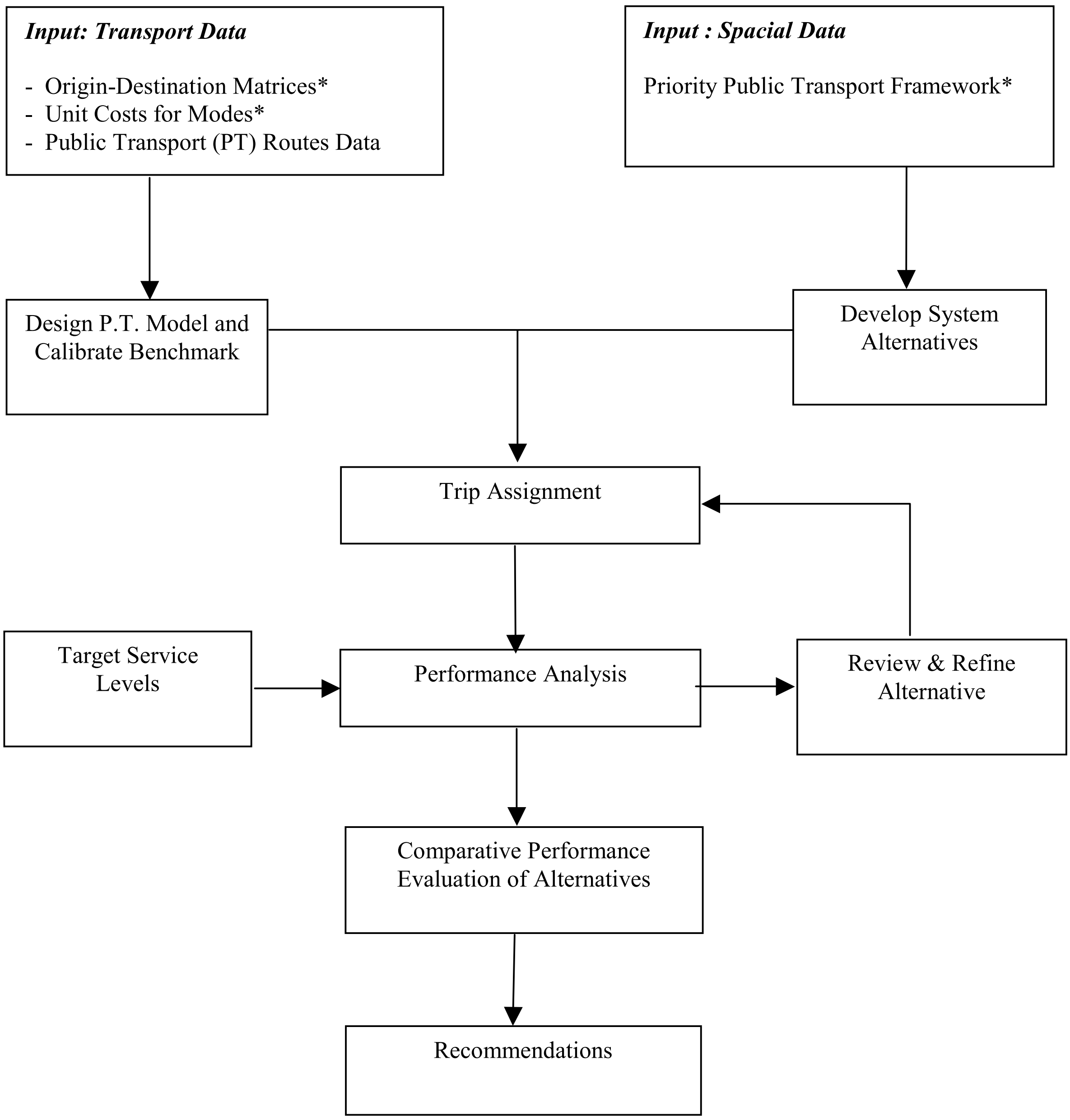
The general approach was to develop a wide range of system options, emphasising different modes in the dominant role, to gain an appreciation of the strengths and weaknesses of different modes playing different roles in the transport system.

Some form of modelling was seen as essential for a comprehensive assessment of the performance of each system and for comparative analysis on a consistent basis. An enhanced version of EMME2, tailored for the particular requirements of this project was developed and interfaced with an extensive EXCEL spreadsheet model, where the performance of any strategy, in terms of a variety of predetermined parameters, could be evaluated against the base year current system benchmark.

Prior to initiating this Study, the Fundamental Re-structuring Project (FRP) produced three key inputs essential to the development and modelling of alternatives. These were:-

* a high priority public transport framework for the metropolitan area;
* a cost model for capital and operating costs for the different modes;
* origin-destination (O-D) and trip transfer surveys by mode;
* bus and rail routes from the CPTR surveys of 1997.

THE STUDY PROCESS



* Source: Other tasks forming part of the Durban Public Transport Re-structuring Project

The high priority framework comprised existing and emerging land use and mode transfer nodes of significance, together with the major corridors of public transport movement between these activity centres. The various system alternatives in the rationalisation study were structured to serve this basic metropolitan framework.

The cost model provided unit costs, comprising combined capital and operating costs, in rands/vehicle hour and rands/vehicle kilometre for a range of transport modes including:-

* 5M trains upgraded to 10M standards;
* 35 seater midibuses;*
* 18 seater minibus taxis;*
* Standard (65 seated/35 standing) buses;
* Articulated buses with adapted seating configuration(95 seated/ 45 standing), for selected longer routes in the system.

* *As specified in the National Government's Taxi Recapitalisation Programme*

The cost model also provided factors for the expansion of the peak hour costs to annual costs taking into consideration off peak, weekend and holiday services.

The existing public transport trips by mode were sourced from:-

* An on-bus O-D survey from 05h00 - 10h00;
* Taxi rank and on board O-D surveys;
* A rail passenger O-D survey.

These were supplemented by mode transfer surveys at key centres throughout the metro area.
For the system as a whole there were 1.13 rides per trip, which account for transfer trips. In total there were 174 000 peak hour trips. The following shows the rides per mode:-

Mode	Passenger Rides
Minibus Taxi	98 500
Bus	59 200
Rail	39 400
	197 100
	======

The network of bus and rail routes was built from the data base of the CPTR surveys of 1997, updated to year 1999. The taxi network used in the study was a synthesised network of routes based on the O-D pattern of surveyed trips.

The network description included existing service frequencies, travel speeds and fares.

EMME2 uses time (or generalised time) to generate optimal route and mode choice strategies. The network building therefore takes into consideration speeds, service frequencies and fares translated into a time equivalency. The fare costs comprise a boarding fee and a per kilometre cost component.

The existing fare structures mitigated against integrated services because of the multiple boarding fee penalty for multi-ride trips. The development of system options therefore modified the fare structures for multi-ride trips by developing a more realistic boarding fee.

3. RANGE OF ALTERNATIVE SYSTEM STRATEGIES

Ten alternative systems were developed, tested and compared against the benchmark of the existing system. These were based on making best use of one of the three principle modes of rail, bus or taxi.

Each alternative was a variation on one of these themes. In each case the principle mode was made to work as effectively as possible with an optimised support system from the other modes. In some alternatives the services were planned to operate on dedicated right-of-way in the most heavily trafficked north-south coastal corridor. In that corridor various options existed between the use of rail and articulated buses operating on dedicated right-of-way within the existing rail reserve. These services were supported by tailored feeder services with different mode options.

The system serving other corridors of lesser demand was defined either in terms of existing rail service or some combination of bus and taxi on the road system. Depending on the location and demand, the bus service could operate with higher capacity articulated buses on routes that extended beyond the busway.

Feeder services included consideration on the new 35 seater midibus from the national government's proposed Recapitalisation Programme. The taxi services were based on the new 18 seater minibus taxi proposed within the same programme.

Other areas of the public transport system, outside of significant demand corridors, for purposes of the strategic analysis, were based on use of the minibus taxis and standard buses.

In addition to routes and modes, the services in each system were defined in terms of service frequency and fare structure. Service frequencies were adjusted during analysis in order that each system should meet targets set for levels of service. The fares remained constant for each mode throughout the analytical process.

The ten alternatives shown in the figure on the following page fit within one of four groups:-

1. The existing system of rail, bus and taxi routes with services optimised.

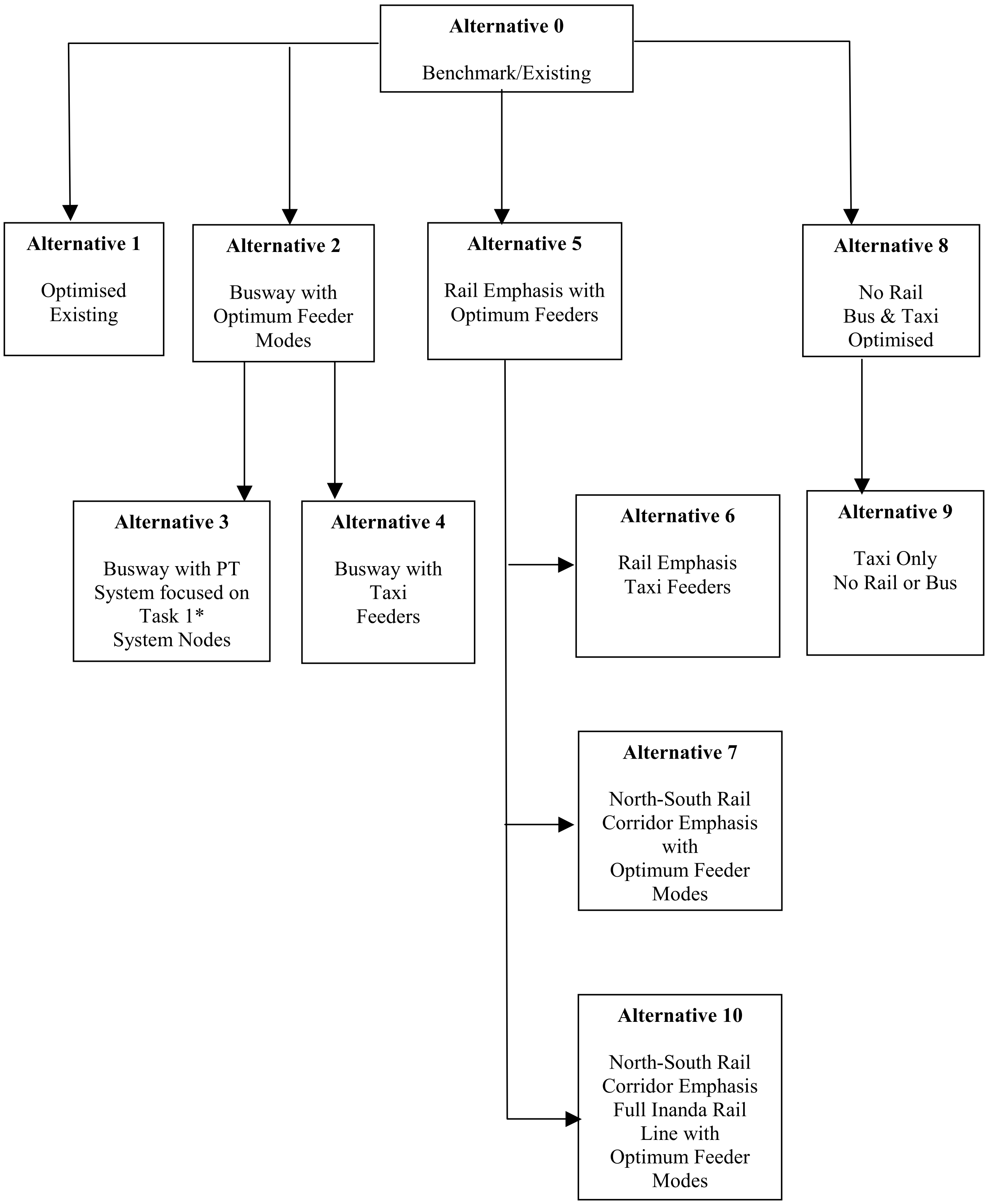
2. Systems with no rail service and an emphasis on bus with a busway operating in the heavily trafficked north-south coastal corridor.

3. Systems with an emphasis on rail, supported by feeder services.

4. Systems with no rail service and either a taxi only or an optimised bus and taxi system.

In developing this wide spectrum of alternatives, the intent was also to embrace a range of alternatives from a limited intervention solution through to extreme options. The purpose of exploring extreme options, at one end of the spectrum, was to understand the financial and service performance impact of radical solutions such as a no rail option or a taxi only solution, without being restricted by political and other equally important considerations.

RANGE OF SYSTEM ALTERNATIVES



** Note: Task 1 from Fundamental Re-structuring Project identifies a system of major development nodes and public transport corridors*

This was valuable in gaining an understanding of the sensitivity of alternatives to modal configuration of the system. At the other end of the spectrum, Alternative 1, the Optimised Existing System looked at the impact of a limited intervention option focussed primarily on elimination of 'unproductive' routes carrying few passengers.

Services in direct competition with the principal mode selected for the major corridors were removed from the system, except in the case of Alternative 1, the Optimised Existing.

In developing the alternatives through the evaluation process, target peak hour load factors were set as follows:-

Mode	**Direction**	**Load Factor**[1]
Bus	Peak from residential origin	0.70
	Peak from mixed land use origin	0.50
	Off-Peak	0.20
Taxi	Peak Direction	0.86
Rail		[2]

Note (1) : Load Factor for a trip = passenger volume + passenger carrying capacity

(2) : Rail service evaluation was based on minimum demand level of 2 000 boarding per hour

With the exception of rail a service headway of not more than 30 minutes, at target load factors or better, was required to retain a service. In the case of rail, headways of greater than 30 minutes were accepted if the demand target of 2 000 boardings per hour was met.

Based on the above, a standard bus route would be removed from the system and served by another bus route or another mode if the peak hour demand was less than 90 to 120 passengers per hour, depending on the land use at the origin. Similarly a minibus taxi route with less than 25 passengers per hour in the peak hour would be removed and the passengers assigned to the nearest viable route or mode.

At the passenger demand level where bus routes using standard buses were removed because of inadequate peak hour demand, the equivalent service by midibus or minibus taxi could be provided by a 20 minute midibus service frequency, or a 7 - 8 minute taxi service.

Although the target load factors should be achievable in an efficient, integrated system, sensitivity analysis was nevertheless carried out at the end of the testing of alternatives to establish the impact on service costs and subsidy requirements.

At the end of all route rationalisation some service areas were inadequately covered. In such cases, provision was made for re-introducing routes to re-establish coverage accepting a lower level of service productivity on such routes.

4. PERFORMANCE EVALUATION

4.1 Key Interest Group Perspectives

In establishing a basis for evaluating the performance of each system, three key interest groups were identified together with quantifiable main areas of concern. These were:-

Interest Group	**Areas of Concern**
The Passengers	Levels of Service considering:- * walking time * waiting time * in-vehicle time * % walking total trip * rides per trip * fare per trip * overcrowding
The Operators	System Utilisation by Mode in terms of:- * market share * service requirement * revenue * protection from competition
The Transport Authority	Service and Productivity considerations including:- * utilisation by mode * impact of changing market share * annual system operating cost * annualised infra-structure cost * annual revenue * annual revenue shortfall

For evaluating the impact of service changes at community level as well as at the macro level, for the system overall, the 626 zone system for the Metro area was aggregated into 27 areas. Results were presented in a series of spreadsheets (22 pages in all) and bandwidth plots of assigned volumes by route and mode. From these, key indicators were used to evaluate the alternatives.

4.2 Performance Evaluation

This section compares the alternatives in terms of the primary objective of a least cost system. The comparison is limited to the best alternatives from each group that placed an emphasis on bus, rail or taxi, along with the 'no rail' and 'optimised existing' alternatives.

For simplicity the comparison in this paper focuses on Level of Service, Market Share and Financial Performance.

Of the alternatives that placed emphasis on the bus mode, without rail support (Alternatives 2, 3 & 4), the system that performed best financially was Alternative 3. This system had a north-south busway along the existing rail reserve, a feeder system optimising the use of different bus modes as well as minibus taxi. The system was designed to best accommodate the recommended public transport framework plan of priority development nodes and corridors, from Task 1 of the PTRP.

Of the alternatives that focused on various rail systems (Alternatives 5, 6, 7 and 10) the best financial performance by far was Alternative 7, which only provided rail in the same heavily trafficked north-south corridor as the busway system. This rail service was also supported by a tailored system of feeders with optimum use of the bus and minibus taxi modes.

4.3 Level of Service

The following table shows level of service performance for the average trip for each alternative:-

Alternative	Wait Time (min)	In-Vehicle Time (min)	Rides/Trip
Benchmark/Existing	4.6	29.3	1.14
1 - Optimised Existing	4.9	28.0	1.18
3 - N-S Busway	4.3	29.9	1.36
7 - N-S Rail Only	5.0	30.1	1.37
8 - No Rail	3.7	29.2	1.20
9 - Taxi Only	3.6	26.5	1.19

In each alternative the trip time is similar to the existing situation notwithstanding the fact that the number of rides per trip has increased, particularly for systems introducing feeder services in support of the major corridor movements.

In the initial analysis, walk times (start of trips, and transfer) increased significantly from the benchmark level of 12.7 minutes to 15.3 for the Optimised Existing and as high as 20.0 for the N-S Rail System Alternative.

The reasons for this problem arise from:-

* increased transfers. There was a strong co-relation between walk times and number of transfers (rides/trip) with excessive walk time at transfers;
* reduced service area coverage;
* due to sensitivity of travel costs some passengers were walking rather than paying the cost of a short feeder trip.

To overcome these problems, provision was made in the service supply costing to re-introduce 100 bus and 100 taxi routes which would ensure adequate coverage.

In refined analysis, not carried out in this strategic study, transfer times would have to be re-modelled based on assumed efficient planning and design of transfer nodes and fare structures on the shorter feeder trips re-formatted to reduce the boarding penalty and make the 'through ticket' price more attractive.

On this basis it was reasonable to assume that for each alternative the full trip time of walk, wait and ride would be similar to the existing situation providing an acceptable level of service in each alternative.

4.3.1 Financial Performance

The following table shows the annual financial performance characteristics:-

Alternative		**R millions per annum**		
		Total Costs (incl. infra-structure)	**Revenue**	**Shortfall**
	Benchmark / Existing	1 106	688	418
1 -	Optimised Existing	770	684	86
3 -	N-S Busway	834	638	196
7 -	N-S Rail Only	772	684	88
8 -	No Rail	806	684	122
9 -	Taxi Only	771	684	87

In each system alternative there was a substantial reduction in the cost of providing service and consequently in the annual deficit needed to support the service.

The top three alternatives (1, 9 and 7) although very different in concept, were effectively the same in overall financial terms. Whilst it was interesting to see how well the Taxi Only solution performed, the high risk and limitations of a single mode monopolistic system precluded this alternative from serious consideration.

Interestingly, Alternative 1 (the Optimised Existing System) performed well above expectations, demonstrating the high impact that rationalisation of bus services could have on a metropolitan wide basis.

Alternative 7, the N-S Rail Corridor System performed equally well, having removed cost ineffective rail services and consolidated around the heavily utilised north-south rail corridor.

4.3.2 Market Share

The following table shows market share characteristics of each alternative in terms of passenger-kilometres, which is a good indicator of service activity by mode:-

	Alternative	Annual Passenger-Kilometres (1 000's)			
		Bus	**Rail**	**Taxi**	**Feeders**
	Benchmark/Existing	720	680	1 560	-
1 -	Optimised Existing	550	670	1 720	-
3 -	N-S Busway	2 040	-	570	290
7 -	N-S Rail Only	1 000	790	800	300
8 -	No Rail	1 080	-	1 850	-
9 -	Taxi Only	-	-	2 920	-

The two alternatives with the best financial performance, 1 and 7, impacted quite differently on market share. In Optimised Existing, rail activity remained essentially the same as existing while bus activity dropped off by 24%, and taxi activity increased by 10%. This was primarily due to the removal of low frequency lightly loaded bus trips, many of these being replaced with lower capacity but more frequent minibus taxi services.

In Alternative 7, the N-S Rail Corridor Option, the reverse was true. Bus activity increased and minibus taxi dramatically reduced. Although potential exists to focus feeder services on the taxi mode there would be at least a 29% reduction in taxi activity.

5. KEY FINDINGS

The following are the most significant findings from the strategic analysis in this investigation:-

(i) Major savings in costs and reductions in subsidy are achievable, with levels of service similar to existing. This can be achieved by removing unproductive trips and if necessary, routes. Passengers on such trips or routes are carried on consolidated, higher frequency, rationalised services of the same mode or more cost effective modes.

(ii) The top two financial performers (excluding the taxi only solution) have potential annual subsidy savings of approximately R330 million (80% of the current subsidy of R418 million). These are Alternative 1 - Optimised Existing and Alternative 7 - The N-S Rail System supported with an optimised feeder system.

Sensitivity analysis in terms of reduced target passenger load factors shows that in the worst case scenario, there would still be a saving of approximately R235 million (>50%) in the current annual subsidy.

If in addition there was an increase in the unit operating and capital costs on all modes by up to 20%, there would still be a subsidy saving of approximately R60 million per annum. Within this range the most probable low end saving scenario would result in a saving of approximately R180 million per annum providing the necessary actions can be taken to achieve the system set out in the Alternative.

(iii) Each alternative has a significant impact on the relative market share of individual modes:-

- Alternative 1: The Optimised Existing results in a 24% reduction in bus market share with a corresponding gain of 10% in taxi share.

- Alternative 7: the rail solution focussing on the north-south rail corridor results in an increase in rail market share of 16%, in bus of approximately 40% and a reduction in taxi of 30%.

Such results could influence the selection of a preferred alternative.

(iv) Replacing rail in the heavily trafficked north-south corridor with some form of busway, operating in the rail reserve, is financially ineffective due to higher operating costs and the high capital cost of the infra-structure.

(v) Total elimination of rail is not a cost effective solution.

(vi) A theoretical system based on taxis only could be cost effective but with major operational problems. Such a system would require heavy investment in capital infra-structure and as a single mode system would probably be unacceptable to the public and politicians alike.

(vii) The negative impact of reduced market share on some modes is unavoidable in achieving reduced costs. Within each alternative however there are ways of minimising this impact on bus or taxi by a more refined analysis of the alternatives.

6. IMPORTANT QUALIFICATIONS

The analysis in this investigation is of a strategic nature and is robust in terms of broad conclusions related to the potential to save cost on provision of service, through a more efficient public transport system configuration.

Beyond the strategic analysis, more detailed planning is required when considering system implementation. This creates the opportunity to explore and refine the use of the different modes in various parts of the system, which could have a significant impact on market share for each mode. In this process other factors such as policy, creating opportunities for SMME's and employment creation will have an important influence on refining the preferred system strategy.

The strategic analysis in this project was not intended to identify cost savings in absolute terms but to identify the cheapest system in relative terms. The sensitivity analysis carried out on potential cost savings, (refer Section 5), considered change in revenue based on different levels of passenger loading, and changes in service supply costs based on different unit cost rates for each mode. Apart from this analysis, a detailed evaluation of the refined systems should be undertaken to account for other factors such as the cost of down-sizing any part of the existing system, enforcement costs, marketing, monitoring and various other elements which did not form part of the strategic assessment.

7. CONCLUSION

This strategic investigation shows there is potential to effect major savings in subsidy expenditure by changing a supply driven public transport system to a demand driven system. Achieving such savings cannot occur without a change to the type of service provided to the public but can be achieved without reducing the level of service provided.

The challenge is to mobilise political commitment and to constructively engage the public transport service providers in developing a programme of system changes that is acceptable to all stakeholders.

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John Simmons is a director of De Leuw Cather Emtateni who has been involved as a consultant in transportation and traffic engineering projects in South Africa for 30 years. He has worked extensively in the field of public transport for over 20 years. John has lectured in transportation planning at the University of Durban-Westville and the University of Natal and has presented a number of papers at the ATC on various aspects of public transport.

He is currently heading a team for the Department of Transport KZN to determine the possible impact of the new larger taxis and midibuses, forming part of the Natural Re-cap Programme, on infra-structure requirements throughout the province.

He is also involved in the Provincial initiative to economically empower the taxi industry through various forms of development and services related to the industry.