A CASE STUDY ON THE FEASIBILITY OF BRT-ASSISTED TRANSPORT AT THE UNIVERSITY OF PRETORIA

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ABSTRACT

This research aims to examine the feasibility of a collaboration between public transport and institutional transport operators to reduce growing traffic congestion around educational facilities. The *A Re Yeng* bus rapid transit system offers the possibility to explore this at the University of Pretoria due to its proximity to major University campuses, particularly, Hatfield and Groenkloof. A comparative study was done in which four scenarios were considered: the existing university transport, the current *A Re Yeng* service and two modified BRT solutions. Passenger demands, service design and cost analyses were considered. It was found that the current BRT offering can cater for the added student capacity although it showed vastly increased travel times due to a required transfer during the journey. It also resulted in far higher costs. The modified solutions accumulated more comparable costs, and also illustrated other operational and systemic efficiencies in the form of route and service design, as well as passenger demand management. The research showed that there are synergies that can be cultivated from a capacity and cost perspective to replace existing institution transport with public-operated transport, but issues such as security and infrastructure should be carefully considered.

Keywords: case study, integration, duplication, public transport, university transport.

1. INTRODUCTION

1.1 Background

Collaborations between public transport operators and institutional transport services are becoming ever present at educational facilities, with several examples seen in North America, Europe and Asia (Rotaris and Danielis, 2014; Hashim et al., 2013). They usually entail the contracting of nearby public transport services, usually shuttle bus services, to assist or replace an institution's transport operators along certain routes on their network. Typical arrangements include: unlimited fare-free access for students, staff and faculty members; seasonal access for specific periods or semesters within the academic year; and partially subsidised access in which users contribute towards their transport in addition to their tuition. Specialised access cards and IDs are generally required to use such services. When executed effectively, the public transport service provider stands to gain assured ridership from a student body and an institution's transport management can reduce operating costs and defer some responsibilities pertaining to student transit.

Tertiary students have unique and complex travel behaviour characterised by increased and unpredictable mobility, constantly changing residences, and diverse trip purposes at irregular times of the day (Limanond et al., 2011; Volosin 2014). This complex travel behaviour requires complex solutions to cater for it. Educational institutions, like other types of private and public establishments, have both positive and negative impacts on surrounding areas. They contribute to the prestige and economy of the area, while still attracting large amounts of traffic and congestion (Rotaris and Danielis, 2014), thereby affecting the well-being and daily experiences of employees and students, as well as the affairs of businesses and residents in nearby areas (Duque et al., 2014). The ability to understand the travel behaviour of their students and successfully manage and balance the impacts thereof, can help institutions and related stakeholders gear toward improvements to infrastructure, programs and policies that encourage the use of public transport, and non-motorised modes of travel (Shannon et al., 2006). An integration of transport operations at tertiary educational facilities can help to reduce congestion in surrounding areas by consolidating traffic from modes that are essentially providing the same service.

1.2 Context

The University of Pretoria (UP), with approximately 62,000 students as of 2017, too experiences increased traffic in surrounding areas and is constantly looking for new solutions for student parking, as is seen in the construction of added parking facilities in adjacent plots. This is highlighted in survey data that shows for approximately 39% of trips, a car is used to arrive at UP, and 25% of those vehicles park outside campus on the streets (UP Facilities Management, 2017 a). The University's transportation network is run on a fixed route schedule. The network spans across five campuses with a fleet of approximately 40 buses from various tendered bus services operating daily at differing schedules, depending on demand and capacity.

The greater Hatfield area, in which the main campus is situated, is home to various modes of public transport, including, rapid rail (*Gautrain* and their fixed-route buses), commuter buses (*Putco* and *Tshwane*), minibus taxis and bus rapid transit (BRT - *A Re Yeng*). *A Re Yeng* operates a combination of trunk and feeder routes within the Tshwane region, and incorporates stops at three UP campuses; the Hatfield main campus, the Groenkloof campus and Prinshof medical campus. The same university survey indicated that 16% of trips arrive to campus with public transport, with *A Re Yeng* accounting for only 3% of the total. A further 14% of trips arrive with UP bus services. Of the inter-campus trips, half are made with UP bus services and almost none with the *A Re Yeng*.

UP bus services delivers its students in a punctual, reliable and safe manner. Although, as of the start of the second semester of 2017, a low seat occupancy of 27% (UP Facilities Management, 2017 b) resulted in the removal of one of the six tendered buses that operated the Groenkloof-Hatfield. Meanwhile, *A Re Yeng*, like most BRT systems in South Africa, is being scrutinised for lack of ridership despite the high subsidies being paid by government. The abovementioned, coupled with the increased motor activity in the area (to which university transport also adds) and the duplicated services in this instance, introduces an opportunity to investigate the feasibility of BRT-assisted transport at the UP.

2. LITERATURE REVIEW

2.1 Network configuration

A variety of basic network configurations can be found in transport operations. These include shuttle services, grid networks, elbow networks, radial networks, diametrical networks, tangential networks, trunk and feeder networks and trunk and branch networks (Bruun, 2013 a). These configurations are put together in a number of ways to form complex transport operations. A shuttle network, which is largely utilised by UP, is one in which there are no intermediate stops on a route, only end points. Shuttle services employ simplicity in organisation and directness, however, they carry limited passenger volumes due to no seat turnover (Danaf et al., 2014). Trunk and feeder networks, as is adopted by *A Re Yeng*, consist of trunks, that are long distance routes connecting major destinations, and feeders that act as collectors and distributers for the trunk (World Bank, 2012). Feeders converge to a stop and passengers must then transfer to the trunk that consolidates traffic, and vice versa (Bruun, 2013 a). It is easier to co-ordinate feeder-to-trunk transfers as trunk frequencies are typically higher than those of a feeder (World Bank, 2012).

2.2 Service design

Historical bus operating data can be leveraged to construct a time-dependent bus network which is associated with the traffic and demand information in different periods of a day (Wang et al., 2017). Travel on scheduled public transport can be viewed as a series of movements and intervals, where the proportionate importance of each varies with the trip length, travel time and the nature of intervals (Bruun, 2013 a). Total user travel time can be expressed as follows:

$$T_{o-D} = t_a + t_{wa} + T_1 + t_e \tag{1}$$

Where, T_{O-D} is the time for a user to get from origin to destination; t_a is the access time, defined as the time elapsed when a passenger travels from their origin to the boarding point of public transportation; t_{wa} is the waiting time before departure, including waiting time during transfers; T_1 is the in-vehicle time including dwell time at stops; and t_e is the egress time, defined as the elapsed time when travelling from the point of alighting until the final destination. Transfers are almost inevitable in large multimodal public transport networks, and public transport users often associate transfers with inconvenience (Vuchic, 2006). Inconvenient or badly designed stop interchanges unnecessarily increase waiting times and can disrupt passenger travel, thus diminishing their travel experience. The frequency of a network plays a vital role in its efficiency and greatly impacts delays. Frequency delay is the difference between ideal and actual departure times, with ideal times being the earliest time of convenient departure. Frequency delay is largely influential on the duration of waiting times (Hensher, 2008). Numerous studies show that people perceive waiting time as more onerous than in-vehicle time, but do enjoy some amount of travel time regardless (He et al., 2011). Under favourable conditions, public transport travel time can be enjoyable and productive. Surveys indicate that passengers often spend time working, reading or resting (Litman, 2012), which can be valuable to students.

2.3 Cost

Transportation costs are either fixed or variable in nature. Fixed costs (which are generally equivalent to capital costs) are those associated with the construction of the system and the purchasing of equipment and rolling stock. That is, they are the costs associated with putting the operation into place. Variable costs (which are generally equivalent to operating costs) are associated with the actual operation of the system. Fixed costs do not vary with the level of day-to-day operation, whereas variable costs do. Variable costs can be further categorised as being direct, indirect, or joint. Direct costs belong to specific components such as labour, fuel and maintenance associated with the operation of a given transit route, as opposed to indirect costs, which are not identified with specific components. Joint costs are those which are shared by two or more services (Meyer & Miller, 1984).

Two basic approaches can be used to construct a model relating route cost to the operating variables of a route, namely, the cost allocation or unit cost method, and the multivariate statistical approach (Bruun, 2013 b). The unit cost approach, adopted in this study, is the more commonly used and involves the examination of individual cost components (expense functions) and assigns them on logical or empirical grounds to one or more operating variables, as illustrated in the following equation (Meyer & Miller, 1984),

$$Annual\ variable\ costs = a\ (vehicle\ hours) + b(vehicle\ miles) + c(peak\ vehicles) + d(route\ miles) + e(stations) + f(stations\ man\ hours) + g(modal\ fixed\ costs) + h(system\ fixed\ costs) \quad (2)$$

Where a to h are the unit costs associated with each of the operating variables in brackets. The major difficulty in applying this method involves determining which operating variables capture the true cost, and then allocating the various cost components to these variables.

3. REASEARCH OBJECTIVES AND APPROACH

The objective of this paper is two-fold, first, to investigate the feasibility of BRT-assisted transport along a selected route of UP's transport network, and second, to explore the strategic issues and implications of implementing such a system. To address the first objective, a number of parameters consisting of route layout, service design, passenger patterns, and cost analyses, were considered to compare the existing University transport solution to the current *A Re Yeng* offering, in addition to a modified BRT route and a route assimilation option. These four variations are described as follows:

1. Existing University transport solution (**ES**) – The tendered UP transport operation between the Hatfield and Groenkloof Campuses.
2. *A Re Yeng* offering **(AO)** – The currently available services that the BRT provides.
3. Modified route **(MR)** – An altered *A Re Yeng* transport route between the campuses.
4. Route assimilation **(RA)** – *A Re Yeng* utilising the existing University route.

The services are proposed to replace the existing University transport and operate parallel to the existing BRT services. For simplicity, it was assumed that students would take the first available bus that passes a station. Travel time would only consider in-vehicle time and station waiting times; access and egress times were ignored. The study was conducted primarily from the University's Facilities Management's point of view and the issues that would arise in implementing alternative solutions. Factors concerning the systemic design of the system, rather than the human factors affecting the respective systems, were the focus for the first objective, although external factors were addressed in the strategic considerations for the second.

4. SCENARIO ANALYSIS

4.1 Routes

Fuel costs make up 50% to 70% of all vehicle operating costs and are escalated by heavier vehicles, longer trip lengths, steeper road grades, and increased stops (at stations, traffic lights or in congestion) (Loprencipe et al., 2017). Figure 1 traces the various route options, and Table 1 summarises the corresponding distance, grade and station information.

The ease of manoeuvrability along the straight sections, lack of intermediate stops, forgiving road grade and predictable traffic conditions in scenario **ES** would suggest more favourable topographical operating costs. In **AO**, a combination of an entire feeder route (F4 or F7) and a portion of a trunk route (T1), between the "Mahatma Ghandi" or "General GL Pitso" stations (situated roughly midway between the end trunk stations) and the "Tukkies" station must be used. The F4 and F7 feeder routes are slight variations of each other, running in reverse directions. The T1 trunk route remains unchanged in both directions between the stations of interest. As is, an *A Re Yeng* bus overcomes the highest grades, traverses the longest distance and makes the most stops, thereby incurring higher fuel costs and thus, higher operating costs. Both **ES** and **AO** interact at the entry of the Groenkloof campus. However, at the Hatfield main campus, **ES** picks up and drops off students at an enclosed parking yard on the south-Eastern side of the campus, whereas with **AO**, students board at a roadside stop and alight across a four-lane road to the campus, at "Tukkies" Station.

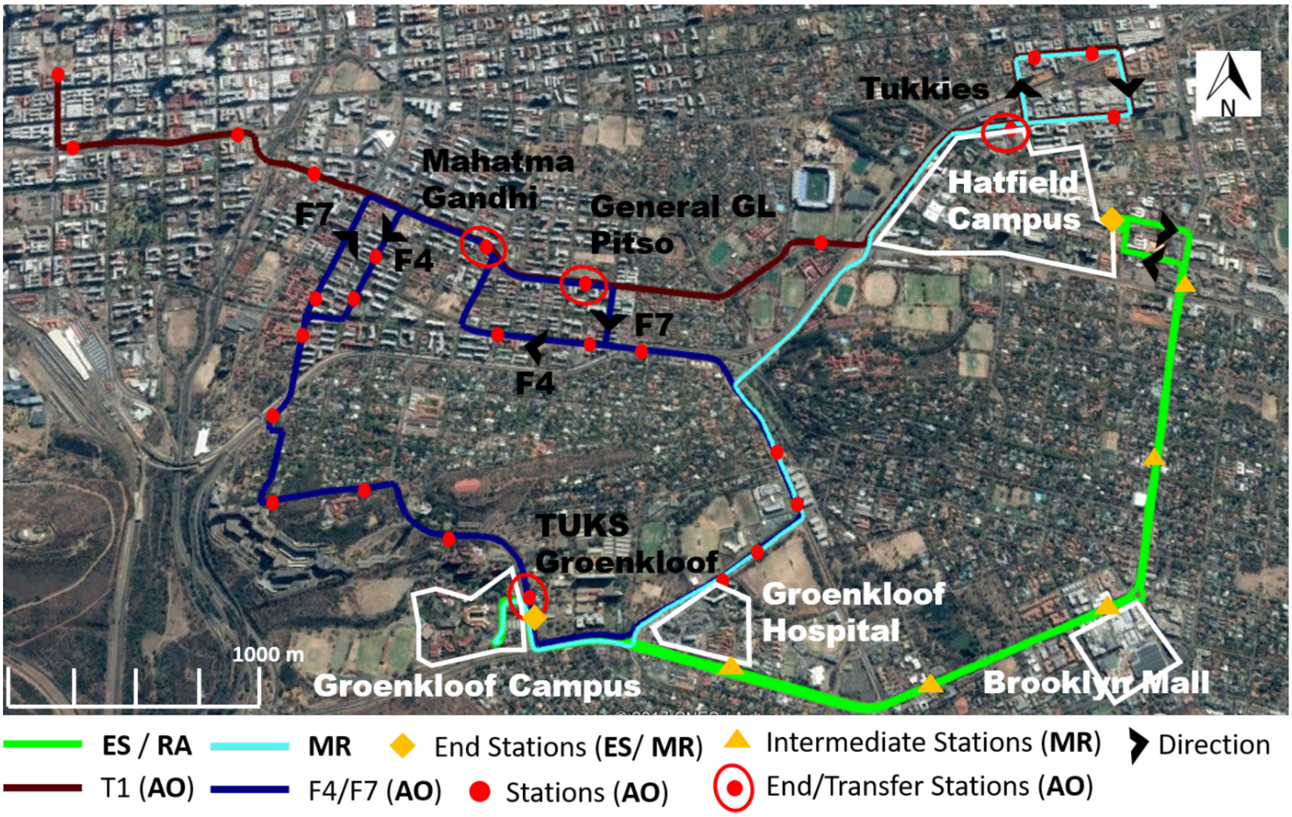

Figure 1: Routes (Google Earth, 2017)

Table 1: Route information

Scenario		Distance (km)	Elevation Change (m)	Average slope		Intermediate Stations	Transfers Required
				Eastbound	Westbound		
ES		5.12	20	-1.70%	2.40%	0	0
A Re Yeng	**AO** (F4 + T1)	6.02	31	3.95%	-4.10%	8	1
	AO (F7 + T1)	6.13	31	3.95%	-4.10%	8	1
	MR	4.11	31	-1.40%	2.90%	3	0
	RA	5.12	20	-1.70%	2.40%	5	0

Modified routes could create strategic opportunities for *A Re Yeng* to isolate or consolidate disparate trip purposes and user demographics; isolate to limit the operational logistics of catering for the students without infringing on the wider network, and consolidate to take advantage of economies of scale on a diverse route. Two routes are suggested in this paper to address these opportunities. **MR** is structured as a semi-direct service for students with shared feeder BRT stations to account for origins and destinations between campuses (which are prohibited on a shuttle service) and to encourage wider public transport use through interactions with the rest of the service. It incorporates both end stations at “Tuks Groenkloof” and “Tukkies” and it shares a portion of the feeder routes closer to the Groenkloof Campus and the end section of the trunk route at the Hatfield side. **RA** assumes the **ES** route, but would accommodate student and general passenger trips by catering for more diverse locations. Apart from UP, this route passes Brooklyn Mall, Groenkloof Hospital and several residences and office parks. **MR** and **RA** offer improvements over **AO** in shorter route lengths, flatter road grade and fewer stops. **ES** still outperforms them all in this regard.

4.2 Service design

Table 2 depicts the real and hypothetical schedules of the four options. **ES** departs every 30 minutes bi-directionally from 06:30 until 17:30, thereafter a single bus departs alternatingly from each campus every 30 minutes until 22:00. On weekends, limited service is offered at specific times. **AO** requires one of two feeder routes (F4/F7), each with departures every 30 minutes (every quarter hour alternatingly) from the “Tuks Groenkloof” station throughout the day. Essentially, a student can catch a bus from there every 15 minutes. A transfer is then required to the T1 trunk route that has headways of 7 minutes during the peak and 20 minutes in the off-peak. This offers better frequencies than the 2 vehicles per hour in the **ES** option, however, the necessary transfer increases travel times. The difference in the last bus departures between the feeder and trunk routes means that the last possible trip between the two campuses is limited by that of the feeder routes. The feeder routes also do not operate on weekends, meaning evening or weekend travel is not possible.

MR would avoid the need for transfers, however, the shared piece of feeder route creates frequency and headway conflicts. To avoid these, it would alternate frequencies with the F4, with which it shares a heading towards the main campus. Like **ES**, buses depart bi-directionally, at the same time. Travel time differences between **MR** and the F7 would ensure that a clash of routes is avoided. **MR** would also run later into the evening and on Saturdays at reduced frequencies. Due to mixed and increased demand, **RA** would expand on **ES**’s service by reducing the weekday headways to 12 and 20 minutes during the peak and off-peak respectively, and maintaining a 30-minute headway on weekend.

Table 2: Bus departures and frequencies (Tuks bus schedules, 2017, Tshwane.gov.za, 2017)

	Approximate Bus Departure Times			Approximate Bus Frequencies			
		First Bus	Last Bus				
ES	**Weekdays**			**Weekdays**			
	Groenkloof	06:30	21:30	7am-6pm	6pm-10pm		
	Hatfield	06:30	22:00	30 mins	60 mins		
	Saturdays			**Saturdays**			
	Groenkloof	07:00	13:00	7am	9am	1pm	
	Hatfield	12:00	17:00	12pm	5pm		
AO (T1)	**Weekdays**			**Weekdays**			
	Mahatma Ghandi	05:13	20:13	6am-8am	8am-3pm	3pm-6pm	6pm-8pm
		05:33		7 mins	20 mins	7 mins	20 mins
		05:53					
	Tukkies	05:35	20:15				
		05:55	20:35				
	Saturdays			**Saturdays**			
	Mahatma Ghandi	06:13	19:13	7am-7pm			
		06:43	19:43	30 mins			
	Tukkies	06:35	20:05				
AO (F4)	**Weekdays**			**Weekdays**			
	Mahatma Ghandi	06:00	18:00	7am-7pm			
		06:30	18:30	30 mins			
	Tuks Groenkloof	06:30	19:00				
AO (F7)	**Weekdays**			**Weekdays**			
	Mahatma Ghandi	06:15	18:15	7am-7pm			
		06:45	18:45	30 mins			
	Tuks Groenkloof	06:45	19:15				
MR	**Weekdays**			**Weekdays**			
	Tuks Groenkloof	06:45	21:30	7am-9am	9am-3pm	3pm-6pm	6pm-10pm
	Tukkies	06:45	22:00	15 mins	30 mins	15 mins	60 mins
	Saturdays			**Saturdays**			
	Tuks Groenkloof	07:00	17:00	7am-7pm			
	Tukkies	08:00	18:00	120 mins			
RA	**Weekdays**			**Weekdays**			
	Tuks Groenkloof	06:00	22:00	6am-9am	9am-3pm	3pm-6pm	6pm-10pm
	Hatfield	06:00	22:00	12 mins	20 mins	12 mins	20 mins
	Weekends			**Weekends**			
	Tuks Groenkloof	06:00	19:00	7am-7pm			
	Hatfield	06:00	19:00	30 mins			

The practicality of these service designs was assessed through recorded and simulated travel times. Numerous **ES** travel times were manually recorded over several days and aggregated to a single representative weekday. **AO** travel times, including transfers, for all possible campus trips were simulated from available bus schedule information (Tshwane.gov.za, 2017). Travel times for **MR** and **RA** were calculated using estimated vehicle speeds of 25 km/h in the off-peak and 15 km/h in the peak, while varying station dwell times according to perceived popularity, to accommodate for changing passenger demand and ease of access into buses. Access and egress times were ignored. Figure 3 shows the calculated travel time progressions throughout a representative day.

Average travel times of 14 and 34 minutes are seen for **ES** and **AO**, respectively. The stark difference in travel time reflects in the directness of **ES** in route length and stop avoidance, typified by the lack of a transfer. Table 4 outlines a basic statistical analysis of the impact of the BRT waiting times, assuming no frequency delay that arises from a required transfer.

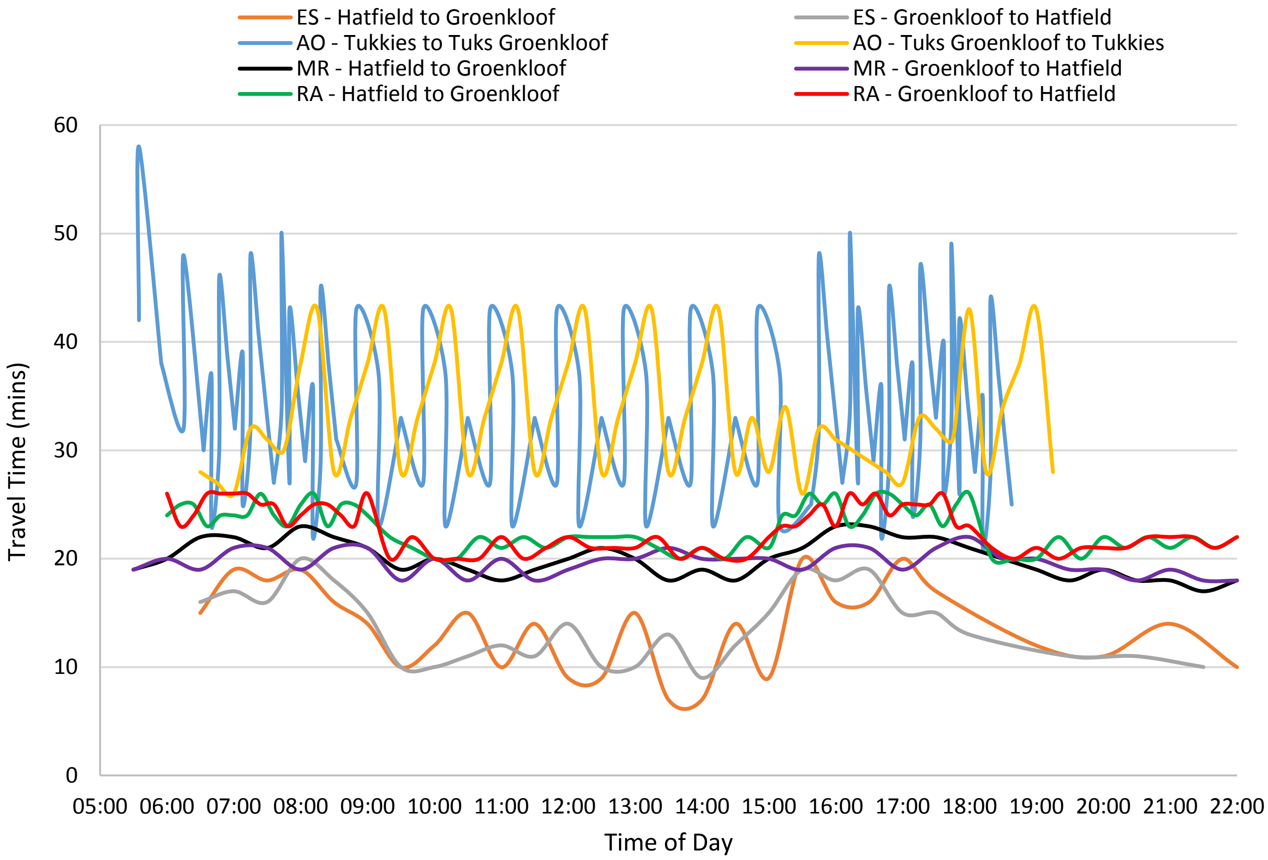

Figure 2: Calculated travel times throughout the day for various scenarios

Table 3: Waiting time analysis (in minutes) for AO

	Sample Mean	Maximum	Sample Standard deviation
Tuks Groenkloof to Tukkies	7.06	17	5.52
Tukkies to Tuks Groenkloof	10.09	29	7.71

The transfer introduces additional average total travel times in the order of 7 and 10 minutes in the indicated directions. Larger waiting times are experienced in the direction towards Groenkloof campus, where trunk-to-feeder transfers are required, which are harder to co-ordinate than feeder-to-trunk services (World Bank, 2012). This is illustrated in the almost double maximum waiting times experienced in that direction, as well as the larger sample standard deviation, indicating a wider spread of data. What's more, is the unreliability in the waiting time illustrated in the erratic fluctuations seen in the travel time of

AO in Figure 3. Although repetitive in distinct portions of the day, the sudden, largely varying waiting times is unreliable for students whose lectures start promptly on the half hour.

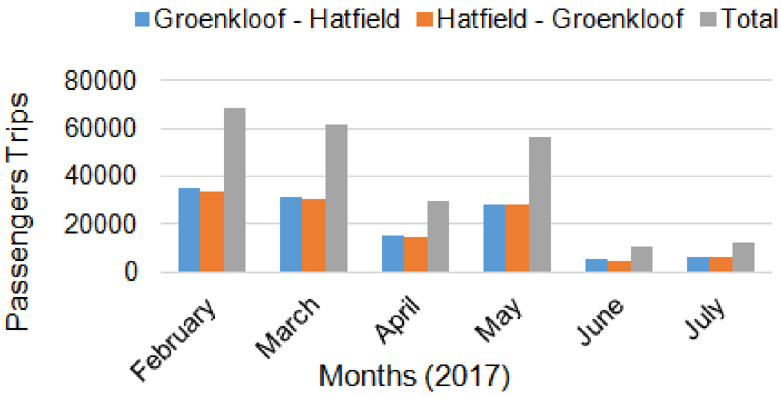

Figure 3: Passenger trips on ES for the first semester of 2017 (UP Facilities Management 2017 b)

MR and **RA** plot travel times in-between **ES** (lower bound) and **AO** (upper bound), demonstrating averages of 20 and 23 minutes, respectively, with the shorter trip length and lower demand benefiting **MR**. They both better **AO** due to the lack of a transfer and less intermediary stations, but they lag behind **ES** as a consequence of incurred station delay. The unpredictability in using **AO** means that students would have to leave significantly earlier in order to be punctual. Similarly, it would have to be determined if the extra in-vehicle travel time on **MR** and **RA** is deemed acceptable by students, or by Facilities Management if they result in lower costs.

4.3 Passenger demand

During the first semester of 2017, approximately 240 000 trips were made using **ES**. Figure 2 displays the break down per direction, with trips being relatively evenly split each month. The months of April, June and July suffer considerable decreases in passenger trips due to recess, examinations and semester holidays. This profile is indicative of the demand during any semester at UP, with higher demands seen in the early months and subsequent reductions following as the semester progresses. This section determines if each scenario can accommodate the additional student trips in place of **ES**, while also including general passenger trips, if any. The following capacity equation was used (Bruun, 2013 a):

$$P_{max} = f * \alpha * C_v \quad (3)$$

Where, P_{max} is the maximum passenger capacity for a given time period, f is the frequency of vehicles, α is the passenger load factor of a given vehicle, and C_v is the vehicle capacity. The total demand of each alternative option including students is first estimated. Their ability to serve that demand through their projected monthly capacities, relative to bus size specifications, is then quantified. The following information and assumptions were used in conjunction with the equation:

- The existing BRT services exist and operate as normal. **AO** frequencies in peak and off-peak hours were used as published by *A Re Yeng*.
- Frequencies were used as per the service designs in the previous section.

- *A Re Yeng* buses are repurposed to the proposed routes.
- A passenger load factor, α, of 0.9 was used for each vehicle.
- Standard buses (75 passengers) are used along the trunk and feeder routes in the off-peak. Articulated buses (120 passengers) are available along the trunk in the peak during times of high demand.
- **MR** induces 20% of the demand from the feeder trips and 5% from the trunk in their respective shared sections. These are best guess assumptions not based on detailed forecasting.
- Due to the assumed high activity, **RA** generates 50% of trips of the T1 trunk route.
- The demand for *A Re Yeng* was projected from figures previously published by SABOA 2016 National Conference and Exhibition, 2016.
- A conservative student demand of 68 827 trips was used, as achieved in February. This may be higher or lower depending on the relative attractiveness of the proposed service.
- A monthly average of 22 weekdays and 4 Saturdays was assumed.

Table 4 depicts these results. In its current arrangement, the T1 trunk route has the capacity to carry approximately 120 000 passengers per month operating only standard buses. This is around 30 000 less than the combined T1 and student demand. However, in incorporating articulated buses during peak periods, that demand is comfortably catered for. The two feeders fall short of meeting the consolidated demand; articulated buses are not permitted on these routes. Increasing the frequency during peak periods would meet the added student demand, however, varied feeder departure times present difficulty in synchronising feeder-trunk transfers or vice versa.

Table 4: Passenger capacity per month (P_{max}/month)

<table>
<tr><th></th><th colspan="2">Demand</th><th colspan="3">Capacity</th></tr>
<tr><th></th><th>A Re Yeng demand without students (SABOA, 2016)</th><th>Demand with students ridership included</th><th colspan="2">Standard bus (peak & off peak)</th><th>Articulated bus (peak)</th></tr>
<tr><td>AO (T1)</td><td>78 143</td><td>146 970</td><td colspan="2">118 665</td><td>158 760</td></tr>
<tr><td>AO (F4)</td><td>4 512</td><td rowspan="2">77 764</td><td>37 125</td><td rowspan="2">72 765</td><td>-</td></tr>
<tr><td>AO (F7)</td><td>4 425</td><td>35 640</td><td>-</td></tr>
<tr><td>MR</td><td>*5 642</td><td>74 469</td><td colspan="2">62 100</td><td>79 920</td></tr>
<tr><td>RA</td><td>*39 072</td><td>107 899</td><td colspan="2">109 350</td><td>-</td></tr>
</table>

**induced ridership from trunk and feeder routes*

MR also fails to meet the consolidated demand while using standard buses, although it comfortably does so with articulated buses during the peak. **RA** is just able to cater for the added student demand with standard buses throughout. All of this is to suggest that service upgrades would permit *A Re Yeng* to cater for the total demand including students.

4.4 Cost analysis

In its tender agreements, the University stipulates that service providers accumulate their own operator costs, which include vehicle kilometres travelled, fuel, driver salaries and vehicle maintenance, and produce a daily rate that UP is to pay. A total daily rate of R10 770 for **ES** was paid in 2017 (UP Facilities Management, 2017 b). As of the 1st of July 2017, *A Re Yeng* introduced new and reduced distance based fares (Table 5) that work in conjunction with a discounted point system that awards more points per monetary value added above R80 to encourage bulk purchases.

Table 5: *A Re Yeng* Rates (Tshwane.gov.za, 2017)

Distance-based fares		Discounted point system			
Distance bands range covered (km)	Fare for single trip for connector cash value (R)	Travel Points	Price (R)	Travel points awarded	Discount %
0-3	R7.00	Connector 20	R20	20	0%
*3-8	R8.00	Connector 60	R60	60	0%
8-14	R10.00	Connector 80	R80	96	17%
14-21	R12.00	Connector 100	R100	120	18%
21-29	R14.00	Connector 150	R150	180	19%
29-38	R16.00	Connector 200	R200	240	20%
38-48	R18.00	Connector 350	R350	440	21%
48-59	R20.00	Connector 500	R500	640	22%
59-71	R22.00				

**Distance band of all four scenarios.*

If the fare structure was the same in Facilities Management completely using **AO**, they would have to pay R8.00 per student trip (3-8 km band) for a maximum of 3400 daily student trips in the busiest month. If the 22% point deduction is applied for bulk purchases, a total daily rate of R21 216 is payable; more than double that of the tendered rate. The University would have to leverage a guaranteed student ridership for a lower fare from *A Re Yeng*, and even that might require further subsidy from alternative sources to be competitive.

A cost allocation model was used to produce daily rates for **MR** and **RA**. Performance based parameters were extrapolated from the previously described service design specifications. Rates, based on *Rea Vaya*'s unit costs, were projected from a more in-depth study of the Johannesburg BRT system done by Hunter van Ryneveld (PTY) Ltd, 2014, for the National Treasury. Table 6 displays the vehicle operating cost rates used, as of 2017. These rates were applied to their corresponding parameters in a cost model to arrive at the respective daily rates for **MR** and **RA**. Table 7 summarises these values.

Table 6: Vehicle Operating Cost Rates, 2017

Variable	Amount	Variable	Amount
Daily use of vehicle	287.7 km (**MR**) 614.4 km (**RA**)	Drivers Per vehicle	2 (**MR**) 3 (**RA**)
Type of fuel	Diesel	Driver rate	R712/day
Fuel consumption per vehicle	1.40 km/l	Maintenance costs/hr/veh	R26.65
Fuel price	12.13	Vehicle km rate/day	R13.06
Student demographic	Route specific	Vehicle hours/ day	15

Table 7: Daily Operating Costs

	MR	RA
Fuel	R3 489.80	R7 452.67
Finance (Salaries)	R1 933.56	R2 845.58
Fixed Costs	R5 448.17	R11 634.87
Maintenance and service	R1 159.28	R1 738.84
% Student demographic	92%	63%
Cost allocated to students	**R11 068.35**	**R14 913.33**

MR and **RA** produce daily rates of approximately R11 100 and R15 000 respectively, which constitutes a slight increase for **MR,** and a 50% for **RA**. In both cases, a fare concession may be negotiated with *A Re Yeng* as lower fare costs may lead to increased ridership and vice versa. More so with the **RA** as further economies of scale could exploited by tapping into alternative demand markets.

4.5 Strategic issues

Routes cannot be understood in isolation from the network in which they operate (Boyce, 2006). That holds true for both *A Re Yeng* and University transport. A joint solution would have to suit both systems and not interfere with the rest of their respective operations. For example, in implementing the **MR**, the scheduling and operations of the two feeder routes and perhaps even the trunk route would have to be altered. The network configuration is often central to performance, even of a single route. Also, demand demographic and demand variation is a major source of route viability. For the *A Re Yeng* to cater so specifically to the student demand would require a sufficient and mobile enough demand to justify a service essentially operating in isolation, but still allowing for enough interaction with the rest of the system to encourage wider public transport use.

Student buy-in is another important aspect. Is the service appealing to the students and do they actually want to use it? Any solution would have to be user friendly and allow for easy assimilation with the systems that UP already has in place, like student cards. Student cards may be loaded with bus credit/points at the beginning of each semester with the portion of their fees going towards this cost as with the existing situation. This could also induce trips towards public transport. Safety of the students is something that the University has less control over in using public transport. That safety extends to the non-motorised transport (NMT) facilities at the stations in question. As mentioned, **ES** drops students off within an enclosed university property. At the "Tukkies" station, students alight on the opposite side of a busy Burnett street. Sufficient NMT and traffic configurations must ensure safety for the mass volumes of students crossing the road. Both end stations are also regular, open plan stops, specified for low volumes with no pre-boarding fare systems. Boarding and alighting at non-enclosed stations requires a user to tap in and tap out. This would cause significant delays that would further impact the travel time.

5. CONCLUSION

The aim of the paper was to investigate the feasibility of public transport supporting university transport options, through a simplified desktop study. Four scenarios were considered including the existing university transport option, the currently available *A Re Yeng* offering, an isolated, modified BRT route and a scenario in which *A Re Yeng* assumes university transport route. The existing system continues to achieve sustained success, so any proposed solution must at the very least match its level of service or better it, at a comparative cost.

The existing solution is exclusively student oriented. It comfortably and safely delivers students in a punctual manner. The current *A Re Yeng* offering can move students between campuses but suffers from extended travel times due to transfers and scheduling conflicts that could prove disorienting to a considerable student population. The daily rate that the University would have to pay far in using that service far exceeds the current rate. The modified route and assumed route matched the existing university transport in directness of route and produced competitive travel times. However, some discomfort might be experienced in the added stops and extensive boarding and alighting times due to the present station infrastructure. The operating costs in comparison to the existing solution were projected to be slightly more for the modified route and 50% higher for the route adoption, however, economies of scale could see those further reduced.

The world is heading towards integrated public transport networks in which mutual goals are aligned in solutions that aim to make the most of public transport. This is also highlighted in South African policy. Like most BRT and public transport systems in the country, the *A Re Yeng* is set to roll out in phases as part of the wider public transport expansion and integration plan. Some of this growth is around major trip generating institutions, like universities. This research has shown that a case can be made for closer collaborations between institutions and local public transport authorities. Demonstrated benefits accrue mostly to authority in the form of guaranteed extra ridership and long-term development of public transport market. For institutions, careful analyses and negotiation might be needed to ensure the service matches their and their members' needs, especially relating to cost. They might need to negotiate to secure affordable payment. If we want to move towards upgraded public transport services around institutions, then this concept warrants careful consideration and investigation into the elasticity of some of these parameters.

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