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## Article

# Operational Challenges and Mega Sporting Events Legacy: The Case of BRT Systems in the Global South

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**Abstract:** This paper examines the bus rapid transit (BRT) legacies of mega sporting events (MSEs) held in the Global South cities of Cape Town and Rio de Janeiro. It discusses the extent to which these transport systems have been operationally sustainable, post-MSE; in other words, their ability to be maintained at a certain rate or level and hence their ability to act as public good as planned and according to specific needs. It argues that in both cities, long-term operational challenges have emerged due to conflictual temporalities between the priorities of the MSE and the mid/long term requirements of a transport system, supplemented by a poor spatial contextualisation of BRT design. These include financial viability, providing a service with appropriate frequency and capacity, integration with other transport systems, and resilience to external shocks such as extreme weather. These findings have key academic and policy implications both by opening further areas of research towards MSEs as a tool to deliver sustainable urban transport, and provides important lessons for future MSE hosts and cities considering BRT.

**Keywords:** mega sporting events; bus rapid transit; Global South; sustainable transport

## 1. Introduction

Mega sporting events (MSEs) such as the Olympic Games or the FIFA (Fédération Internationale de Football Association) Football World Cup can have a long-term impact on the infrastructure of their host cities. This may include new public transport infrastructure that fundamentally changes both the urban form of the city and the daily travel patterns of its residents, for decades after the MSE. These transport legacies have been the subject of academic research, within the broader context of MSE legacies (e.g., [1–4]) and as a separate research area, typically focusing on the role of awarding bodies such as the International Olympic Committee or FIFA in transport planning [5–7]. However, no research to date has considered how these new transport systems operate and serve the city over the long term (i.e., post-MSEs), specifically in middle and lower income countries predominantly located in Africa, Latin America, and Asia (often grouped within the term of ‘Global South’). In line with this,

there is very little insight into how these MSE-led infrastructures have been delivering the purposes for which they have been built, and specifically how the MSE imperatives may have affected its long-term development. In other words, we look here at the possible tensions of priorities between short-term ambitions (MSE) and long-term everyday needs. This indeed has a key impact on the authorities and operators who manage and fund public transport systems, and on the passengers who rely on it. To achieve this, the paper uses the term of operational sustainability, which is here shaped around the aim of assessing conflicting temporalities during setup of the project and hence reflecting on the wider implications for the long-term running and management of the network. We do so by bringing together the literature on MSE, sustainability, transport management, and infrastructure [8–12].

This paper focuses on two cities whose transport network has been significantly impacted by hosting MSEs: Cape Town (South Africa) with the 2010 FIFA Football World Cup, and Rio de Janeiro (Brazil) with the 2016 Olympic Games. Each city constructed new bus rapid transit (BRT systems) under the auspices of hosting a MSE, and self-identified this in their proprietary communications and strategies as a transport legacy of the MSE. Through interviews with key stakeholders located in each city, this study assesses the benefits of the MSE for transport within the cities, such as reduced travel time in Rio de Janeiro, and a step-change in the quality of transport provision in Cape Town. It also considers the longer-term operational challenges such as financial viability that these BRT systems are facing post-MSE because they have not been sufficiently contextualised to the local transport situation and/or aligned with existing plans or policies. It is worth noting that this comparative research sits within two separate larger-scale interdisciplinary projects; the first in South Africa within a 30-month project that looked at the challenges encountered by planning practitioners in the country, drawing upon 89 in-depth qualitative interviews, and a large-scale survey (e.g., [13,14]); and the second in Brazil, a 6-month project that examined transport resilience and climate adaptation within Rio de Janeiro via qualitative interviews. These projects provided significant insights into the understanding of the urban, environment, economic, and policy contexts of our two studied cities.

This paper therefore furthers the debate in the field of sustainable urban transport and MSE legacy. It builds on work by Chalip [15] by describing two new case studies whereby MSEs were used proactively to lever new investment in transport infrastructure, and demonstrates how sustainable event leverage is problematic when there is overt focus on the short-term event needs. It thus informs debate on how such infrastructures, in the developing context of South Africa and Brazil, are funded and operated in line—or not—with local needs and contexts. In other words, by querying the pathways through which money comes from to pay for the infrastructure over time in accordance to how the infrastructure is used, it demonstrates the importance of a detailed understanding of the transport and mobility patterns, prior to the implementation of such networks. This builds upon the range of critics and limitations made towards MSEs in general (e.g., [1,4]) from a policy and practice point of view for MSE host cities who are considering their own transport legacy, and for cities considering new transport systems, not least BRT.

Our argument is delivered as follows. Section 2 reviews the selected MSE, BRT, and transport literature and demonstrates the challenges raised by the combination of different timeframes and priorities and hence what we will name as the ‘operational sustainability’ of those networks. Section 3 details the methods and overviews the urban environment of Cape Town and Rio de Janeiro. Section 4 analyses the BRT systems in Cape Town and Rio de Janeiro and Section 5 discusses the comparative results from the research and draws wider conclusive points.

## 2. Mega Sporting Events, Transport Legacies, Bus Rapid Transit, and Operational Sustainability

### 2.1. MSE Legacies and BRT

In the last decade, there has been a rapid increase in the number of studies concerning MSEs and their legacies across a range of disciplines, including events management, health, sports management, tourism, geography, and urban planning (see the review by Thomson [16] and references therein).

Leopkey and Parent [8] describe how the MSE legacy concept evolved from something that was simply beneficial to the host city to a series of defined social, economic, and/or environmental legacy themes linked to city and regional strategies. Others have developed approaches to define or type “legacy” in order to assess whether it (or they) delivers a positive or negative impact to the host city, albeit noting that this varies with stakeholder perspective [1–4,17,18]. Kassens-Noor discussed the dreams and realities of Olympic transport legacies, describing how the influence of the International Olympic Committee in the design of new transport systems in event cities has produced generic transport legacies, ignoring local contexts [5,6]. Except for Kassens-Noor, transport is relatively understudied within the literature on MSE legacies. Indeed, of the 264 papers on MSE legacies identified by a systematic literature review of the field, only 39 considered non-sporting infrastructure, which includes all urban development, regeneration, and redevelopment of host cities including transport infrastructure [16].

From its origins in 1974 in Curitiba, Brazil, BRT has recently been promoted as a flagship transportation mode in the Global South. BRT is characterised by main trunk routes that operate in dedicated bus corridors with relatively few stations, which are supplemented by feeder lines that extend deeper into local communities. These features combined with platform level boarding and fare collection off-board are designed to reduce travel time. BRT is considered a cheaper, quicker alternative to subway systems that require underground construction and are slower and more expensive to build [19,20]. This is attractive to cities in the Global South where transportation is required to accommodate fast-rising urban growth rates, but where financial resources are limited. There are now more than 170 cities with BRT systems, approximately 100 of which are located in the Global South, [21], many having been constructed since the 2000s [20]. BRT systems are most prevalent in Latin America (55 cities; Brazil 21 cities), Europe (44 cities), and Asia (44 cities), with fewer systems in North America (19 cities), Africa (five cities; South Africa three cities), and Oceania (four cities) [21]. BRT operates in cities with differing urban forms, populations (including from cities to megacities) and relative wealth, and transports differing numbers of passengers, depending on the size of the BRT infrastructure. This global expansion in BRT is attributed to a combination of federal initiatives [22] and the global advocacy of high-profile exemplars such as Curitiba [23], and Transmilenio in Bogotá, Columbia [24–26].

However, BRT is currently facing a growing body of critiques. For example, many BRT systems have focused on improving mobility at low cost, hence facilitating urban sprawl [11]. Additionally, BRT requires a specific urban density profile to be financially viable that many Global South, and in particular, African cities lack [27]. Furthermore, whilst BRT has the potential to improve mobility for low-income users, evidence suggests that the benefits are skewed towards middle-income users [28,29]. From an environmental perspective, BRT is a road-based transport system that causes air pollution and emits greenhouse gases contributing to climate change (noting however that there are various pilot projects underway testing the viability of zero emission BRT bus systems). Globally, outdoor air pollution kills approximately three million people annually, with the greatest burden in the Global South [30].

Having said this, the reputation of BRT as a world-class transport system, combined with its relatively short construction time that permits implementation within MSE timeframes, and its comparatively inexpensive costs, have made it a favourable option within MSE bids and legacy strategies [31]. This is of particular relevance for fast-growing Global South cities where public transport development struggles to match the pace of urban growth and where MSEs are viewed as catalysts for major urban transformations. In this regard, Wood has brought together research on BRT and MSEs within the context of South Africa, describing the international exchange of best practice between South America and South Africa prior to the 2010 World Cup that contributed to the development of BRT in South Africa, and the adoption of BRT as an indirect legacy of the MSE [7,32,33].

This paper builds on existing work that describes the concept and creation of transport legacies by moving the discussions forward in time to consider how the BRT systems of Cape Town and Rio de

Janeiro, constructed under the banner of a MSE legacy, now operate on a daily basis. This is separate to the short-term transport requirements of the spectators and tourists who attended during the MSE (2010 World Cup—1 month; 2016 Olympics—16 days), which are not considered here. The paper analyses the different perspectives of customers, transport operators, and municipal-level planners using a specific framework developed for this purpose.

## 2.2. *Challenges of Conflicting Temporalities and Operational Sustainability*

The key aim of a public transport system is to carry urban residents from their homes to employment or other amenities, safely and comfortably. To evaluate the operability of the system, transport operators typically focus on metrics that describe the individual customer journey such as performance to schedule and value the customer experience of reliability, accessibility, safety, and travel time [34,35]. Other quantitative performance indicators including average trip length, maximum people per hour, and demand peak to base ratio, enable comparisons across different transport networks and cities [36]. Both Cape Town (see, for example, [37]) and Rio de Janeiro [38] have relevant modelling systems in place in order to forecast and estimate traffic predictions that are crucial when designing and operating new transport modes, and integrate long-term planning. A key parameter in transport modelling, in any context, is the density of the urban areas where new transport networks are set up. Density affects the number of potential users within reachable distance of the transport network, and thus low densities can result in there being an insufficient number of users to financially sustain the network [37]. In other words, space and location considerably matter.

Once built, the purpose and contribution of transport infrastructure is to provide everyday services, and hence act as a public good. To do so, it is expected to be reliable, sustainable, and resilient [39] to sudden short-term shocks such as extreme weather events (e.g., heavy rainfall and flooding), and longer-term transformations such as urban expansions. To be sustainable as a public good, it also needs to be financially sustainable, hence have a viable business model to continue operating; as a matter of illustration, this explains the recent diversification of forms of funding (and financing) across the world to operate transport infrastructures (see, for example, [12]). Private operators, who as a business need to cover their operational costs and hence the continuous funding of the infrastructure while making profit in order to provide the service, often manage transport operations and/or infrastructure in urban areas. If subsidies are required to attract customers or make the system accessible for low-income users, these must be managed by the municipal or national subsidising authority. To illustrate this point and using the example of Curitiba, again, the city started with buses and simple separation from traffic, keeping costs as low as possible until they could afford a more sophisticated level of BRT service [23]; this demonstrates the importance of financial sustainability to ensure the operability of a network. Thus, in the short term, effective, sustainable and resilient transport rests upon facilitating the flow of users and information through the transport system while, in the longer term, integration of transportation with city-level strategic planning can ensure that new housing developments connect to public transport and support economic development. All these factors are crucial as they participate to ensure that transport infrastructure generates revenue and allows their funding over the long term. This is particularly relevant in the Global South to address both social imperatives including access to decent living, tackling poverty [40], and environmental challenges such as air pollution [30].

When transport infrastructure development is coupled and financially incentivized by the organisation of an MSE, other factors are added to the standard parameters inherent to transport planning (briefly described above), such as giving priority to access and circulation between key facilities (e.g., airport, sport venues). In essence, MSE is a ‘temporary’ and short-term event, which while relying on strategic and mid-term planning, prior to the organisation, is shaped by priorities allowing a city and various neighbourhoods to respond to a very significant increase in traffic flow (both human and motorised), coupled with international media attention. Governance mechanisms are hence complexified along with policies, all characterised by challenging and often conflicting temporalities (i.e., long-term priorities based on a non-MSE context versus MSE-led policy highly focused and



limited in time). Adding to this is also, of course, is the crucial political nature of planning [5,13] for both MSEs and transport development, which may lead to choices and decisions being made that are not fundamentally in line with rational and data-driven models. Factors hindering the long-term sustainability of a network can hence be challenged if key parameters related to transport modelling and density or financing and funding are affected by the MSE organisation.

Drawing on these points, and in order to discuss the impact of contrasting temporalities when assessing the MSE transport legacy, this paper uses the concept of operational sustainability to query the extent to which the development and operability of MSE-led transport networks in both Cape Town and Rio de Janeiro have been impacted by such a one-off event. We use the word ‘sustainability’ to refer to the ability of the transport system to be maintained at a certain rate or level, and hence operational sustainability to focus on its ability to act as a public good as planned and according to specific needs, at a level acceptable to the stakeholders including customers, operator(s), and municipal authorities. It explores operational sustainability via three questions:

- (i) Does BRT move the population where they need to go and in a manner they consider acceptable?
- (ii) Is the system able to respond to changes and/or shocks?
- (iii) Is the business model financially viable?

The following section applies operational sustainability to BRT systems in Cape Town and Rio de Janeiro to evaluate the long-term legacy that these MSE transport systems have for the host cities.

### 3. Method and Study Area

#### 3.1. Sampling

Our research design was comparative and qualitative, including the collection of secondary data (desk-based including policy, planning, and transport strategy documents) and primary data (interviews) that were then combined during the analysis. The project purposefully selected participants who had direct professional or personal (in the case of the community representatives) experience and knowledge of the BRT systems, undertaking 30 interviews (Table 1). The in-country research teams utilised their existing established networks to initially invite candidates for interview, with later candidates selected from interviewee recommendations, and in line with the evolving conceptual framework and content of the interview material. Interviewees included senior professionals from the public and private sectors such as BRT operatives; other rail, bus, and metro transport operators; civil servants working within the local government; and academics at established universities. In South Africa, 14 interviews were conducted in Cape Town with civil servants, academics, and transport operators, and two interviews in Johannesburg with professionals involved in the implementation of BRT in South Africa. In Rio de Janeiro, 16 interviews were conducted with civil servants, academics, transport operators, community representatives, and politicians. A comparable selection of community representatives was not available in Cape Town; the history of apartheid and lower levels of community activism (in comparison to Rio de Janeiro) make this a hard to reach group. It is worth mentioning the time-lapse difference between the MSE and these interviews; in Cape Town, the World Cup took place eight years earlier; in Rio de Janeiro, there were only six to eighteen months between the Summer Olympics and the interviews.

The interviews were semi-structured and followed the same series of basic open-ended questions and prompts, and allowed the interviewees to add depth where appropriate as per their expertise or knowledge. To ensure consistency across the sample, the interview team (see author contributions) used the same questions, and initially worked in pairs to establish a common interview format. Where possible, interviews were conducted in person; seven were conducted via telephone or Skype. Although the interviews were undertaken under the condition of anonymity in line with university ethical procedures, the participants (excluding community representatives) were interviewed whilst operating in their professional capacity. That said, all interviewees offered critical responses with both positive and negative aspects of the BRT systems. There was no noted bias between personal or

telephone interviews; the interviews had a similar duration and depth of information. Two interviews had three people present during the interviews; this was a choice of the interviewee organisation. These interviews lasted a similar duration, and contained a similar depth of information, and are considered as the collective view of three people working for the same organisation, rather than one individual, and are therefore only listed as one interview in Table 1.

**Table 1.** Interviews classified by location and stakeholder group. Interviews RJ1–RJ8 were undertaken in January 2017. All other interviews were undertaken between January and April 2018.

Stakeholder Group	South Africa	Rio de Janeiro
Academic	SA1, SA2	RJ5, RJ6,
Transport operator	SA7, SA12, SA10, SA11	RJ1, RJ2, RJ3, RJ4 *
Civil servant (planning)	SA3, SA6	
Civil servant (resilience)		RJ7
Civil servant (transport)	SA4, SA8, SA9, SA13, SA14	RJ8 *
Consultant (finance)	SA5	
NGO (transport)		RJ11
Politician		RJ9, RJ10
Community representative		RJ12, RJ13, RJ14, RJ15, RJ16

\* RJ4 and RJ8: Each interview represents the collective views of three people interviewed together.

The interviews were coded using NVivo software, using a mix of structured coding, defined prior to the analysis of the data; and unstructured coding, developed through the process of coding itself, highlighting emerging subjects that were common across interviews with the different stakeholders and cities. The codes were grouped into themes that helped shape the conceptual framework of operational sustainability. All codes mentioned in ten or more of the interviews were discussed in this paper.

To ensure rigour in this qualitative research, the researchers used several strategies proposed by Smith and Noble [41] to ensure validity (i.e., the degree to which the findings represent the data) and reliability (i.e., consistency in approach and bias reduction). These are shown in Table 2.

**Table 2.** Strategies used to ensure the rigour of qualitative research in this project. Adapted from Noble and Smith [41].

Concept	Measures Taken
<b>Validity</b>	Reflexivity and reflection on own perspectives
	- Regular debriefing before and during the interview process between researchers to ensure the approach was collecting the data required to address research aims
	- During sampling, ongoing differences (biases) were noted and addressed where possible to ensure all perspectives are included
	- Representativeness of findings
	- Audio transcripts enabled repeated revisiting of data to check emerging themes and our understanding of the responses
	- Coded text was not considered in isolation, but within the broader context of the transcript to ensure it was true to account
	- Extracts from the interviews are provided for the reader
	- Sampling biases are acknowledged and discussed in text (Section 5.2)
<b>Reliability</b>	Achieving Auditability
	- The researchers used the same interview transcript, and initially interviewed together to ensure consistency in approach
	- Audio transcripts were transcribed verbatim for coding
	- Coding was undertaken systematically using specialist software for qualitative data analysis
	- Coding was shared by two researchers, who used the same codes, and cross-checked each other's coding. Where new codes evolved these were retrospectively applied to previously coded work
	- Emerging themes were discussed as a team to reach consensus on findings and concepts

### 3.2. Cape Town

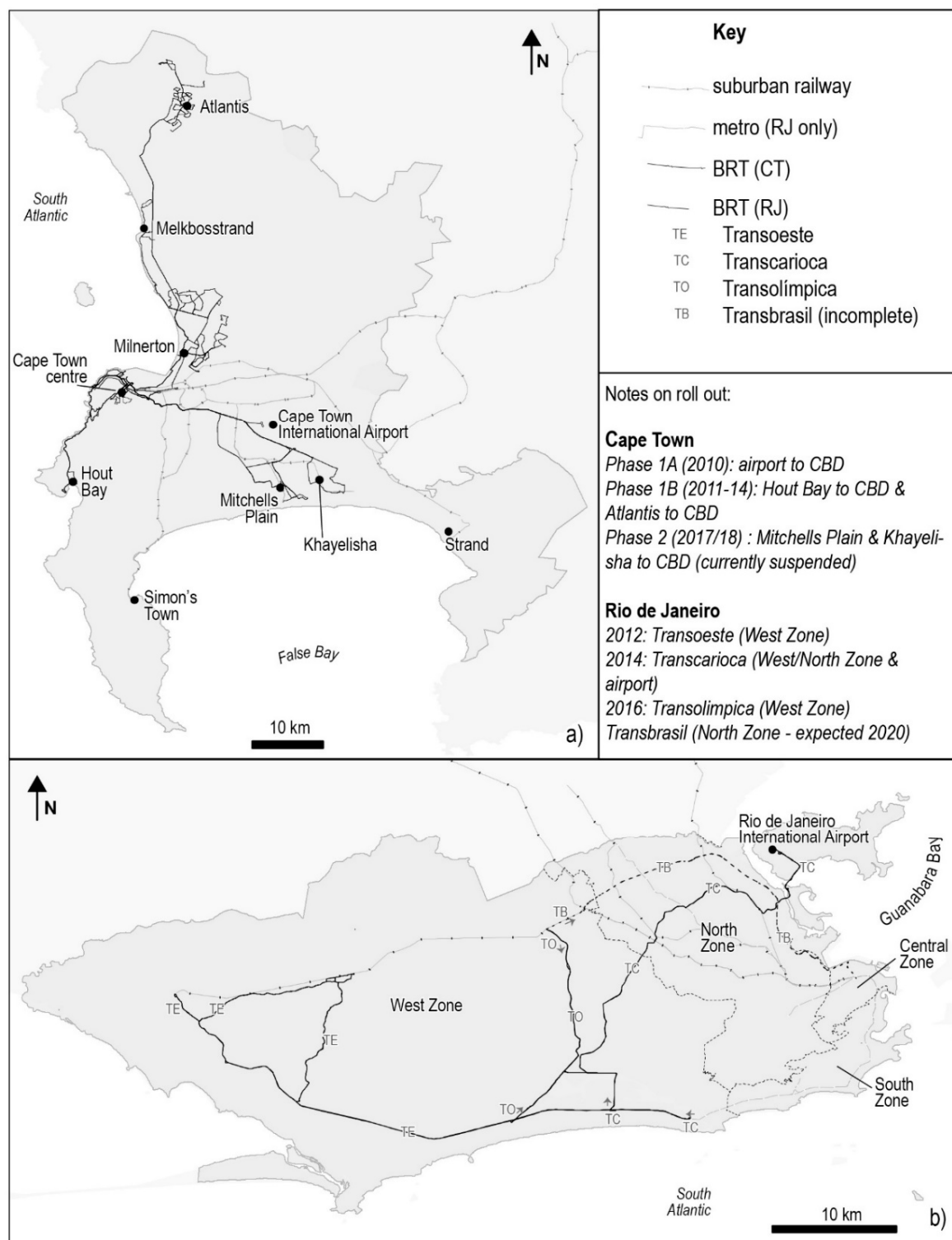
Cape Town had a population of 4.174 million in 2017 [42]. As a legacy of apartheid planning and design, it has a polarised density profile, with dense and low income communities located on the periphery of the city or in satellite suburbs such as Atlantis (Figure 1a)). Between the central business district (CBD) and these low-income communities is a sprawling mass of suburbs catering to wealthier communities and areas of undeveloped land. Employment opportunities are concentrated in the city centre, and historically, public transport was designed to transfer low-income workers to and from the city every day. Public transport accounts for 38% of journeys, with a modal split of rail (18%), bus (6%), mini-bus taxi (12%), and BRT (2%) [43]. BRT carries 65,000–70,000 people per day (SA4). In recent years, underfunding has led to a decline in the quality of metro rail; services are frequently late, 70% run overcapacity, and the rates of crime and vandalism are high [44]. Private cars are used for 53% of journeys, and 90% of these journeys are made by white South Africans [7,44].

The construction of BRT in Cape Town is a consequence of the international advocacy of BRT as a transport solution made possible by public funding leveraged by the 2010 World Cup, and is consequently considered as an indirect legacy of the MSE [7]. BRT only appeared in the Cape Town transport planning documents two years after the successful bidding proposal for the World Cup [45], but by 2009, it was central to the city's transport plans [46]. The rollout of BRT in Cape Town (MyCiTi) has been staggered (Figure 1a)), and future phases are planned [47]. The first BRT provided a shuttle service between the CBD and Cape Town International Airport, prior to the start of the World Cup in 2010. There was expansion into the northern and western suburbs in 2011, then northwards to Atlantis in 2013 (Figure 1a)). More recently, BRT services have been extended south-eastwards towards Khayelitsha and Mitchells Plain located on the Cape Flats, an area predominately comprised of low-income communities who depend on public transport to access their employment [48]. The BRT network is currently operated by a consortium comprised of former minibus taxi drivers and existing transport providers such as the bus company Golden Arrow, which operates specific routes as a vehicle operating company.

### 3.3. Rio de Janeiro

Greater Rio de Janeiro has a population of almost 13 million [49], with approximately 6.5 million people living within the municipality of Rio de Janeiro. Population density is highest in the North Zone (Figure 1b)) along a corridor that includes rail, road, and metro links to employment opportunities. These are concentrated in the industrial northwest and port area, the central business district; and domestic and service sector jobs in the wealthier South Zone [50]. Public transport constitutes 47% of journeys, split into bus (38%), metro (4%), rail (2%), and others (e.g., light rail/boat). Bus journeys include BRT, but this system carries no more than 1.5% of total modal share (a ridership of 364,000 people/day, BRT pers. comm. 2017). In contrast to Cape Town, the 2016 Olympic bid for Rio de Janeiro directly included BRT as a transport legacy from the games for the people of Rio de Janeiro, and BRT was subsequently adopted into the strategic transport plan for the city following the successful Olympic bid [6]. In Rio de Janeiro, BRT is a municipal-level concession operated by consortia of 17 different operators who own and manage separate assets (e.g., buses, depots, garages) within the system (Figure 1b)). There are currently three operational lines: TransOeste 2012 (189,000 people/day); TransCarioca, 2014 (150,000 people/day); and TransOímpica, 2016 (25,000 people/day; BRT pers. comm. 2017). These serve the West and North Zones of the Rio de Janeiro municipality. The TransBrasil line will operate in the North and Central Zone when complete (estimated 2020).





**Figure 1.** Bus Rapid Transit routes in: (a) Cape Town, and (b) Rio de Janeiro. Correct as of November 2019.

## 4. Applying Operational Sustainability in Cape Town and Rio de Janeiro

### 4.1. Cape Town

#### 4.1.1. Does BRT Move the Population Where They Need to Go, in a Manner They Consider Acceptable?

BRT moves a subset of the population safely and comfortably, but the airport link is underused (SA1, SA2, SA10). BRT is universally considered to have delivered a step-change in the quality of public transport in the city in terms of cleanliness, comfort, safety, reliability, and accessibility, as compared to existing alternative provisions such as scheduled bus, rail, and minibus taxi (SA1, SA2, SA4, SA5, SA8, SA12), albeit in specific locations, and only account for 2% of public transport journeys [41]. It provides a public transport network to the north of the city, where there is no rail provision, and connects residents in these suburbs and satellite towns (e.g., Atlantis) up to 40 km from Cape Town with employment opportunities and the rail network in the central city. Travel is predominantly unidirectional, with full buses travelling towards Cape Town in the morning, and the reverse in the evening. BRT stations are regularly spaced along this route, as per the South American model, but some stations have relatively few boarders, and these mid-route passengers complain that the services are often full (SA2, SA5, SA10). Outside of peak hours, there is less demand and capacity is managed by increasing the headway so buses only travel when full (SA4, SA10). Unfortunately, the BRT service to Mitchells Plain and Khayelitsha is currently suspended, without an agreed operator (as of November 2019), and passengers and staff on this route have previously complained of safety concerns on the buses and in stations (SA8, SA12). Generally, the time reduction offered by BRT is negligible, particularly to the north where there is little congestion and therefore no need for separate BRT buses into separate corridors.

Integration between BRT and other transport systems needs to improve (SA4, SA10, SA12) with a unified ticketing system (SA2, SA4) as the current integration between systems is only via the colocation of stations (e.g., Woodstock, Century City). Minibus taxis carry the most passengers in Cape Town [41], but initially, there was no integration between BRT and mini-bus taxis. Currently, as part of a broader localisation initiative, a hybrid system that uses minibuses as feeders to the main BRT trunk routes is under consideration in order to integrate the minibuses, and reduce BRT operational costs, particularly along the feeder lines (SA1, SA5, SA8, SA10, SA12). An electronic transport payment card with the potential to unify tickets was rolled out alongside MyCiTi, although there have been challenges incorporating informality (e.g., mini-bus taxis, users unaccustomed or without banking facilities) with this new technology.

#### 4.1.2. Is the System Able to Respond to Changes and/or Shocks?

Weather was not considered as an external shock to transport, nor did extreme weather such as high temperatures or heavy rainfall significantly impact operations (SA1, SA2, SA10, SA12). The 2018 drought had minimal impact on operations; buses were washed less often to preserve water, which may (or may not) reduce the long-term durability of the vehicle paint (SA10). Theft and vandalism are considered the biggest challenges for transport services, along with the safety of the passengers and staff (SA3, SA11, SA12), and operations to the Cape Flats have ceased, showing that BRT was not resilient to these short-term shocks. Originally, BRT planned to replace all existing road based transport in Cape Town; this disruptive change and the following protracted negotiations strained relationships with this community [45], potentially contributing to the current vandalism and consequential service disruption.

There is no climate change adaptation plan for BRT, and adaptive planning for longer term changes in climate increases resilience [51]. The municipal authority is currently procuring electric vehicles for current and future operations, building resilience by diversifying power source, and increasing environmental sustainability, which will become increasingly important as cities develop carbon emissions targets (SA3, SA4, SA6, SA8) and thereby building resilience to potential longer-term changes.

#### 4.1.3. Is the Business Model Financially Viable?

The BRT system requires municipal and national subsidies in order to operate, and the long-term financial sustainability is both a major concern and source of tension (SA1, SA2, SA4, SA5, SA6, SA10, SA12, SA13). BRT was originally “sold” by internal and external advocates as not requiring subsidies for operations (SA1, SA5, SA10), who cited profitable operations in Curitiba and Bogotá. However, Cape Town has a lower density urban form than these cities, and the polarisation of accommodation in satellite towns and distant suburbs, and employment opportunities in the centre ensures long-distance unidirectional travel, therefore limiting fare renewal (i.e., passengers getting on, and then off, selling the seat multiple times) and consequently reduces revenue. The feeder buses that link to the main trunk routes are also a source of deficit (SA5, SA12), and the structure of BRT, with different organisations responsible for operation, security, maintenance, monitoring and more, requires multiple management teams and therefore a bigger profit margin (SA2, SA10). BRT has also failed to attract long-term users and therefore revenue from both higher economic classes who prefer private road transport (SA7, SA10, SA14), and from some lower economic class users, who prefer minibus taxis for their demand responsiveness around boarding and alighting such as dropping passengers closer to home when they have heavy bags or in bad weather (SA1, SA2, SA9).

#### 4.2. Rio de Janeiro

##### 4.2.1. Does BRT Move the Population Where They Need to Go, in a Manner They Consider Acceptable?

BRT provides an alternative transport provision for some residents, with some reductions in travel time, but can be overcrowded and uncomfortable for users. For residents living in the West Zone, the TransOeste corridor has the potential to reduce travel time from three hours to 50 min (RJ1). BRT provides free travel for students and the elderly (RJ1), and is considered accessible to low-income communities (RJ1, RJ11, RJ12, RJ14, RJ15), although public transport is prohibitive for the lowest income earners who may prefer to sleep in the streets instead of paying multiple tariffs to get home (RJ6). However, overcrowding compromises the quality of the service on the TransOeste and TransCarioca corridors (RJ3, RJ9, RJ12, RJ15, RJ16). Discomforts include overheating, and practical problems “*how do they come with their shopping bags inside the BRT?*” (RJ16). Interviewees also complained of insufficient or no air-conditioning on BRT and feeder services, bumpy and slow rides with frequent breakdowns (weather damage to TransOeste discussed below), and cockroaches on feeder buses (RJ9, RJ11, RJ12, RJ15, RJ16). Regarding accessibility, although buses are accessible by lift, in some areas (e.g., Vargem Grande) there may be inadequate or no sidewalks, so disabled users struggle to access bus stops (RJ11, RJ14). There is also insufficient shade at bus stops (RJ15). The frequency and timing of feeder buses are considered poor (RJ9, RJ11, RJ12, RJ15), as is the information provided to the passengers about these transfers (RJ11, RJ12, RJ16). Indeed “*the significant gain that we have of travelling time in the BRT, we sometimes lose time because of the feeders, because the integration is awful*” (RJ13). In contrast, along the TransOlimpica corridor that connects the former Olympic venues and the portion of the TransCarioca that links out to the airport are underused; the TransOlimpica corridor carries only 40,000 passengers per day against projections of 70,000 (RJ1, RJ10).

There are multiple integration concerns for the BRT system in Rio de Janeiro. At the planning and design stage, there was no integrated vision between the State, who manages the rail and metro, and the municipal BRT concession (RJ3) so there were missed opportunities to co-locate the new BRT stations with existing rail and metro stations to enable passenger transfer between systems (RJ3, RJ16, RJ8). There is integrated ticketing across different transport modes via a *bilhete unico* that allows two trips per journey; however, many trips are three steps: feeder–trunk–feeder (RJ1) necessitating two separate fares to be paid for one commute or journey, impacting the lowest income communities generally travelling the longest distances who are most reliant on transport (RJ4, RJ5, RJ11). BRT does not integrate with social housing programs such as *Minha Casa Minha Vida*, which was built contemporaneously in the Western Zone (RJ9, RJ13), and these new communities can be up to 1.5 km away from public transport.

#### 4.2.2. Is the System Able to Respond to Changes and/or Shocks?

Hot temperatures and heavy rainfall impact BRT operations, but the operators have significant experience operating under extreme weather and restoring operations. On hot days, up to 20% of the fleet can be out of service following the failure of air-conditioning units, and a poor decision to use asphalt instead of concrete for the TransOeste corridor against expert advice (RJ1, RJ2) has led to accelerated surface degradation by heat and flooding events, necessitating repairs to the surface and the buses' undercarriages (RJ2, RJ11), thus impacting the quality of service and increasing operating costs. In the North Zone (Figure 1b)), heavy rainfall events cause neighbourhood flooding, inundating BRT stations and corridors approximately 4 to 6 times per year between November and March (RJ1, RJ2). To mitigate disruption, the operator uses high resolution heat, rain, and flood forecasts supplied by the municipal centre of operations to increase preparedness, and has contingency plans to transfer buses onto public roads, but services can be cancelled due to flooding (RJ1, RJ2, RJ7). To enable quick recovery, garages are on standby on hot days to mend heat-related failures and minimise the time the bus is out of service (RJ2). Longer-term, there is no climate change adaptation plan for the BRT system, and the new TransBrasil corridor is under construction using asphalt, despite the weather-related impacts experienced on the TransOeste corridor, and represents a future challenge to resilience for the BRT.

Despite the impact of weather, from an operational perspective, vandalism is considered the most challenging short-term shock for the system (RJ1, RJ2), with community users describing regular vandalism of the buses (RJ11, RJ12, RJ15, RJ16), and BRT buses can be a focus for vandalism during protests on different matters such as water supply (RJ2). The lack of community consultation about the new BRT system and the associated route changes have created resentment and tension within the user groups (RJ9, RJ10, RJ12, RJ13, RJ14, RJ15, RJ16).

#### 4.2.3. Is the Business Model Financially Viable?

BRT in Rio de Janeiro is a non-subsidised privately run system by a consortium of 50 operators. It is experiencing unexpectedly high maintenance costs arising from vandalism and the impact of weather (RJ1, RJ2). The service has failed to attract higher income earners, who have not switched from private vehicles to BRT, and this market represents the shortfall in users of the TransOlímpica corridor (RJ1). Attracting this market share is problematic as many reside in condominiums, and are unlikely to travel 0.5 to 1 kilometres from their home to reach a bus stop to use a crowded service, particularly when some condominiums offer a private downtown bus service for residents (RJ5, RJ12). Concerns over the quality of service provided by the BRT system is another reason why private car owners are not switching to this mode (RJ4, RJ5, RJ6). The airport extension is considered as a poor economic decision given the construction costs and the few customers who use it (RJ10). There are regular discussions to increase the ticket price to incorporate unexpected expenses from vandalism and the impact of weather, and other increases driven by inflation, but this idea is unpopular with the municipal authorities (RJ1). The opening of the TransBrasil line (expected 2020) will provide more revenue. For now, the business model is viable, but profit margins are tight (RJ2).

### 5. Discussion and Conclusions

#### 5.1. Comparing MSE Transport Legacies in Cape Town and Rio de Janeiro

For both cities, the different challenges to operational sustainability outlined in Section 4 are derived from the same two causes which impact the funding, viability, and operability of the infrastructure and are linked to the conflicting temporalities that arose from the MSE hosting: (i) limited contextualization of BRT design, and, (ii) prioritisation of the short-term transport requirements for the MSE rather than the long-term transport demands and movement patterns of the residents. These issues were exacerbated by the fixed deadline of the MSE, which led to rapid decision-making and reduced the opportunity of integration with other existing municipal plans and policies, not least

because BRT was not included in municipal planning documents prior to each city's confirmation as MSE hosts. Rapid decision-making, the relative ease in constructing BRT and pressure towards the branding and international image behind MSEs means that poor decisions were made, and not only with regard to BRT. It also involved beautification projects, typically the fast-track construction of 'beautiful' formal housing developments, along the main motorway between the airport and the city which rested on massive slum eradication [52]. Regarding the BRT design, national and local decision makers supported choices that went against local expertise and knowledge and followed strategies and models that were not contextualised enough. Typically, the low-density urban form of Cape Town is not appropriate for the BRT model imported from South America [27,36], thus impacting profitability and long-term financial sustainability; *"It's not one size fits all and I think that was lost in the original aspect"* (SA10). In hindsight, stakeholders commented that incorporating, rather than replacing, the existing minibus taxi system could have created a hybrid solution appropriate for the urban form and travel requirements of the residents, and future rollout of the BRT will use a different, more profitable model (SA4, SA8, SA10, SA13, SA14). In Rio de Janeiro, BRT cannot support the travel demand, which requires a high-capacity system such as suburban rail or metro. Indeed, the original plans for the subway developed in 1978 include a proposed line along the current TransCarioca route, and the two previously unsuccessful Olympic bids included significant investment in rail and subway infrastructure [6]. The overheating of buses and degradation of asphalt surfacing is a consequence of using materials not suitable for the local climate, hence ignoring the local context. The problems of overcrowding and weather impacts seem likely to continue; projected passenger numbers for the new TransBrasil line are 800,000 people/day [53], a ridership more than double the existing usership, and asphalt (unlike the concrete of TransCarioca and TransOeste) is being used for surfacing.

Both cities have also prioritized an airport link, matching what was implemented in cities in the Global North and here incentivised by political ambitions and the goal of managing the visitors' flow in travelling to the city centre to attend the event; *"we knew that what we absolutely needed was a good shuttle service that impressed the visitors coming from all over the world and the teams between the airport and the CBD"* (SA12). These are now underused, and considered *"from an economic point of view"* as *"a gigantic irrationality"* (RJ10). These two contrasting points again reflect the impact of conflicting priorities where those specific to the MSE surpassed pragmatic transport modelling decisions, which could have been made in line with a more coherent sustainable transport strategy. Indeed, in Rio de Janeiro, the TransOlimpia was designed to provide transport between the different Olympic zones [6]. These short-term transport requirements cannot provide a long-term transport legacy for the city, unless there is an existing transport demand requiring these routes. In both Cape Town and Rio de Janeiro, transport planners forewarned issues with system design (RJ5, RJ8, SA4), but international pressure from consultants engaged in policy transfer, along with the FIFA and IOC, influenced the decision-making. The official bid originally suggested Athlone Stadium as a practice venue for the World Cup; this was rejected as FIFA wanted views of Table Mountain for the backdrop [7]. This would have made public transport along the Cape Flats a priority for investment at the outset, potentially revolutionising public transport for these transport captive communities. In Rio, as the state of Rio de Janeiro was declared bankrupt in 2016 and the former State Governor of Rio de Janeiro was found guilty of passive corruption and money laundering in June 2017, ongoing fraud investigations have been connected to MSE infrastructure projects. This testifies again to the highly political and subjective nature of BRT design and development in the city, in the MSE context.

The MSE deadline was also a double-edged sword. Without the MSE and the deadline, there would have been no large investment in transport infrastructure. However, the impending MSE deadline influenced and hastened the decision-making process, reducing the opportunity to integrate transport systems with long-term and more sustainable strategic plans for the urban environment. Gaffney [54] describes the governance during MSE preparations as a shock doctrine (i.e., a temporary, extra-legal form of governance used during political, environmental, or economic disasters). The MSE forced and permitted quick decisions; *"we had to design literally on the fly and stay ahead of contractors"*



(SA4), and led to costly mistakes. In Rio de Janeiro, the speed of BRT development left no time for integration with social housing or existing transport systems, and permitted costly mistakes. An estimated R\$ 1 million was spent on the Maria Tereza BRT station on the Transoeste line; though completed in 2014, the BRT route has changed and the station was dismantled unused in 2018 (RJ12). The MSE deadline also moved the focus of the decision away from delivering strategic transport to delivering something that met the deadline; *“We needed an airport shuttle service okay, and we couldn’t build a railway line . . . and it was relatively cheap, and we could do it in time”* (SA10).

This situation is not unique to MSE-led development and is a common problem in the Global South context where limited resources are in place for planning and developing cities. As noted in a report by Urban Landmark [55], a lack of human resources, typically in Africa, is resulting in planning departments being pressured to prioritise the most urgent actions (e.g., the provision of housing or any other agenda that are politically raised as priorities, typically here the MSE) over others. This often leads to the outsourcing of spatial plan drafting to consultancy firms. These firms, which are frequently large multinationals, tend to propose futuristic style cities where poverty is eliminated, everything is sustainable, and everything happens in glistening futuristic style skyscrapers [56]. This outsourcing is in many instances flawed as the planners and politicians within the municipality often lack the skills and understanding to grasp that what these multinational firms offer is typically unrealistic, deeply harmful, and ignorant of the local specificities of African cities. Furthermore, these plans rarely show understanding of the subtleties of the political system and everyday needs of local communities and transport systems. Such lack of local planning expertise then creates difficulties in the local understanding of spatial issues and their implications, steering some of the decisions towards specific segments of the markets [57]. The development of BRT system networks and their limited operational sustainability result from similar dynamics. We do not intend here to argue that the development of the BRT system networks in both cities has been a mistake and a failure. Despite the multiple challenges that we have highlighted, it has allowed the development of a more extensive public transport network in both cities, which was not available prior to being selected as a MSE host city. Having said that, the transport legacy of the MSEs has not reached the level it could have been expected to, in principle, if more rational and localized decisions, less politically-driven, had been made when designing the network. This would have significantly enhanced its long-term operational sustainability.

## 5.2. Limitations of the Study

The interviewees were selected using a clear rationale, based on their personal and professional experience and knowledge of the implementation and operation of BRT systems within their city, following principles outlined in Cleary, Haferburg, and Ley [58]. Care was taken to recruit a diversity of interviewees from varied professional backgrounds, many of whom were regarded as international experts in their field. The nuanced and considered critiques the interviewees provided of the BRT systems and the broader urban transport context demonstrated their professionalism and expertise. The responses were studied intensely, as appropriate for this sample size, by using structured and unstructured coding to develop themes and the conceptual framework. That said, it is important to note that the range of stakeholders interviewed in the two cities differed slightly, and that the perspectives of community users and politicians were not available for Cape Town. Accordingly, there was comparatively less information available for Cape Town on the personal experiences of riding MyCiti. Previous studies have found that passengers preferred BRT for its cost effectiveness, safety from crime, time efficiency, and comfort [48,59], suggesting that passengers in Cape Town had a more positive experience of BRT than those in Rio de Janeiro. There were also some differences between the professional stakeholder groups interviewed in each city, for example, four interviews were undertaken with civil servants in Cape Town, compared to one interview in Rio de Janeiro, although as noted in Table 1, three people were present in the RJ interview, bringing more than 70 years of cumulative professional experience and providing invaluable knowledge.

### 5.3. Conclusions and Further Work

To conclude, this paper brings new insights into the understanding of the MSE legacy of transport infrastructure in host cities by focusing on its operational sustainability over the long-term. It highlights the tensions arising from the temporalities and pace of the MSE versus the need to better account for the context of the place and local needs (i.e., long-term strategic planning). It also unwraps the challenges this raises for the funding of the infrastructure where spatial inadequacies have led to challenges in generating revenues and operating the network. This in turn has key impacts on the local users and specifically those who rely on those modes of transport to fulfil their everyday needs. Conceptually, it broadens the legacy discussion into the sustainable urban transport arena; much of the early research (e.g., [1–3,17,18]) is from a sports or events perspective [16], but the evolving themes of legacies as tools to deliver socio-economic benefits to the host city [8] requires alignment with research into sustainable urban development. This is paramount for transport legacies, which as levers of public funding [12,15] must be integrated with long-term strategic urban planning.

On a more practical level, for prospective MSE hosts, those considering BRT, and the Global South more broadly, these case studies are a cautionary story. Hosting a MSE levers much-needed public funding for transport infrastructure, which has the potential to improve transport networks in rapidly growing cities, connecting residents with employment, education, healthcare, and other amenities, ultimately to reduce inequalities as part of sustainable urban development. For success, the time-limited requirements and priorities of the MSE need to be handled very carefully and decisions cannot be made to the detriment of the long-term operational sustainability of the system. This unfortunately did not happen in Cape Town nor Rio de Janeiro, which represents a missed opportunity to utilise the funding leveraged by the MSE, noting that the World Cup drained resources meant to focus on other key priorities (e.g., housing) in South Africa [60–62].

Moving forward, future research in other complementary research fields, should employ quantitative methods and modelling tools to allow cities to adopt more adaptable strategies in order to account for the contrasting and conflicting temporalities facing MSE hosting cities. Studies towards the skills and knowledge required in such contexts and in line with capacity and resource shortages in the Global South would also benefit ongoing debates.

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