STUDENTS' VISION ON PUBLIC TRANSPORT NETWORKS: CASE CAPE TOWN

P ONDERWATER[1], M PRETORIUS[2] and M ZUIDGEEST[3]

[1]Hatch Africa; Tel: 073 0418294; Email: pieter.onderwater@hatch.com
[2]Independent Consultant; Tel: 083 4590162: Email: mpretorius387@gmail.com
[3]UCT; Tel: 072 0859320; Email: mark.zuidgeest@uct.ac.za

ABSTRACT

As part of its Transport Studies Programme, the University of Cape Town (UCT) offers a post-graduate course 'Public Transport Systems Design and Operations Management'. This 20 Credits (200 hours) course includes a major assignment where students, individually, develop a Public Transport (PT) Corridor Plan for a corridor of their choice, although not being an existing or planned IPTN corridor. In the 10 year existence of the course in its current format, over 100 corridor plans have been submitted for different parts of South Africa and some elsewhere on the continent. Listing those locations gives a good indication of the spread of private and/or work origins of students in the Transport Studies Programme, but also gives an indication where PT need improvements from these students' perspective.

Roughly a third of the plans were in the wider Cape Town area. This gives an opportunity to assess a possible future PT network for the City of Cape Town and its surroundings. The proposed future PT network (rail and BRT) would consist of several radial networks around the Cape Town CBD, Bellville, and the townships on the Cape Flats, Khayelitsha and Mitchells Plain, but should also include a radial network around Stellenbosch, although not directly in the City's responsibility. Furthermore, these submissions could assist the City in their future IPTN planning. There are also lessons to be learned from the common mistakes that the students (who are mostly transport professionals already) make in actual PT planning situations.

1. INTRODUCTION

1.1 Background

At the University of Cape Town (UCT), the Centre for Transport Studies has a series of post-graduate courses in the field of transportation planning. The course CIV5071Z 'Public Transport Systems Design and Operations Management' deals with public transport (PT) and rail planning. These courses are all 20 Credits, meaning 200 nominal hours of study. In the 10 year existence of the course in its current format, some 200 people have followed the course, many as students, some as an external professional wanting to know more on PT planning, and/or attending to collect CPD points for registration requirements.

The final / major course assignment requires students to develop a PT Corridor Plan for a corridor of their choice; the assignment, which is supposed to take 10 Credits, or 100 nominal hours of work, is described in Section 2. In these 10 years, over 100 corridor plans have been submitted for different parts of the country and elsewhere on the continent. Listing the locations of these corridor plans (Section 3), not only gives an indication of the private and/or work origin of the students, but also provides some direction as to where PT in South Africa need improvements, often based on students' own real-life and work experiences, as most of the students are early career, sometimes mid-career professionals.

Given the location of the actual Transport Studies Programme, roughly a third of the students' corridor plans are located in the wider Cape Town area. In section 4, these Cape Town corridors are mapped, indicating a possible next generation of 'Integrated Public Transport Network' (IPTN) corridors, beyond the current plans for City of Cape Town's IPTN trunk routes. These routes possibly express desire lines that could indicate a way of improving public transport in underserviced areas, based on students' perspectives on gaps in existing services. This assessment could assist the City in their future IPTN planning.

The paper concludes (section 5) with a summary of recommendations, with lessons learned based on common mistakes that the students made (similar mistakes that other transport planners sometimes make). The IPTN recommendations would not only be useful for the City of Cape Town, but for all transport planners.

2. COURSE DESCRIPTION AND POST-ASSIGNMENT

The course CIV5071Z 'Public Transport Systems Design and Operations Management' deals with public transport (PT) and rail planning and operations, with the main focus on passengers' quality aspects, the related functionalities of the PT and rail systems, their operations, and a small focus on engineering of infrastructure. The course consists of five parts (UCT, 2023):

- A (35 hour) pre-assignment, where students must prepare for the course by reading suggested literature and answer a few test questions.
- Lectures, during a block-week in the mornings (20 to 25 hours), with some theory on public transport and rail planning, and often lively discussions.
- A group case study assignment, during the lecture-week's afternoons (15 to 20 hours), where the theory is put into practice, developing a Corridor Plan for the Southern Suburbs corridor in Cape Town.
- A test (assuming 25 hours of study), where the students are asked open-ended questions on PT planning and required to perform certain quantitative PT operational analyses.
- A (100 hour) post-assignment, where the students, individually, develop a PT Corridor Plan for a corridor of their choice using all knowledge and skills gained in the taught part of the course.

The external CPD attendants are not required to do the pre- and post-assignments nor the test, but do participate in the group assignment.

2.1 Course Framework

The primary focus of the course is on the Passengers, as the end-users of the PT system, with secondary attention given to the Operator and the Transport Authority. The following framework, developed by the first author based on academic literature and global best-practice in PT planning and design, is used to structure the course content as well as the group assignment and post-assignment (see Figure 1).

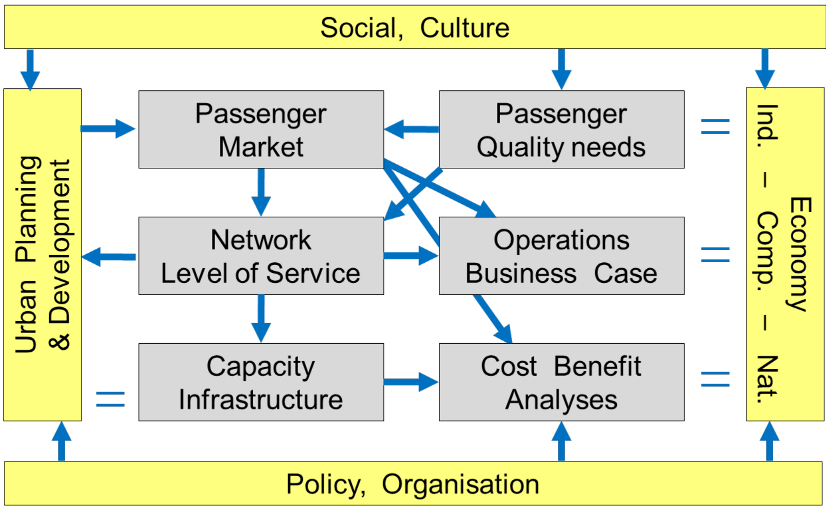

Figure 1: Public Transport Framework (Source: UCT, 2023)

In brief, the framework indicates that the PT passenger market is derived from several quantitative indicators and influenced by several quality aspects. The demand for transport is a result of PT trip generation and distribution, for several purposes (work, education, social, etc.) and is largely determined by land use patterns (residential, working areas, education, facilities, etc.) as well as the PT infrastructure itself.

The modal split assessment (whether or not PT is used) is an individual economic assessment and will be different for 'captive' PT users and 'choice users'. The service quality provided in operations (in terms of trip fares, trip time and frequency, safety and security, comfort and convenience, etc.) is assessed against the individuals' travel budget (in terms of money, time and effort). This is very much dependent on social and cultural background, and each and every society would behave differently; even within one country, there are regional differences in passengers' attitude towards PT quality service levels.

Passenger demand and quality needs determine the required Level of Service of the PT network and the individual corridors. If the Level of Service at a station node is good, it could attract new urban developments (Transit Oriented Development). In its operations business case, the Operator performs a financial assessment, comparing the costs of the operations with the revenue from the passenger market. Additional subsidies may be required, as very few PT services in the world generate a profit.

The operations on the network or corridor require certain infrastructure capacity, and if not adequately available, new infrastructure may be required. This has to fit in the existing urban pattern. The wider socio-economic value of this new infrastructure can be assessed in a national economic assessment, via a Cost Benefit Analyses.

The basis underlying the framework is the governance structure: transport policies and responsibilities (this is subject of another UCT course: CIV5070Z).

As can be seen from the Framework, PT planning is more than transport planning and engineering, but includes social sciences, land use planning, transport economics, and public administration.

2.2 Post-Assignment

The post-assignment is intended to provide the students with the opportunity to revisit and reflect upon all the taught material to which the students have been exposed during the lecture week, and based on the Framework in Figure 1. This reflection requires collating and synthesising information and issues discussed in presentations and readings, to think critically about the prospects for road-based and/or rail-based public transport system design and operations in contemporary South African or southern African cities.

The actual brief in the post-assignment is to develop a Public Transport (PT) Corridor Plan (UCT, 2023). The students are asked to identify any corridor in their own living / working city, hometown, or other area they know well. It should be a corridor of some 20-50 km long (and 5-15 km wide), either an urban / metropolitan corridor, or in a rural area, but motivated deviations from these stipulations are welcomed.

It should *not* be a corridor which already has good PT, or where currently improvement plans are underway or extensively studied (like Gautrain, metropolitan BRT plans, Moloto, amongst others); and *not* the Southern Suburbs corridor in Cape Town, as this was used as an example in the course. The ask is to choose a PT corridor where there is still need for improvement.

As the designated effort for this post-assignment is 100 hours, the purpose is *not* to develop a *detailed* corridor plan, but to demonstrate that the student has acquired the necessary understanding and skills level to develop a corridor plan. Estimations are allowed, as long as these are in the right order of magnitude, and motivated.

It is suggested to follow the PT Planning Framework, and perform the following tasks:

1) Describe the general <u>context</u> of the corridor (urban/rural development, land use, population, terrain, etc.)
2) Assess the <u>current PT provision</u> on the corridor, with the service quality aspects from the course as checklist: what is good quality, and what can be improved (i.e. a SWOT analysis).
3) Conduct an <u>urban analysis</u> of the corridor: determine the hierarchy of nodes, activities, working areas, and high-level size of population (when data is not easily available, the use of Google Earth and other assumptions are permitted).
4) Develop a <u>PT Network</u> for this corridor: what type of network, connect nodes with trunk and branch/feeder lines and appropriate station spacing.
5) Calculate (estimate) <u>passenger demand</u> for (at least) three different station nodes (one major, one medium, one smaller node), based upon (existing data or best-guesses on) population and jobs in the influence area of these stations and the use of PT trip generation parameters and appropriate distribution / modal split. With this insight: roughly estimate the total patronage on the corridor: per day in both directions, and per maximum peak hour direction.
6) Determine the <u>appropriate systems</u>: rail, BRT, bus, minibus-taxi, or other. Propose the required infrastructure (guideway), and specifications of proposed rolling stock, as well as the network of the trunk route and feeders.
7) Calculate the <u>operations</u>: passenger demand, capacity, frequency, single trip time, average speed (riding, and dwell time etc.), Level of Service for the trunk route and some of the feeders/branches. Calculate the required number of train sets and/or buses (or other modes).

8) Make a conceptual design for the required infrastructure in the corridor (rail, BRT), and/or other traffic measures; and one for at least one of the bigger (rail/bus) station locations with intermodal connections. Finally, make a rough estimate of the cost of the corridor.
9) Make a qualitative operational business case; and also indicate other wider social, economic, and environmental benefits.
10) Also discuss any other relevant issues related to organisation and management (operator versus authorities) and urban development (i.e. chances for TOD). This is part of the course on Public Transport Policy and Regulations and may therefore be limited to a very general discussion.

3. GEOGRAPHICAL SPREAD OF CORRIDOR PLANS

This section indicates the geographical spread of the submitted Corridor Plans (not necessarily the spread of students' origins themselves), over the African continent (Section 3.1) and within South Africa (Section 3.2).

3.1 Spread Over the African Continent

Of the more than 100 PT Corridor Plans submitted so far (as far as they could be retrieved), 82 were located in South Africa and 22 (20%) in other countries in southern Africa and the continent (see Figure 2):

- Lesotho = 2
- Namibia = 6
- Botswana = 1
- Zimbabwe = 4
- eSwatini = 1
- Mozambique = 1
- Malawi = 1
- Tanzania = 2
- Kenya = 3
- Nigeria = 1

This spread may say something about the origin of the students, although some international students might have chosen a South African corridor (e.g. in Cape Town, where they study). It is noticed that UCT mainly attracts students from English speaking countries (1 corridor plan from Mozambique), and mainly from southern Africa.

3.2 Spread Within South Africa

Within South Africa, the majority of corridor plans are located in the wider Cape Town area. As per previous sub-section, this would not necessarily indicate that these students originate from Cape Town, but they could possibly currently be based and/or working in Cape Town. The spread of the 82 corridor plans around South African provinces is as follows (Figure 3):

- Western Cape = 31, of which 30 in the wider Cape Town area.
- Eastern Cape = 9, of which 4 for the Port Elizabeth (currently known as Gqeberha) – Uitenhage corridor, and 3 elsewhere in the Nelson Mandela Bay Municipality.
- KwaZulu-Natal = 9, of which 7 in the greater Durban area.

- Mpumalanga = 4.
- Limpopo = 8, with 3 in Polokwane.
- Gauteng = 16, of which 5 corridors serving Diepsloot (apparently a township in dire need of good PT).
- Free State = 4, of which 3 for the Bloemfontein – Botshabelo / Thaba Nchu corridor.
- North West = 1.
- Northern Cape = 0.

Figure 2: Spread of students' PT Corridor Pans over Southern Africa

Figure 3: Spread of students' PT Corridor Plans over South Africa

This spread would indicate that there is most need to improve PT in metropolitan areas (Cape Town, Gauteng, Durban, Nelson Mandela Bay), and also in densely populated rural areas (Limpopo, Mpumalanga, Eastern Cape), but hardly or not in less dense rural provinces (Northern Cape, North West). Interestingly, the corridor Bloemfontein – Botshabelo – Thaba Nchu was assessed several times, where students propose a rail connection replacing the current subsidised buses.

4. CAPE TOWN PT NETWORK

As 30 students chose to develop a PT Corridor Plan in the wider Cape Town area, this section explores the PT network for Cape Town, and analyses what corridors students deem to be required in the future Cape Town PT network.

The existing rail corridors (presumed to be modernised in the medium-term) and BRT/ MyCiti corridors (including the next phase of MyCiti corridors) were excluded from the post-assignment and considered as a given (the black and red lines in Figure 4; the students' proposed corridors are added in blue).

The following sub-sections discuss the current, planned and proposed PT corridors. It must be stated that the resulting network would not be exhaustive, as it depended on individual students' proposals for one corridor.

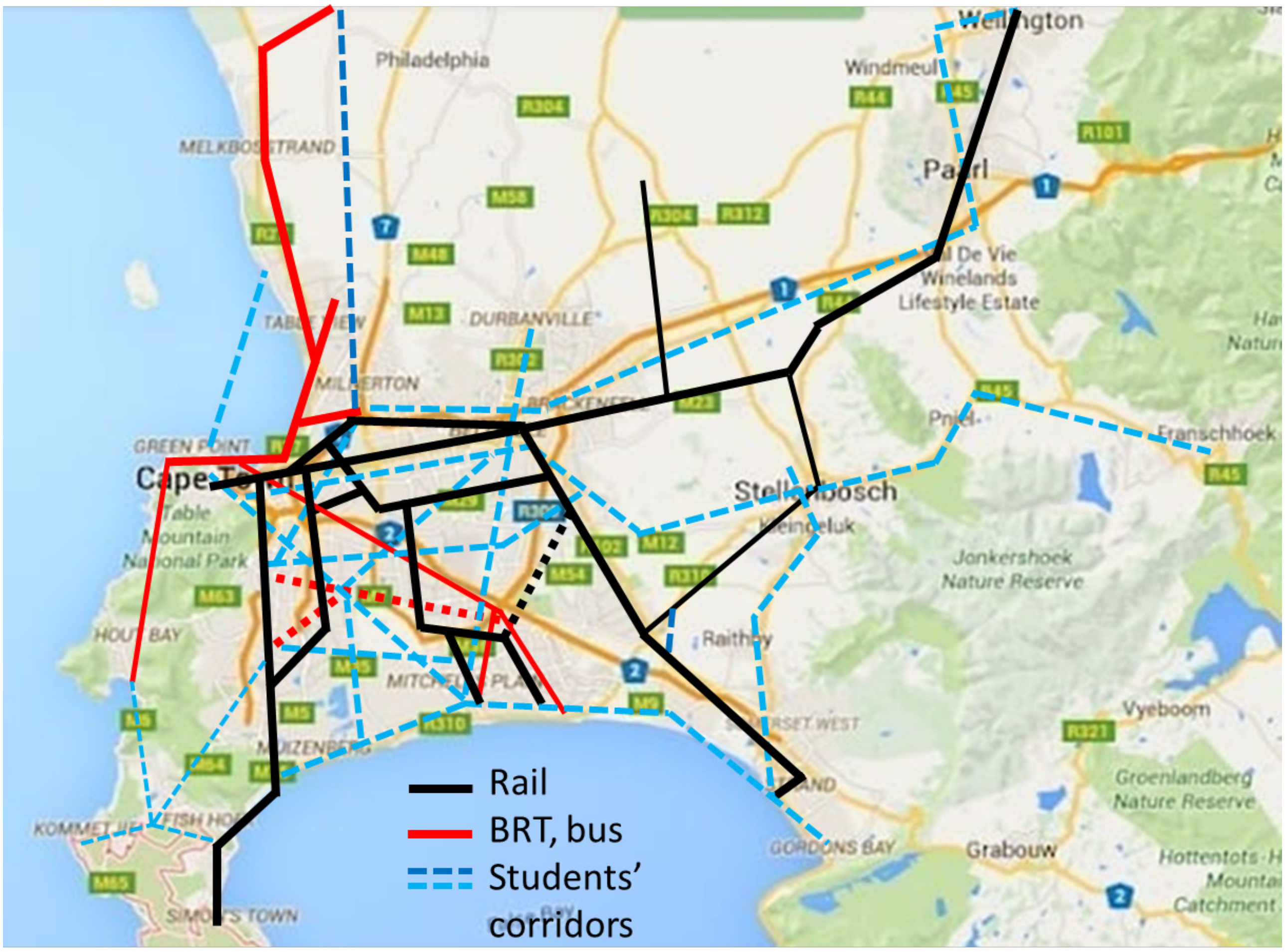

Figure 4: Map of proposed rail and IPTN network in Cape Town, plus students' plans

4.1 Radial network to/From Cape Town CBD

The current Metrorail and MyCiti networks are mostly radial oriented towards Cape Town CBD, so there seems to be little need to add more CBD-oriented corridors. Still, students assessed that a few more radial corridors need to be added, as the CBD was included in 40% of the corridor plans. Interestingly, many corridor plans included an assessment of the Bellville – CBD corridor, of which 2 from Durbanville and 2 from Kraaifontein and Paarl, where the existing rail corridor functions (functioned) well. However, students saw additional PT market along the R101 (Voortrekker Road), where there are many residential areas, work opportunities and activities further away from railway stations, and an additional BRT (light) with shorter station spacings was proposed.

4.2 Radial network to/From Bellville and Century City

Bellville was clearly assessed as the second biggest node in the Cape Town area, with 40% of the corridors to/from Bellville as a secondary radial network, with BRT connectivity from Durbanville, Stellenbosch, and the Cape Flats, Khayelitsha and Mitchells Plain townships, complementing the existing rail network.

Similarly, it was assessed that the newly emerged node of Century City lacks good PT.

4.3 Radial Network to/From Cape Flats, Khayelitsha and Mitchells Plain Townships

Another roughly 40% of the PT corridors were proposed from the wider Cape Flats, Khayelitsha and Mitchells Plain areas in multiple directions. The current rail network connects these areas towards the CBD, although the service quality of these corridors reduced in the last decade, and train service stopped altogether from 2019. Currently, MyCiti runs direct bus services to CBD as an interim measure.

Some students proposed seemingly parallel BRT services towards the CBD. They propose to connect other working and activity areas along these routes, outside the rail influence sphere. Also, students proposed additional BRT / bus routes from Khayelitsha and Mitchells Plain to other working areas, to different nodes in the Southern Suburbs, Strand – Gordons Bay, Bellville and Kuilsriver.

4.4 Radial Network to/From Stellenbosch

Some 20% of the proposed PT routes were oriented to/from Stellenbosch, as this is considered an important node in the greater Cape Town area. Stellenbosch would not only be connected by rail to Bellville and Cape Town CBD (although with a detour), but also by proposed additional BRT routes to Kuilsriver and Bellville, and being the centre of its own PT (BRT or bus) network from Franschhoek and Strand – Sommerset-West, the latter either via rail with a short direct link near Eerste River, or as BRT along the main road.

However, Stellenbosch is not within the City of Cape Town municipality, and gets little attention in the City's PT plans (as can be seen from Figure 5 below). Students – and passengers! – however, assess preferred travel corridors independent of boundaries or municipal responsibilities. Let that be a lesson for Transport Authorities.

Same (but to lesser extent) applies to Paarl, where 10% of the students' corridors were proposed, seemingly parallel to a rail corridor, but with a more local function to access residential and working areas where rail is not available.

4.5 Other Assessments

There is a current MyCiti corridor from Atlantis to CBD. A few students suggested improving that service with a rail corridor, also past Century City. This is indeed an old idea from the City and PRASA, possibly worth reviewing.

Special reference should be made to a proposed ferry corridor between Blouberg and Cape Town Waterfront, where indeed a route over water is more direct and faster (non-stop) than the BRT 'detour' around the port.

4.6 PT Modes Selected

Table 1 provides an overview of the mode selected for the proposed corridors, with the corridors mapped in Figure 4. For feeder or branch routes mostly midibus or minibus-taxi were proposed.

The current rail network is already quite dense, and few additional rail corridors could be added. However, most of the students' assessments propose additional road-based modes to fill the network gaps with BRT, or a lighter form.

Table 1: Mode selected for the main corridor

Mode Selected	Number of Corridors
Train	3
Train, Light Rail, BRT combination	4
BRT	14
BRT light	1
Bus	5
Bus-MBT combination	2
Ferry	1
Total	**30**

4.7 Cape Town's IPTN Plans

Comparing the students' corridor plans (Figure 4) with the recently developed long-term IPTN network by the City of Cape Town (Figure 5) shows a fairly similar pattern, with radial networks around Cape Town CBD, to a lesser extent around Bellville, and connecting the townships with several activity nodes along the Southern Suburbs. Both maps seem to have a very dense PT network, with corridor spacing of some 5 km, which is not unusual for a metropolitan PT network.

However, as can be seen from Figure 5, no attention is given to connect the City of Cape Town to nearby nodes as Stellenbosch and Paarl (apart from the existing rail corridor), as this is outside the municipal boundary and not the City's responsibility.

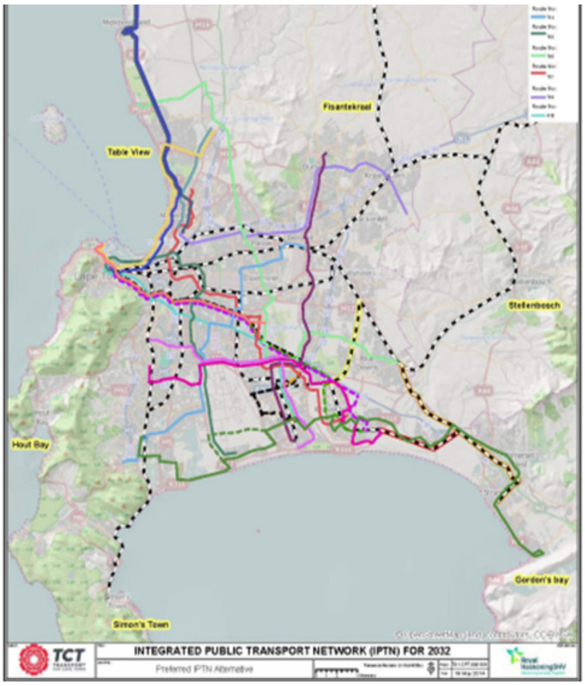

Figure 5: Long-term IPTN plans (City of Cape Town, 2023)

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Corridor Planning Requires a Mixed Expertise

A similar methodology for the students' corridor post-assignment (as per section 2.2) can also be used in 'real-life' corridor studies. Then, more detailed input is required and assumptions better substantiated. Obviously, this would require more than the 100 hours that students have available, and would require a mixed team with urban planning, transport planning, transport engineering, social sciences, and transport economic expertise.

5.2 Common Mistakes Made by Students

The analysis of students' corridor plans over the last 10 years led to the development of 'Banana Peels', which are defined as common mistakes that make the students slip, not only found in the post-assignments, but also assessed from other project work by transport professionals.

Below are some of these common mistakes:

- One should *not* use the 'Committee of Transport Officials' (COTO) trip generation parameters to determine PT trips. The COTO manual (COTO, 2011) was developed to determine vehicle traffic for new developments and can be used in Traffic Impact Assessments. Trying to calculate PT passenger volumes out of these parameters requires too many unreliable assumptions on vehicle occupancy and modal split, excluding other vehicle types (trucks), including other PT modes (train), and many other assumptions. Besides that, the COTO parameters are sometimes based on examples from the USA (where there is often hardly any PT use). Also, the COTO parameters should be on the safe side to determine maximum required future road capacity. There is an easier and more reliable way to determine PT trip generation parameters, derived from the NHTS (Onderwater, 2015).
- Many students determine the trip generation and modal split of an area quite well, but then assign all these trips to 'their' corridor, neglecting the 'distribution' of those trips. In reality, many passenger trips stay within an origin area, and there are other corridors where people travel in multiple directions, etc. Also, the destination of their corridor would not only be the CBD, but also other sub-nodes and work areas elsewhere in the destination area.
- Many planners (not only students) overestimate the average speed of PT services. They sometimes assess urban PT corridors with average speeds of 60 km/h, where 60 is generally the maximum speed a vehicle is allowed to travel (indeed, few minibus-taxis go faster), but traffic conditions, stopping at traffic lights and bus stops, reduce the average speed enormously. A city bus will not go any faster than 20 km/h on average. Even a well-designed BRT service is not much faster than 30 km/h start-to-end. As another example, Gautrain runs 160 km/h at max, but 'merely' 80 on average.
- The capacity of a PT system should not be designed for the maximum (crush) capacity of vehicles. There is always a slight variation of passenger volumes within a peak hour, and even the busiest vehicle should stay below the max crush capacity. It is general practice to plan for a capacity at 85% level of the crush capacity. If designing average peak vehicles with maximum capacity, half the vehicles will be overcrowded.
- In some plans, it is anticipated that BRT could over time be converted to Light Rail, as LR has higher capacity, a better accepted right of way, and is (with high passenger volumes) generally cheaper in operations. However, LR cannot be designed with the same steep gradients as BRT (4-5% at max, not 8-10%) and curves should be wider. So, if the future option is to convert BRT to LR, one must design the BRT corridor with LR requirements from the beginning.

5.3 Integrated PT Network Planning Should be More Integrated

The ‘I’ within ‘IPTN’ stands for Integrated. Where previously the idea behind IPTN was to develop BRT trunk routes with midibus feeder routes (hardly integrating existing minibus-taxi services), contemporary IPTN planning is better at integrating the various PT modes: rail, BRT, traditional bus, and minibus-taxi. This could be better understood when the hierarchy of networks is also assessed: regional / metropolitan ‘trunk’ corridors are best serviced by rail, or BRT where no rail is available; urban / local corridors can be branched-off as BRT-light, or feedered by traditional bus and/or minibus-taxi. Then it will also become clear that a regional / metropolitan rail corridor can co-exist with a seemingly parallel urban / local BRT corridor (with shorter station spacings), as they open-up different PT markets.

Also, integration between transport planning and urban economic planning is often addressed by the local transport authorities.

Another place where ‘integration’ is required is a better planning collaboration between municipalities. In the Cape Town example, we see that some integration is required with the adjacent Stellenbosch and Drakenstein Municipalities in the Cape Winelands District.

5.4 Concluding Remarks

In the 10 years of existence of the ‘Public Transport Systems Design and Operations Management’ course in its current format, the course has reached some 200 students and other transport officials, of which 100 have completed the post-assignment, where they developed a PT Corridor Plan. The taught PT Framework gave them the understanding that PT planning is more than transport planning and engineering, but requires insights in urban planning, social sciences, and transport economics.

This course, and the whole UCT’s Transport Studies Programme, has groomed a next generation of transport planners, that can solve the country’s and continent’s transport challenges in an integrated way. With this paper, the lectures want to share some of the insights with the wider transport fraternity.

6. REFERENCES

City of Cape Town, 2023. *IPTN Presentation.*

Committee of Transport Officials (COTO). 2011. *South Africa Traffic Impact and Site Traffic Assessment Manual.*

Onderwater, P. 2015. *Public Transport Trip Generation Parameters for South Africa.* Southern Africa Transport Conference. Pretoria

University of Cape Town (UCT). 2023. *Course CIV5071Z: Public Transport System Design and Operations Management.*