RESTRUCTURING THE FRAGMENTED GAUTENG CITY REGION: COULD SMART SHELTERS BE THE ANSWER?

S TERWIN

GAPP Architects and Urban Designers, 97 2nd Ave, Melville, Johannesburg, 2109,
084 418 9950; Email: steph.terwin@gmail.com

ABSTRACT

Cities are traditionally built along a high-capacity public transport backbone, thus increasing opportunities at points of accessibility. The Gauteng City Region (GCR) is not built on a strong mass transit backbone, there is an expansive road network and the spatial economy is fragmented. The minibus taxi industry has established due to the sprawling urban form, carrying 67% of national commuters, although the industry receives no subsidy funding (Venter, 2018). Legibility of the public transport service is constrained for the commuter and tourist, because there is negligible integrated timetables and ticketing between transport operators. Public transport infrastructure is insufficient, where bus shelters have no spatial relevance or timetable information displays. The informal and on-demand taxi operation lacks supportive commuter infrastructure within the expansive and undefined urban landscape. If affordable, private car use and Uber (e-hailing taxi service) are preferred means of transportation. Urban and transportation policies (such as the Metropolitan Spatial Development Frameworks and Transport Masterplans) are complex, and implementation of such plans are drawn out and financially and construction-time intensive, such as bus rapid transit (BRT) infrastructure. The contradiction to the high commuter share of taxis, is that BRT's and the Gautrain carry 2% and 1% of the national population respectively, and receive R15.12 (BRT) and R63 (Gautrain) per trip in subsidy finance (Venter, 2018). There is a need to act with urgency and democratise the playing field for city inhabitants. Urban acupuncture and smart city applications offer a smart and incremental way of intervening problems the urban region represents. This paper interrogates the status quo of the GCR's urban structure and urban systems, as well as case study examples of urban acupuncture and smart city applications. A physical and technological solution is then suggested to bridge of the gap between the current fragmented city region, and the future progressive, democratic and enabling city region. The solution offers an immediate support structure, a Smart Shelter, to the current lacking commuter infrastructure. Smart Shelters are built at strategic locations along two pilot urban corridors, near to high-pedestrian foot traffic, such as corporate and retail buildings, and major intersections. Depending on the success of the Smart Shelter, the city region could become a progressive city with consequential socio-economic benefits, such as education, health and employment.

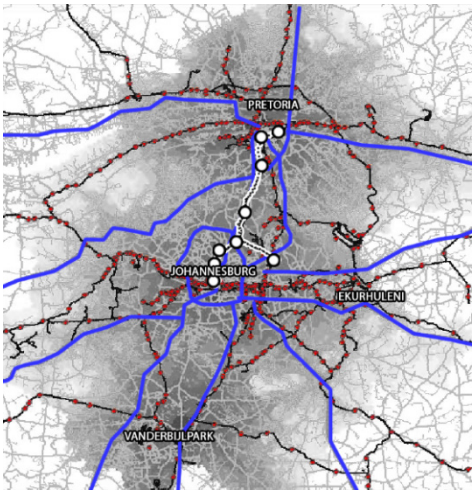
Keywords: Spatial fragmentation, spatial restructuring, urban systems, city region, transit oriented development (TOD), urban acupuncture, incrementalism, disruption, Smart City, telecommunications, sharing economy, online education, co-work, behaviour economics.

1. INTRODUCTION

The Gauteng city region forms the economic hub in South Africa; generating close to 45% of the country's Gross Domestic Product (GDP) (GCRO, 2019). The population has grown to 14,7 million people, since gold was first discovered in Johannesburg in 1886 (SAHO, 2019). As shown in Figure 1 and Figure 2 below, the GCR includes the Gauteng Province and corridors that radiate to surrounding economic towns, Sasolburg, Rustenburg and Witbank. The region is spatially fragmented because of urban sprawl, private vehicle ownership and declining modal share of public transport (Adeboyejo et al., 2018). Public transportation is intensely subsidised to guarantee access and mobility for spatially dislocated urban residents (Adeboyejo et al., 2018). There is a job-housing mismatch and residents have to spend money and time on public transport. The predominant public transport service are minibus taxis, at 67% national commuter share, which receive no subsidy funding (Venter, 2018). The taxi industry has established itself within the sprawling urban form, as depicted in Figure 2, offering a flexible and on-demand service. The informal operation lacks supportive commuter infrastructure within the expansive and undefined open spaces. Public and private sectors of South Africa have been inefficient in comprehensively and collectively planning for urbanisation (Meyer, 2016). There is a limited co-operative governance system, an over-regulated development environment, timeous approval processes, and a limited centralised database (Gauteng DED, 2011). Planning and implementation of large-scale infrastructure, such the Gautrain and Rea Vaya bus rapid transit (BRT), are financially and construction-time intensive (Venter, 2018).

Source: GCRO, 2019.

Figure 1: Surrounding economic-generating towns outside the Gauteng Province boundary



Source: Recreated from GSDF 2011.

Figure 2: The urban region is patterned by regional development corridors to surrounding economic regions

Urban regions of the continent are experiencing a technology shift, and the nature of urban land, and employment space markets is changing (Hult, 2017). The sharing economy, online education and co-working spaces have disrupted traditional spatial requirements and confounded traditional regulatory systems (Hult, 2017). A rigorous understanding of the context and status quo of urban systems within the GCR, as well as a broad understanding of successful and innovative urban interventions is necessary, in order to form an argument for a suggested urban intervention.

2. RESEARCH METHODOLOGY

The research methodology begins with a literature review, placing the GCR within the urban, global and technological context. Secondly, the status quo of urban systems, development perspectives, and the political agenda, are discussed. Thirdly, global smart city applications and urban acupuncture projects are reviewed, and lastly, a potential solution is tested against the argument for bridging the disconnect between the status quo and the future progressive, democratic and enabling Gauteng City Region. The research methodology is a mixed method that covers both quantitative and qualitative data, including: interviews, direct observation of transportation modes (locally and internationally), photographic studies and desktop mapping exercises. Research data includes online content, and peer-reviewed literature. The paper begins to ask further questions: Can a spatial and technical transportation solution contribute to the socio-economic progression of the country?

3. THEORETICAL FRAMEWORK | LITERATURE REVIEW

Understanding spatial restructuring and transportation solutions for the Gauteng city region requires a review of urbanism theory and urbanism trends. This section, therefore, reviews the key concepts of urbanism theory, such as, spatial fragmentation, spatial restructuring, urban systems, transit oriented development and urban acupuncture. Urbanism trends, include, online education, disruption and the smart city. The literature review provides a critical theoretical framework to the research analysis and argument.

3.1 The concept of spatial fragmentation

Spatial fragmentation is defined as the physical separation of urban land parcels from socio-economic opportunity areas by buffering techniques of roads and open spaces. Low density sprawled settlements that promote the use of motor vehicles demonstrate this concept (Adeboyejo et al., 2018).

3.2 The concept of spatial restructuring

Spatial restructuring means to spatially transform an urban area from one of fragmentation to mixed-use land use integration and densification, through infill developments promoting transit oriented development principles. Spatial restructuring manifests itself in plans to redress spatial inefficiencies, promote mass transit and support of vertical density development (Adeboyejo et al., 2018).

3.3 City regions and urban systems

Cities are not independent entities, but rather exist within interdependent national or regional systems (Eden Strategy Institute, 2018). The urban structure is a complex system with the following elements: movement and accessibility; economic integration and diversity of activities; open space systems; infrastructure and services; and policy, institutions, governance and management arrangements (Gauteng DED, 2011). Elements are interdependent and interrelated, and operate through dynamics of change, flow, competition and connectivity (Clark et al., 2014).

3.4 Transit Oriented Development (TOD)

Transportation is the network that moves people between places; it provides a means of access and opportunity (Aigbavboa et al., 2017). Transit Oriented Development presents an efficient concept for traditional spatial planning methods, where transportation and land use align. Peter Calthorpe, a renowned architect and urbanist, is widely considered the first authority of TOD, who claims public transport should provide the backbone of a sustainable and efficient transportation system which is supported by nodes of concentration - where people can 'live, work, and play' within their immediate environments (Aigbavboa et al., 2017).

3.5 Smart City

Smart City applications, include the collection of intelligent and accurate data of city processes, which can be used to develop intelligent solutions to problems. The integration of digital technology, physical assets, and knowledge can be used to interpret real-time information and improve city services coherently across stakeholders (Eden Strategy Institute, 2018).

3.6 Urban acupuncture

Urban acupuncture is a socio-environmental theory that combines urban design with traditional Chinese acupuncture, where small-scale interventions offer the potential to transform the larger urban context (Lerner, 2014). Just as the practice of acupuncture is aimed at relieving stress in the human body, the goal of urban acupuncture is to relieve stress in the built environment (Lerner, 2014). Jaime Lerner, the former mayor of Curitiba, suggests urban acupuncture as the future solution for contemporary urban issues; by focusing on very narrow pressure points in cities, we can initiate positive ripple effects for the greater society (Lerner, 2014).

3.7 Incrementalism

Incremental planning is a pragmatic gradual approach to developing solutions to problems as they arise rather than planning for them in a comprehensive, overarching way as rational planning does (Brooks, 2002).

3.8 Disruptive innovation

Disruption displaces an existing market, industry, or technology and produces something new and more efficient and worthwhile. "It is at once destructive and creative," according to Harvard Business School professor, Clayton Christensen, whom first coined the theory (Christensen Institute, 2019).

3.9 Online education and employment

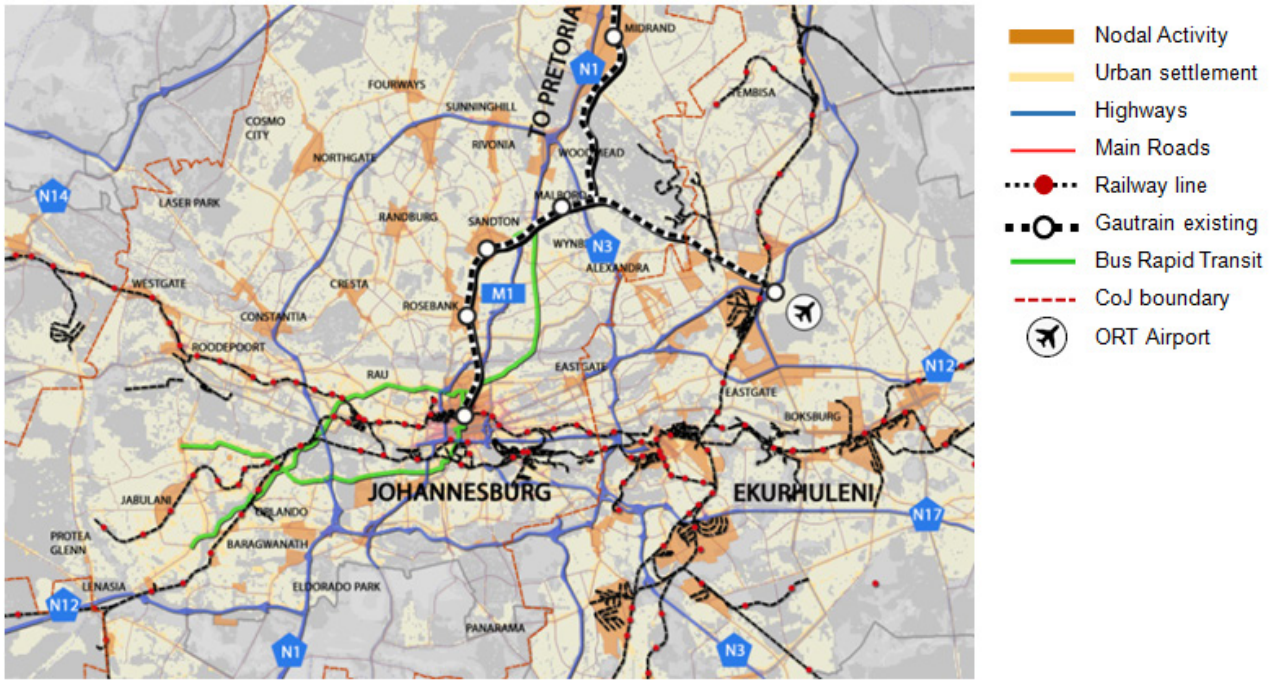
The nature of urban land and employment space markets is changing (Hult, 2017). Online education is disrupting the enrolment at education facilities that are physically bound, because online education opportunities can be decentralised and accessible for more people. The World Economic Forum calls online learning "the future of education" in its Global Shapers report (Sidler, 2018). Furthermore, job profiles are changing, and are also becoming less dependent on spatially bound locations. This is because the online marketplace has provided this opportunity.

4. RESEARCH FINDINGS: GCR STATUS QUO ASSESSMENT

The status quo assessment reviews how the Gauteng city region has developed over time including development trends, public transport services and public transport commuter infrastructure. Policies and plans, and the political implementation framework are reviewed. Lastly, a list of opportunities are drawn from the constraints.

4.1 Status quo: spatial structure of Gauteng City Region

In referring to Figure 3 below, Johannesburg (JHB), central to the GCR, originated as a mining town where a railway service formed a significant backbone to development of the central business district (CBD) (Adeboyejo et al., 2018). The opposite city building approach has occurred where apartheid spatial planning and the introduction of the motor car in the 20th century, has led to a road dominated and spatially fragmented urban development (Kgatjepe et al., 2016). The morphological[1] structure of Johannesburg resembles inverted polycentricity,[2] where large residential suburbs on the periphery of the urban core have little economic base and residents spend time and money on public transport (City of Johannesburg, 2016). To the contrary, supporting morphological activity of nodal intensity has established over time, such as Roodepoort, Randburg, Rosebank, Sandton and Baragwanath, as depicted in Figure 3. Property development trends have seen expansion north-wards from the originating JHB CBD, along the N1 corridor to Pretoria and western parts of the Ekurhuleni Metropolitan Municipality, such as OR Tambo International Airport (Gauteng DED, 2011).



Source: Recreated from GSDF 2011.

Figure 3: Urban development within the City of Johannesburg; the demand for a flexible minibus taxi network is evident in the expansive road and development network

[1] Urban morphology is the study of the form of human settlements and the process of their formation and transformation (Gauteng DED, 2011).

[2] A traditional polycentric city has a strong core, connected to economic sub centres by efficient public transit, with high housing densities surrounding cores (City of Johannesburg. 2016).

Public transport services within the GCR include, the Gautrain rail, passenger rail, bus rapid transit (BRT), conventional busses and minibus taxis. As seen in Figure 3 above, the Gautrain (high capacity rail) reaches strategic, yet limited areas. The minibus taxi service has established due to the sprawling urban form, carrying 67% of commuters nationally, although the industry receives no subsidy funding support (Venter, 2018). National Treasury data shows that Gautrain carries 1%, receiving a subsidy of R63 per passenger trip, while BRT's carry 2% and receive R15.12 per trip. Conventional buses carry 8%, and Metrorail, 21% (Venter, 2018). Legibility of the public transport service is constrained for the commuter and tourist, because there is negligible integrated timetables and ticketing between transport operators (Kgatjepe et al., 2016).

4.2 Status quo: Physical interface of public transport infrastructure

Figure 4 depicts a typical bus shelter in South African cities. Transport shelters are undesirable places for pedestrians in the current expansive urban landscape. There is insufficient lighting, safety and way-finding functions. It is evident that the shelter provides limited timetable information, therefore means of navigation is limited. Shelters have no spatial relevance, and are located within vast open areas. Figure 5 demonstrates how the majority of commuters use public transport; minibus taxis provide a flexible and on-demand transport service. The service is dependant of people, places and demand. Commuters do not use technology or cashless payment methods, instead, transport information is transacted by on-the-ground networks.

Source: Author photograph

Figure 4: Typical bus shelter within South African cities, taken at Oxford Road, JHB. Shelters have no spatial relevance, and there is insufficient lighting and way-finding functions

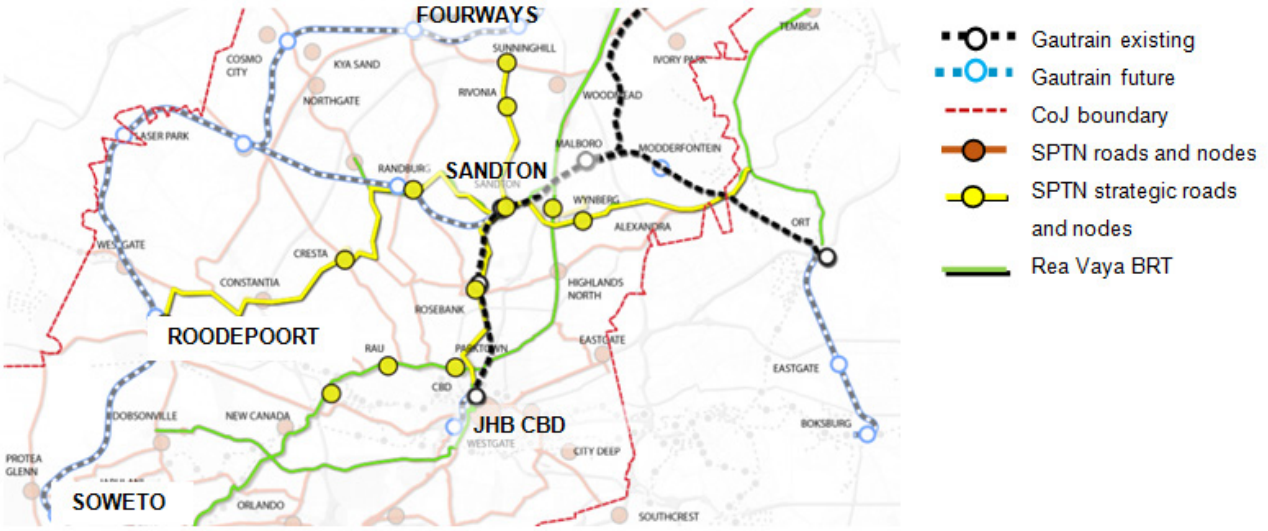
Source: citizen.co.za

Figure 5: Minibus taxi services operate informally; there is a lacking of supportive commuter infrastructure

4.3 Policies and plans

Figure 6 is recreated figure (by author) of combined policy plans, including the Johannesburg Strategic Public Transport Network (SPTN), Gautrain and Rea Vaya BRT Network. The SPTN (2013) policy plan is designed to spatially restructure the city, where a public transport 'grid' connects key high-density nodes and dense residential areas (CoJ, 2013). The Gautrain extension includes western Johannesburg, from Fourways (north) to Roodepoort and Soweto (south). The Rea Vaya BRT Phase 1A, 1B has been completed, and phase 1C is due completion for 2019. The success of BRT is underwhelming, according to Ibrahim Seedat, Department of Transport public transport policies director:

"High capital expenses and subsidies, coupled with low ridership, have muddied the waters for a system that was once regarded as the silver bullet that would provide fast, affordable public transport for all." He adds, "We don't have any BRT in South Africa…we need strong, functional, capable public authorities with the capacity to regulate, plan and enforce. In 2009, BRTs were the flavour of the month. All Integrated Public Transport Network (IPTN)'s now need to be updated to incorporate bus services, rail and taxis in that 20-year forecast. IPTN planning is not BRT planning" (Venter, 2018). In summary, it has been realised by the public sector, that intensive infrastructure is not the only solution. Instead, alternative solutions must be reviewed, in order to achieve an enabling and democratic city for multiple modes to operate and compete.



Source: www.joburg.org.za, www.gautrain.co.za, and www.reavaya.org.za.

Figure 6: Recreated figure of SPTN network, Gautrain and Rea Vaya BRT Network

4.4 Opportunities drawn from the constraints

The following list provides an evaluation of urban systems within the GCR, offering an informed understanding prior to making recommendations for intervention.

- The GCR resembles a sprawling road network, and the minibus taxi industry has established because of this. The service receives no subsidies, yet carry 67% of the national public transport commuter share (Venter, 2018). The service operates informally thus there is inefficient commuter infrastructure such as wayfinding, street lights, shelter, thus resulting in poor safety;
- The BRT and Gautrain are infrastructure intensive. On the other hand, municipalities have acknowledged that future IPTN planning must incorporate all transit services, with a reduced primary focus on BRT (Venter, 2018).
- The nature of urban land and employment space markets is changing as expressed in the literature review of, 'online education and employment' and 'disruptive innovation.' Telecommunications offers an opportunistic reality, it is a fast growing industry in South Africa providing broadband infrastructure (Sidler, 2018). This provides new possibilities for education and employment opportunities.

- There is limited modal integration between transport operators, and negligible integrated ticketing (Kgatjepe et al., 2016). Opportunistic to this reality, is the future reality of a Gauteng Transport Authority, announced on 01 April 2009 by Gauteng MEC for Roads and Transport, Dr Ismail Vadi. The Authority is set to facilitate the co-governance and co-ownership of public transport in Gauteng city region, and will act as a single point of contact with National Treasury on operational and capital expenditure (South African Government, 2019).
- Public-Private Partnership (PPP)'s show a limited set of case studies in South Africa (Meyer, 2016). On the positive trajectory, the Gautrain Management Authority PPP leads by example. This model has potential to be replicated as intended by government (South African Government, 2019).
- Timeous approval processes are apparent within government. There is a need to synthesize approval process between inter-municipal departments, and municipal to provisional departments, so that development applications are fast-tracked.
- The complex three-tiered co-operative governance structure has led to poor leadership, accountability and corrupt practices (Meyer, 2016). The resourceful strategy for a smart government, offers an alternative approach to the current unproductive political structures. Nationally, the e-government interface is being established, as well as smart city programs in the Gauteng Province and Johannesburg Municipality (Domus 1015, 2017).

The following section reviews how cities are advancing within the fourth industrial revolution by adopting smart city applications to progress city building. Additionally spatial principles are discussed through urban acupuncture projects. These tools can be read against the opportunities and constraints of the GCR, in order to suggest informed solutions.

5. CASE STUDIES: SMART CITY APPLICATIONS AND URBAN ACUPUNCTURE

Progressive cities demonstrate alternative solutions to address city problems. The following case studies reveal physical and technical solutions to city building problems. Smart city strategies, such as legibility and wayfinding, smart spaces, and smart street lighting are discussed, projects which provide a technical interface to the spatial realm. Urban acupuncture projects, such as live-work units and public amenities, reveal the importance of support structures in challenging environments. These projects are discussed as precedent to the suggested Smart Shelter project.

5.1 Legibility and smart signage

Citizens feel secure when they have a mental map of where they are and where they are going (de Lange, 2009).[3] Public transport signage is key to providing a responsive public transport service. Printed signage has advanced with the technology age to digital signs. This is evident for digital transit stops, as seen in corresponding Figure 7. Real-time transit information is made available by global positioning system (GPS) trackers installed in moving vehicles (Eden Strategy Institute, 2018). Furthermore, smartphones function as smart devices, where commuters can view trips prior to arriving at a transit stop, and also receive integrated ticketing, and payment services.

[3] The concept of city legibility originates from Kevin Lynch, an American urban planner in the 60s, most known for his study The Image of the City (1960), the result of a 5-year study on how people take in information in the city. It was in this publication that Lynch coined the term wayfinding and developed the idea of city legibility (de Lange, M. 2009).

Figure 7: Real-time transit information display
Source: Smartcitydisplay.co.uk.

Figure 8: Students and teachers can communicate through a computer screen through online networks

5.2 Smart spaces, smart people

Technology has demonstrated the accessibility to information, for education and employment benefits. This democratises the necessary physical space into alternative spaces. According to the report on 50 Smart City Governments, what is necessary for a smart city, to include ‘smart people’, is smart spaces that enable people access to the digital world (Eden Strategy Institute, 2018). For example, innovation hubs provide entrepreneurship platforms, and co-working spaces allows citizens to have flexible work arrangements. Educational institutions, worldwide, have made it possible to pursue online courses, as depicted in Figure 8. LinkNYC kiosks in New York City, replace old phone booths with Wi-Fi and wayfinding information. Lastly, internet cafes in Brazil charge low rates per hour, providing cheap accessibility to internet.

5.3 Smart safety

Well-lit spaces offer pedestrians increased perceived safety. Cities that have invested in well-lit streets, provide consequential benefits to the success of public life, such as, extended operating hours. Street lights have a dual-purpose in Rotterdam as shown in Figure 9; they provide light as well as acoustic monitoring and incident detection technology (Eden Strategy Institute, 2018). The connected lights are able to raise the brightness of the light, record ten seconds of audio and alert the emergency services. Furthermore, Smart Camera technologies also contribute to public safety. Vumacam, in South Africa, implement interlinked CCTV cameras between neighbourhoods. The company is in discussions with the police and car tracking companies to provide their CCTV feed and license plate recognition (LPR) functionality (mybroadband, 2019).

5.4 Smart transport

Bike sharing infrastructure, as shown in Figure 10, provides free or affordable access to bicycles for short-distance trips as an alternative to private vehicles or public transport, thereby reducing congestion. Bicycle-sharing systems have also been cited as a way to solve the "last kilometre" problem, where citizens can commute to and from a transit stop (Aigbavboa, 2017). This enhances intermodality between transport modes.

Figure 9: Additional components of a street light

Figure 10: Bike dock provides payment service and secure docking

5.5 Urban acupuncture

As defined in the literature review, urban acupuncture is a socio-environmental theory, where small-scale interventions offer the potential to transform the larger urban context (Lerner, 2014). This is achieved in the following two projects.

5.5.1 Active boxes in Khayelitsha

The Violence Prevention through Urban Upgrading (VPUU) programme aims to transform township areas into sustainable and safer neighbourhoods (VPUU, 2019). Khayelitsha, a lower income suburb, comprises single storey architecture; there is limited height to the precinct. The project involves 'active boxes' located at strategic locations along a pedestrian route. They provide height, thus surveillance to the precinct, as depicted in Figure 11. The active boxes encompass 'Live-work' activities that cater for the individual and the collective community.

5.5.2 Refilwe business node upgrade, Tshwane, South Africa: Holm Jordaan Architects and Urban Designer

The project involved formalizing open space, as shown in Figure 12, with the provision of basic infrastructure and amenities, including ablution, water, roof shelter and seating. The structure enables alternative activities to unfold, such as car washing, waiting areas for taxi drop-off, informal trading space and so on. This upgrade albeit a small and humble urban intervention, serves as an example of a local community taking great pride in the renewal of public space.

Source: vpuu.org.za

Figure 11: Active Boxes provide height to the precinct

Source: http://www.archidatum.com

Figure 12: The humble project provides essential services to the local community

The case study examples have provided snapshot examples of urban interventions that solve significant problems. They demonstrate how to target spatial / technical voids with responsive solutions. The following section reviews how these snapshot examples can be

read against the opportunities and constraints of the GCR, in order to suggest informed solutions.

6. CONSOLIDATION OF KEY FINDINGS

There is limited integration between public transport operators, such as integrated ticketing, and insufficient public transport infrastructure, such as navigable and safe bus and taxi stops. Private vehicle ridership is rising due to this inefficient public transport service. Urban and transportation policies (such as the Metropolitan Spatial Development Framework and Transport Masterplans) are complex, and implementation of such plans are drawn out, and financially and construction-time intensive, such as BRT infrastructure (Engineering News, 2018). There is a need to act with urgency and democratise the playing field for city inhabitants. If the GCR is to be a resilient urban region, city building has to be a priority. Conversely, the case study analysis on smart city applications and urban acupuncture projects have provided snapshot examples of urban interventions that solve significant problems. Urban acupuncture projects provide small-scale interventions with the potential to transform the larger urban context (Lerner, 2014).

University of Pretoria Centre of Transport Development Christo Venter says*: "We went with full BRT. Full BRT is not the only option. We can go with an intermediate setup without the massive funds full BRT requires. 'BRT Light', which does not require the heavy engineering of building a median station, for example, could be considered a future solution" (*Engineering News, 2018). The concept of 'BRT Light' is interrogated as a potential solution as follows.

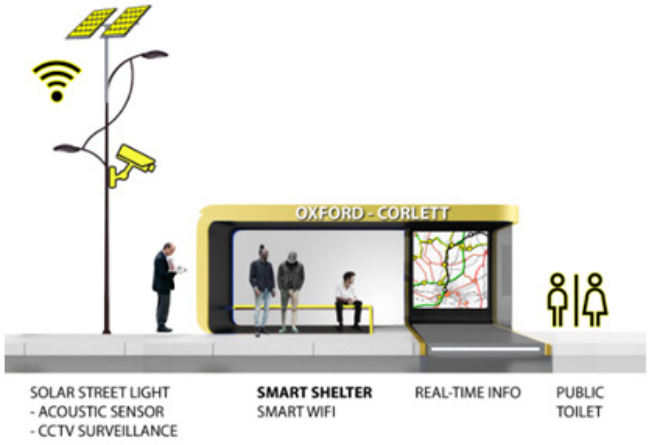
7. RECOMMENDATIONS: A POTENTIAL SOLUTION

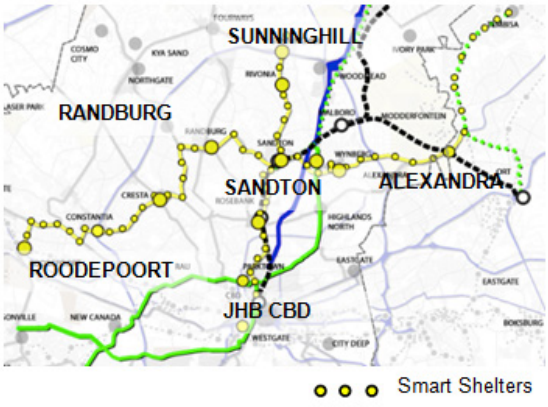
The fragmented spatial form and expansive road network of the GCR presents an opportunity for a 'BRT Light', an intervention that will target immediate problems in a financially implementable way. Transport shelters are undesirable places for pedestrians in the current expansive urban landscape. There is insufficient lighting, safety and way-finding functions. The minibus taxi operation provides certain clues for how one may intervene, as they function on the demand of foot traffic, thus informal ranking locates at major business nodes and key road intersections. There is a need for the informal ranking to be supported by commuter infrastructure, such as lighting, surveillance, and way-finding information.

The suggested solution takes on a smart city and urban acupuncture approach, where a prototype is tested, refined, and potentially replicated – to pursue the desired vision.

7.1 Phase One

What: The Smart Shelter is a prototype for the first phase of the suggested urban acupuncture vision, shown in Figure 13. 'Smart,' because it incorporates smart technologies, and 'Shelter' as it is a physical support structure to the current lacking commuter infrastructure. The shelter encompasses the following: a prefabricated structure providing roofing, seating and public toilets. Furthermore, smart technologies include: solar street lights, CCTV connected cameras, Wi-Fi, and digital information screens. Real-time transport scheduling could be displayed (at a later phase). Vulnerable, dark and unsafe spaces are supported with well-lit and monitored support structures, potentially encouraging private vehicle riders to convert to public transport.





Source: Author image

Figure 13: Smart shelters, principally, offer shelter from weather conditions, wayfinding signage, Wi-Fi, street light, and monitored cameras

Figure 14: Smart Shelters are built at strategic locations along a north-south and east-west corridor

Where: Smart Shelters are built at strategic locations along two pilot urban corridors, shown in Figure 14 above. The pilot corridors include the north-south corridor (Oxford Road from Johannesburg CBD, to Sunninghill, passing Sandton) and an east-west corridor (Alexandra to Roodepoort, passing Randburg and Sandton). The urban corridor is reinforced by parallel movement routes Oxford Road, M1 highway, Louis Botha BRT and the Gautrain line. Strategic locations of Smart Shelters are at major business nodes and key road intersections along the corridors.

7.1.1 Interface between consumer and producer

The current means of navigation within in the city is limited, as transit timetable information is separate and complex. There is limited timetable information on existing bus shelters, as expressed in Figure 4. It is essential to progress towards an integrated transport service by co-ordinating scheduling information and integrating ticketing between transport operators, as shown in corresponding Figure 15. This has been a policy directive that has yet to be fully realised (Venter, 2018). Individual transport operators have unique ticketing and scheduling, for example, Gautrain, BRT and conventional busses utilise individual reloading cards. Minibus taxis operate in cash. Uber operates in both cash, and smartphone e-payment. A possible integrated solution could include three mechanisms of payment. Firstly, one distinct transport card can be reloaded and used on any transport service. Secondly, e-payments could be made from a smartphone, ‘zapper’ and ‘snapscan’, e-payment portals used in South Africa. Lastly, paper tickets could be purchased at transit stops by cash and card. The case study example on smart signage, demonstrates how legibility of the city can persuade private car users to convert to public transport.

7.2 Phase Two

7.2.1 Smart shelter development

Depending on the success of the two urban corridors, the next phase of implementation includes further development of the Smart Shelter, such as additional commuter infrastructure and intelligent smart city applications, shown in Figure 16. Subject to the context and land use regulations, additions may include retail, recycling, health, co-work,

bike sharing, vehicle electric-charging, and online education facilities. Shelters provide the case for supportive functions and additional activities. With increased value, businesses attach and the shared economy generates. As demonstrated in the case study example on 'smart spaces, smart people,' there is a case for disruption within the traditional education and employment market. Innovation hubs for entrepreneurs, online education facilities, and co-working spaces, become reinforced with a transit connection. Transit and land-use continue to support and re-in force one another.

Figure 15: Device provides information on trip planning and payment service

Source: Author image.

Figure 16: Smart Shelters develop incrementally into transport hubs that include additional facilities

7.2.2 Smart devices

An Internet of Things (IoT) network is set up between the alternative components of street lights, CCTV cameras, Wi-Fi, and digital information screens. Intelligent sensors and technology enable the IoT network to proceed. The intention is to progress toward systemised, safe community hubs.

7.3 Phase Three

7.3.1 Smart infrastructure and additional corridors

Dependent on the success of the north-south, east-west pilot corridors, the Strategic Public Transport Network (SPTN) policy plan for a grid of regional connections to nodal activity, can be further developed, as depicted in Figure 17 below. Corridors and business nodes are upgraded to include designated public transport lanes, mixed traffic lanes and

non-motorised transport (NMT) surfaces, for pedestrian and cycle paths. This requires road reclassing, and new road connections.

Source: Author Image

Figure 17: Grid of regional connections to zones of urban intensity and nodal activity, such as Roodepoort and Westgate

7.3.2 Smart vehicles, the case for intermodality

An enabling city demonstrates walking and cycling as the primary mode of movement supported by mixed-use densities. Transport services, such as busses, taxis, Ubers and trains should accommodate storage space for bicycles and scooters, as depicted in Figure 18 alongside. Commuters should walk, scoot or cycle to and from a transport service, as documented in the case study example for bike sharing, Figure 10. Alternative vehicle prototypes such as foldable bicycles, and electric scooters should be encouraged.

Source: Author image

Figure 18: Storage space for bicycles and scooters in public transport modes

7.3.3 Implementation: Smart Governance, systems and funding sources

"Spatial justice won't come only through policy. The struggle is to transform how we think about the implementation of spatial policy. How do we steer urban growth towards a sustainable model?" - Khalied Jacobs, director of Jakupa Architects and Urban Designs (Smith, 2018).

Policy supports the case for urban structuring, density and transit-oriented-development. The major challenge remains in the implementation of this plan in a cohesive structured way. The following plan is suggested.

7.3.4 Smart Government & smart systems

The Department of e-Government on the Gauteng Province official website is established. The department has a vision to create '*a connected Gauteng city region that leverages technology to provide quality services to citizens'* (Gauteng Province, 2019). It is suggested that part of their mandate, includes a unique task team to drive this Smart Shelter strategy. The task team's role would be to facilitate co-ordination between stakeholders, such as the Gauteng Transport Authority, provincial and municipal departments, and the private sector. Smart Procurement procedures are set up, where precinct plan frameworks are procured by government and private companies collectively as guidelines for future development. Land legal procedures are fast tracked to incentivise progressive property development along the suggested strategic roads.

7.3.5 Smart funding (public and private)

Strategic infrastructure investment is crucial towards an enabling spatial form of the GCR. President Cyril Ramaphosa announced on 21 September 2018 the establishment of a R400 billion infrastructure fund to drive economic growth through infrastructure development (Dludla, 2018). This Smart Shelter strategy could be included in infrastructure fund.

Furthermore, value capture mechanisms could provide an alternative source of finance as local municipalities are constrained by the fiscal budget (McGaffin, 2016). 'Value Capture' funding, is the process of extracting the additional value that accrues to a property following specific infrastructure investment (McGaffin, 2016). The provincial task team, suggested above, could facilitate the value capture mechanism between municipalities and private sector. As the spatial form becomes more efficient, and enabling for all participants, value capture mechanisms advance, and funds are generated for mass transportation, as portrayed in Figure 19 below.

Source: Author image

Figure 19: The future phase, where funding resources, across public and private sectors, is significant to implement high capacity transit. For example, the median along Oxford road is upgraded to include a mono-rail mass transit line

8. DISCUSSION

The literature review set up the theoretical framework including, spatial fragmentation, spatial structuring, urban principles of incrementalism and urban acupuncture, transit oriented development and smart city trends. The research methodology, includes two directions of study, firstly, a status quo analysis of urban systems with the Gauteng City Region (GCR), and the policies and plans associated with it. Secondly, a review of case study examples, where smart city applications and urban acupuncture projects, have benefited cities worldwide.

The research findings frame the discussion for a suggested solution that aims to bridge the vast gap between the current fragmented GCR, towards a resilient and enabling city structure. The suggested plan entails a prototype for a Smart Shelter, where support structures locate at high-pedestrian foot traffic, such as corporate and retail buildings. Pedestrians are exposed to a safe, well-lit transport shelters. The intention is to plug the void of vulnerable, dark and unsafe spaces, with safe support structures. Private vehicle riders have greater exposure to the ease of using public transport, with an overriding intention for a navigable, safe and efficient public transport service. Shelters provide the case for supportive functions and additional activities. With increased value, businesses attach and the shared economy generates.

Depending on the success of the smart shelter prototype, smart infrastructure becomes the next priority. Road infrastructure to these nodes and corridors of urban intensity becomes important, in order to cater for a densified, mixed-use and walkable environment. Precinct plan frameworks are procured by government and private companies collectively, to form guidelines for future development. Roads are upgraded to include designated public transport lanes, mixed traffic lanes and the non-motorised transport (NMT) component for pedestrian and cycle paths.

Furthermore, depending on the success of corridors and nodal activity (areas of urban intensity), the Strategic Public Transport Network (SPTN) policy plan for a grid of regional connections, can be further developed. This requires road reclassing, new road connections and road infrastructure upgrades. Both, local municipalities and the private sector, develop mechanisms for capturing value of public transport infrastructure upgrades. As the spatial form becomes more efficient, and enabling for all participants, value capture mechanisms advance, and funds are generated for mass transportation. The plan does not limit existing transportation and business operators, instead, it provides an enabling spatial form for multiple citizens to participate within. In conclusion, the recommendations for the Smart Shelter strategy have demonstrated how the Gauteng city region can be restructured to become a progressive and enabling city region.

9. REFERENCES

Aigbavboa, C, Ndebele, R and Ogra, A. Public Private Partnerships (PPPs): An effective and legitimate finance model for TOD in South Africa? International Conference on Industrial Engineering and Operations Management Rabat, Morocco, April 11-13, 2017

Adeboyejo, T, Bikam, P and Chakwizira, J. Restructuring Gauteng City Region in South Africa: Is a Transportation Solution the Answer? Intech Open. 2018.

Brooks, MP. Planning Theory for Practitioners. Chicago: Planners Press. 2002

Christensen Institute. www.christenseninstitute.org/. Accessed: 05.01.2019

Clark, G and Moir, E. The Business of Cities. UK Government's Foresight Future of Cities Project. 09.2014

City of Johannesburg: Department of Development Planning. Spatial Development Framework 2040. 2016. Accessed: 27.04.2019.

City of Johannesburg. Johannesburg Strategic ITP Framework. 13.05.2013. Accessed: 27.04.2019.

de Lange, M. Review: Kevin Lynch – The Image of the City. 08.05.2009. http://themobilecity.nl. Accessed: 27.04.2019.

Dludla, S. *Government's R400bn Infrastructure Fund needs to generate revenue – IRDC*. IOL. 10.10.18. https://www.iol.co.za/. Accessed: 05.01.19

Domus 1015. Future African Cities. S.p.A. Rozzano (MI) Italia. July / August 2017

Eden Strategy Institute and ONG&ONG Pte Ltd. Top 50 Smart City Governments. 2018. Accessed: 27.04.2019.

Gauteng Province. 2019. http://www.gauteng.gov.za. Accessed: 27.04.2019.

Gauteng Department of Economic Development. Gauteng Spatial Development Framework. 2011. Accessed: 05.04.2019.

GCRO. 2019. http://www.gcro.ac.za/. Accessed: 27.04.2019.

Hult, A and Bradley, K. Planning for Sharing – Providing Infrastructure for Citizens to be Makers and Sharers, Planning Theory & Practice, 18:4, 597-615. 2017. Accessed: 05.04.2019.

Kgatjepe, K and Ogra, A. Sustainable Transport for Urban Poor: A Case of Johannesburg. 7th Planning Africa Conference 2016.

Lerner, Jaime. Urban Acupuncture. Celebrating Pinpricks of Change that Enrich City Life. London: Island Press, 2014.

McGaffin, R, Kirova, M, Viruly, F and Mitchell, K. Value Capture in South Africa – A way to overcome urban management challenges and unlock development opportunities? UCT-Nedbank Urban Real Estate Research Unit. 2016. Accessed: 05.04.2019.

Meyer, M. The Leadership Crisis. Talent Talks. 06.11.2016. www.talenttalks.net. Accessed: 05.04.19.

Sidler, V. Online learning – The future of education in South Africa. 20.06.2018 mybroadband.co.za. Accessed: 05.04.19.

Smith, C. *There's a problem with 'Wakanda visions' for African cities – academic*. Fin24. 08.10.18. https://www.fin24.com/Economy/theres-a-problem-with-wakanda-visions-for-african-cities-academic-20181008. Accessed: 05.01.19.

Venter, I. No longer flavour of the month, SA rethinks its bus rapid transit systems. Engineering News. 27.08.18. Accessed 27.04.19.

SA History. The Gold Rush. Adapted from Gold and Workers by Luli Callinicos, 1980. https://www.sahistory.org.za. Accessed 27.04.19.

South African Government. MEC Ismail Vadi welcomes adoption of Gauteng Transport Authority Bill. 01.04.2019. Accessed 27.04.19.

Warnich, S and Verster, B. The Answer is: Corridor Development, but what is the question? Dpt Town Planning, CPUT. SATC. 2005.