

TUT Student Bus Transport System: A Case Study

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Abstract

With the merger of the former Technikon Northern Gauteng, Technikon North-West and Technikon Pretoria, Tshwane University of Technology (TUT) inherited the need to link all of its five campuses located in different parts of the City of Tshwane through a student bus transport system. The challenge for the provision of such a service grew with the increase of its student body to more than 50,000, close to 10% of whom reside on TUT off-campus residence facilities. These residence students are also provided with a bus transport service to access their campuses. The recent steep fuel cost hikes have brought forward the issue of transport cost. Historically transport was not taken into account for any decisions taken by facilities management. Student residences were leased amongst others, according to affordability of the facility, irrespective of their location and without considering the financial implications of such decisions. University facility managers are now realizing the huge financial savings that can be made by factoring in transport cost in their decision making processes. TUT commissioned a study to investigate the possibility of reducing the operational cost of its student bus transport services. The study was carried out by the CSIR. There are many possible scenarios emanating from the study, however this paper is limited to the scope of the undertaking to develop a financial model for the bus service, undertake scenario modelling for the service, and to furthermore establish the financial implications on the results of the study and to propose possible recommendations to TUT. The study utilized the basic public transport service design principles and the fully allocated transport cost model. Passenger counts were carried out on the existing TUT bus routes to enable profiling the demand for the service and supply of the service. Based on the findings of the study, practical recommendations were made to TUT. The presentation will focus on the lessons learned from the TUT student bus transport service study. It will highlight the implications of transport costs within the facilities management finances as well. Recommendations in relation to curbing costs and generating enough revenue to cover the cost of the service will also be discussed.

1. Introduction

The transport unit within the Logistical Services Directorate of the University acquired the responsibility to transport residence students between their official residences and their relevant academic learning site. Provision is also made for the non-resident students who wish to use the bus transport from the Pretoria main campus to their respective learning campus within the Tshwane Metro Region. Both these student commuter groups pay for the usage of the bus transport service. TUT is not licensed as a public transport company and may therefore not compete with other public transport service companies. Bus transport services are not a core business of TUT. Therefore the unit has, however, outsourced the service to external contractors by means of a public tender procurement process. The unit also offers an inter-campus bus shuttle service, thus allowing the ease of movement for students to reach their designated destination to utilize the Universities facilities. However the following key constraints are:-

- TUT may not render transport service on any route that is already being serviced by any public transport service provider with a valid licence to service such a route, and
- It may not pick-up or drop-off any of its students along any of the authorised routes except at their official TUT facilities.

2. Purpose of Study

Logistical Services which forms part of the Universities Institutional Support Operations Management, has to render a bus transport service to its student community on a break-even basis, i.e., to recover the actual cost of providing the bus transport service from the fees charged without necessarily making any profit or losses. TUT also acquired permission to provide bus transport services on the following routes which are also defined as public routes, but are not serviced by an official Metro Council or contractor to the relevant Metro Council:-

- Route between Arcadia Campus and the Pretoria West Campus.
- Route between Soshanguve North Campus and Soshanguve South Campus.

The site maps in Figure 1-3 below show the extensive distances between the Tshwane campuses and the off-campus residences where bus transport service is provided.

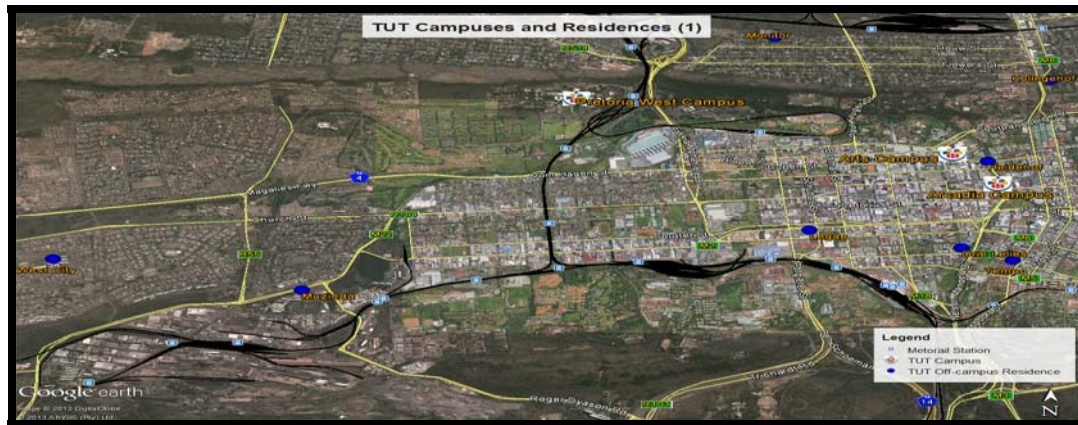


Figure 1: Location map of TUT facilities in Central Tshwane Metro Region

Figure 1 above indicates the Pretoria West (Main campus), Arcadia and Arts campuses that are located in the central area of the Tshwane Metro. Of the nine off-campus residences, West City and Muzinda residences lie approximately 10km west of the Pretoria West campus while Monitor residence is 4.5km east of the campus. The rest (Legae, Tempo, Kollegehof, Heidehoff and Drie Lelies) are within 10km diameter from the Arcadia campus.

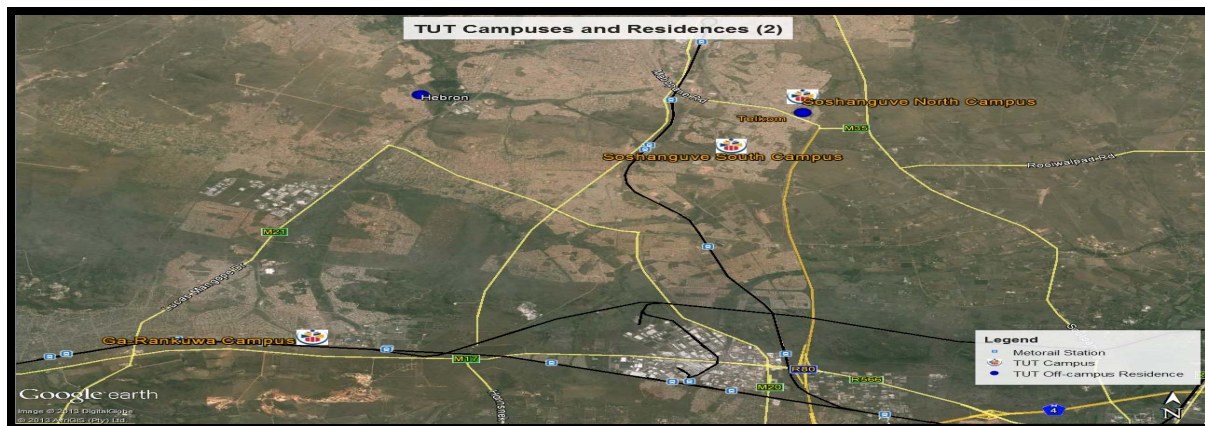


Figure 2: Location map of TUT facilities in the North-west of Tshwane Metro Region

Figure 2 above indicates the two Soshanguve North and South and the Ga-Rankuwa campuses that lie in the far north western part of Tshwane and ± 35 km from the CBD. The Drie Lelies residence is currently occupied by mostly Ga-Rankuwa students who commute 37km daily on TUT buses and the Hebron residence which also accommodates Ga-Rankuwa campus students is located 15km further north of the campus and it is closer to the Soshanguve campuses.

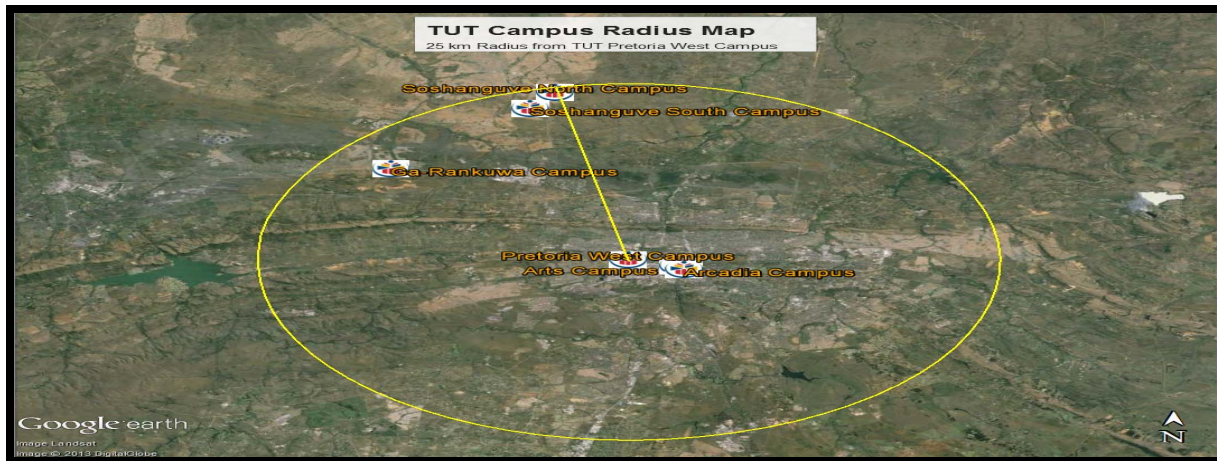


Figure 3: Radius indicator from Pretoria West Campus to Soshanguve North and South campuses.

Figure 3 indicates the 25km radius from the Pretoria West Main Campus to the Soshanguve North and South campuses. The Ga-rankuwa campus is closer to the Pretoria West Main campus.

3. Methodology

The case study consists of two complementary data collection methods with their objectives. Detailed interviews and consultations with TUT staff allowed CSIR to clearly define the scope of the study. These collations of information assisted in the review of the current TUT bus transport operations. The data collated from the interviews regarding the bus transport service was mainly related to the financial situation. Following a number of consultations with TUT during the course of the study, a number of design principles were formulated.

The survey conducted for passenger count on the intercampus bus service routes analyzed the demand and supply profiles, whilst the residence survey allowed for the determination of the number of buses to fulfill the residence capacity demand and hence the design principles to address the cost implications. There was no reliable data available regarding the current ridership on their transport service to enable service design. The study conducted passenger count on the inter-campus routes to get a more accurate service demand and supply profiles. Guided by those principles and the results from the passenger count survey, the maximum number of buses and other service operations aspects were designed for each of the current inter-campus routes. A similar approach was also adopted for the design of the residence shuttle service except where demand estimates were required, in which case, the house capacities were used. Alternative residence shuttle routes were also investigated and their effect on the vehicle resources required.

Finally, recommendations were deduced from the findings, including benchmarking with best practices with regards to cost recovery.

3.1. Limitations of the study

The service design provided in the study has the following limitations that need to be considered prior to implementation.

- Where applicable, sensitivity analysis and assessment were done to inform TUT how any changes in the assumptions would influence the results.
- Bus numbers and frequencies are designed based on actual demand for the inter-campus service as measured during the study and may change significantly during the exam periods.
- For the residence shuttle design, the demand is influenced by the total capacity of the residences serviced on the routes.
- Service designs are only for the weekdays and do not include weekends.

Unit costs of the existing service contracts entered into with operators are fixed with agreed annual increases.

4. Design Principles

The design principles were formulated via the TUT staff consultation process bearing the following restrictions:-

- No campus destination would require more than one transfer from any of the Tshwane Campuses. Soshanguve North and Soshanguve South campuses are treated as one campus in this respect due to the short distance between them. The Arts campus is not part of any of the inter-campus bus routes.
- Services are classified as inter-campus service and residence shuttle service. Each classification may only cross-subsidize within their respective classes and not between each other. Inter-campus service costs should be recovered by revenue from students using the inter-campus service only and those of the residence shuttle service from the residence students only.

It is assumed that the buses operate strictly based on the officially designed TUT routes and no interchange points are allowed except at TUT facilities.

The following service design models were developed for this study.

- Intercampus service model and,
- Residence design model.

4.1. Intercampus bus model

The inter-campus bus services operate only in Tshwane Metro where there is a need to connect the TUT campuses. The bus routes that service the five Tshwane campuses together with their distances and the maximum number of buses operating on the route (peak period) as provided by the Logistical/Transport Services are shown in Table 1.

Table 1: TUT Inter-campus Bus Service

ROUTE	ROUTE DISTANCE (KM)	NUMBER OF BUSES
Pretoria West-Arcadia	7.5	10
Pretoria West - Soshanguve South	36	6
Ga-Rankuwa-Pretoria West	35	4
Ga-Rankuwa-Soshanguve South	18	2
Soshanguve North - Soshanguve South	3.5	6

Table 1 above indicates the five Tshwane campuses together with their distances and the maximum number of buses operating on the route (peak period) as provided by the Logistical/Transport Services unit of TUT. Distances between campuses have a significant influence on the extent of resources required and the service costs. The distance to Pretoria West from the Soshanguve South campus and Ga-Rankuwa campus is 35-36km whereas only 3.5km separates Soshanguve South from Soshanguve North. Assuming these routes operate at the same speed and service the same demand, the number of buses required for Pretoria West – Ga-Rankuwa or Pretoria West – Soshanguve South would be 10 times that for Soshanguve South – Soshanguve North route. This means that the nominal cost is ten times more and thus to break even, the passengers fare need to be increased proportionately.

The following are two ways that determine the frequency/headway of a service.

1. Policy head ways - where specific headways that meet the policy goals are determined. Tut does not have a headway policy.
2. Demand based headways - is based on managing demand at the peak load point along the route. The peak load point is that point along the route that experiences the largest number of passengers per hour. The headway is determined by the minimum number of buses required per hour to make sure that a particular load factor is not violated.

For each TUT route the following inputs are required:

- Length of route (km)
- Average speed on route (km/h)
- Layover time (min) –loading and unloading time at the start and end of a route
- Peak demand on route (pax/h)
- Vehicle seating capacity (seats/vehicle)
- Load Factor –ratio of passengers actually carried versus the total passenger seating capacity of a vehicle. A load factor of greater than 1.0 indicates that there are standees on the vehicle.

- Operating hours (h) –Length of time periods when service is provided, e.g., if service is operated from 06:00 to 18:00, operating hours is 12.

Once the above parameters are specified, the following was calculated.

- Cycle time - is the time for one vehicle to make a complete cycle of the route.

Cycle Time (min) = $(2 \times \text{Length of route} \times 60 / \text{Speed on route}) + \text{Layover time}$

- The peak demand – this is the highest demand at the peak load point on the route, in the peak direction and at the peak time of the day given in passengers per hour.

Headway (min) = $\frac{\text{Vehicle seating capacity} \times \text{Load Factor} \times 60}{\text{Peak demand}}$

- Number of vehicles required to service the route.

Number of vehicles = $\frac{2 \times \text{Length of route} \times \text{Peak demand}}{\text{Speed} \times \text{Seating capacity} \times \text{Load Factor}} + \frac{\text{Peak demand} \times \text{Layover time}}{\text{Seating capacity} \times \text{Load Factor} \times 60}$

- The vehicle hours and the vehicles km

Daily vehicle hours = Number of Vehicles x Operating Hours

Daily vehicle km = Number of trips x Length of route

The headway and number of vehicles thus calculated are rounded to the nearest practical whole numbers and the new cycle time and route capacity is calculated by rearranging terms in the equations above. The new cycle time and route capacity should not be less than the cycle time and peak demand initially used.

Hence the number of vehicles used, vehicle hours and vehicle kilometres for each route is then used in the cost allocation model.

4.1.1. Supply and Demand Profiles

Figure 4 above indicates the CBD bus route map depicted in pink, from Pretoria West to Arcadia . This is one of the busiest yet shortest of the routes. Soshanguve North – Soshanguve South route is the other busiest bus route. These two routes are relatively short and yet require high number of buses which is a clear indication of high frequency service.

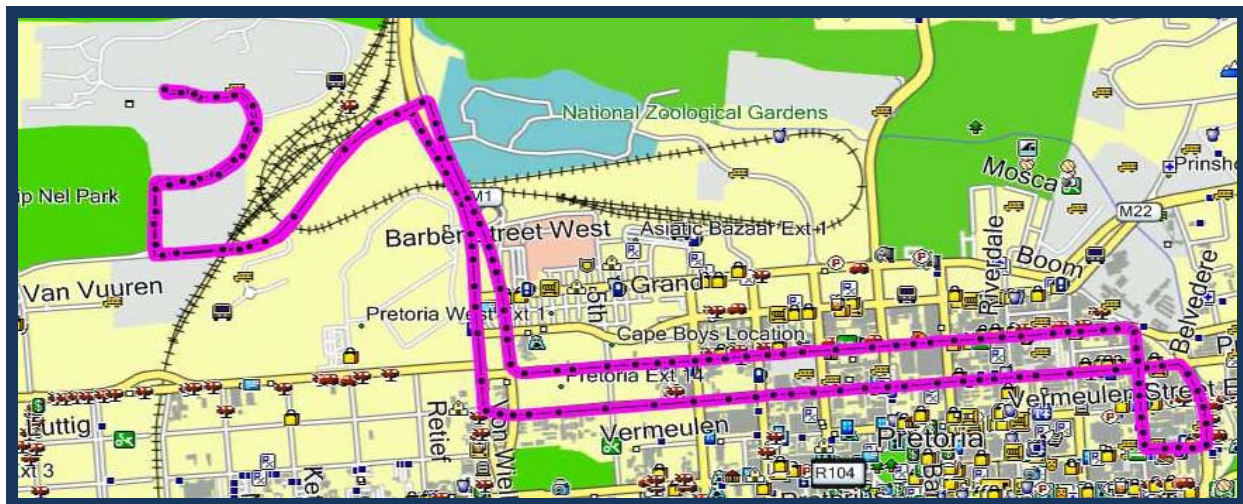
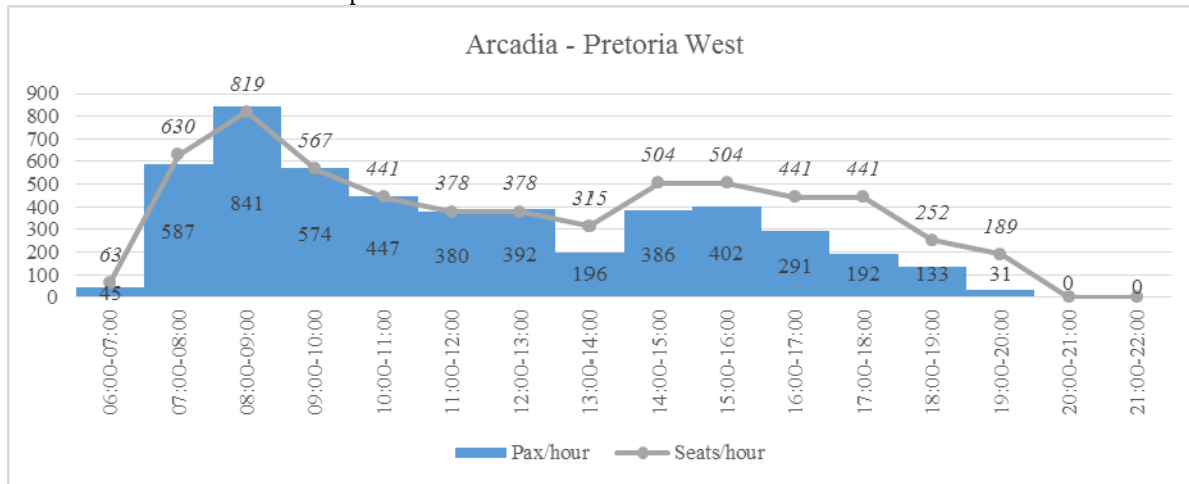


Figure 4: Indicates the Shortest yet busiest routes on the bus service schedule.

The route that connects Pretoria West campus to the Arcadia campus is the busiest of all the inter-campus routes serving close to 10,000 passenger trips a day. It runs through the central business district (CBD) area of the city as shown in Figure 4. It is operated by 10(ten) STABUS buses on a fixed 5 year contract basis scheduled to expire in 2015.

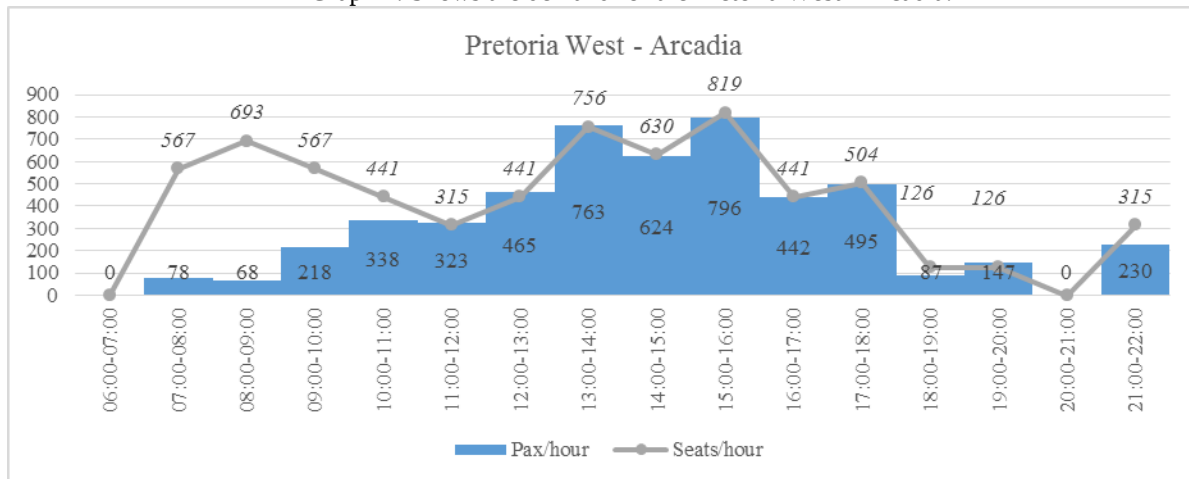
Graph 1: Shows the demand for the Arcadia –Pretoria West.



Graph 1 above demonstrates the demand for the Arcadia – Pretoria West direction.

The demand for the service is relatively high between 7:00 and 9:00 reaching 841pax/h as expected since the route services about 50% of the registered student population. This demand is high while during the same period the demand for the opposite direction, i.e., Pretoria West – Arcadia is at only 78pax/h, as seen in Graph 2 below.

Graph 2: Shows the demand for the Pretoria West –Arcadia.



Graph 2 above demonstrates the demand for the Pretoria West - Arcadia direction. In graph 2, the reverse occurs to graph 1. Between 13:00 and 18:00 the demand for the Pretoria West – Arcadia is about double that for the Arcadia – Pretoria West direction. Beyond 18:00 the demand reduces significantly to less than a quarter that of peak period.

4.2. Residence Design Model

The Residence design model, takes into account the student population at the various residences. Anecdotal evidence suggests for a given route length, the higher the travel speed, the lower the travel time. A reduction in travel time translates into shorter cycle times and higher number of vehicle trips. An increase in the number of vehicle trips means potential increase in volumes of passenger movement for a given period.

TUT operates nine routes connecting nine off-campus residences to their facilities within the City of Tshwane. In addition, three residences in eMalahleni and Nelspruit are serviced by two shuttle services to their respective TUT campuses. These are listed in Table 11 below together with their assigned number of buses and route distances.

Table 2: TUT Residence Shuttle Service Routes

ROUTE	ROUTE DISTANCE (KM)	NUMBER OF BUSES
Kollegehof/Heidehof/Arcadia	10	1
Legae/Tempo/Arts/Arcadia	8.5	1
Monitor/Pretoria West	4.5	1
Tempo/Kollegehof/Pretoria West	15	1
Muzinda/Pretoria West	8	4
West City/Pretoria West	10	5
Drie Lelies/Ga-Rankuwa	37	5
Hebron/Ga-Rankuwa	15	4
eMalahleni Campus	1.4	1
Nelspruit Campus	8	3
Total Number of Buses		26

Residence students are provided with a premium door-to-door shuttle service. The cost of running such a service is relatively high and proportionately requires additional funds. Currently, however, TUT does not charge residence students equivalent fees to fully cover the costs for this service.

All buses operate on a fill up and go basis during the peak demand hours. Timetables are inaccurate in their assumptions that all the buses assigned to the routes will be available at the indicated time. The cycle times of most of the routes do not allow for all the buses allocated to the route to be on schedule. The capacity of each of the off-campus residences serviced is provided in Table 3.

Table 3: Off-campus Residence Capacity

Residence	Capacity (Students)
Heidehof	328
Monitor	296
Kollegehof	218
Tempo	145
Legae	259
Muzinda	601
West City	1022
Telkom	512
Hebron	384
Drie Lelies	542
Mebala (Nelspruit)	124
Urban Cove (Nelspruit)	157
Mabaleng (eMalahleni)	198

4.2.1. Residence Shuttle Service Recommendations

TUT has a policy of providing students with transport that enables them to participate in academic, cultural and sporting activities. To fulfil this policy, it operates a highly subsidized bus transport service for its students which is managed through its Logistical/Transport Services Unit. This undertaking is costly and it needs to be understood that student residence placement plays a vital part. Information should be provided to the students on the financial implication of where they take up residence to enable them to budget for their transport needs.

5. Cost Recovery

In the case of TUT, the sprawl of its satellite campuses to areas as far as 35km from the Pretoria West campus adds more strain to its transport services.

The principal goal for TUT is to provide the transport service to its students on a break-even basis. The cost of the transport service is currently paid through transport levy collected from all the residence students; whether they use the service or not and non- residence students who choose to use the service. Revenue from the transport levy still doesn't match up to the cost of the service and the university injects an average of 35% subsidy annually. Transport services still ends up with a deficit annually as the total revenue from the transport levy and the TUT central budget comes short of recovering the cost of the service.

In 2012, revenue from students amounted to only 30% of the cost of providing the bus transport service. In 2013, the cost recovery improved dramatically with the introduction of compulsory transport levy of R1600 to all residence students and the same amount for willing day students (non-residence students). Currently, close to 19% of students registered in Tshwane campuses participate in the levy system. So far, revenue from the transport levy amounts to 59% of the cost of the transport service (Refer Table 5 below).

Table 4: The current annual cost of TUT's student bus transport service

ROUTE NAME	SERVICE PROVIDER	Type of Contract	No. of busses	Monthly Cost	Annual Cost
Intercampus bus service			28	R 2,283,024.00	R 27,396,288.00
Pretoria – Arcadia	Stabus	Fixed (until 2015)	10	R 1,059,480.00	R 12,713,760.00
Soshanguve North - Soshanguve South	Stabus	Fixed (until 2015)	6	R 282,528.00	R 3,390,336.00
Soshanguve to Ga-Rankuwa	Stabus	Annual	2	R 124,832.00	R 1,497,984.00
Soshanguve to Pretoria	Stabus	Annual	6	R 497,808.00	R 5,973,696.00
Ga-Rankuwa to Pretoria	Stabus	Annual	4	R 318,376.00	R 3,820,512.00
Residence shuttle service			26	R 2,196,484.72	R 26,357,816.64
Legae, Tempo, Kollegehof, Monitor, Heidehof, West City, and Muzinda	Stabus	Fixed (until 2015)	13	R 1,212,351.41	R 14,548,216.92
Hebron to Ga-Rankuwa	Amogelang	Fixed (until 2015)	4	R 236,611.31	R 2,839,335.72
Drie Lelies to Ga-Rankuwa	Amogelang	Fixed (until 2015)	5	R 441,450.00	R 5,297,400.00
Nelspruit Campus	David Sekgobela & Assoc	Fixed (until 2015)	3	R 229,554.00	R 2,754,648.00
eMalahleni Campus	David Sekgobela & Assoc	Fixed (until 2015)	1	R 76,518.00	R 918,216.00
Grand Total			54	R 4,479,508.72	R 53,754,104.64

Table 5: Current revenue to cover bus transport cost

Revenue Type	Number of Students	Levy	Revenue
Transport Levy from residence students	11532	R1600.00	R 18 451 200.00
Transport Levy from non-residence students	8268	R1600.00	R 13 228 800.00
Grand Total A	19800		R 31 680 000.00
% of Cost			59%
TUT subsidy B			R 17 963 511.00
Annual cost of Bus transport			R 53 754 104.64
Subtract Revenue A + B			-R 49 533 511.00
			(R4 110 593.64)

Table 5 above confirms the costs that TUT is currently outlaying apart from the levies recovered by students for this service. Hence it is clear that there will be a continuation of this deficit growth if TUT does not promulgate an adjusted student levy to fully recover the cost for the bus transport service to its students.

6. Conclusions and Recommendations

Table 6 above provides the template to be used by the University to determine the Route Summary as indicated in the last 4 lines of the table, thus leading to the financial modelling of the bus transport cost. However the following must be taken into cognizance for the University's consideration to improve the financial contribution of the subsidy provided to date.

Table 6: A Working Template to Remodel bus transport cost

Route Name	PTA_ARC	PTA_SOSHA S	GKW_PTA	GKWA_SO SHAS	SOSHAN_S OSHAS
Route Length – km – (L)	7	31	30.5	16	3.5
Average Speed – km/h – (S)	20	45	45	45	20
Layover – min – (Ta+Tb)	10	10	10	10	10
Compute					
Cycle Time CT= (120*L/S)+Ta+Tb	52	92.66666667	91.33333333	52.66666667	31
Weekdays					
Demand – pax/h – (D)	964	388	90	24	618
Seating Capacity – (C)-	63	63	63	23	63
Load Factor – (LF)	1.1	1	1	1	1.1
Compute					
Headway -min- (H= C*LF*60/D)	4.313278008	9.742268041	42	57.5	6.72815534
Fleet number -NV – (CT/H)	12.05579606	9.511816578	2.174603175	0.915942029	4.607503608
USE					
Fleet number - NV:	3	10	2	1	6
Headway	20	10	45	60	6
Operating Hours- P	4	14	10	9	15
Cycle Time:	60	100	90	60	36
Route Capacity (pax/h)	207.9	378	84	23	693
Number of Trips - NT	24	168	26.66666667	18	300
Total Vehicle Hour – VH- VH= NV*P	12	140	20	9	90
Total Vehicle Kilometers – VK – VK=NT*L	168	5208	813.3333333	288	1050
Saturday					
Demand – pax/h – (D)	100	100	100	100	100
Seating Capacity – (C)-	63	63	23	63	63
Load Factor – LF	1.1	1	1	1	1.1
Compute					
Headway -min- (H= C*LF*60/D)	41.58	37.8	13.8	37.8	41.58
Fleet number -NV – (CT/H)	1.250601251	2.451499118	6.618357488	1.39329806	0.745550746
USE					

Fleet number:	2	3	7	2	1
Headway	41	37	13	37	41
Operating Hours	4	4	4	4	4
Cycle Time:	82	111	91	74	41
Route Capacity (pax/h)	101	102	106	102	101
No Trips	12	13	37	13	12
Total Vehicle Hour – VH- $VH = NV * P$	8	12	28	8	4
Total Vehicle Kilometers – VK – $VK = VH * S$	82	402	1126	208	41
Route Summary					
Max Number of Buses	3	10	7	2	6
Total Vehicle Hour	20	152	48	17	94
Total Vehicle Kilometers	250	5610	1939	496	1091

6.1. Routes

Revise existing timetables to indicate at what times a bus is available on each stops for each route. Each off-campus residence should only be serviced to the closest TUT campus. Students should be clearly informed of the financial implication of taking up residence far from the campus of their study. Alternatively, if current residence routes are to be maintained, transport services cost on residences that are connected to both Pretoria West and Arcadia campuses (Tempo, Kollegehof and Legae) should be increased. This could be compulsory payment of inter-campus transport levy as well as the residence shuttle transport levy on residence students.

6.2. Vehicle Size

Vehicles with bigger capacity usually require more capital and operating cost to run. While high capacity vehicles could be economical where the demand matches the capacity, they are costly where demand is low.

6.3. Contracting

The cost allocation model attached with this document should be used negotiated contract or tender bus transport service. TUT may also consider using Model Tender and Contract Documents developed by the Department of Transport in terms of National Land Transport Act of 2009.

6.4. Fare Structure

It is strongly recommended that the current fare structure be revised based on the type of TUT transport services. The residence shuttle service levy need to be R190/calendar month or R2279 annually to cover the residence shuttle transport cost for the year 2013. Inter-campus transport levy should initially be set at an agreed upon amount, ranging from R1400 to around R3500 annually for the year 2013. The cost of providing the residence shuttle service is R2, 196,484.7 per month. Each of the 11567 resident's share comes to be R190/calendar month or R2279 annually. The annual increment should be considered when estimating the residence shuttle service transport levy as they are all under the 5 year contract ending 2015.

6.5. Alternative Sources of Revenue

Bus services at universities are funded in a number of ways. University funds may be generated by students fees and parking revenue. Some universities allocate institutional funds to support bus service.

6.6. Flexibility of Service Provision

The selected provider must have the capability to implement changes to the bus transport service as requested by the TUT. These changes may include route alterations, both permanent and temporary, ability to add vehicles on a temporary or permanent basis, the ability to add technology, and the ability to expand or reduce service within reasonable ranges. The provider should agree to implement these changes, in most situations, as soon as possible after the request has been made. In all but the most extreme cases, or where vehicles must be procured, all changes should be implemented within 30-45 days (maximum) after request and agreement by both parties.

6.7. Service Level Expectations/Requirements

The terms of reference should include service level expectations for vehicle uptime, customer service, and training, safety, and maintenance items. All contractors should be required to meet agreed upon service standards, and understand and accept penalties for failure to adhere to these requirements. Reporting requirements should be

developed and enforced to help ensure that service levels are maintained in all areas. Technology is also a key factor in verifying compliance with service standards. Monthly performance evaluations should be undertaken.

Biography

Venessa Ranjit is a Director of the University's Logistical Services at Tshwane University of Technology, in Pretoria South Africa. She earned a Masters in International Construction Management at the University of Bath, UK. Her research interests are in construction contracting, development of small scale contractors and operations management, and have published 3 conference papers to date. In her portfolio, Ms Ranjit is responsible for the Universities facilities management, transport (bus and TUT allocated fleet), printing and the restaurants. She is a board member of the South African Women's Empowerment Foundation, and a council member of the CIOB-Africa.

Semira Mohammed is a researcher at the Council for Scientific and Industrial Research (CSIR) in the field of Transport Engineering. She obtained her BSc in Civil Engineering in 2004 in her home country of Eritrea and moved to South Africa in 2006 to pursue her Masters studies in Transport Planning at the University of Pretoria. She completed her Masters degree in 2008 and immediately joined the CSIR. Her research interests include public transport, road safety, transport energy and the environment.