Research in Transportation Economics 112 (2025) 101604

Contents lists available at ScienceDirect

Research in Transportation Economics

journal homepage: www.elsevier.com/locate/retrec

Research paper

Evolution of bus rapid transit concepts in Sub-Saharan Africa: towards lighter design and incremental deployment

Alison Chetty [*], Christoffel Venter

Department of Civil Engineering and Centre for Transport Development, University of Pretoria, Hatfield, 0002, South Africa

A R T I C L E I N F O

JEL classification:
R42
R40
H54

Keywords:
Incremental BRT
Sub-Saharan Africa
BRT deployment
Development pathways
Design standards
Full BRT
BRT lite
Flexible design approach
Paratransit

A B S T R A C T

While Bus Rapid Transit (BRT) has matured into a standardised set of technologies worldwide, its slow adoption in Sub-Saharan African (SSA) cities has raised questions about its suitability in some contexts. A number of key factors affect BRT adoption in SSA, including poorly developed road networks, constrained demand and affordability limits, and the strength and importance of the legacy informal public transport (PT) ecosystem. In response, some cities have increasingly departed from the conventional infrastructure-heavy BRT design approach towards lighter, more incremental deployment concepts, in an effort to better match local realities and constraints. This paper aims to describe this shift and put it into the context of a continuum of BRT deployment approaches. A literature review presents clarifying terminology and an overview of recent BRT system design in SSA cities. We then describe a phased implementation approach evolving in South African cities that focus on improving existing services gradually towards the final BRT design. Two examples of BRT evolution in large (City of Tshwane) and medium-sized (Rustenburg) cities are described in more detail. The potential implications of design standards are explored and provide insight for cities in developing countries seeking designs best-suited to enhance PT services with limited funding.

1. Introduction

The upgrade of road-based public transport (PT) services can take many forms, ranging from the improvement of existing services to implementing a bus rapid transit (BRT) system, to achieve desired operational enhancements (Niles & Jerram, 2010). BRT systems are defined differently around the world, from infrastructure 'lite' designs to full BRT, modelled on best practices of Latin American cities (Transport Global Practice, 2020). To date, different levels of BRT features have been implemented in 191 cities globally, and majority have adopted a heavy infrastructure approach (BRT+Centre of Excellence and EMBARQ, 2024).

While cities in developed countries introduce bus transit improvements to increase system ridership, developing countries lacking formal PT are dependent on unsafe and unreliable paratransit services and seek mass transit systems for high travel demand (Lindau et al., 2016). Attracted by the benefits offered by the full BRT model, earlier projects implemented the full BRT system to introduce a new business model or reform the PT sector and replace existing PT modes. BRT has evolved into integrated transit networks and is seen as a tool to achieve integration of PT modes. However, many barriers to integration exist in developing countries, such as fragmented institutional frameworks and the informal PT sector (Hidalgo et al., 2016). Cities in Sub-Saharan Africa (SSA) have experienced significant challenges implementing full BRT and achieving the anticipated performance benefits. Some cities revised their designs after recognising the cost and complexity of full BRT and a few, like Lagos, followed a flexible design approach by adapting BRT to local conditions.

While research has been done on systems around the world, there is limited reporting on BRT system design in SSA cities and a need to understand and document recent approaches (Venter et al., 2020). More research is required to understand the preferred approaches in SSA cities, influencing and limiting factors – to respond to questions around "which BRT model is being adopted and why?" and "what kinds of public transport reforms do African cities need and what would work best given the nature of how the system works now?" (Klopp et al., 2019). Success factors and lessons learnt may provide insight for other cities on the implications of selected designs and deployment (Lindau

This article is part of a special issue entitled: Selected Papers from the Thredbo 18 Conference published in Research in Transportation Economics.

* Corresponding author.
E-mail addresses: alisonchetty4@gmail.com (A. Chetty), christo.venter@up.ac.za (C. Venter).

https://doi.org/10.1016/j.retrec.2025.101604
Received 14 March 2025; Accepted 24 June 2025
Available online 30 June 2025

et al., 2016).

The aim of this research is to explore BRT system design approaches in SSA cities. The objectives are:

- To document current approaches towards BRT system design in SSA cities,
- To investigate the potential implications of incremental approaches in SSA, and
- To consider suggestions for other cities introducing PT interventions.

This paper provides the theoretical background related to the BRT concept, BRT design and system development in SSA cities in the Literature Review in Section 2. Section 3 presents examples of BRT evolution in two cities in South Africa (SA), followed by insight into implications of design approaches in Section 4. Section 5 concludes the study and provides recommendations for further research.

2. Literature: BRT concepts and pathways

This section introduces concepts and clarifying terminology on BRT design and development pathways. BRT deployment and an overview of system design approaches are explored in selected SSA cities. Information was gathered from published literature, guidelines, evaluations and local reports.

2.1. BRT design concepts

Buses are a flexible means of providing access and connectivity and accommodate changes in travel demand (Olyslagers et al., 2021). Improvements to conventional bus services in North America are known as 'BRT Lite', bus-priority systems in Europe as Bus with High Level of Service (BHLS) and mass transit systems in South America are labelled full BRT (Ferbrache, 2019; Lindau et al., 2016; Olyslagers et al., 2021). The broader definition of BRT encompasses a spectrum of infrastructure and operational improvements that can be applied as individual features or packages to achieve speed and capacity performance benefits (Niles & Jerram, 2010). Lower-cost BRT systems with limited infrastructure are termed 'BRT Lite' and the fully-fledged BRT model contains segregated right-of-way with median busway alignment, off-board fare collection, platform-level boarding, and priority at intersections, to achieve maximum performance benefits (Institute for Transportation and Development Policy, 2024b). While full BRT is seen to offer the benefits of light passenger rail at a reduced cost (Wright & Hook, 2007), BRT Lite may offer 80 % of full BRT benefits at 20 % of the cost (Venter et al., 2020).

2.2. Full BRT

In 2012, the Institute for Transportation and Development Policy (ITDP) (2024b), a non-profit organisation that works towards sustainable transportation in urban areas, developed the BRT Standard to establish a common definition of BRT and guide cities in delivering world-class BRT systems. The original BRT Standard is based on best practices of BRT systems in Curitiba and Bogotá and serves as a planning tool for cities to achieve the benefits of BRT. Recognising high-quality system designs with a gold, silver or bronze scoring, the BRT Standard prescribes basic elements as a minimum requirement (ITDP, 2024b). It has been criticised for a one-size-fits all approach and Lindau et al. (2016) caution that the BRT Standard must be "interpreted carefully since it does not necessarily focus on performance and need, and it does not account for how operation is affected by its urban context". The most recent revision, the 2024 BRT Standard, was informed by an advanced understanding of BRT and feedback from BRT specialists. It acknowledges the need for more flexibility with improved scoring for diverse systems and operations and advises that BRT "may not be the best solution in all instances" (ITDP, 2024a). Particularly in Africa, international BRT advocates have been criticised for portraying BRT as "cheaper, more effective, and easier to implement than it actually is" (Klopp et al., 2019) and "propagating BRT to open up PT markets in developing countries" to further their interests by providing loans and influencing the adoption of full BRT systems (Rizzo, 2014).

Some cities adopted BRT designs with varied infrastructure which were best-suited to their local context and show success in improving PT conditions. Challenges related to technical, operational and institutional matters may be encountered in BRT deployment (Deng & Nelson, 2011), as seen in some BRT projects (Klopp et al., 2019; Nguyen & Pojani, 2018). Some cities have been laden with planning and implementation issues due to an inadequate understanding of the complexity of full BRT, long-term design and financial implications, necessary institutional capacity and political will, among others (Olyslagers et al., 2021). There is a growing appreciation of the need for more flexible and adaptable approaches which are tailored to individual city contexts. Agents like the BRT + Centre of Excellence assist cities in developing BRT projects which improve user mobility and accessibility within local needs and conditions (ITDP, 2024a).

2.3. Incremental deployment

Incrementalism is used to describe a continuum of options related to BRT deployment with respect to timeframe, network and design features. This section differentiates these and provides clarifying terminology that will be used throughout the paper. Firstly, BRT systems around the world have been implemented using two timescales (Asimeng, 2021), leapfrog and incremental approaches, which have been applied to various degrees (demonstrated by Fig. 1). Incrementalism taken as a stepped approach to develop systems towards the final design will be referred to as the '*gradual approach*'.

Secondly, incremental BRT from a spatial viewpoint is "either or both geographical extensions or additions of features" (Niles & Jerram, 2010). Hitge and van Dijk (2012) infer that the incremental approach to introduce targeted features successively across the entire network or corridor-by-corridor approach can be applied to achieve the same ultimate system, or both strategically applied to achieve PT improvements. In this paper, the following terminology will be used with reference to gradual deployment:

- '*Phased approach*' – sequentially deploying features (or improvements) towards the final system, for widespread benefits (Niles & Jerram, 2010).
- '*Corridor approach*' – deploying a single high volume corridor followed by additional routes (Venter et al., 2020).

These development pathways are illustrated in Fig. 1 on a hypothetical system with three corridors of unspecified service design.

Almost all systems have been implemented using the gradual approach. The world-renowned Curitiba BRT System was established over a 30-year period by avoiding "large-scale and expensive projects in favour of hundreds of modest initiatives" (Goodman et al., 1997). Following success in Curitiba, Bogotá gradually introduced an Integrated PT System (IPTS) with BRT corridors, paving the way for what became known as full BRT (Hidalgo et al., 2016). Meanwhile, Santiago deployed an IPTS in 2007 to integrate bus and rail passenger services which was launched in a single event using a "Big Bang" approach (Muñoz & Gschwender, 2008), and followed by further improvements (Hidalgo et al., 2016). Both systems were implemented at higher costs than anticipated and when comparing deployment strategies, Hidalgo et al. (2016) conclude that "an adaptive system seems a more sensible approach than a thorough transformation of service provision". A gradual approach allows users to adjust to changes and the system to stabilise before further measures are implemented, which reduces risk and complexity (Hidalgo et al., 2016; Olyslagers et al., 2021). An essential part of achieving successful and sustainable systems is

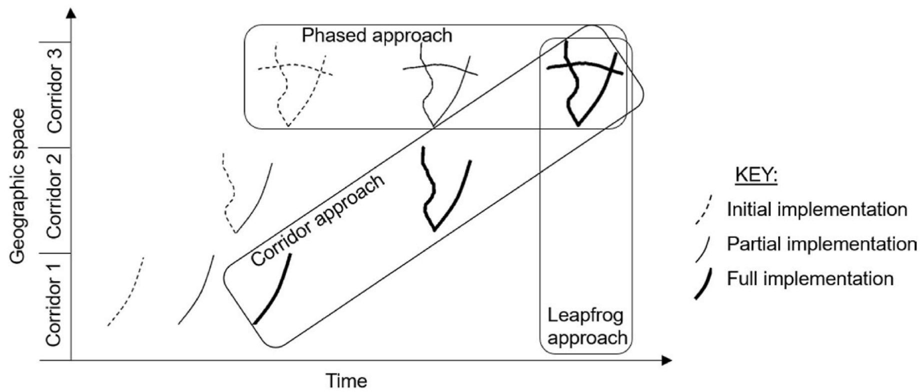


Fig. 1. BRT development pathways (Source: Authors).

understanding user needs and expectations, which may change over time.

Thirdly, incremental BRT describes the application of system design features to achieve a desired level of service. A selection of BRT features is applied from the spectrum of options to upgrade PT services – up to the maximum full BRT model (Niles & Jerram, 2010). In this paper, BRT infrastructure deployment will be described as '*flexible*' when applying a tailored package of design improvements; each at a specified quality. The *flexible BRT design approach* addresses which features should be applied, to which degree and to which routes, to achieve system objectives. It is key to creating a system that achieves the benefits of BRT by adapting the suite of BRT features to local context and conditions (Olyslagers et al., 2021).

2.4. BRT in Sub-Saharan African cities: an overview of developments

Rapid population growth and urban sprawl in SSA cities has resulted in unplanned spatial dev-elopment and growing transport and mobility needs (Acheampong et al., 2022; Ka'bange et al., 2014; Stucki, 2015). Passenger transport in SSA cities is often characterised by poor quality formal PT modes, an oversupply of unregulated paratransit operators and surge of private vehicle usage along inadequate road networks (Stucki, 2015; Vermeiren et al., 2015). Users are burdened with fragmented journeys, variable fares, long travel times and dependence on unsafe and unreliable paratransit operations (Acheampong et al., 2022; Kaenzig et al., 2010). SSA cities lack funding for adequate PT provision and are attracted to BRT as a means of transforming PT (Asimeng, 2022; Fan & Beukes, 2021). This section explores the development of BRT in SSA cities with focus on design standards and motivating factors. The BRT Lite system in Lagos was followed by the full BRT infrastructure design in SA cities, Dar es Salaam, and Accra. This is contrasted by the Public Bus Service in George and lighter infrastructure designs considered in preliminary stages in Nairobi and Kampala.

2.4.1. BRT Lite in Lagos

The first BRT system in Africa was implemented in Lagos in 2008. The enhanced bus service, termed 'BRT Lite', is a reduced infrastructure approach which was tailored to improve the operational characteristics of poorly regulated PT services in Lagos within cost and time constraints. The BRT Lite was financed by the government and planned in conjunction with consultants from the World Bank. Using the corridor approach, a major travel route was prioritised to improve low levels of service. The BRT Lite was deployed in 15 months using the most suitable design for existing road infrastructure. The 19.2 km corridor comprised full right of way along 85 % of the route (65 % segregated and 20 % demarcated as bus lane) and mixed traffic conditions for the remainder – such combinations are referred to as '*hybrid*' infrastructure designs in this paper. The BRT Lite achieved immediate benefits which were attributed to a holistic approach (Kaenzig et al., 2010). Criticism was received over capacity constraints and issues such as limited operating speeds and overcrowding at bus stops (Integrated Transport Planning Ltd & IBIS Transport Consultants Ltd, 2009). In 2016, Lagos implemented Phase 2 under the technical assistance and financing of the World Bank. The Phase 2 corridor was a full BRT extension of the BRT Lite route which required upgrades to stations along the BRT Lite corridor and widening along the existing roadway of the extension, to accommodate the segregated lane for operational exclusivity (Transport Global Practice, 2020).

2.4.2. The swing towards full BRT projects

The first city in SSA to adopt the full BRT infrastructure design was Dar es Salaam. In 2002, initially planned as the first BRT in Africa, Dar es Salaam Rapid Transit (DART), envisaged a 137 km trunk corridor as the backbone of PT with 18 terminals and 228 stations. The project was funded internationally which included a loan from the World Bank and visits to Bogotá sponsored by the ITDP (Rizzo, 2014). The BRT system was planned to be implemented in six phases, using the corridor approach. Dar es Salaam lacked co-ordination between transport and land use planning and BRT lane construction subsequently required the relocation of informal settlements adjacent to the existing roadway, increasing project costs and delays (Jacobsen, 2021; Joseph et al., 2021). It became apparent that "on-the-ground realities were not sufficiently understood or considered" (Transport Global Practice, 2020); however, Dar es Salaam did not stray from the full design standard. Despite the challenges encountered, DART Phase 1 reduced congestion in the city and offers travel time benefits to users (Morten et al., 2020). Subsequent phases are being implemented and land acquisition is underway (Nachilongo, 2024).

In SA cities, initial PT plans to improve bus and formalise and integrate paratransit operators were influenced by international consultants advocating for BRT. These 'experts' gained local support by providing technical advice and linking decision-makers and planners with Bogotá officials. This was seen as pivotal to the adoption of the full BRT design in SA cities (Wood, 2014). Under the PT Action Plan (National Department of Transport, 2007), development was accelerated in preparation of the 2010 FIFA Soccer World Cup. Modal upgrades were prioritised and the implementation of integrated PT networks (IPTNs) in 12 cities (including host cities) were funded by the Public Transport Network Grant (PTNG). The full BRT standard was mandated uniformly across cities and a heavy infrastructure design (comprising trunk services in segregated lanes with median stations, and feeder routes in mixed traffic conditions) was imposed for cities to gain access to funding through the PTNG. Lessons learnt from early implementation of the full BRT design standard (Fan & Beukes, 2021) contributed to the revised national policy on IPTNs – detailed in Section 4. Some of the major challenges include cost and duration of paratransit reform and continued competing services (Jennings et al., 2023), low ridership (for example Rea Vaya achieved only 22 % of planned patronage (Grütter Consulting, 2011)) and high direct operating subsidies due to low farebox recovery ratios (30 % in Rea Vaya and 40 % in MyCiTi (Venter & Hayes, 2017)). Major criticism of BRT systems in SA stems from inadequate consideration of the unique conditions in adopting the full BRT model (Scorcia & Muñoz-Raskin, 2019). Long travel distances between employment nodes and low-income areas are a legacy of apartheid and although developing countries without formal systems seek BRT to cater for high travel volumes (Lindau et al., 2016), Scorcia and Muñoz-Raskin (2019) infer that the travel demand patterns in SA cities are typical of commuter transport – not traditional urban transport.

Meanwhile, a full BRT system with nine corridors was planned in Accra. The fully segregated BRT lane required excessive infrastructure investment and highway expansion. After construction began, the design was no longer financially viable. Following revisions, the full BRT system was downscaled to a scheduled bus service with limited priority measures, due to a lack of funds for a dedicated lane (Transport Global Practice, 2020). The system was launched in 2016 in mixed traffic conditions and, operating in competition with paratransit services, did not offer the anticipated travel time savings (Mimano, 2022). The bus service was suspended in 2018 due to operational deficits, and subsequently relaunched as a morning and evening peak service in 2019 (Asimeng, 2021).

2.4.3. The emergence of flexible infrastructure design approaches

In contrast to the full BRT design standard in SA cities, a pilot project of a differentiated approach was run in the medium-sized city of George, Western Cape (National Department of Transport, 2020). The George IPTN involved transforming PT services by establishing a company with previous paratransit and bus operators under a scheduled bus service contract (George IPTN, 2025), which serves as an example to similar-sized cities. Due to the limited funding allocated to George (based on travel demand of the city), instead of a full BRT system, features were designed with minimal infrastructure and developed using a phased approach. At present, GoGeorge operates in mixed-traffic with in-lane stops and few embayments which can be upgraded in the future according to demand and budgetary provisions (Robb, 2024).

Early designs considered in Nairobi and Kampala deviated from the full BRT standard. Nairobi followed the corridor approach, and the service plan favoured a BRT Lite design for Line 1 which consisted of full BRT and mixed traffic operating conditions, similar to the Lagos BRT Lite hybrid infrastructure design. Instead of a trunk-feeder configuration, a direct service was recommended to reduce passenger transfers (Weinstock et al., 2015) however, the full BRT design standard (which required road expansion to accommodate the BRT lane) was selected prior to the service plan (Integrated Transport Planning Ltd, 2017) and a Full BRT Pilot Project is underway. In Kampala, a BRT Prefeasibility Study financed by the World Bank favoured a design with median segregated lanes and open stations along nine trunk corridors (Japan International Cooperation Agency, 2010). A pilot project was planned along two BRT corridors with a median segregated lane and hybrid infrastructure similar to the Lagos BRT Lite, respectively (Integrated Transport Planning Ltd, 2010), but the BRT project was suspended due to design challenges related to road constraints. As a way forward, the Tondeka Metro Mass Transit Bus System (comprising 15 routes) was proposed as a reduced-cost alternative to provide a bus service with the capacity of BRT without the exclusive infrastructure and large vehicles – to potentially serve as a precursor to BRT (Muyinza, 2020). However, Kampala opted for a full BRT pilot project (Non-Aligned Moment – Uganda, 2024).

2.4.4. Critical role of the paratransit industry

Paratransit operations are the backbone of PT in SSA cities, but these adaptable services are often viewed as a barrier to PT improvement (Klopp & Cavoli, 2019). The full BRT model, for the most part, has been implemented to replace existing services by incorporating these under formal operating companies, but paratransit owners in SSA lack the capacity to provide formal services and require capacity-building programmes and training to become operators (Asimeng, 2021). Foreign loans influenced the operating model of BRT projects in SSA – labelled as "colonial mentality" (Ndibatya & Booysen, 2020). This took the form of buy-in to bus operating companies in plans in Nairobi and Kampala, which placed a financial burden on operators (Muyinza, 2020). In Dar es Salaam, exclusion of the paratransit industry from BRT planning led to resistance and ongoing competing services. Questions arose around whether BRT was the most suitable solution to PT issues in SSA cities, or if the improvement of existing paratransit services was considered as an alternative – "general trademarks of BRTs" (Rizzo, 2014). In SA, paratransit transformation was performed in a leap. This involved compensation (required to incentivise participation) of affected paratransit operators and option to buy-in to a vehicle operating company (VOC) to run BRT services (Moody et al., 2014). National government did not equip cities with a blueprint for paratransit transition and different business models were tried across the municipalities (Matolong, 2022), resulting in insurmountable costs, lengthy delays, violent opposition and illegal parallel services (Klopp et al., 2019; Schalekamp & Behrens, 2010). A successful model to participation of paratransit operators was achieved in Johannesburg, where vehicles and licences – owned by operators – were invested for a share in the VOC (Venter, 2013).

In contrast, the operating model in Lagos incorporated paratransit operators by permitting operations along the BRT Lite corridor (excluding bus lane). This did not hamper the project, rather Lagos capitalised on the subsidy-free service for increased capacity and network coverage, within its local context. A similar operating model has been adopted for the pilot project in Nairobi to serve the corridor demand (NaMATA, 2022). Hybrid operating models are emerging in SSA cities to create integrated PT systems which value the role of paratransit services.

2.4.5. Summary and research gaps

In summary, cities in SSA deployed two general approaches to BRT system design – flexible and full BRT. Specific system features in the selected cities are summarized in Table 1. Detailed features of BRT systems in SSA cities were tabulated (Venter et al., 2020). As shown, most cities implemented BRT using a corridor approach (Jennings & Behrens, 2017).

3. Recent BRT evolution in two South African cities

This section explores BRT design approaches and motivating factors in SA cities. Under the updated Strategic Plan (National Department of Transport, 2020), the revised approach to downscale PT infrastructure encourages differentiated designs based on city populations and passenger projections. In response to the challenges encountered with the Phase 1 replacement model (mentioned in Section 2.4.2), the flexible approach attempts to reform and incorporate paratransit services, which service majority of PT passenger trips in SA, to potentially prevent future operational deficits (Schalekamp & Klopp, 2018). Hybrid systems comprising formally integrated bus and paratransit services are prioritised to improve the quality of PT and urban mobility on the whole (National Department of Transport, 2020).

Cities have subsequently adapted their approaches. Notably, the City of Cape Town initiated an operator capacity building programme to advance paratransit participation and reform through the formation of a transport operating company. This resulted in the hybrid trunk-feeder model comprising bus operations along the trunk corridor and on-demand paratransit services (known as minibus-taxis (MBTs) in SA) along feeder routes to reduce operating costs, and improve service coverage and operational flexibility for passengers (Jennings et al., 2023).

Actual system designs and attempts to transition the paratransit industry are exemplified in two SA cities of different sizes to represent emerging flexible BRT system designs in other SA cities. The City of

Table 1
BRT design approaches and features in selected SSA cities.

City	Design approach	Right of way	Stations and stops	Route structure	Source
Lagos	BRT Lite (Phase 1)	Hybrid design (kerbside)	Partially enclosed stations	Direct services	Transport Global Practice (2020)
	BRT Lane (Phase 2)	Median segregated lane	Kerbside stations	Trunk route	LAMATA (2024)
Dar es Salaam	Full BRT	Median segregated lane	Median enclosed stations	Trunk and feeder	Jacobsen (2021); Joseph et al. (2021)
SA cities	Full BRT (Phase 1)	Median segregated lane	Median enclosed stations	Trunk and feeder	City of Tshwane (2018); National Department of Transport (2007, 2020); Rustenburg Rapid Transport (2016)
	BRT Lite (Phase 2)	Trunk service in segregated lane and mixed traffic	Hybrid station design, kerbside stops	Variations of direct service and trunk routes	
Accra	Full BRT revised to bus service	Mixed traffic and segregated lane	Kerbside stations	Direct service	Transport Global Practice (2020)
Nairobi	Full BRT pilot under construction	Median segregated lane	Staggered stations	Trunk and feeder	ITDP (2019)
Kampala	Full BRT pilot (design update out to tender)	Median segregated lane	Staggered stations	Trunk and feeder	Non-Aligned Moment – Uganda (2024)

Tshwane and Rustenburg are presented to demonstrate developing approaches in a metropolitan municipality and medium-sized city. Design approaches and details of selected features of both cities are summarized in Table 2. Interviews with municipal officials and contracted consultants served as the primary data sources.

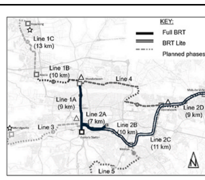
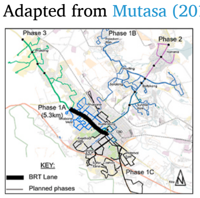
3.1. City of Tshwane

3.1.1. BRT system design

Tshwane Metropolitan Municipality is the capital city of South Africa, and the largest by area in the Gauteng region. 38 % of residents in the City of Tshwane are dependent on PT as the main mode of transport (City of Tshwane, 2015). The City's IPTN, called A Re Yeng, was deployed using the full BRT design for Phase 1A following the corridor approach (features shown in Table 2). Tshwane subsequently implemented an Optimisation Strategy to introduce services ahead of infrastructure. The key shift was the tri-phase approach to introduce immediate operations of bus services with essential infrastructure, interim operations prioritising infrastructure in critical areas, and upgrading to full BRT infrastructure for the final projected system demand. An inventory of infrastructure was created to assess requirements to complete the core trunk network, while ensuring the roll-out of services to achieve the benefits of a completed system. The aim was to enhance existing services to benefit residents and commuters, and reduce high operating and capital costs of the system (City of Tshwane, 2018). Under the BRT Lite design for Line 2B, 2C and 2D, buses will operate in mixed traffic conditions along existing road infrastructure using existing bus stops (shared with the municipal Tshwane Bus Services), until the BRT lane is constructed. This resulted in a hybrid infrastructure approach for Phase 2 consisting of BRT Lite corridors and constructed segregated lanes along Line 2A, which can be seen in Fig. 2. Additionally, an express service is planned from Line 2A to Line 2D to create a seamless journey along the Phase 2 corridor (Mashile, 2024).

The revised operating strategy included running larger (18m articulated) buses along segregated infrastructure for Line 1A and 2A during peak periods and smaller (12m standard) buses for lower volumes. This reduced the operational fleet and allowed timetable changes along low volume feeder routes. Feeder routes for the entire system are under review and new feeders planned with preliminary results indicating that a mixed vehicle fleet with different capacities is required (Mashile, 2024). As with some other SA cities, "over-estimated" passenger demand was used for BRT design and infrastructure implementation in Tshwane. A Re Yeng corridors were designed using travel demand forecast for the ultimate year (2037) and "no incremental growth was considered" (City of Tshwane, 2018), which resulted in over-designed corridors in the short term (du Preez & Venter, 2022). As such, Tshwane updated the travel demand model for future planning, in alignment with the Optimisation Strategy.

Table 2
Detailed BRT design approaches for the City of Tshwane and Rustenburg.

City details	IPTN operational and planned phases (length of trunk route)	Phase	Right-of-way	Stations and stops	Route structure	Vehicles	Source
Tshwane		Line 1A and 2A (9 routes)	Segregated lane along trunk route	Closed median stations	Trunk- feeder	18m articulated, 12m standard low entry buses	Mashile (2024)
Population: 3 597 000[a]		Line 2B	Mixed traffic	Kerbside stops	Trunk route	12m standard bus	
PT mode share: 38 %[b]	Adapted from Mutasa (2019)	Line 2C and 2D	Mixed traffic	Kerbside stops and interim transfer station	Trunk route	12m standard bus	
Rustenburg Population: 719 000[c] PT mode share: 51 %[c]	 Adapted from Wattel (2024)	Phase 1A (13 routes)	Segregated lane and mixed traffic	Closed and open stations. Kerbside stops (mixed traffic section).	Trunk-feeder model revised to direct routes	12m low entry bus (national design guideline) and (5.4m) MBT	Wattel and Marumoloa (2024)

[a] City of Tshwane. 2022–2026 Integrated Development Plan.
[b] City of Tshwane. Comprehensive Integrated Transport Plan (CITP) 2015–2020.
[c] Rustenburg Local Municipality. 2022/2027 Integrated Development Plan.

Fig. 2. A Re Yeng buses operating in mixed traffic and dedicated running way (Sources: Gary Hayes and Davis Muhungazi).

3.1.2. Paratransit reform

The large MBT industry consisting of legal and illegal operators presented a major challenge in Tshwane. The initial strategy to buy-out MBT owners along affected routes was an expensive and lengthy process which affected the overall deployment and patronage of the system (City of Tshwane, 2018). For example, paratransit resistance over BRT lane acquisition for Line 2B (from the existing two lane mixed traffic configuration) resulted in an almost four year roll-out delay. To prevent a "severely negative impact on the economy", a new lane is under construction for BRT operations (Tshwane Rapid Transit, 2020). Additionally, Phase 1A (Wonderboom to Pretoria CBD) was implemented along the direct route from Pretoria North to CBD and commuters were forced to transfer at Wonderboom, as MBTs were terminated along Phase 1A. A transfer station was planned, however due to infrastructure delays, passengers experienced difficulty transferring and preferred the previous direct MBT service (Mokoma & Venter, 2023). The situation was exacerbated by illegal operators. Case studies are required to assess the feasibility of contracting MBTs as feeders in effort to curb competing services (Mashile, 2024).

3.2. Rustenburg

3.2.1. Historical overview of BRT design

Rustenburg Local Municipality is located in the North West Province. The medium-sized city has a population of 719 000, 51 % are dependent on PT modes (Rustenburg Local Municipality, 2022). The initial full BRT envisaged for Rustenburg (when the local municipality was considered to be an emerging metropolitan municipality) consisted of a trunk-feeder network with enclosed stations to be operated by universally accessible standard buses (Chetty et al., 2024). Following budgetary cuts from National Treasury, Rustenburg updated the travel demand model and implemented a "planning-alongside-operations" strategy to understand user needs and paratransit operations. This was a key shift towards the provision of a user-centred (as opposed to infrastructure-oriented) system (Wattel, 2022). Seeing as the segregated lane and six closed stations along the R104 corridor were partly constructed as per the initial national guideline for Phase 1A, the feasible option was to incorporate the permanent BRT infrastructure into the new design. The full BRT design was converted to a bus service with direct routes operating in mixed traffic conditions, which overlap along the R104 (segregated lane), detailed in Table 2. The IPTN, named Yarona, is being implemented using a gradual approach according to the availability of funding, infrastructure and fleet. To date, Phase 1A consists of 13 operational routes which were strategically launched to facilitate the roll-out of other routes (Rustenburg Rapid Transport, 2016). Although the BRT lane was constructed, not all stations were completed. As such, the route is mostly operated in mixed traffic until the full segregated lane can be utilised (Wattel & Marumoloa, 2024). There is a possibility of upgrading operations to a trunk-feeder network with six closed stations in the future, however, Yarona relies on funding from the PTNG and changes and further upgrades will be informed by budgetary allocations (Rustenburg Rapid Transport, 2016).

The revision also included a hybrid station approach incorporating the constructed closed stations and outstanding stations as open stations. To reduce operational costs, most stations would be operated as open stations with on-board fare validation (Rustenburg Rapid Transport, 2016). The flexible approach for demand-responsive planning and operations, as applied in Rustenburg, allows for route adjustment and optimisation along mixed traffic sections. This approach was also adopted for the development of route stops. Namely, the position of bus stops were determined using onboard passenger surveys and temporary poles with signage were installed which, after testing and confirming bus stop locations, would be upgraded with permanent shelters (Wattel, 2022). A hybrid operating model comprising standard buses and rebranded MBT was introduced as an interim strategy to roll-out services according to the Go Live Operational Plan. Due to delays with standard bus procurement (under the initial design guideline) and to minimise costs, on-hand MBT were introduced to prevent delays in the roll-out of services. Under the flexible approach, smaller vehicles (rebranded MBT) were introduced along new routes and would be upgraded in phases, as necessitated by passenger demand (Chetty et al., 2024). Fig. 3 shows running ways, stations and fleet of the operational hybrid model of Yarona Phase 1A.

3.2.2. Paratransit reform

Ongoing negotiations with owners resulted in a unique collaboration and MBT operators in Rustenburg were described as "receptive" (Kühl, 2024). Under the formation of an integrated PT operating company (IPTOC), compensated owners were contracted to operate MBTs along routes in a scheduled capacity using rebranded MBTs (which were surrendered under the compensation agreement). MBTs were also contracted in a paratransit capacity to improve network coverage in areas where Yarona routes were not yet deployed, and account for demand variability. This contracting model serves as a first step to regulating the paratransit industry (Chetty et al., 2024).

3.3. Summary of approaches

Under the "build and operate" strategy (National Department of Transport, 2020), heavy BRT infrastructure was implemented for Phase 1 in SA cities, using the corridor approach. City responses to the revised strategy (captured in Table 2) show a general shift towards understanding passenger behaviour and creating a system suited to the travel demand model, notwithstanding challenges with inaccurate or outdated models. The updated scaled-down approaches of the two cities indicate that differentiated, more flexible designs could have been implemented from the start, shown by the operational reduced-cost alternatives developing in SA cities. Innovative solutions are being adopted due to budgetary constraints, like the use of existing vehicles to operate services, with plans to upgrade fleet gradually. As suggested by Hidalgo et al. (2016), the phased approach may assist cities in gaining user support and establishing demand prior to implementation of permanent infrastructure, to ensure long-term success. The revised strategy adopted in Tshwane and Rustenburg with focus to "operate then build" allows for system stabilisation before further infrastructure investment. Despite fears that cities will not progress towards ultimate system designs, the

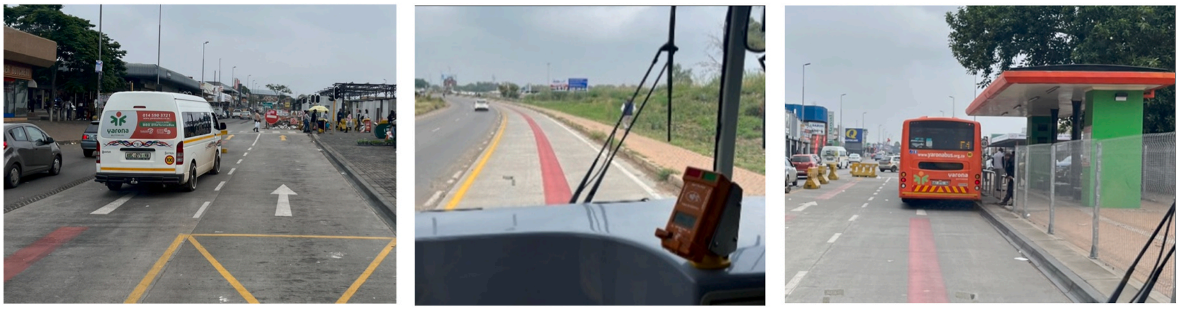


Fig. 3. Yarona Phase 1A infrastructure and fleet (Source: Alison Chetty).

lighter infrastructure indicated in Table 2 may be upgraded in phases (as and when needed) and prioritised by funding allocations, after services are established and routes altered based on demand. Regardless of pressure to deliver in the PT sector, proper long-term planning of BRT interventions is key to achieving the goal of successful systems (Wood, 2019). Measures such as developing a Master Plan for PT integration (Hook, 2022) and a National Compensation Strategy (Matolong, 2022) may assist in standardising city approaches and provide guidance for system design and implementation.

4. Implications of the flexible BRT design approach

There are numerous BRT deployment pathways along the spectrum of options. Fig. 4 shows infrastructure investment for a BRT Lite and Full BRT design standard along a corridor – to compare two variations of the available selections. The flexible design approach is demonstrated under two implementation strategies – corridor and phased deployment. These two possibilities exemplify Phase 1 BRT deployment in SA cities and the revised strategy (to implement infrastructure after operations are established). The potential system capacities of the design and network development pathways are also shown in Fig. 4, to illustrate benefits. The initial passenger capacity (C_i) of the existing system increases to the total planned capacity as infrastructure is deployed according to BRT Lite (C_L) and Full BRT (C_F) designs. These vary based on several factors such as vehicle design and frequency, and the most significant are running way, station and vehicle capacities (Wirasinghe et al., 2013).

While shorter implementation timeframes and lower costs are observed for lighter infrastructure designs (compared to Full BRT), BRT Lite alternatives only partially achieve the performance benefits of Full BRT, highlighting the cost-benefit trade-offs. Moreover, the desired quality of service determines the level of subsidisation which is pertinent to developing countries with limited funds for subsidies. Heavy infrastructure investment necessary to provide these levels of service may translate into higher user fares and contribute to transport exclusion.

Implementing full BRT infrastructure at the start of the project requires high capital, expansion of existing road networks and an extended construction period. Furthermore, implementing heavy infrastructure prior to establishing services may result in a suboptimal or failed system which offers no benefits or is deemed a waste of funds, as observed in some SSA cities (e.g. Nelson Mandela Bay, SA). If deployment of a single corridor depletes available funding, future corridors and completion of the network will be at risk, as seen in Accra. In comparison, a lighter infrastructure design could be piloted before further infrastructure investment to reduce risk and allow changes to be made accordingly. A phased approach offers flexibility to address uncertainty encountered in the African context, instead of waiting until the system is completed or irreversible, as seen in the revised approach in SA cities to achieve PT improvements gradually. The flexible approach to paratransit transformation could take the form of upskilling operators for integration into the BRT system, which could reduce operating costs, as seen in the City of Cape Town. This approach requires time but differs from the replacement model which led to interminable delays in many cities due to paratransit resistance and cost overruns.

The full BRT design standard adopted in Dar es Salaam, SA and Accra with varying outcomes, resulted in different infrastructure approaches for future deployment. Cities in SSA that adopted the full BRT model have, for the most part, been criticised for neglecting to understand the local context and project impact. Government officials in Nairobi and Kampala favoured large infrastructure projects and were unwilling to stray from the full BRT design standard, despite lighter infrastructure designs considered in preliminary stages (Klopp et al., 2019). In contrast, the adaptive approach of Lagos is seen as an exemplar of a tailored approach to BRT design for local user needs within operational and sociopolitical context (Kaenzig et al., 2010; Olyslagers et al., 2021). The flexible design approach was also adopted in the pilot project in George through phased deployment, which is pertinent to small cities in SSA. Certain variations of the flexible design approach, however, may not work in all contexts, as seen in the downgrade of the full BRT to a bus service with limited priority in Accra.

While the influence of international BRT lobbyists and financiers is

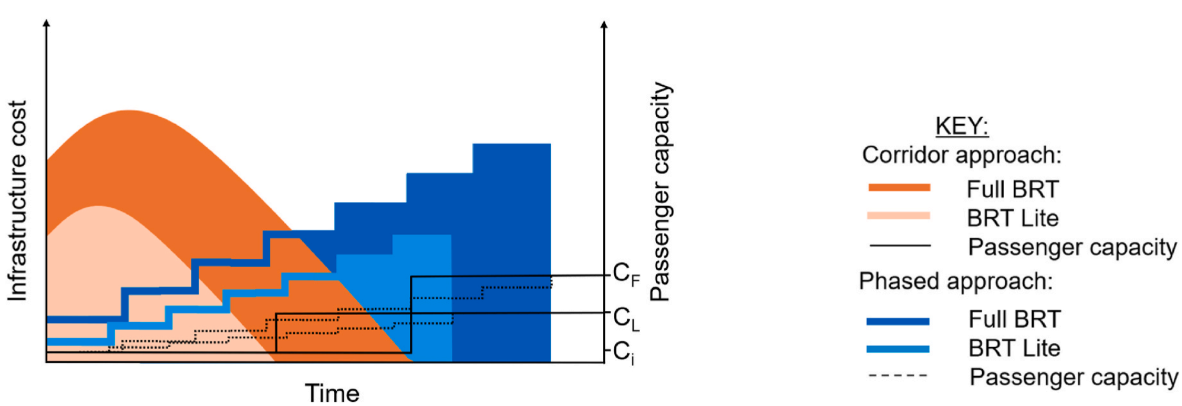


Fig. 4. Hypothetical infrastructure costs and capacity for deployment of flexible design approaches (Source: Authors).

apparent in SSA cities, the full BRT design modelled on best practices demands a great depth of change in the African context (Asimeng, 2022). Scholars propose that African cities, instead of replicating developed countries, implement plans best-suited to their needs and goals using a "whole-system integrated urban design" approach (Acheampong et al., 2022; Stucki, 2015). To this end, gradual BRT implementation, similar to Curitiba where BRT was developed over many years, is recommended (Moody et al., 2014; Stucki, 2015). Moreover, the paratransit industry performs a necessary service and must be integrated into PT systems in some form (Asimeng, 2022), as failing to include paratransit operators endangers the success of IPTNs (Jennings & Behrens, 2017). Kumar et al. (2021) provide a strategy to reform paratransit, however, there is no exact process to achieve this (Venter et al., 2019). As such, a multifaceted approach must be developed for each city, starting with an in depth understanding of local conditions (Jennings & Behrens, 2017). Asimeng (2022) recommends a phased approach to progressively improve paratransit services towards the deployment of a desired form of BRT, which would eliminate the introduction of an entirely new BRT service from inception, and its challenges. Applied within the city context, this approach considers challenges faced by African cities in relation to financial limitations and dominating paratransit sector. Nevertheless, political changes experienced over several years may present conflicting agendas and obstacles to projects. There is a need for information and knowledge to develop and implement this vision in an African context (Stucki, 2015).

5. Conclusion and recommendations

BRT systems have been implemented around the world using a spectrum of design features and deployment pathways to reform or improve PT services. Cities in developing countries with poor quality formal PT services, dominating paratransit industries, growing transport needs and limited funding seek appropriate and affordable BRT design solutions. The success of Latin American cities and BRT advocates influenced system design and some SSA cities are still struggling to adopt the full BRT model, with limited success.

In response, there is a shift towards BRT designs that are better adapted to local conditions and limitations. The BRT Lite in Lagos is seen as an exemplar of a BRT design tailored to the city's context to create the best-suited system. Lagos' flexible design approach has lighter infrastructure and incorporates existing paratransit services for increased service coverage and capacity. The adaptive approach is also seen in the George IPTN, which transformed paratransit operators into a scheduled bus service. Moreover, following the low performing full BRT model in SA cities, flexible BRT designs are being implemented using the phased approach. The "operate then build" strategy focuses on hybridisation (incorporating paratransit services) and the possibility to upgrade to full BRT infrastructure in the future. The flexible BRT design approach is a tool to address challenges faced in the African context. It applies a custom selection of BRT features based on suitability to local conditions and constraints, as there is no one-size-fits-all model. Hybrid designs and operating models are emerging in SSA cities with paratransit as a vital component of integrated PT systems.

When considering BRT design approaches, a lighter infrastructure design allows for adaptation to existing road networks. However, the downside of BRT Lite alternatives is lower speed and capacity performance benefits compared to Full BRT infrastructure. With respect to BRT development pathways, gradual deployment appears to be the best option based on experience thus far. An ultimate BRT design can be implemented over time (or in phases), by deploying an initial lighter infrastructure approach and upgrading at a later stage. Moreover, a phased approach can be applied for capacity building of existing paratransit operators, as a potential step for integration into a formal system.

Developing cities seeking to implement BRT systems may benefit from an overview and understanding of potential implications of design approaches in SSA cities. Further research is needed to understand if the transport landscape in SA (dispersed spatial patterns with low passenger demand) is unique, or if similar conditions are observed in other cities in SSA and the Global South which could favour lighter infrastructure designs. An appraisal of the performance implications of potential combinations of BRT features to understand benefits offered by infrastructure investments will be carried out in further studies. This requires evidence of deployment pathways and actual performance of alternative designs. A cost-benefit analysis, to understand the trade-offs involved with the flexible approach, is proposed. Furthermore, a framework is recommended to assess BRT designs under consideration, to prioritise funds and align measures with system objectives.

CRediT authorship contribution statement

Alison Chetty: Writing – review & editing, Writing – original draft, Data curation, Formal analysis, Conceptualization. **Christoffel Venter:** Conceptualization, Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We would like to thank the Thredbo 18: Workshop 7 conference attendees and members of the National Department of Transport for their contributions.

References

Acheampong, R. A., Lucas, K., Poku-Boansi, M., & Uzondu, C. (2022). Conclusions: What futures for transport and mobility in African cities? In R. A. Acheampong, K. Lucas, M. Poku-Boansi, & C. Uzondu (Eds.), *Transport and mobility futures in urban Africa* (pp. 397–401). Switzerland: Springer.

Asimeng, E. T. (2021). Bus rapid transit implementation with the inclusion of incumbent paratransit operators in African cities: Lessons from Accra. *Urban Planning and Transport Research, 9*(1), 534–548. https://doi.org/10.1080/21650020.2021.2000485

Asimeng, E. T. (2022). Bus rapid transit implementation in African cities: The case for a more incremental reform approach. In R. A. Acheampong, K. Lucas, M. Poku-Boansi, & C. Uzondu (Eds.), *Transport and mobility futures in urban Africa* (pp. 181–197). Switzerland: Springer.

BRT+ Centre of Excellence and EMBARQ. (2024). Corridor indicators: Length of segregated lanes. https://brtdata.org/indicators/corridors/length_of_segregated_lanes_corridor_km Accessed 23.02.24.

Chetty, A., Venter, C., Anguirini, M., Muhanguzi, D. M., & Moleele, O. (2024). Incorporating contracted minibus-taxis into transitional integrated public transport networks: The case of rustenburg. In *Proceedings of the 42nd southern African transport conference (SATC 2024), Pretoria*.

City of Tshwane. (2015). Comprehensive integrated transport plan. *Draft report*. Pretoria: Department of Roads and Transport.

City of Tshwane. (2018). *2017-2029 tshwane rapid transit/A re yeng operational plan, volume F: Optimisation strategy*. Pretoria: Department of Roads and Transport.

Deng, T., & Nelson, J. D. (2011). Recent developments in bus rapid transit: A review of the literature. *Transport Reviews, 31*(1), 69–96.

du Preez, S. J., & Venter, C. (2022). Mixing the formal with the informal in shared right-of-way systems: A simulation-based case study in Tshwane, South Africa. *Case Studies on Transport Policy, 10*, 145–155.

Fan, H., & Beukes, E. A. (2021). *Enhancing financial sustainability and commercial viability of bus rapid transits (BRTs) in Sub-Saharan Africa (SSA): The factor analysis report*. Washington, DC: World Bank.

Ferbrache, F. (2019). The value of bus rapid transit in urban spaces. In F. Ferbrache (Ed.), *Developing bus rapid transit: The value of BRT in urban spaces* (pp. 1–13). Cheltenham: Edward Elgar Publishing.

George Integrated Public Transport Network. (2025). Go George. https://www.gogeorge.org.za/. (Accessed 7 February 2024).

Goodman, J., Laube, M., & Schwenk, J. (1997). *Issues in bus rapid transit*. Washington, DC: Federal Transportation Administration.

Grütter Consulting. (2011). *VCS project document BRT Rea Vaya hase 1A and 1B, South Africa*.

Hidalgo, D., Muñoz, J. C., & Velasquez, J. M. (2016). A path toward integrated systems. In J. C. Muñoz, & L. Paget-Seekins (Eds.), *Restructuring Public Transport through bus rapid transit: An international and interdisciplinary perspective* (pp. 31–49). Bristol: Policy Press.

Hitge, G., & van Dijk, E. N. R. (2012). Incremental approach to public transport system improvements. In *Proceedings of the 31st annual southern African transport conference (SATC 2012), Pretoria*.

Hook, W. (2022). South African integrated public transit: The way forward. Transport forum. *IPTN Implementation and the Way Forward*. https://www.youtube.com/watch?v=_jIs5uHQXyI. (Accessed 17 February 2022).

Institute for Transportation and Development Policy. (2019). *Service plan for Nairobi BRT line 2*. Nairobi Metropolitan Area Transport Authority [NaMATA].

Institute for Transportation and Development Policy. (2024a). The BRT standard 2024 edition. Retrieved 4 April 2024 from https://www.itdp.org/wp-content/uploads/2024/03/BRT-STANDARD_MAR-2024_ITDP.pdf.

Institute for Transportation and Development Policy. (2024b). What is BRT?. Retrieved 4 April 2024 from https://www.itdp.org/library/standards-and-guides/the-bus-rapid-transit-standard/what-is-brt/.

Integrated Transport Planning Ltd. (2010). *Prefeasibility studies for the development of a longterm integrated bus rapid transit system for greater kampala metropolitan area*. Washington, DC: World Bank.

Integrated Transport Planning Ltd. (2017). Nairobi urban transport improvement project (NUTRIP) BRT feasibility study and business plan preparation. *BRT line 1: JKIA to James Gichuru road. Final report (v1-0)*. Washington, DC: World Bank.

Integrated Transport Planning Ltd, & IBIS Transport Consultants Ltd. (2009). Lagos BRT-lite summary evaluation report. *Lagos Metropolitan Area Transport Authority*. Retrieved 29 October 2023 from https://nairametrics.com/wp-content/uploads/2012/01/BRT-Lite-Summary-Report-FINAL.pdf.

Jacobsen, M. (2021). Co-producing urban transport systems: Adapting a global model in Dar es Salaam. *Sustainability: Science, Practice and Policy, 17*(1), 47–61. https://doi.org/10.1080/15487733.2020.1862545

Japan International Cooperation Agency. (2010). The study of Greater Kampala road network and transport improvement in the republic of Uganda. *Final Report. Executive Summary. Republic of Uganda Ministry of Works and Transport (MOWT)*.

Jennings, G., Arroyo-Arroyo, F., Chevre, A., Schalekamp, H., McLachlan, N., Hoyez, M., Ferro, P. S., Benmaamar, M., Diouf, I., Saddier, S., Niina, K., Breuil, L., Spooner, S., & Chaussavoine, A. (2023). *Studies of Informal Passenger transport reforms in Sub-Saharan Africa: From complete 'formalization' encompassing bus rapid transit (BRT) to corporatization of informal public transport owner/operators*. Cape Town, South Africa. Washington, DC: Africa Transport Policy Program (SSATP).

Jennings, G., & Behrens, R. (2017). *The case for investing in paratransit: Strategies for regulation and reform*. Gothenberg, Sweden: Volvo Research and Educational Foundations.

Joseph, L., Neven, A., Martens, K., Kweka, O., Wets, G., & Janssens, D. (2021). Exploring changes in individuals travel behaviour after bus Rapid Transit implementation in Dar es Salaam. *Travel Behaviour and Society, 27*, 139–147.

Ka'bange, A., Mfinanga, D., & Hema, E. (2014). Paradoxes of establishing mass rapid transit systems in African cities - A case of Dar es Salaam rapid transit (DART) system, Tanzania. *Research in Transportation Economics, 48*, 176–183.

Kaenzig, R., Mobereola, D., & Brader, C. (2010). Africa's first bus rapid transit system. *Transportation Research Record, 2193*(1), 1–8.

Klopp, J. M., & Cavoli, C. (2019). Mapping minibuses in Maputo and Nairobi: Engaging paratransit in transportation planning in African cities. *Transport Reviews, 39*(5), 657–676. https://doi.org/10.1080/01441647.2019.1598513

Klopp, J. M., Harber, J., & Quarshie, M. (2019). *A review of BRT as public transport reform in African cities, VREF research synthesis project governance of metropolitan transport background paper*. Gothenberg, Sweden: Volvo Research and Educational Foundations.

Kühl, J. (2024). Innovative partnerships and incremental implementation: Learnings from Rustenburg, transport forum. *IPTN Implementation Progress*. https://www.youtube.com/watch?v=zMUfEIY43Yw&list=PLe04sDiMmldRjJIwXmxXoEpiitAMgSV8c&index=4 Accessed 24.07.24.

Kumar, A., Zimmerman, S., & Arroyo-Arroyo, F. (2021). *Myths and realities of "informal" public transport in developing countries: Approaches for improving the sector*. Washington, DC: Africa Transport Policy Program (SSATP).

Lagos Metropolitan Area Transport Authority [LAMATA]. (2024). BRT. https://www.lamata-ng.com/services/brt/#1452765420119-d4dfaf69-4fae Accessed 12.07.24.

Lindau, L. A., da Silva, C. A. M., Petzhold, G., & Facchini, D. (2016). Global overview of BRT and bus corridors. In J. C. Muñoz, & L. Paget-Seekins (Eds.), *Restructuring public transport through bus rapid transit: An international and interdisciplinary perspective* (pp. 15–26). Bristol: Policy Press.

Mashile, S. (2024). *Update: Optimisation strategy* [Interview].

Matolong, M. (2022). Key insights from the national treasury cities support programme. Transport forum. *IPTN Implementation and the Way Forward*. https://www.youtube.com/watch?v=_jIs5uHQXyI Accessed 17.02.22.

Mimano, C. (2022). Enhancing the viability of bus rapid transit in Nairobi. *ITDP Africa*. https://africa.itdp.org/enhancing-the-viability-of-bus-rapid-transit-in-nairobi/ Accessed 24.10.24.

Mokoma, L., & Venter, C. (2023). Pathways to integrating paratransit and formal public transport: Case studies from tshwane, South Africa. *Research in Transportation Economics, 102*.

Moody, M., Esson, R., von der Heyden, C., & Laing, K. (2014). Public transport transformation: An incremental approach to delivering public transport systems in South Africa. In *Proceedings of the 33rd southern African transport conference (SATC 2014), Pretoria*.

Morten, M., Bryan, G., Siddiqi, B., & Balboni, C. (2020). Evaluating the impacts of the Dar es Salaam bus rapid transit system. *Impact evaluation report 110*. New Delhi: International Initiative for Impact Evaluation (3ie).

Muñoz, J. C., & Gschwender, A. (2008). Transantiago: A tale of two cities. *Research in Transportation Economics, 22*(1), 45–53.

Mutasa, R. (2019). Progress, lessons & innovation in the implementation of IPTN. *Pretoria: City of Tshwane*.

Muyinza, I. (2020). Service plan assessment report. *Abridged version. Bus rapid Transit-KCCA/GKMA. Kampala: Cities and infrastructure for growth Uganda*.

Nachilongo, H. (2024). Government okays Sh102 billion compensation for next phases of BRT project. ***The Citizen***. https://www.thecitizen.co.tz/tanzania/news/national/government-okays-sh102-billion-compensation-for-next-phases-of-brt-project-4622620#google_vignette Accessed 14.05.24.

Nairobi Metropolitan Area Transport Authority [NaMATA]. (2022). *Establishing the line 2 bus rapid transit bus operating company. Industry discussion document*. Nairobi: NAMATA.

National Department of Transport. (2007). Public transport action plan. *Phase 1 (2007-2010): Catalytic integrated rapid public transport network projects*. Pretoria: National Department of Transport.

National Department of Transport. (2020). *Strategic plan for the fiscal years 2020/21 – 2024/25*. Pretoria: National Department of Transport.

Ndibatya, I., & Booysen, M. J. (2020). Transforming paratransit in Africa's congested cities: An ICT- enabled integrated demand responsive transport (iDRT) approach. In *2020 IST-Africa conference (IST-Africa), Kampala, Uganda*.

Nguyen, M. H., & Pojani, D. (2018). Why do some BRT systems in the global south fail to perform or expand? *Advances in Transport Policy and Planning, 1*, 35–61. https://doi.org/10.1016/bs.atpp.2018.07.005

Niles, J., & Jerram, L. C. (2010). *From buses to BRT: Case studies of incremental BRT projects in North America. San José*. Mineta Transportation Institute.

Non-Aligned Moment – Uganda [NAM_Uganda]. (2024). The pilot BRT project, part of Kampala city's integrated BRT network, will cover 25km on three major routes, contributing to the Greater Kampala Metropolitan Area's integrated land use and transport planning.X. https://x.com/NAM_Uganda/status/1746124940338987065 Accessed 22.02.24.

Olyslagers, F., Mulley, C., & Nelson, J. D. (2021). Bus: From workhorse to thoroughbred. In C. Mulley, J. D. Nelson, & S. Ison (Eds.), *The routledge handbook of public transport*. Abingdon: Routledge.

Rizzo, M. (2014). The political economy of an urban megaproject: The bus rapid transit project in Tanzania. *African Affairs, 114*, 249–270.

Robb, J. (2024). Approach to achieving city wide impact: Learnings from George. ***Transport Forum***. https://www.youtube.com/watch?v=zMUfEIY43Yw&list=PLe04sDiMmldRjJIwXmxXoEpiitAMgSV8c&index=4 Accessed 25.07.24.

Rustenburg Local Municipality. (2022). *Five year 2022/2027 integrated development plan. Rustenburg*.

Rustenburg Rapid Transport. (2016). *Go live phase 1A operational plan 2016-2020: Technical operational plan phase 1A. Rustenburg: Rustenburg local municipality*.

Schalekamp, H., & Behrens, R. (2010). Engaging paratransit on PT reform initiatives in SA: A critique of policy and an investigation of appropriate engagement approaches. *Research in Transportation Economics, 29*, 371–378.

Schalekamp, H., & Klopp, J. M. (2018). Beyond BRT: Innovation in minibus-taxi reform in South African cities. In *37th annual southern African transport conference (SATC 2018), Pretoria, South Africa*.

Scorcia, H., & Muñoz-Raskin, R. (2019). Why South African cities are different? Comparing Johannesburg's Rea Vaya bus rapid transit system with its Latin American siblings. *Case Studies on Transport Policy, 7*(2), 395–403.

Stucki, M. (2015). *Policies for sustainable accessibility and mobility in urban areas of Africa*. Washington, DC: Africa Transport Policy Program (SSATP).

Transport Global Practice. (2020). *Synopsis of learnings from bank-funded BRT projects*. Washington, DC: World Bank. Working Paper.

Tshwane Rapid Transit. (2020). Discussion of the A re yeng alignment from Menlyn to Denneboom station. *Pretoria: City of Tshwane*.

Venter, C. (2013). The lurch towards formalisation: Lessons from the implementation of BRT in Johannesburg, South Africa. *Research in Transportation Economics, 39*, 114–120.

Venter, C., Barrett, I., Zuidgeest, M., & Cheure, N. (2020). *Public transport system design and modal integration in Sub-Saharan Africa cities. The state of knowledge and research*. Gothenberg, Sweden: Volvo Research and Educational Foundations.

Venter, C., & Hayes, G. (2017). Op-Ed: South Africa needs to revamp its new public transport system. *CNBC Africa*. https://www.cnbcafrica.com/2017/op-ed-south-africa-needs-revamp-new-public-transport-system/ Accessed 03.03.2024.

Venter, C., Mahendra, A., & Hidalgo, D. (2019). *Towards a more equal city. From mobility to access for all: Expanding urban transportation choices in the global south*. Washington, DC: World Resources Institute.

Vermeiren, K., Verachtert, E., Kasaija, P., Loopmans, M., & Poesen, J. (2015). Who could benefit from a bus rapid transit system in cities from developing countries? A case study from Kampala, Uganda. *Journal of Transport Geography, 47*, 13–22.

Wattel, N. (2022). *Rustenburg Rapid Transport system design approach* [Interview].

Wattel, N. (2024). *IPTN – Yarona – Service area*.

Wattel, N., & Marumoloa, M. (2024). *Yarona system design approach* [Interview].

Weinstock, A., Hook, W., & Lotshaw, S. (2015). *Nairobi Ndovu/A104 BRT service plan*. New York: Institute for Transportation and Development Policy.

Wirasinghe, S., Kattan, L., Rahman, M., Hubbell, J., Thilakaratne, R., & Anowar, S. (2013). Bus rapid transit – A review. *International Journal of Urban Sciences, 17*(1), 1–31. https://doi.org/10.1080/12265934.2013.777514

Wood, A. (2014). Moving policy: Global and local characters circulating bus rapid transit through South African cities. *Urban Geography, 35*(8), 1238–1254.

Wright, L., & Hook, W. (2007). *Bus rapid transit planning guide*. New York: Institute for Transportation and Development Policy.