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INTELLIGENT TRANSPORT SYSTEMS AS GENERATORS OF BUILT FORM: Towards the design of a transport interchange in Harare, Zimbabwe

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Dissertation submitted to the School of Built Environment and Development Studies, University of KwaZulu-Natal, in partial-fulfillment of the requirements for the degree of Master in Architecture
2015

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in

The School of Architecture, Planning and Housing
University of KwaZulu-Natal
Durban, South Africa
December 2015

DECLARATION

COLLEGE OF HUMANITIES

DECLARATION - PLAGIARISM

I, ……..……., declare that

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2. This thesis has not been submitted for any degree or examination at any other university.

3. This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

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Signed

……

ACKNOWLEDGEMENTS

The strength and courage to complete this task is entirely attributed to the almighty God I serve. Special thanks also goes out to;

- My parents for their endless love and support
- Mr M. N Mthethwa for his supervision
- The original gangsters – Khule BraBiza, Ced, Baks, BK, Freemano! Thanks s million fellaz
- Nomfundo Qwabe for the awesome pep talks and motivation. Thanks for being there.

DEDICATION

The Sunshine City

Your warmth will forever embrace my soul

ABSTRACT

Rapid urbanisation in the last century resulted in a more urban population although some countries and continents still have higher rural population. It is estimated that by the year 2050 more than 75% of the world's population will be living in urban areas (WB, 2013; OECD, 2015). Most of this increase in global urbanisation is forecast to take place in the emerging, developing and less developed, or third world Africa, Asia and South America (Pojani & Stead, 2015). Transport plays a critically important role within urban areas in ensuring that urban dwellers gain access to resources and socioeconomic opportunities. The transport systems in most urbanized and urbanizing areas of developing nations are largely unsustainable and cause numerous problems that directly affect the quality of social, economic and environmental urban systems. With limited access to financial capital and strong institutional structures these nations struggle to develop their urban infrastructures to keep up with the increasing human populations and demands of safe, reliable and sustainable transportation services.

The information and communications technology (ICT) sector has recorded unprecedented growth in Africa over the last decade. In Zimbabwe, for example, telecommunications technology, in the form of an electronic mobile payment system, has enabled the sustainable growth of the informal economy by creating a cashless society. The system has enabled the poorest of citizens access to financial and credit facilities and helped them start up and run profitable small businesses (www.econetwireless.com). It provided a sustainable solution for managing the financial crisis in the country. With more than 75% of the population now owning mobile telephones and wireless devices technologies like the payment systems can be used to improve other sectors of the economy currently under stress and strain.

This research study intends to investigate the use of advanced transport systems and technologies in improving transport in the major urban centers of Zimbabwe. The study will investigate intelligent transport systems as tools of improving urban transport and how their operational and functional requirements can be used by design professional to create sustainable and meaningful urban built form.

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CHAPTER 1

RESEARCH INTRODUCTION

INTRODUCTION

Transport plays an important role in enabling urban dwellers access to resources, pursue opportunities and manage their daily activities. It is a key component in maintaining the balance of social, economic and environmental aspects of human settlements and development. Numerous approaches are being taken to provide efficient, equitable and safe urban transportation services to meet the increasing demand arising from population growth and urbanization. Africa, Asia and South America where urbanization rates still lag the developed economies, will account for most of the growth in global urbanization that is expected to reach 80% by 2050. In view of the climatic and environmental challenges arising from economic activities including transport services, it is imperative that future urban development and associated transport systems are sustainable.

There has been a notable rise in infrastructure projects in developing countries to extend transport networks and enhance capacity. However, most of the growth has been car oriented than mass transport resulting in significant increase in traffic volume, congestion and pollution levels in most cities. The unintended effects of urban transport system expansion include the demise in the quality of physical environments and urban social networks. A number of measures aimed at mitigating transport problems in urban areas including hybrid fuel technologies, congestion and carbon emission control have been implemented with varying success across the world. However, there often lacks integrated measures that effectively address the complex social, economic and environmental facets of urban settlements.

Urban areas in the developing world are no exception to the challenges associated with urbanization and limitations of response measures. In the case of Zimbabwe, the challenges mounted with policy changes in the 1990s following structural reforms where private sector involvement in the economy was promoted and state participation in public service provision was cut back as means of reducing non-productive expenditure. Economic deterioration in the new millennium exacerbated transport challenges as transport infrastructure collapsed and mass transportation services tottered. Furthermore, the proliferation of unlicensed small passenger vehicles, poorly functioning traffic control mechanisms and disorderly parking contributed to mounting congestion in Harare.

Beyond the above, it is worth noting additional factors that contributed to congestion in the central business district (CBD). Street vending that began during the economic crisis period chocked streets that were originally designed for a small section of the community during the colonial period. From this backdrop, it is important to explore the redesign of Harare's built form as means towards an intelligent transport system (ITS).

Literature on urban architecture and transport systems in developing countries, particularly sub-Saharan Africa is sparse. Thus this study is an attempt at exploring the development of the urban built form that promotes and efficient public transport system in Harare and is intended to contribute to the existing literature. The remainder of the chapter is arranged in sections presenting the background of the study area, motivation of the study, aims and objectives, theoretical framework and methodology.

BACKGROUND

Zimbabwe

Zimbabwe is a landlocked country in Southern Africa bordered by Mozambique, South Africa, Botswana, Namibia and Zambia to the east, south, west, north-west and north respectively. The country comprises of 10 administrative provinces that are subdivided into districts and wards. Harare is one of the two cities classified as metropolitan provinces while the remaining eight consist of both rural and urban areas. Between 1980 and 2012, the country's population almost doubled while urbanization increased more than 10 percentage points as shown in table 1.1.

Table 1.1. Population indicators, Zimbabwe

	1980	**1990**	**2000**	**2012**
Population (million)	7.2	10.4	11.6	13.06
Urbanization (%)	22.1	29	33.8	33

(Source: Zimstat)

Economic growth patterns in Zimbabwe

Gross domestic product (GDP) and formal sector growth averaged 4.3% (World Bank data) and 1.9% (Makina, 2010) per annum respectively in the 1980s. However, per capita

income (PCI) declined by 8.4%, 33.5% and 35.4% from $916.3 to $805, $535 and $345.4 between 1980, 1990, 2000 and 2008 respectively (World Bank data). National output declined by 40% between 2000 and 2008 and rising hyperinflation topped 231 million % by September 2008 (ibid.). Unemployment rose sharply during the 2000s following the collapse of the manufacturing sector and consequently employment patterns altered and the majority of the urban population is employed in the informal sector (ZIMSTAT, 2013). Despite recovery to almost $800 by 2012, PCI is still significantly lower than the highest level ($1 082) achieved in 1981.

Harare

Harare is the capital city of Zimbabwe and covers an area of 980 sqkm. Its population was enumerated at just above 2 million in the most recent national census (ZimStats, 2012). A variety of cultural, social and economic activities spread out across the city. The central business district plays host to the majority of these activities. the majority of the population live on the outskirts of the central business district and make daily trips to the CBD to access opportunities, goods and services.

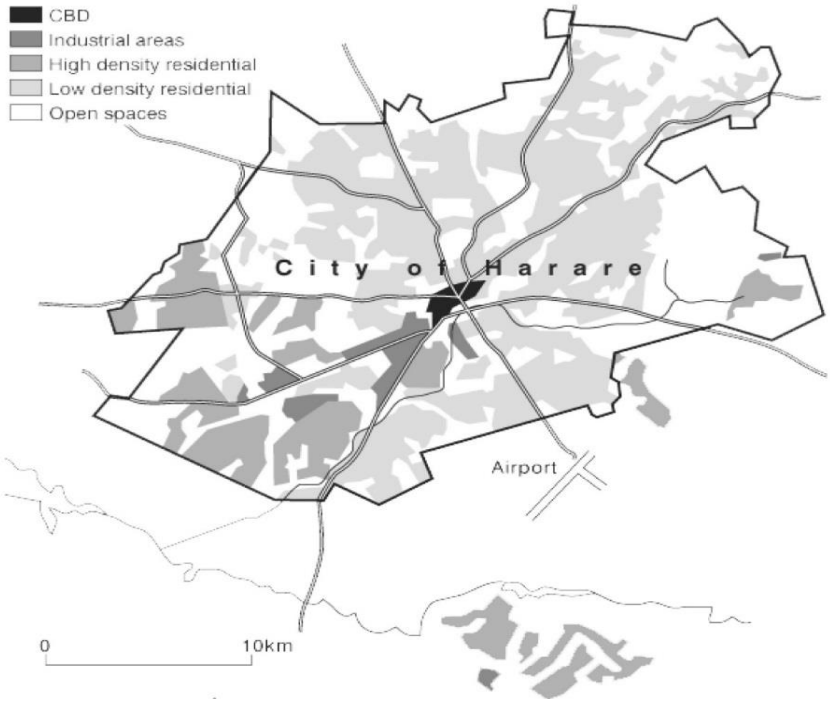

Figure 1-1. Greater Harare. Source: www.wikipedia.org

Harare urban mobility

To cater to the mobility needs of Harare citizens the Local Municipal authority started providing public transport services in 1942 during the British colonial era. The city operated a bus service that made trips between suburban areas and the CBD at scheduled times. As the city grew in size, the local municipal authority opened the provision of transport services to private operators. The partnership lasted until independence in 1980 where changes in both national and local governments resulted in changing policies. Transport was one of the sectors neglected in the decades following independence. The city lost funding to continue transport operations and steadily lost control over the sector. Today public transport services are provided entirely by private operators.

Motivation for the study

Zimbabwe experienced an extended period of decline in the new millennium. The resultant fiscal constraints affected transport systems across the country. In fact, transport infrastructure deteriorated as government lacked resources. Public and private sector transport corporations also collapsed. The economy has improved since 2009 and car ownership in urban areas has increased remarkably. However, transport infrastructure in urban areas remains in a state of collapse and as a result, traffic congestion especially in Harare affects residents.

In contrast, there have been initiatives in many countries to improve travel experience in urban areas through improving transport infrastructure and the deployment of ITS. Intelligent transport systems enable automatic traffic congestion management and enhance performance of public mass transport modes like buses, trams and trains. Traffic management has also benefited from the progress in other sectors, most notably from improvements in information technology. While Zimbabwe is not at the frontier of innovation, there have been significant developments including mobile technology applications.

Harare's transport system is faced with multiple operational challenges including malfunctioning traffic management systems, dilapidated transport infrastructure, absence of mass transport system, ineffective enforcement of traffic rules, and rising car

ownership. Consequently, the users of transport services continue to face problems that include congestion, pollution and general threats to public safety. The nationwide road rehabilitation program embarked by the national government does not cover areas under municipalities. Furthermore, the nature of services and challenges on national and urban road systems differ.

The benefits of ITS are well documented and cities like Nottingham in the United Kingdom and Johannesburg in South Africa have successfully transformed mobility in their cities. In this backdrop, it is imperative to assess the role of the urban built form as a platform of improving travel experiences in urban areas. Appropriately designed built form also acts as an enabler of ITS. As such, it is also worthwhile examining the role of technology in improving traffic flow and promoting seamless travel across Harare.

Science fiction writer Iain M. Banks writes about a future society he calls the "culture" where humans have delegated the control of the planet and its resources to a network of artificial intelligence. This network looks after the resources and allocates the resources to everybody according to their needs. Everybody's needs are met and strife is eliminated. The internet of things will not produce this utopia but perhaps elements of it are possible. Is we can better manage and control traffic maybe we can finally eliminate the carnage on our roads.

- *The internet of things by Dr J. Barrett at Ted Talks CIT*

OUTINE OF RESEARCH PROBLEM, AIMS AND OBJECTIVES

Research problem

The spatial configuration and built form standards of the settings in which ITS are to be implemented and operated need to be of a specific configuration that maximizes ITS functionality, usability, and efficiency. Harare's urban built form needs to be reconfigured in order to successfully make use of ITS.

Aim

To investigate the role that built form plays in enhancing the use of intelligent transport systems.

Objectives

- To establish an understanding of intelligent transport systems
- To develop a design framework that will inform the design of a transport interchange in Harare central business district

SETTING OUT THE SCOPE

Delimitation of Research Problem

This research study will present a description of the relationship between urban transport and the built form and analyse the consequences of this relationship on the social, economic and environmental spheres of the African urban context. The research will then analyse some of the factors that present challenges to the rectification or reversal of the social, economic and environmental consequences of the transport-built form relationship before justifying the use of advanced transport technologies as the most cost effective and sustainable solution. The main part of the research will discuss the strategies and principles that can be used to inform the design of a suitable built form for these advanced transport technologies being cognizant of the social, economic, political and physical urban contexts. The research acknowledges that advanced transport technologies as just but a tool and not the end all solution for addressing the urban transport related issues. The research will therefore combine advanced transport systems data and sustainable development design principles to create a framework that will enable architects and urban designers to design appropriate built forms. It will not go into the technical specificities of advanced transport systems that have not relation or impact on the desired urban and architectural objectives.

DEFINITION OF TERMS

Urban fabric – the physical qualities that make up a city. These include building types, open spaces, building frontages and streetscapes (www.wikipedia.org - re[lace citation).

Technology (transit systems) - Set of technical components and characteristics of a transit system. The main items characterizing technology and their common forms in transit systems are support (highway or rail), guidance (driver-steering or guidance by wheels/guide way contacts), propulsion (internal combustion engine or electric) and control (visual, signal, automated).

Urban mobility – the ability to move from one point to another within the urban fabric.

Urban accessibility – the ease with commuters reach desired destination or resources within the built form

Transport infrastructure – the network of routes, lines and links that provide for the movement of people and goods

Multi-modal interchange – built form that enables the arrival or departure of passengers and exchange between, at least two, transport modes.

Personal transportation - transportation where each individual travels independently, such as walking, on bicycle or in a personal car (Vuchic).

Public transportation - service provided by public or private agencies which is available to all persons who pay the prescribed fare. In urban areas, typical public transportation systems are bus, trolleybus, LRT, metro, regional rail and other modes operating on prescribed lines/routes on established and announced schedule. Also known as Public transport, transit, public transit and mass transit (Vuchic).

Right of way - Strip of land with pavement or railroad track on which transit vehicles operate. Right of way's have three categories; *Category C* - common streets with general traffic; *Category B* – partially separated, but with crossings at grade; *Category A* - fully separated and controlled by the transit (Vuchic)

Semi-rapid transit - transit systems operating mostly on ROW category B. Most typical mode is Light Rail Transit, but BST is also in this category (Vuchic).

Bus Semi-rapid Transit - bus system operating mostly on ROW category B, with preferential signals, separate stations with fare collection prior to boarding, regular

articulated buses and other amenities increasing line performance. Superior to regular buses in passenger attraction (Vuchic).

Stating the Assumptions

This study proceeds from the following premises;

- The majority of commuters in Harare use and rely on public transport
- The urban transport system is overloaded and a system crash is imminent
- There are negative perceptions surrounding public transport in Harare
- ITS and architecture treated in isolation of each other will not successfully redress the urban transport challenges in Harare

Hypothesis

ITS can be used to inform a framework that can be used to generate a meaningful architectural and urban built form.

Research questions

Key question:

- How can intelligent transport systems inform the design of appropriate urban and architectural built form?

Sub questions

- What are intelligent transport systems?
- What is sustainable transport?
- What is a sustainable built form?
- What are the principles and guidelines for good or sustainable urban transport interchange design?

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THEORETICAL FRAMEWORK: KEY CONCEPTS AND THEORIES

A conceptual framework serves an important role in research. It is "a tool to scaffold research and, to assist a researcher to make meaning of subsequent findings" (Smyth, 2004). This section outlines concepts and theories that will be used in examining urban architecture, transport and ITS in Harare, Zimbabwe.

Sustainable development

Sustainable development is a critical concept in development discourses including urbanization. It is at the intersection of the environment, society and economy. The precepts of sustainable development ensure equal and fair attention to social, economic and environmental aspects. Sustainable development has been discussed widely from numerous angles and as such has been defined differently. The World Council for Economic Development, in the Bruntland Report of 1987 (WCED, Our common future, 1987), defines sustainable development as, "*meeting the needs of present without compromising the ability of future generations to meet their needs."*

The structured approach to sustainable development has been criticised for underplaying the equal importance of environment, economy and society. This misrepresentation is believed to be responsible for the unfortunate reality where the 'economy' dominates and influences urban development agenda often at the expense of society and environment (Giddings, Hopwood, & O'brien, 2002) and thus the quality of life and the environment are viewed in isolation from economic growth initiatives. Urban transportation has immense impact on the socio-economic and environmental aspects of human settlement and in the face of overall and urban population growth in developing nations, should be guided by the precepts of sustainable development.

Transit oriented development

Peter Calthorpe, architect and urban planner, pioneered transit oriented development (TOD) in the late 20th century. TOD is characterized as development that mixes residential, retail office, open space and public uses in walkable environments situated close to transport infrastructure in order to increase convenience for residents, visitors

and workers (Calthorpe, 1993). The core principle of transit oriented development is the development of urban nodes that exhibit a balances mix of land uses and is well served by mass-transit or conducive to transit riding (Calthorpe, 1993; Cervero, Ferrel, & Murphy, 2002).

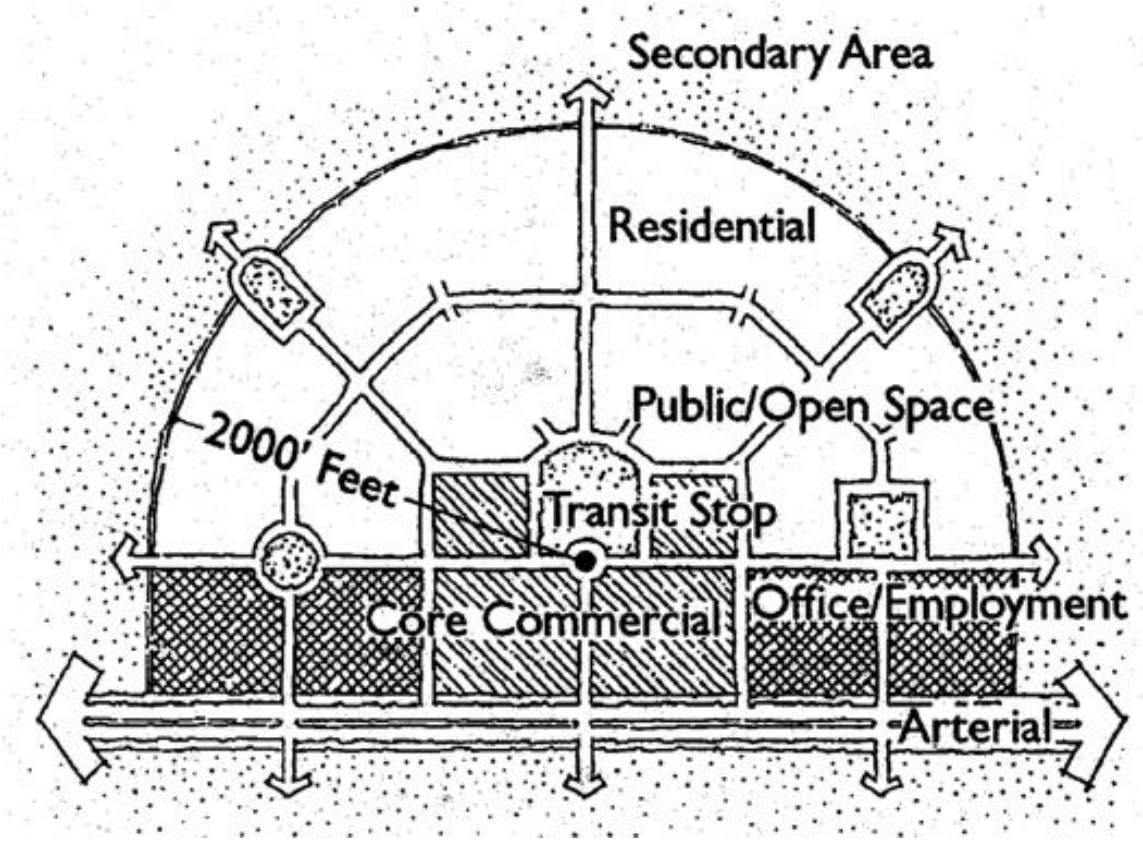


Figure 1-2. Conception of a good transit oriented development. Source:www.placemakers.com

Faced with the challenge of several unfavourable urban conditions plaguing the urban scene and dominating land-use in cities across the world, advocates of smart growth posit that suburbanisation, a phenomenon caused by the increasing use and dependence on private motor vehicles, is responsible for many of today's inefficient land-use patterns and mobility woes. The major challenges identified are a decline of the economic character of urban cores, increased traffic congestion in the developing world context, few retail and service opportunities in residential areas, and low quality housing alternatives to the suburban house (Duany, Plater-Zyberk, & Speck, 2000). Transit oriented development has therefore been regarded by many as the best solution to improve environmental quality, accommodate travel needs of the public that depends on

public transportation, and ease traffic congestion in urban transportation networks (Jacobson, et al,2008).

Transit oriented development is not aimed at prohibiting motor vehicles in urban areas. Instead, it advocates for a balanced use of a pool of transportation modes in recognition that different users of urban space have varying preferences and income levels. Thus most of the efforts by TOD practitioners have advocated for policies governing transit service, pricing, equity, development mechanisms and regulations (Cervero, 1994). Importantly, TOD goals and ideas can be implemented at architectural and urban design levels to achieve, arguably, more liveable and efficient settlements.

Space syntax

Space syntax is a science-based and human-focused approach to the study of relationships between space and cultural, social, economic and environmental phenomena. The process uses quantitative methods and geospatial computer technology techniques, based on urban spatial theories formulated by Bill Hillier and Julienne Hanson in the 1970s, to analyse spatial configurations at different scales in understanding societies that built or formed them (Hillier & Hanson, 1984; Holscher, Dalton, & Turner, 2006). Space syntax achieves this by simulating building and urban interventions then documenting and/or predicting, among other things, patterns of movement, social interactions, trade, density, land-uses, land values, safety and crime, and growth within and around the built or proposed form(s)[1].

Recent space syntax studies carried out in cities across the world have shown that movement patterns and the sense of security or insecurity are shaped by spatial layout or design (cite studies). It was also shown that there exist a strong link between spatial configuration and social [dis]advantages in cities. Building and urban scale interventions can be used to [re]create sustainable, interactive and inclusive social and cultural organisational structures[2]. Space syntax can be applied to urban and building scale

[1] www.spacesyntax.com (accessed on 17 April 2015)

[2] ibid.

interventions and accurately predict how society interacts with built form of different physical qualities like height, depth, texture, etc. The built form interventions are interpreted by society as rules of how to behave in socially acceptable manners in space (Bafna, 2003.pp.17-29). The socio-cultural, movement patterns and spatial design qualities of urban settlement is responsible for the evolution of city liveability.

Critical regionalism

Critical Regionalism is a concept that places regionalism and preservation of architectural heritage into perspective while pursuing modern taste and retaining contextual appropriateness of the built form. The theory of critical regionalism is centered around Kenneth Frampton's question of, "*how can a building be designed in this modern era without loss of its locale's core contextual essence which gives it relevance and identity?*" (Frampton, 1985). Paul Ricouer in Forster (1985) presents critical regionalism as "how to become modern and to return to sources; how to survive an old, dormant civilization and take part in a universal civilization". It is opposed to blindly revisiting tradition and as such, encourages critical rethinking of generational practices and adapting them to prevailing contexts. Tzonis and Lefaivre (2001) cite Lewis Mumford, "Human regionalism is not a matter of using the most available local material or construction neither is it in conflict with the universal."

Work by Alexander Tzonis and Liane Lefaivre expressed an urgent need for architecture to begin to move away from the seemingly senseless mass-produced and repetitious forms that made up cities to an architecture that recognized local culture, tradition, site, climate and materials (Tzonis & Lefaivre, 2003). According to Frampton (1985) for architecture to become relevant to its age of '*today*' it needs to take an *arriere-garde* or sub / secondary position to the local socio-cultural and spatial context. It should not be too futuristic of archaic to the point of losing identity and touch from the present. The manner in which buildings sit on site, materials used, sculptural forms created should reflect the nature of the local (Nesbitt, 1996. p.483). Critical regionalism is exemplified in works of prominent architects like Eero Saarinen, Tadao Ando and Alvar Aalto who are considered to be its pioneer practitioners. The simplicity of form, material, orientation and site alignment enables architectural pieces to become platforms upon which reigning

dynamic processes and culture of a society can be unashamedly celebrated and, efficiently and fairly accommodated. This allows for seamless integration of culture, and place-form and the perfect conditions for democratic socio-economic expression.

Genius loci: a sense of place

The concept of genius loci was put forth by architectural theorist Christian Norberg-Schulz in the late 1970s to describe the spirit or sense of a place influenced by Edmund Husserl's writing on phenomenology. Phenomenology is concerned with the study of structures of consciousness and the phenomena that appear in acts of daily consciousness. As such, the notion of place should be comprehended from the viewpoint of a frequent or daily user of a space (Norberg-Schulz, 1980). The manner in which individuals or groups of people operate in a space contributes towards its spirit and determines the perceptions about the place. However, Jackle (1987) suggests it is better observed from the perspective of a visitor. As a visitor, one intentionally searches for the spirit of a place and it is often discovered in the processes that constitute the activities happening in that place. The subjective interpretation of the spirit of that place is what often creates a perception of that environment.

Norberg-Schulz (Norberg-Schulz, 1980) describes the spirit (of a place) as having two facets within the construct of genius loci. The spirit is either natural or psychological where the former refers to the physical characteristics of place, that is, topography and climate. The psychological side refers to the aspects of place including the appearance of objects – building scale and form – and colour or texture of material. From this, Norberg-Schulz posits that architecture is, "a place in nature that must be interpreted when designing within the built environment" (ibid) and should be constructed from activities that occur within the space. Emphasis of Norberg-Schulz's work appears to be more concerned with the quality of life or living within a space or building which enables a person, community of city to function effectively. This creates a sense of ubuntu or according to Jane Jacobs (1993), neighborliness. If a place is used by people daily and has no meaning or value to the people it will become a failed place. Successful places have the ability to invite people and encourage them to dwell. Human scaled environments are successful because people relate to such surrounds a lot better.

Pedestrian friendly streets, promenades and domains all contribute to successful people places. Therefore, buildings and spaces should be designed to be proportional to human scale.

Conclusions

Transport architecture transcends the social, economic and environmental spheres of human settlements and should be developed in ways that ensure the equal preservation of stocks of all three sectors of the sustainable design paradigm for the benefit of now and the future. Transit oriented development principles offer a practical framework to guide development. Both urban building scale interventions of transport design should aim to recognise existing patterns of movement, socioeconomic, and cultural trends and enhance them instead of imposing itself and becoming the root cause of inefficiency in urban mobility.

METHODOLOGY

Introduction

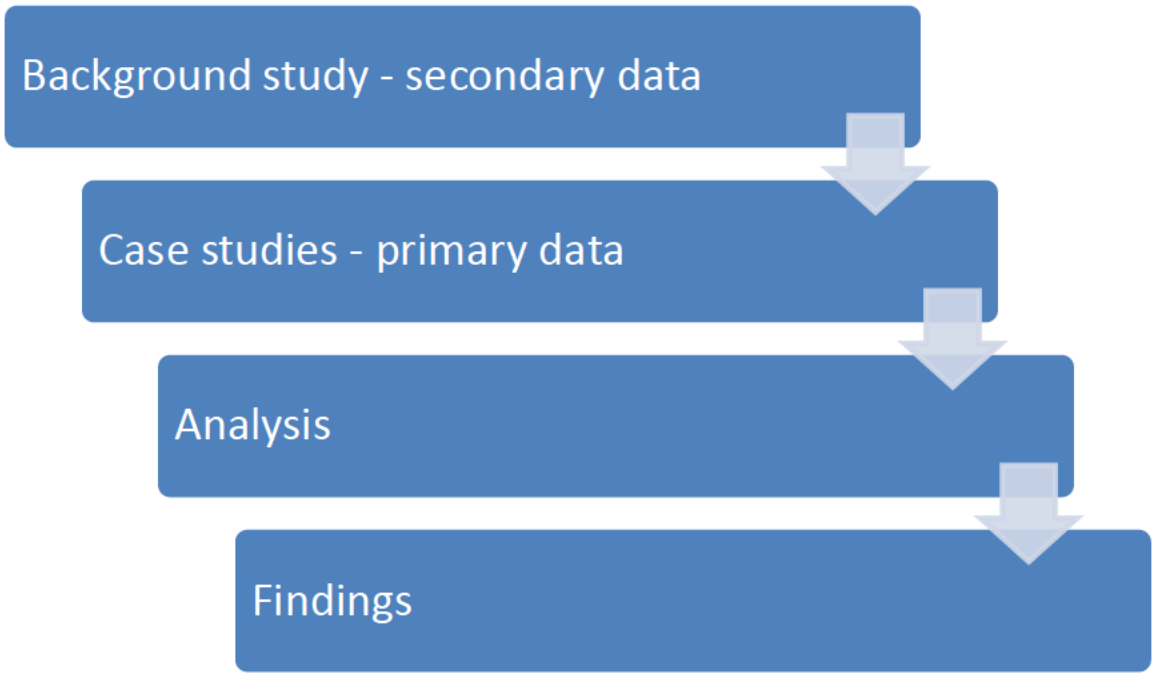
This section presents the methods to be used in collecting and examining data for this study. The intent is to take a methodical approach in collecting, compiling and analysing the data and use it to inform solutions to the stated problem. The study is qualitative in nature as it seeks to understand phenomena in a context-specific setting (Patton, 2002). Information will be obtained from five key urban transport stakeholders;

- Government, Local Municipal authority,
- Architectural and planning professionals,
- Researchers and academics,
- Transport operators and
- Public and private commuters.

Opportunities, limitations, personal views, development plans and operational, and management challenges of the transport system will be the main areas of research interest. The selection of such a broad participant group was done in order receive unique perspectives on the transportation system.

Research design

A research design is an overall strategy that a researcher chooses in a systematic manner to carry out a study (Creswell, 2009). Terell (2012) describes a research design as a broad and clear road map that determines the most appropriate route to take when carrying out the study. A research design is also a summary of steps and techniques a researcher uses to gather, analyze and interpret research. Furthermore, it also specifies how and when the data will be collected including arranging for the resources to be used for the research. To achieve the objectives set for the research, this study follows a qualitative design. Qualitative research is also suitable in view of the historical component of the study to assess how the built form and transport systems have evolved over time. where major characteristics and patterns from the case studies were compared.



Qualitative research

When using qualitative research approach, a problem is investigated in its entirety. In qualitative research, investigators should be cautious to avoid imposing their personal assumptions, limitations and be ready to accept that reality exists as given by respondents (Denzin & Lincoln, 2005). In qualitative research, the researcher records all details, accurately and without bias as heard or observed. Furthermore, qualitative studies

emphasize the natural setting and entities and processes that are not experimentally examined (Creswell 2009; McMillan & Schumacher, 2010). This study uses primary and secondary data gathered from observations, interviews and analysis of secondary sources. Patton (2002) notes that in qualitative research, direct quotations and excerpts from interviews can be cited as they present the participants' perceptions. In this study, verbal quotes from respondents were included if they were found providing key historical data and key evidence in support of ground realities and emerging themes. Given that qualitative research is the interpretive study of a problem, the researcher assumes a central role the collection and analysis of data (Denzin & Lincoln, 2005, Wiersman & Jurs, 2009).

However, qualitative research has limitations. Bias is a major limitation that arises from personal interpretations of the researcher (Patton, 2002). In cases where subjectivity prevails, the presentation of results could be easily affected by the researcher's personal position on the problem under investigation. Also, data collected through qualitative techniques can be inaccurate because respondents could be untruthful or biased (Creswell, 2009). To mitigate the limitations of qualitative research, the researcher put in effort to create a conducive environment during interviews in to create trust with respondents. To remain objective, the researcher continuously referred to the theoretical framework and upheld ethical standards as expected.

Primary research and data collection methods

Investigations will focus on developing and understanding phenomena prevalent in the research setting that will be useful in the formulation of final recommendations. Setting conditions, social and cultural trends, historical background will be investigated. Techniques for primary data collection will include:

Observation

This method of research enquiry involves the systematic watching of people; big and small groups, individuals; and how they behave within and use the built form. Attention will be paid to their patterns of movement and the extent to which the built form enables

or prohibits efficient, safe and comfortable movement or behaviours. Observation will be actively used to better understand the existing urban transport network.

Focused interviews

Interviews are a methodical probing mechanism for finding out the feelings, thoughts, and reasons for why people behave and do things in certain manner. Focused interviews focus on a specific phenomenon and investigate human behaviour, feelings and thoughts related to that phenomenon. Open-ended questions will be conducted with professionals in the built environment, urban commuters and transport operators (or their respective representative bodies), and city officials in traffic and planning departments. The purpose for this is to;

- Gather detailed information about the performance and public perceptions transportation system
- crosscheck the validity and authenticity of research data before final analyses, conclusions and recommendations

Case studies

This method of inquiry involves the systematic observation, analysis and review of carefully selected transport related urban and architectural projects. Case studies will be carried in order to get a deeper and practical understanding of the design process, outcome and impact of the built form. This knowledge will be adopted to inform and guide the proposed final solution. Purposive sampling will be used to select cities with similar contexts and urban transportation – urban form relationships.

Secondary research and data collection

This set of data consisted of data captured and recommendations by other researchers and professionals who conducted research studies in urban transportation systems. Data sources will be literature and precedent studies. The literature reviewed will be in the form of books, journals, published theses and dissertations, conference reports, national and statistical reports and newspaper articles. Precedent studies selected will be of buildings and urban forms that fulfil the aims and objectives and represent the elements of the theoretical framework contained herein. The information on building typologies,

ideas or concepts related to the resolution of the research study question will be gathered from books, journals, internet articles and analysed to contribute towards the framework to be used to inform the research building design.

Analysis

Data from secondary sources, case investigations and interviews were gathered and analyzed. Firstly, data were analyzed according to themes and sub-headings that were aligned to the theoretical framework. Findings were assessed from the case studies in an attempt to identify patterns, and finally, findings from the different sources and cases were triangulated.

ETHICAL CONSIDERATIONS

The following ethical issues were observed:

Permission: Permission to carry out a study makes the research authentic and makes it possible/easier to conduct (Christians, 2005).

Informed consent: Patton (2002) and McMillan and Schumacher (2006) discuss informed consent as the process through which respondents give their consent to participate in a research study after getting honest information from the researcher relating to procedures, risks and benefits. To ensure this, the researcher informed respondents about the purpose of the study and allowed participants to decide whether they wanted to participate and informed them the provision to withdraw at any point in the study.

Confidentiality: Patton (2002) highlights the significance of confidentiality in research. Confidentiality means that, other than the researcher, no one has access to the participants' data and that no one should be able to match information presented in the final research output with that of a participant (where requested or assured).

Anonymity: A participant has the right to have their identity to remain unknown to the public. According to Christians (2005), it is the researcher's obligation to ensure that the respondents' identity and responses are anonymized in the best way possible. anonymity of participants is guaranteed when responses cannot be matched with a participant.

Harm to participants: It is important to ensure that participants are protected from physical, social, emotional or harm of any nature (Patton, 2002). The researcher made sure participants were not exposed to any form of harm.

Chapter summary

This chapter introduced the study problem, background of the study area and a succinct theoretical framework. The chapter also presented the aim and objectives of the study and the research methodology.

CHAPTER 2

CONCEPTUALISING INTELLIGENT TRANSPORT SYSTEMS

INTRODUCTION

Cities exist because of the economics of agglomeration associated with manufacturing, economic and social activities. Cities offer critical opportunities for socioeconomic development, are the centres for advanced urban sectors, and have higher productivity and consumptions levels than any other form of human settlement (Cohen, 2006). The increase in population, geographical size and number of urban settlements over the last half century highlights the widespread desire for and increased recognition of city advantages. The world is now more urban than it is rural and global population increments in the period 2005 to 2035 are expected to increase the proportion of global urbanisation reaching 70% by 2050 (Cohen, 2006; OECD, 2015). A large percentage of this expected growth will take place in the existing small-medium urban settlements of the developing world (UNPF, 2007; Pojani & Stead, 2015).

Central to the efficient production of goods and provision of services is transport and as urban human and vehicle populations continue to rise, with limited infrastructure development, it is becoming increasingly difficult for cities to manage the negative effects of mass motorisation and inefficient energy urban development patterns on the environment, society and economy. There is need for monitoring and managing urban development and steering it along a sustainable path. Technology and the internet have enabled the creation of physical cities that are not only driven by good public realm design, green space and land-use planning but now digitally enhanced with a layer of connectivity, data, and interactivity that not more than 3 to 5 years ago was virtually impossible.

This section of the study will start off by looking at the working definitions of sustainable development and sustainable transport. This is to set the desired target most widely agreed as the ideal path for urban development in the face of rising global population increase and urbanisation and natural resource depletion. This will be followed by a discussion on the technological solutions and strategies that can be employed to increase the rate of attainment of the sustainable development goals, at the most reasonable and affordable cost(s), and their impact on transport modes and travel patterns.

Evolution of urban transport and the need for sustainable transport

Transport has been an engine of growth since the beginning of human history. Modern global economies were founded on the existence of good transportation systems and networks and will not work properly, or as efficiently, without the goods and services provided by cars, lorries, buses, high speed trains, and aeroplanes. Transport has established itself as a major industry on which other industries rely for overall well-being of social networks and national economies (Greene & Wegener, 1997). As the majority of the world's population has become urban there has been an increase in the use of fossil based vehicles and transport modes. The increase in rates of motorisation and urban traffic volumes is responsible for congestion which causes pollution, economic decline, increased accident and human death rates, lack of accessibility for the poor and vulnerable, and degradation of urban and natural environments (Pojani & Stead, 2015).

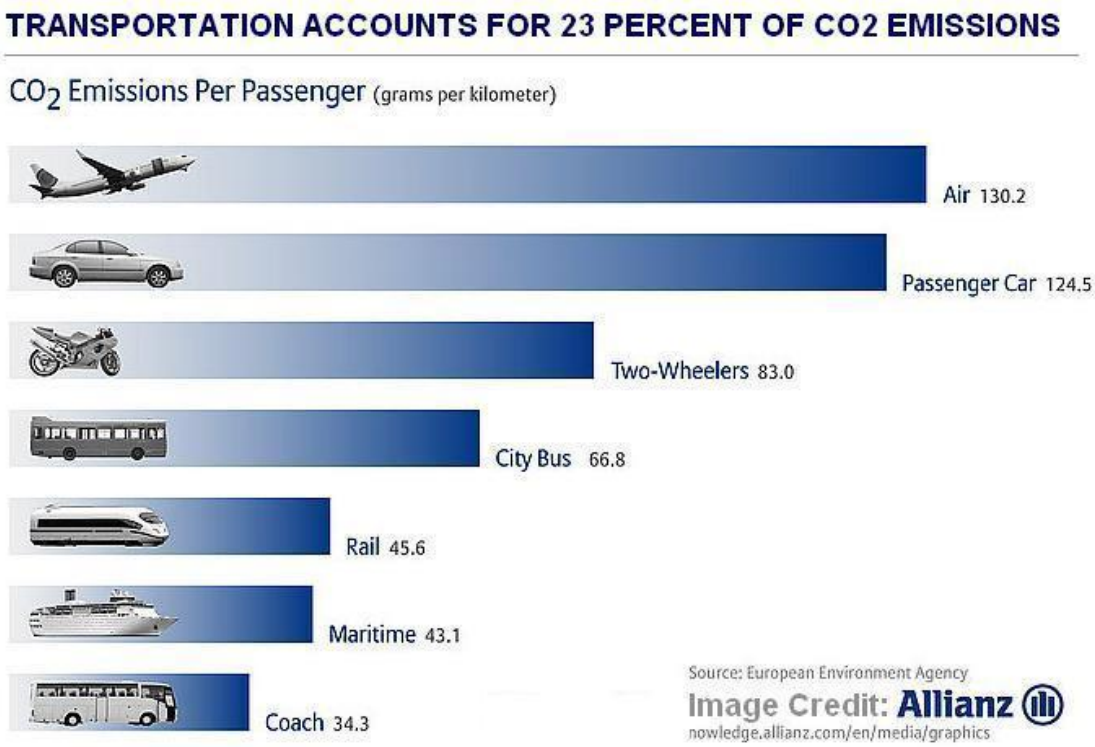


Figure 2-1. CO2 emissions per passenger. Source: European Environmental Agency

Some developed nations have been successful in reducing the effects of motorisation by reclaiming urban space from the personal vehicles through the implementation of strategies such as congestion charging, creation of car-free/pedestrian zones, and parking

management programs. In developing nations however, motorisation and its ills, especially traffic congestion, air pollution and reduced road and commuter safety, continue to increase and this is presenting major concerns and development challenges. The negative impacts of most urban transport operations, modes and practices have negative impacts on the social, environmental and economic spheres of urbanism hence the general consensus that urban transport today is unsustainable. There is an urgent need for the undoing of the damage presented by auto-dependency and fundamental transformations in travel patterns and decisions, transport services and technology, urban planning and infrastructure design, and the operation and financing of urban transport systems are long overdue (Greene & Wegener, 1997; Pojani & Stead, 2015).

Defining sustainable transport

Travel in the urban context is a functional necessity that enables people to access desired destinations, opportunities and services. This is often achieved by walking, cycling, driving or sharing a car, and riding a bus, tram, train. These modes have varying impacts on urban economics, society and environments. The most obvious is the impact on the physical environment – congestion and pollution. The cheapest and most effective first step in mitigating the negative impacts of urban transport and moving away from this unsustainable pathway is to improve urban public transport. This has long been considered the most effective way to counteract these challenges and enhance urban accessibility (Cervero & Mason, 1998; Pirie, 2013). The majority of commuters in the developing world rely on non-motorised transport (NMT); mainly walking and cycling; and public transport mainly buses or mini-buses although there is a consistent backlog in the provision of public transport infrastructure and services due financial and political hurdles (Pirie, 2013)..

Numerous viewpoints have been provided by researchers regarding the definition of sustainable transportation. Some definitions specifically cover the economic, environmental or social (equity) aspects of urban development while others cover all. Repogle (Sustainable transport strategies for third world development, 1987) provides a multi-dimensional definition by suggesting that sustainable transportation is guided by economic viability, financial viability and efficiency; the degree to which the mobility

system meets the needs of everyone. The World Bank's report on priorities for policy report (WB, 1996) offers an economic perspective on sustainable transport by putting emphasis on the efficient use and maintenance of economic and financial resources, fully considering the external effects and the broad distribution of transportation benefits.

An environmental perspective is expressed by the environmentally sustainable transport project run by the Organisation for Economic Co-operation and Development (2002) which defines sustainable transport as that which meets the access needs without endangering public health or ecosystems. A people focused, access oriented definitions is provided by the Centre for Sustainable Transportation (CST) which emphasises the importance of safely, equitably and healthily (human and ecosystem) meeting the basic need for people, within and between generations, to enjoy access to urban resources, opportunities, destinations and activities (CST, 2002). Zegras (2005) suggests that sustainable transportation is movement that enables access across time (emphasis on provision of access to future generations).

Minken et al (2003) are inclined towards services provision by defining sustainable transport as *transport that provides access to goods and services in an efficient manner and protects the natural and cultural heritages of today and the future generations.* Recent definitions of sustainable seem to be inclined towards energy consumption and limited natural resource use. The Earth Times defines sustainable transport as any form of transport that does not rely on non-renewable resources and has low effects on the environment. The common thread in the perspectives on the definition of sustainable transport is the improvement and maintenance of accessibility, resource preservation, economic affordability and the balanced distribution of transportation benefits within and between generations, also called equity.

A sustainable urban transport system is one that shows strong mobility (the ease of physical movement from one point to another within as defined space), accessibility (the ease of reaching elements within a defined area), affordability, social equity, efficiency, safety, security, convenience, low carbon emissions, and people and environment friendliness. Sustainable transport covers a wide range of separate but interdependent

factors that need to be integrated and systematically controlled in order for the systems to be self-regulating and be free of bottlenecks.

The internet of things: towards sentient urban transport

As the world becomes more and more technologically savvy and digitally advanced human settlements have become digitally enhanced with layer upon layer of connectivity, data, and interactivity that 3-5 years ago was virtually unimaginable. The high levels data connectivity present in human settlements has been made reality by the internet of things (IoT); one of the biggest and fastest growing tech trends today. The internet of things was first used by Kevin Ashton in 1999 to describe how internet-connected devices would transform lives (Wood, 2015).

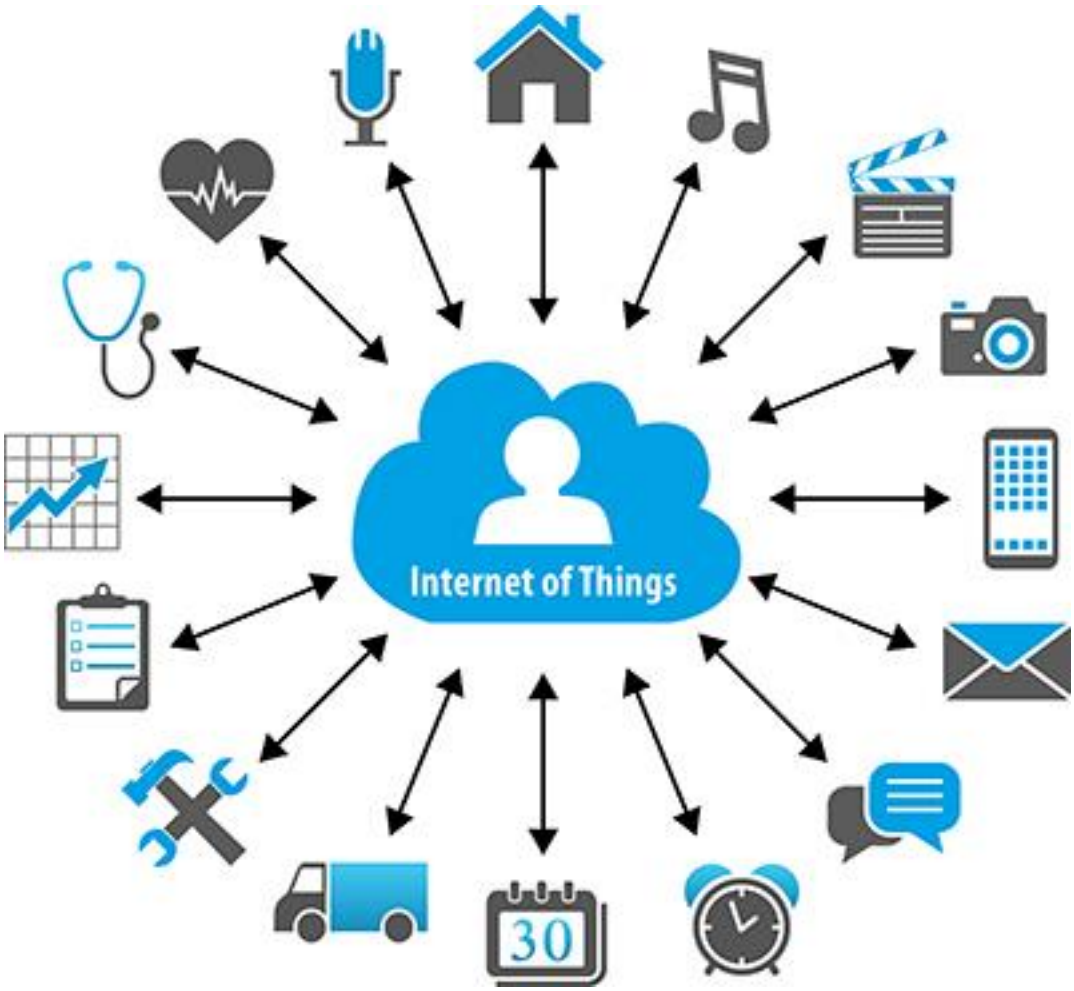


Figure 2-7. diagrammatic illustration of IoT and how it effects smart living

IoT is a virtual and physical network of objects embedded with micro-sensors, software, and network connectivity capability that enables these objects to collect and exchange data, be sensed and remotely controlled within the network infrastructure to provide advanced services (IoT-GSI, 2014). IoT has been in use for more than two decades having mainly been being used by companies, research institutes and city authorities across the world to collect information about the state of the environment, and location and management of business fleet vehicles (HBR, 2014).

IoT is based on cloud computing and networks of data-gathering sensors that increase machine to machine (M2M) communication in order to make everyday life processes more convenient, efficient, safer and faster (Burrus, 2014). The devices, things or objects that operate in IoT networks range from transport vehicles to [transponders in] domestic and wild animals. These collect data of their states of being and surroundings and with the use of supporting infrastructure transmit the data to remote devices, such as cellular phones and laptops, or locations where it is analysed and used for system enhancements or identifying potential threats to systems performance. IoT enhances connectivity of devices, systems and services and enables automation and self-regulation of systems giving birth to advances systems such as smart grids and smart cities and environments.

> *In 2007, a bridge collapsed in Minnesota, killing many people, because of steel plates that were inadequate to handle the bridge's load. When we rebuild bridges, we can use smart cement: cement equipped with sensors to monitor stresses, cracks, and warpages. This is cement that alerts us to fix problems before they cause a catastrophe. And these technologies aren't limited to the bridge's structure. If there's ice on the bridge, the same sensors in the concrete will detect it and communicate the information via the wireless internet to your car. Once your car knows there's a hazard ahead, it will instruct the driver to slow down, and if the driver doesn't, then the car will slow down for him. This is just one of the ways that sensor-to-machine and machine-to-machine communication can take place. Sensors on the bridge connect to machines in the car: we turn information into action.* (Burrus, 2014)

Central to IoT is increasing response time to catastrophes, emergencies, or the ability of the end user, which is the receiver of the data, to make better decisions that decrease risk

of harm or delay. In a recent survey conducted by Harvard Business School on adopters of IoT, benefits of IoT deployment in business operations include (HBR, 2014);

- Increased revenue from services
- Enhanced customer satisfaction
- Improved use of assets in the field
- Access to more information and data that gives insight into how products and services are being used by consumers and when, or if, they require maintenance.
- Increased sustainable use of resources such as water and energy

Burrus (2014) discusses other benefits of IoT and cites traffic flow optimisation and more meaningful use of data collected. These improve management and operation of public transport for example and set up self-regulating systems that keep the system efficient and uncongested.

Intelligent transport systems

Information Communications Technology (ICT) has transformed many sectors and industries from health to governance to education and is now changing the transportation industry. Intelligent transport systems (ITS) is a generic term for the range of communications, control and information processing technology tools and services which are applied to [urban] transportation systems or networks in an integrated manner with the aim of saving lives, time, money, energy and the environment. ITS are applicable to all types of transport modes and considers all elements of the transport system from the vehicles and infrastructure to the driver/operator and end-users (PIARC, 2004). The main function of ITS is to enhance decision making by operators, managers and users of a transport systems in order to improve overall system safety, convenience, and efficiency.

The term ITS also refers to the techniques and approaches employed either as stand-alone technological applications or enhancements to other transport strategies aimed at enabling city authorities, road operators, transport providers and commuters to make operational and travel decisions that are smarter, safer, and more coordinated (PIARC, 2004). ITS technology was originally made for use on roads with urban traffic signals control systems to improve (private) car journey times (Robertson & Hunt, 1982; 1991).

Service	Systems	Use
Traffic management	Advanced traffic management systems	o Urban traffic control o Freeway corridor and expressway management o Demand management o Enforcement
Traffic and travel information	Advanced traveller information systems	o In-vehicle ATIS o Infrastructure based ATIS o Location independent ATIS o Route guidance and navigation
Freight transport management	Advanced vehicle control systems	o Intelligent vehicle systems o Intelligent vehicle-highway systems o Cooperative vehicle-highway systems o Safety systems
	Commercial vehicle operation systems	o Hazardous goods management o Fleet management
Collective transport management	Advanced public transport systems	o Public transport information o Public transport priority o Public transport fleet management and logistics o Flexible shared transport services
Integrated payment	Electronic payment systems	o Electronic toll/fare collection (ETC/EFC) systems o Public transport fares and ticketing
Security and emergency management	Security and emergency response systems	o Homeland security o Emergency management services o Security in transport operations

Table 2-1. ITS themes Adapted from ITS toolbox and ITS Handbook..Source: (PIARC, 2004)

It has now been extended to urban public transport to make it more attractive and convenient and covers a wide range of applications designed to (PIARC, 2004);

- Provide and display travel times for private or public urban commuters

- Help to relieve congestion by providing seamless traffic flows
- Improve commuter safety
- Enable electronic payment and cash-free travel
- Reduce environmental impact of transport
- Enable efficient and seamless integration of transport modes

Applications of ITS

ITS can be applied to a wide range of urban services that have anything and everything to do with urban transport. The table below describes the range of services to which ITS can be applied.

With respect to urban public transport services ITS can be applied to services which include;

- traveller information,
- electronic payment
- Public transport management and operations.

Plate 2-1. Smart card and card readers validate tickets, enhance traveller experience and convenience, and increase operator efficiency. Source: www.thekooza.com Accessed 22/10/2015

Systems	Potential use
Advances traffic management systems	Predict traffic congestion and provide alternative routing directions to vehicles in real time to improve the efficiency of the road network and maintain priorities for high-occupancy and transit vehicles
Advanced traveller information systems	Provide commuters with data and information in their vehicles, homes or workplaces about the location of incidents, weather problems, road conditions, parking availability, and best routing options. These help with routing and modal choice decisions
Advanced vehicle control systems	Enhance drivers' control of the vehicle to make travel both safer and more efficient and range from collision warning systems to self-driving electronic vehicles
Automated vehicles	System of connected vehicles that include personal cars, automated taxis with fares similar to public transport
Automated road systems	Systems that control infrastructure to automatically control the movements of high-occupancy or transit vehicles in dedicated lanes
Advanced electronic payment systems	Enable integrated payment and pre-booking solutions for a range of different modes. Enable cost-effective planning and payment for commuters and urban poor

Table 2-2. Potential applications of ITS. Source: (Sussman, 2005; Pojani & Stead, 2015)

ITS in road based public transport

Road based public transport is the most common form of accessing urban resources and services in developing world cities. Cars and buses are the most common type of vehicle in used on roads urban areas. The disadvantages of personal vehicles have been discussed at length in previous sections of this study.

Buses

This mode of transport can be described as a more sustainable mode of urban transportation than personal vehicles. As congestion levels have increased in urban areas,

however, buses have become unreliable, uncomfortable, unsafe, and inconvenient. This has caused commuters to prefer other modes of transport. To reverse this several strategies have been implanted. The creation of bus lanes on existing roads has been a common solution for attempts to create priority service for the bus (Pojani & Stead, 2015). Traffic control systems have also been adopted to enable priority for buses at urban road intersections and enable them to operate on an exclusive right of way basis. The construction of bus stations in the median sections of urban trunk roads for the exclusive use by buses and high occupancy vehicles is an effective means of promoting mass transit. Bus semi-rapid transit (also known as Bus rapid transit/BRT) systems are becoming popular in medium-sized developing cities. The bus semirapid transit (BST) system is a specific type of mass transportation mode that has gained much popularity and fame over the years especially in developing countries. This is due to the system's moderate cost of implementation, short implementation time, high quality of service, and high passenger capacity; capable of transporting up to 13000 passengers per hour (Pardo, Jiemian, Hongyuan, & Monhanty, 2015).

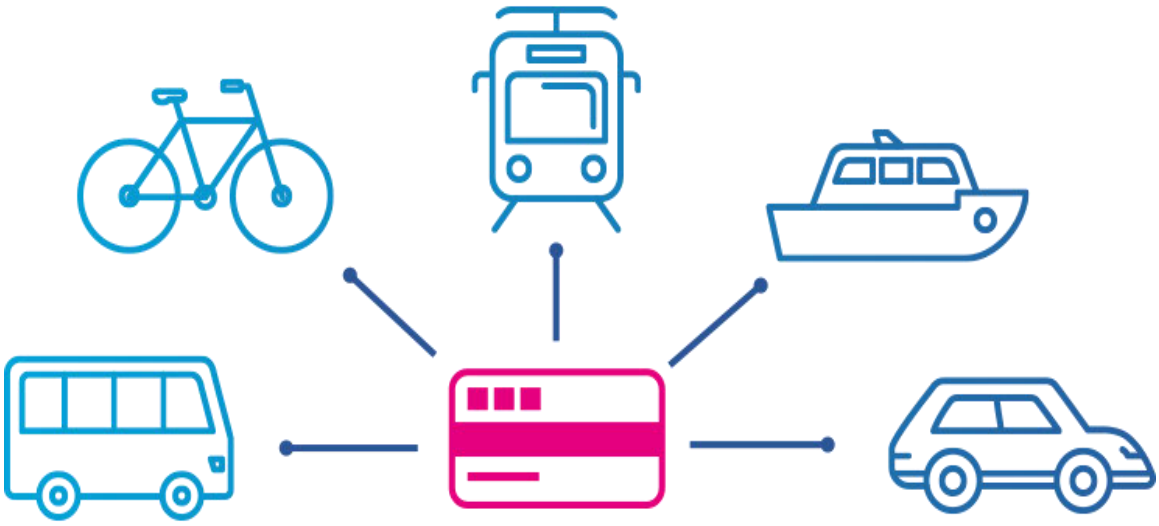


Figure 2-2. Integrated smart card technology. Source: www.smart-transport.parkeon.co. accessed 22/10/15

Plate 2-2. Bogota's TransMilenio BRT. Source:www.streetsblog.org

BST systems are more attractive for commuters and more economically viable for operators if they offer the option to move between points in a city. BST systems are relatively cheap to implement, costing between US$1m and US$8m per km for medium-sized urban fabrics, and economically sustainable for commuters. Prices are affordable with fares typically falling in the $1/ride range (Wright & Hook, 2007). BST transit systems are also compatible with several ITS technologies such as advanced information systems and advanced payment systems.

BST vehicles also make use of fuel technologies which include natural gas, electricity and bio-fuels and this makes them environmentally sustainable. Well-designed BST stations or termini are simple to comprehend, offer safe and comfortable environments, and provide clear and accurate information on travel times and modes (Tolley & Turton, 1995). Hybrid train-bus forms have also been introduced to increase commuter comfort and carrying capacity.

Personal vehicles

Personal vehicles are not as bad as some parts of the literature and reports included in this study might suggest. The problem with cars is that they bring with them undesirable side effects for which the market does not provide compensation. These externalities include poor air quality, traffic congestion and undesirable impacts on the socioeconomic fabric of urban life (Boarnet & Crane, 2001). Vehicle automation has helped create a new generation of advanced urban transport systems. Personal Rapid Transit (PRT) vehicles operate with personal car quality of service and public transport impact. These automated vehicles provide on-demand service with the aim of replacing private cars and inefficient public transport systems (Alesandrini, Filippi, Stam, & Tripodi, 2010). PRT function like private cabs only that they always operate in reserved and protected lanes, are driverless and can be physically connected to each other to form a "train" of PRT during peak hour to meet transit demand and increase capacity. PRT vehicles are electric battery operated and require electric charging station infrastructure for (re)charging. PRT vehicles can operate efficiently at low speeds and their small size enable them to safely share urban space with non-motorised transport like walking and cycling (Alesandrini, Filippi, Stam, & Tripodi, 2010). In some parts of Europe PRT are already in use to take people up hills, transfer between terminals at airports and in carbon free urban zones (Parent & Yang, 2004 cited in; Alesandrini, Filippi, Stam, & Tripodi, 2010)

Electric cars are vehicles that run on electric energy supplied by various types of electric energy storage devices like rechargeable batteries. Electric vehicles are believed to three times more energy efficient that ordinary fossil-fuel based vehicles. the first electric vehicles were manufactured in the late 17th century and were popular until the creation and mass production of the cheaper conventional internal combustion fuel engine vehicle the world has become accustomed today (Roth, 2011). In light of the problems such as GHG emissions, depletion of fossil fuel natural resources and need for energy management the electric care has (re)gained popularity in the 21st century. The exists a variety of electric cars;

- Electric vehicle – any vehicles that is propelled by electric motors
- Electric car – highway capable automobiles powered by electricity

- Neighbourhood electric vehicles (NEV) – plug in electric powered micro-cars or city cars that operate on city streets and are of a limited weight, power and speed
- Solar car – electric car that makes carries solar panels and powered by solar electric energy

Electric cars have economic, environmental and social advantages. Although electric cars are more expensive than conventional cars they are cheaper in the long run and are become cheaper with increased mass production (NRC, 2010). The electric manufacturing industry will provide many opportunities for employment and research and development. Electric do not emit any exhaust gases such as carbon monoxide, lead, nitrogen oxides, etc., and contribute less to air pollution in urban areas than conventional fossil fuel combustion vehicles. The methods used to produce electricity for electric cars and the use of electric cars produces low GHG emissions (Sperling & Gordon, 2009).


Plate 2-3, 2-4. Solar energy electric car charging station and the Nissan leaf electric car, 2010 model. Source: www.wikipedia.org

The charging of electric vehicles should be done periodically and this required adequate charging infrastructure. Cars can be charged from user homes off the power grids that make use of electricity from thermal or hydro-electric plants. In most developing countries this is an unreliable means form of charging infrastructure because off unreliable supply of electricity. There is also the option of charging vehicles from street of shop charging station. These stations normally make use of off-grid electricity often generated from the sun although wind is increasingly becoming common. With the abundance of sun in Africa and most other developing nations such infrastructure would be of great use.

Plate 2-5. Tesla motors supercharger station in California, USA. Source: www.wikipedia.org

Plate 2-6. Public charging station in Rio de Janeiro, Brazil. Source: www.wikipedia.org

Plate 2-7. Electric cars charging at a street station in Amsterdam, Netherlands.

Support for non-motorised transport (NMT)

African and Asian cities rank top in terms of use of NMT in their urban areas. NMT include modes such as walking, cycling, pedicabs and other human operated vehicles. The urban poor are the most common users of NMT as they lack financial capacity to access other forms of transport. NMT also provides opportunities for employment. Levels of safety in urban areas that have high NMT usage have been proved to be significantly higher. The probability of accidents involving a pedestrian or cyclist and a motor vehicle is inversely proportional to cycle of foot traffic volumes (Jacobsen, 2003). Urban policy and architectural interventions in the built form are the most effective way of promoting NMT. The social stigma associated with NMT in developing world context is also a great challenge to its successful implementation.

Walking

In both developing and developed nations walking constitutes a primary mode of transportation over short distances within the urban fabric and movement between transport modes at transport interchanges (Tolley, Sustainable Transport: Planning for walking and cycling in urban environments, 2003). Comfortable walking distance according to the walkable neighbourhoods' principle of transit oriented development (TOD) ranges from 500m-800m (Calthorpe, 1993). Most users of the urban fabric will at some point of their journey become a pedestrian. Walking, however, is often discounted and overlooked as a reliable and important means of transport in urban infrastructure

design and development plans. Space syntax analysis methods can be used to identify ways of (re)designing city street to increase urban walkability.

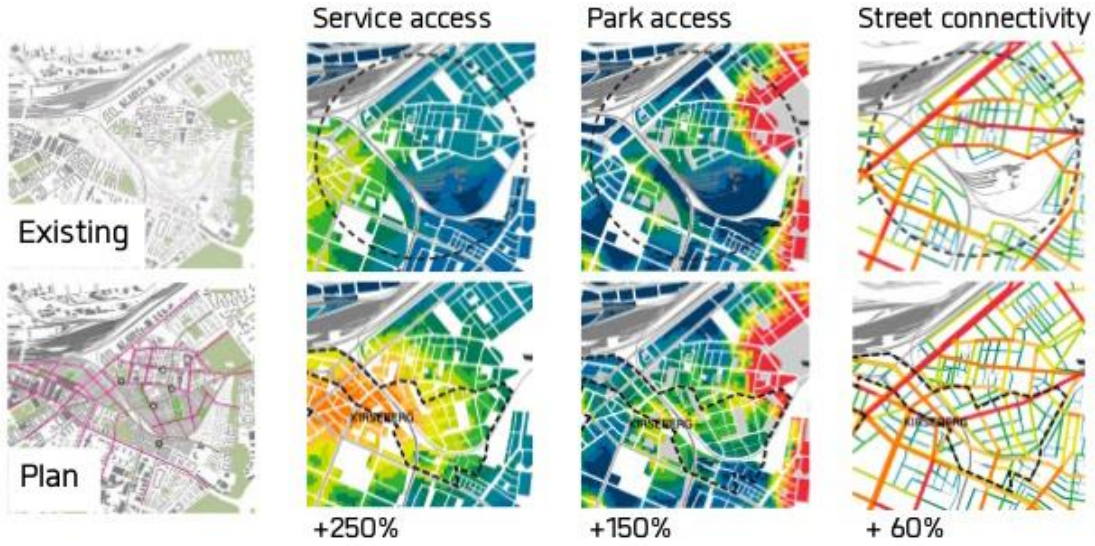


Figure 2-3. Testing walkability in urban built form. Source: www.slideshare.net

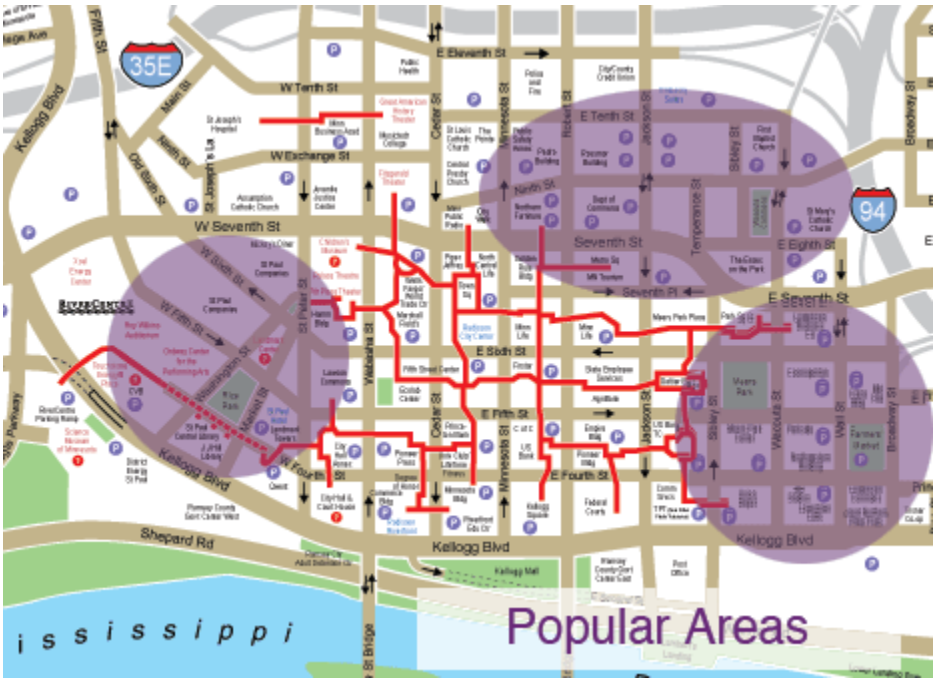


Figure 2-4. Increasing urban connectivity through active mobility. Source: www.tcdailyplanet.net

Due to the different individual speeds and levels of mobility with walking Edwards (2011) suggests that design emphasis needs to be put in creating;

- pedestrian walkways on both sides of streets
- smooth, level and non-slippery pedestrian pavements
- Seating areas along pedestrians routes
- Unobstructed sight lines
- Shaded outside areas

Plate 2-8. Non-motorised urban street/zones. Source: www.smartgrowthtulasa.com

Urban design interventions for increasing walkability should include (www.ottawa.ca);

- accommodation of adequate pedestrian space in Right Of Way (ROW) plans
- provision of continuous sidewalk and distinctive streetscape
- planting of street trees and raised pot plants
- street furniture and other amenities
- transit services with adequate high quality transit stops
- improve design of pedestrian crossing points

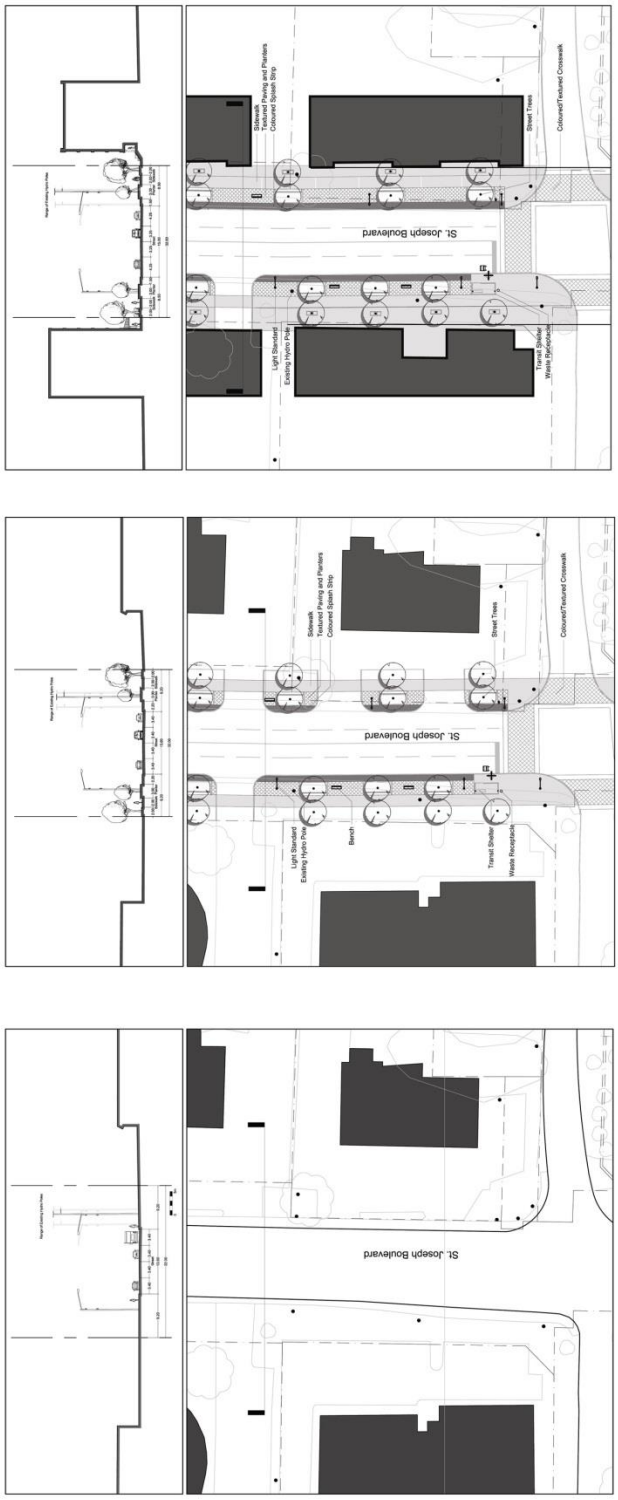


Figure 2-5. Urban design intervention using guidelines for walkable street design. Ottawa, CA. Source: www.ottawa.ca

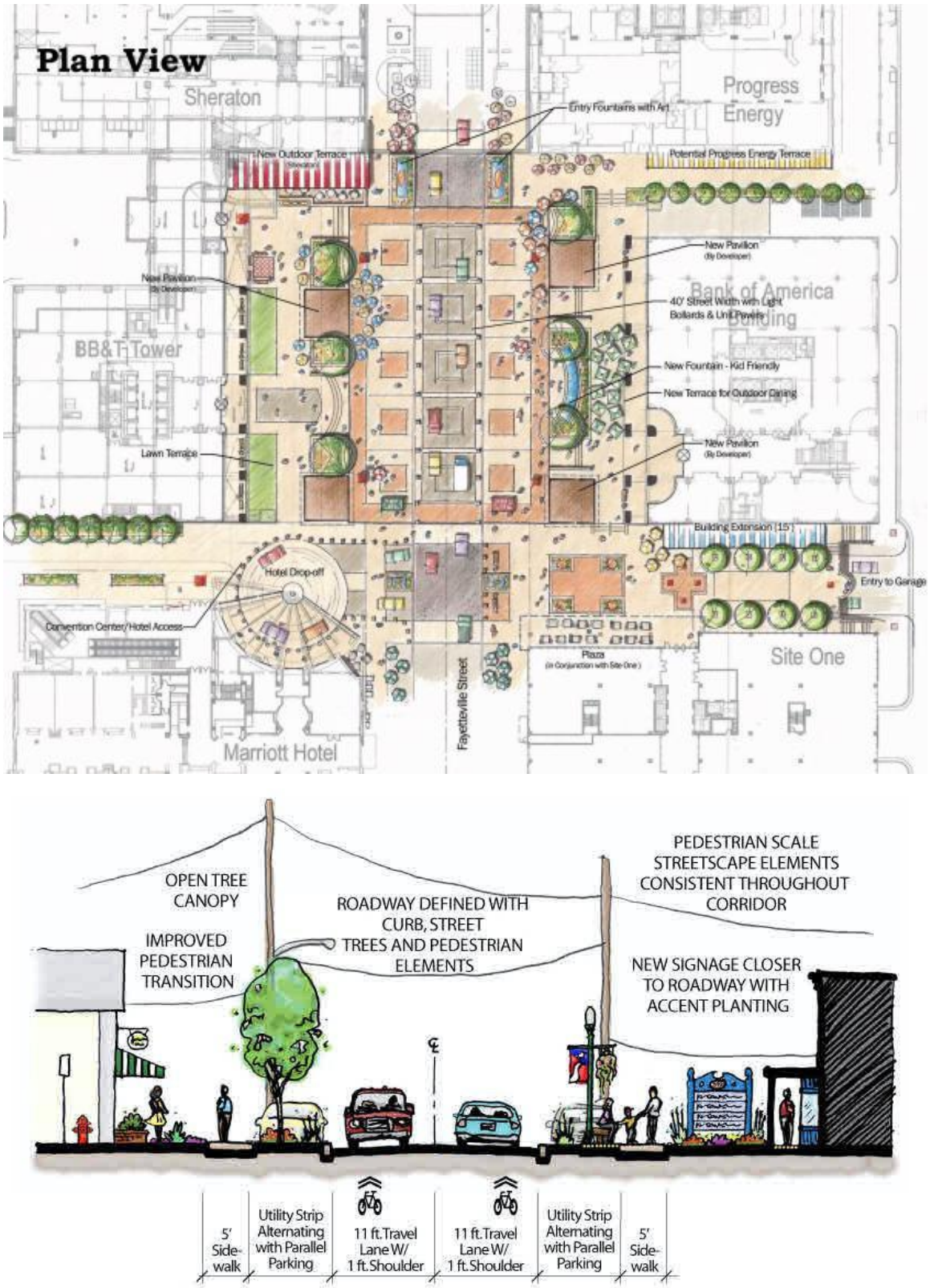


Figure 2-6. Examples of design interventions for creating walkable urban streets. Source: www.metrojacksonville.com

Cycling

Cycling is another form of NMT that has grown to become one of the most sustainable modes of transportation in the post-fossil age of today. The bicycle is a quick and cheap means of transport and offers the benefits of good health and well-being for its users. The bicycle is an efficient means of cross-city movements is one of the most important modes of interconnection and major transport hubs (Edwards, 2011). With the bicycle's growing recognition as a safe, affordable, and energy efficient mode of transport several ITS applications have been created to enhance its service.

Technological solutions such as electronic bikes, bicycles clubs, and e-bike sharing schemes have enjoyed much success in major Asian and South American cities. These offer cyclists the convenience of access to bicycles without the extra costs of personal maintenance, security.

Plate 2-9,2-10. Londond bicycle sharing programs. Source : (transitiondeal.com)

The central concept of bicycle sharing programs is to provide free or affordable access to bicycles for short-distance trips within an urban area as an alternative to motorised public transport or private vehicles. Increased bicycle use reduces traffic congestion, noise, and air pollution. Bicycles in bike sharing schemes are accessed via Bicycle-sharing systems also solve the "last mile" problem by efficiently and effectively connecting users to public transit networks (BAAQMD, 2011). Bike sharing systems operate on subscriptions or pay-as-you go basis and make use of smart cards which commuters can swipe at bike stations for payment and or access. Interconnectivity with smartphone technology enables

commuters to locate nearby stations and view availability, pre-book or pre-pay bicycles. Evidence suggests that bike sharing schemes have led to an overall increase in the in bicycle use. These innovations have been instrumental in shifting mindsets and modal choices of the middle to upper class citizens towards NMT (Weinert, Ma, & Cherry, 2007; Midgley, 2011).

Plate 2-11. Bike sharing station in Hangzhou, China. Source: www.flickr.com

Cycle networks are another intervention that has been implemented particularly in South American cities. These networks are similar to the BST systems in that they are grade separated from motorised vehicles. Bicycles as a mode of urban transportation have the advantages of;

- Less parking and storage space for bicycles as different users use the same bicycle for different sectors of their journeys
- No pollution
- convenience for commuters as they don't have to worry about securing the bicycle at drop off or exchange points
- Creation of bike repair employment opportunities for the urban poor and unemployed

Benefits of intelligent transport systems

The benefits of ITS can be broadly categorised into five classes;

- Commuter safety
- Transport network efficiency
- Urban mobility
- Environmental friendliness
- Economic growth, productivity and employment opportunities (Ezell, 2010)

The primary beneficiaries of ITS are all road users. Operators of motorised transport, users of non-motorised transport and users of public transport all enjoy the benefits of;

- Greater safety
- Increased certainty in journeys
- Shorter journey times
- Access to accurate, real time information
- Easier interchange between public transport modes
- Direct travel routes
- Easier access to parking

Private (car) commuters gain greater safety, more certainty in journeys, shorter journey times, and best (and often shortest) travel routes.

Public transport commuters benefit from increased productivity, commuter safety, shorter travel time, lower financial costs and the ability to reach more places with more ease. ITS has been proven to significantly improve the integration of urban transportation modes by saving commuters up to three minutes of connection time per trip (Balcombe, et al., 2004).

Transport planners and city managers and authorities, that is the police, transport network providers and transport operators, also benefit a great deal from the efficiency afforded by ITS when it comes to traffic network designs, law enforcement operations, response to service and rescue, and travel demand situations (PIARC, 2004).

Local residents gain the benefits of being able to exercise a certain level of control over the negative impacts of traffic on their living, working and recreational activities. Business operations, both formal and informal, gain the benefit of having easier access to locations and wider range of delivery options. They will also be able to maintain high customer service standards. An added benefit of ITS is its ability to steer development from the path of sprawling urbanism to smart urbanism, and healthier and more livable environments. From an **urban or community development** perspective ITS enables developing and less developed countries the advantage of buying time in expansion of urban infrastructure to accommodate growing traffic. Using ITS to smooth and manage traffic flows, and improve journey times reduces the immediate need to build roads; a nightmare for nations where financial resources are scarce and there is an acute lack of strong and functional institutional structures (PIARC, 2004).

Other more general benefits of ITS include;

(a) **Improving traffic flow**:

- Signalised junction controls can improve traffic flow and reduce air pollution.
- Urban traffic management and control can enable police, local authorities and public transport operators to share information and help develop a truly integrated and more efficient transport system.

(b) **Improving road safety**:

Enforcement cameras deter speeding and discourage traffic violations at traffic lights;

- Intelligent traffic signals can increase the time available for people crossing roads, where and when this is needed.

(c) **Improving security and reducing crime**:

- Closed circuit television can deter crime and improve response time to incidents;
- Traffic information services can improve the quality of information available to travellers.
- VMS can provide information on current travel conditions, the availability of parking spaces or real-time public transport information.

(d) **Reducing traffic environmental impact**:

- Reduced congestion, a more efficient transport network together with better-informed travellers and more sustainable transport choices can help tackle climate change and reduce air pollution.

(e) **Improving freight efficiency**:

- Improved traffic flow and more accurate positioning information will result in faster and more reliable movement of goods.

(f) **Improving public transport**:

- Operators can improve their services by having accurate information on the location and progress of vehicles.
- Travellers can get up-to-date information from the appropriate websites.

Conclusion

Urbanisation is on the rise and the majority of the world's population is now more urban than rural. In urban centres across the globe transport plays an in important role in ensuring economic productivity and access to resources and opportunities. Motor vehicles offer speed, convenience and comfort as a means of urban transport. Their use in urban areas is on the rise. They are however increasing at a pace faster than urban populations and infrastructure. Most urban areas are becoming congested losing a lot of money and economic viability, becoming a health and safety hazard and harming the earth's ecosystem. The unsustainable nature of modern transportation systems and practices needs to change if the future generations are to benefit from the world's natural, social and economic stocks.

Improving urban public transport and encouraging a mass shift from private, inefficient and unsustainable transport modes is the most time-cost efficient option available. Public transport enhancement can be increased by the use of intelligent transport systems. ITS offer safe and convenient means of moving urban populations, while ensuring efficient operation and management of transport networks. The social, environmental and economic benefits sustained by the use of ITS in urban transport make ITS and their application to urban transport modes sustainable.

CHAPTER 3
THEORISING URBAN TRANSPORT [RE]FORM

Introduction

This chapter introduces and discusses the strategies, elements, principles and guidelines that extracted from the previous section and uses them to generate a meaningful built form. The chapter will start off with a description of the sustainable city in order to lay down the parameters or desired design product. It will then discuss the urban and architectural characteristics, principles and guidelines for good and effective transport interchange design before closing out with a detailed description of the design elements of best transport interchange design practice.

Form follows function: the sustainable city

Louis Sullivan coined the term *form follows function* as an architectural design principle in the 20th century. The term was has its roots in Vitruvian principles of *firmitas, utilitas and venustas* – firmness, utility and delight (Sullivan L. , 1924). The understanding of this principle in most design disciplines is that form needs to meet the functional requirements of a system or elements operating within it in for optimum functionality and interoperability. The main reason cities have become places of social disconnect and environmental destruction is because of their car oriented designs. The rectification of this situation calls for a shift from the traditional urban planning and design practice which promote boulevard and highway provision - which often leads to urban sprawl and facilitates car-dependent lifestyles; where congestion, severance and air quality problems are all too evident, and where highways and parking provision take up a hugely inefficient proportion of urban land in the means of transportation (Bannister, 2005). It has been agreed that sustainable transport modes, identified in the previous section, would promote the shift back to people focused urbanism. If form indeed follows function then it is equally correct to conclude that function dictates form. Sustainable transport modes generate a sustainable urban form.

A sustainable urban form is an urban settlement that *meets the needs of the present without compromising the ability of future generations to meet their economic, environmental and social needs* (WCED, 1987) is generally the desired outcome for urban settlements. This is by definition the sustainable city. Another way of describing the sustainable city is a ‘good settlement’ which Lynch (1984) describes as, “*a settlement*

or urban area that responds to human beings and connects general values to specific actions." The basis of Lynch's definition of the good city has its roots in normative theories; hypotheses and statements about what is right and wrong, desirable or undesirable, just or unjust in society (Marshall, 1998). Lynch (1984) developed a set of universally agreed principles that govern the development of the good or sustainable city. The principles of a good or sustainable city are outlined as vitality, sense, fit, access, control, and efficiency and justice. These principles are largely aimed at creating a human focused urban form which, among other things, promotes and enables the use of efficient modes of transportation.

Vitality; the extent to which urban fabric protects biological (human, animal and plant) species networks and supports overall ecological stability; **sense,** the ability of the urban fabric to allow the perceptibility and differentiation of space within and across time; **fit,** the extent to which urban formal and spatial qualities allow inhabitants to do what they do, or would like to do, when they want to do it or go to places they have to go, or would like to go, when they want to go there; **access**, the extent to which the urban fabric allows people to reach facilities, resources and opportunities available and last, but not least, **control**, the ability for inhabitants of a settlement to have power in determining the management of spaces. **Efficiency** and **justice** are two major baseline principles upon which the above listed are developed. Efficiency is the cost of building and maintaining the settlement while justice refers to distribution of benefits and costs (ibid).

Control, sense and vitality are intangible qualities which collectively enable convivial living; human existence in society which enables a community to choose its own social arrangements. This allows individuals within the community to live their lives in ways that bring out the best of their creativity and imaginations. This process facilitates personal independence, strengthens interpersonal and community bonds, and significantly improves quality of life (Illich, 1973).

Bennigner (2001) adds to Lynch's principles of the good or sustainable city with 10 principles he believes are the basis for intelligent or smart urban growth/urbanism. The principles of intelligent urbanism are derived from a range of urban factors namely;

environmental sustainability, place-making, use of appropriate technology, transit oriented development, culture and heritage conservation, maintenance of human scale, social access, infrastructure efficiency, urban and regional integration, and institutional integrity. The principles are aimed at reconciling and integrating diverse urban planning, architectural and urban management issues. Intelligent urbanism describes a range of strategies that can be implemented at urban and building scales in order to create urban systems and built forms that adequately meet the needs of people. Efficiency, human scale, regional integration and balanced movement are the most relevant to the context of this study and will be further described below.

Efficiency is described as an important characteristic of a sustainable city. A good node must allow the presence and growth of a variety of socioeconomic activities. To ensure their use is maximized and prolonged the urban form needs to be shaped in a manner that supports their growth. **Human scale** is a key factor in creating successful places. The construction of natural surface-level pedestrian streets designed around anthropometric dimensions or proportions. These walkable streets are the connections between and within urban nodes. The surface texture and scales of architectural elements of building forms and open spaces that define the edges of the linkages should be articulated using natural materials, textures and built to human proportions.

Regional integration is another critical proponent for creating a sustainable urban mobility framework. Intelligent urbanism conceives the city as an organism with different hierarchies of networks ranging from nodal to regional and national. Benninger suggests that the pedestrian movement networks be linked with mass transit systems at strategic interchange nodes or hubs. This can be achieved by planning the walkable activity or residential nodes within comfortable walking or cycling distance of each other or in close proximity to major interchange hubs which allow connectivity to further afar hubs via bus, train or private motor vehicle transport modes. This creates an accessible and rational urban spatial and mobility framework. An integration of transport modes will create balanced movement within the urban fabric. Infrastructure such as pedestrian walkways, cycle paths, bus lanes and restricted private vehicle corridors will enhance safety and appropriate functionality of each mode. The overall objectives of the

principles for the development of the sustainable city as outlined by Lynch and Benninger as summed up by Bannister who outlines seven objectives namely to;

- Reduce the need for travel
- Reduce the absolute levels of car use and road freight
- Promote energy efficient modes
- Reduce noise and vehicle emissions
- Encourage efficient use of vehicle stock
- Improve safety of pedestrians and all road users
- Improve the image of cities (Bannister, 2005)

The transport interchange

Transport architecture has an important part to play in helping to deliver sustainable transport. Mobility that is based on energy efficient modes rather than inefficient transport is key to sustainable development. The intersection of the various urban transport modes and their paths or transport corridors is where the interchange can occur. The interchange exists at urban and building scales and is defined as a place or building where two or more modes of public transport interconnect and for people to transfer between two or more modes of public transport. The switching between modes is referred to as interchange and there are two main types of interchange. The first type is intermodal interchange, the switching between different modes, and the other type is intra-modal interchange, the switching between vehicles of the same mode (Edwards, 2011).

If the switch from largely inefficient private transport to more sustainable [public] transport modes is to be effectively carried out the quality of design of the interchange should be high. The interchange emerges as an important transport facility – one that is justified by the need for energy efficiency and social sustainability. The interchange is the hub that permits the transfer from one transport mode to another and creates conditions whereby transport interconnection is achieved (Edwards, 2011). Good transport architecture celebrates circulation and movement by creating uplifting spaces that reduce stress and anxiety among commuter (Harbour, 2006).

Common characteristics of the transport interchange

- Interchange design should occur at three main levels; urban, building and interior. In order to ensure that infrastructure provision, urban planning and people movements are well-integrated adequately addressed.
- There also needs to be an integration of flows from transport modes, pedestrian cross-currents, and flows from information desks, displays and signs.
- The interchange is a place of connection, transfer and interaction. It needs to serve mobility well in functional and aesthetic terms. Spaces for interaction, transfer, integration, interconnection, and intersection need to be provided.
- The interchange should be the hub of environmental sustainability and energy efficiency. Well-designed transport interchanges make significant contributions towards reductions in CO2 and GHG emissions, and urban energy savings through adopting green design principles.
- The interchange also creates a sense of place; a phenomenon often lacking in urban transport interchanges across the world today. Interchanges are often remembered in generic terms with no specific reference to place, time, and culture associated with architecture. Much of the modern transport interchanges design processes have fallen to the ills of globalization and industrialization; phenomena which do not unify the shape and function of architecture. Attention to social needs, climatic and environmental forces, and culture break the barriers presented by globalization and the standardization of engineering. Interchange is both a process and a place, operates at different scales, interacts in detail between buildings and their intimate spaces and interfaces between landscapes and urban elements. It contains concourses, rooms and passages that functions in programmed and unprogrammed ways leading to spaces that are mainly open and waiting for people to give them life and colour as the passage of trains, buses, planes and comes and goes.
- A good transport interchange is a framework for people rather than an architectural monument. The ideal interchanges contain both fluid and fixed elements. Within the urban context the transport interchange acts as a catalyst of socioeconomic as much as urban regeneration providing a focus for commerce and the flow of ideas and people movements. "*The presence of shops, food & beverage outlets and business and convenience services can drastically improve customer experience by developing*

a coherent and warm atmosphere within and around the stations and is a key lever of value creation for infrastructure operators" (VanAudenhove, Korniichuk, Dauby, & Pourbaix, 2014) . New transport interchanges are places rather than spaces – the phenomenology of transfer spaces (Edwards, 2011).

The interchange generates traffic within and around its edges and this encourages a lot of economic activity and creates employment opportunities. Alexander (Timeless way of buildng, 1979) suggests that human behavioural patterns or sequences within provide an important means of shaping the built environment to suit their needs. The transport interchange accommodates a multitude of movements and threads and Edwards (2011) also suggests this as a reason for selecting loosely jointed infrastructure over tight configurations.

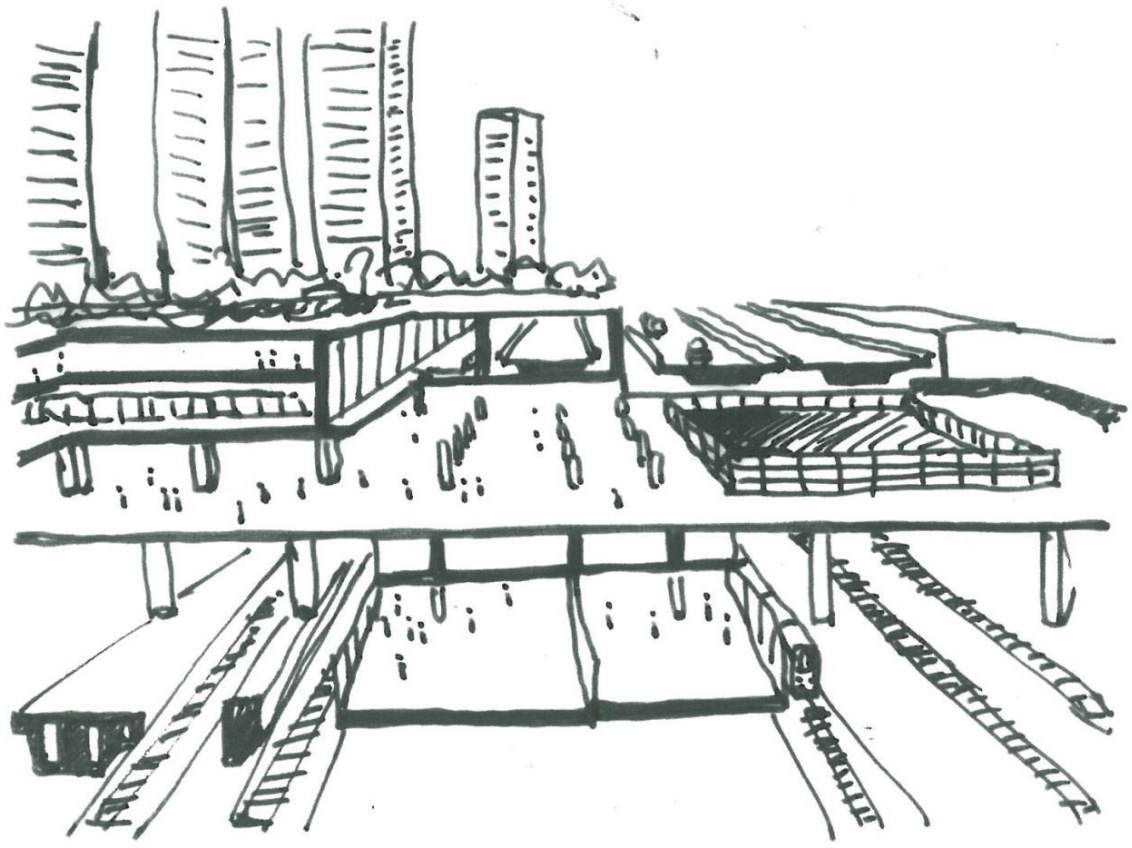


Figure 3-1. Hierarchy and integration of space and transport modes. Source: (Edwards, 2011)

Interchange design principles and guidelines

Effective designs for sustainable transport require designing the interchange at both the urban and building levels. When designing the interchange the existing urban form, the spatial movement logic of transport systems, and people movement and activity patterns within the urban form need to be reconciled and integrated (Edwards, 2011). Other tactile issues such as materiality, lighting and signage, spatial arrangements and hierarchies are also dealt with.

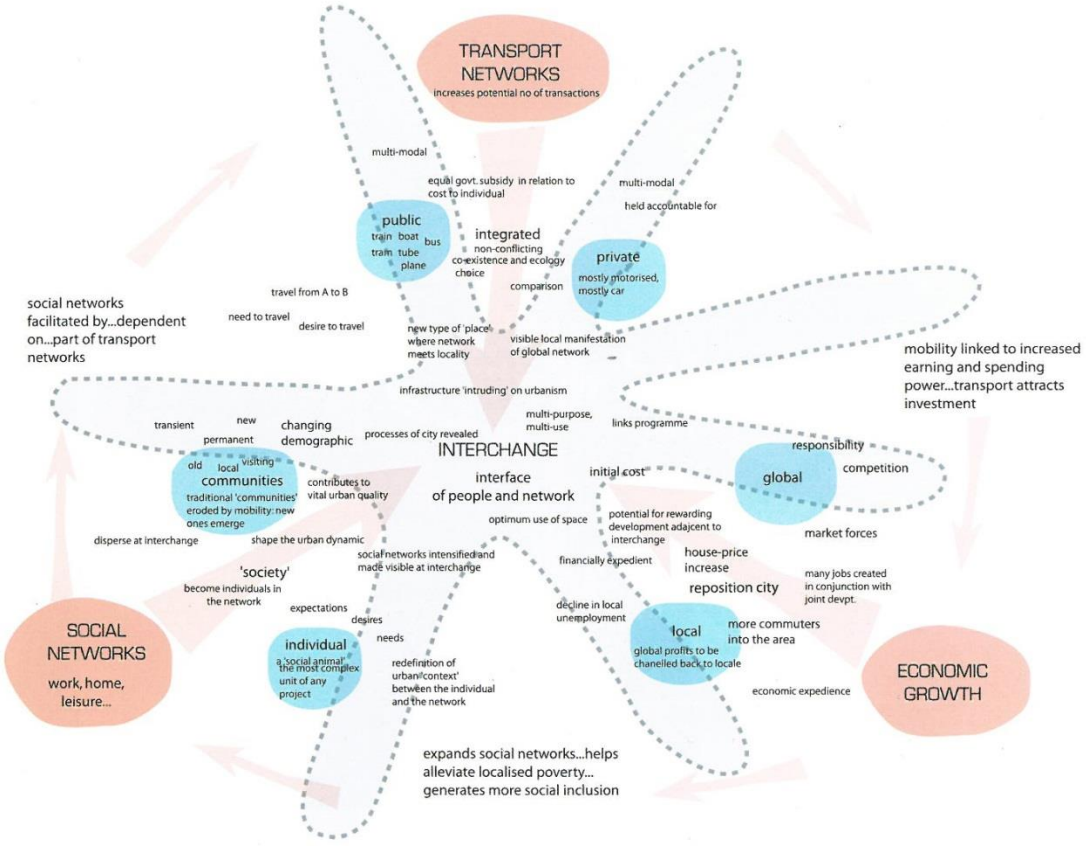


Figure 3-2. Model of the qualities for effective transport interchange. Source: (Scott, 2003)

According to the British Highways Agency transport interchanges need to be designed in such a way that they offer an **uplifting experience** where arrival and departure points are interesting and welcoming. **Visibility** of transport modes available is important and user sight lines should be unobstructed and maximised to aid navigation. In addition, the internal environments of the interchange should be **naturally lit**, provide enough circulation space for **efficient movement** and have good **air quality** (cited in Blow,

2005). In addition Edwards (2011) asserts that the interchange should be well integrated with the existing urban form and movement patterns by ensuring that interconnection is achieved by foot and urban space is reclaimed for the pedestrian. Since the focus is on adequate provision for people there is a need for social and economic space(s).

Space, movement and permeability

The fundamental planning objective for any new transport interchange is integration with existing built form and movement patterns. The complexity of this task is evident in many cities world over where transport modes interfere with and create barriers to efficient and free flowing movement. A large open or closed space enables the efficient movement and gathering of people. Priority within this space should follow a hierarchical manner starting with modes that have the least number of wheels.

Figure 3-3. Gathering space and public plaza at Strasbourg TGV station. Source: (Edwards, 2011.p.153)

Emphasis on space over infrastructure is important aspect to be considered in the design of transport interchanges in order to ensure that social objectives are given priority over

economic objectives. This assists with the (re)balancing of the sustainable triad structure alluded to earlier and enables a public shift in modal choices and travel behaviour. In articulating the plaza at transport interchanges two approaches can be considered;

- Creating an external space connected to the urban street grid
- Creating an internal or enclosed space big enough to accommodate a considerable number of people and a variety of social and economic activities (Edwards, 2011)

Since human beings, from controller to operator to commuter, are at the centre of these processes such spaces require a high level of spatial legibility, transparency and fluidity which allows for correct perception of information, efficient movement, aesthetically pleasant spaces to induce positive perceptions and secure waiting (Edwards, 2011). Easy and efficient movement in all directions increases opportunity for economic and social exchange and contributes to the growth of the socioeconomic fabric of the city.

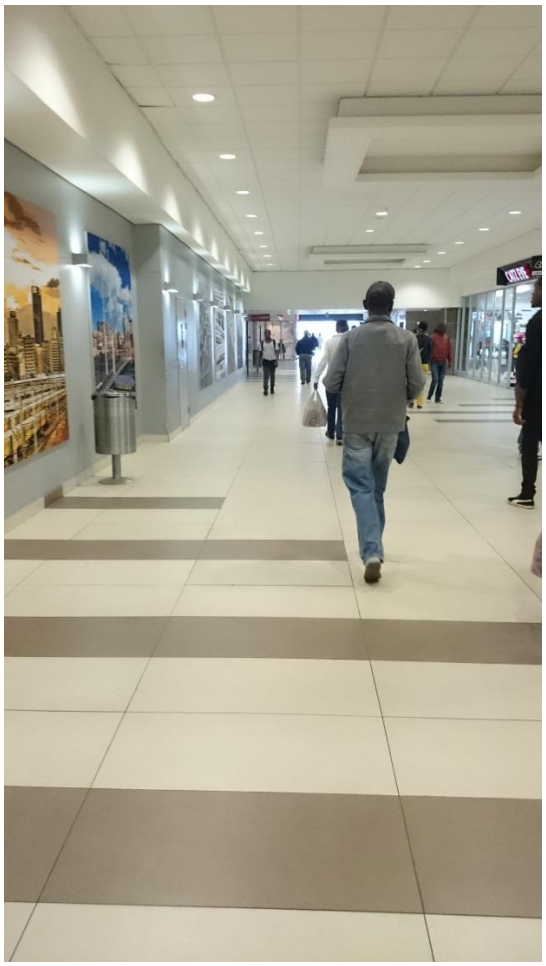


Plate 3-1, 3-2. Interior and exterior concourses at Park Station Johannesburg. Adequate space provision for formal and informal social and economic activities. Source: Author 2015

Free flowing and unobstructed movement is vital to the success of any transport interchange. The interchange should be open to all users and allow comfortable and unrestricted movement through and along its edges making good connections to surrounding urban context. It should not be open only to the travelling commuter but to all urban users (Edwards, 2011).

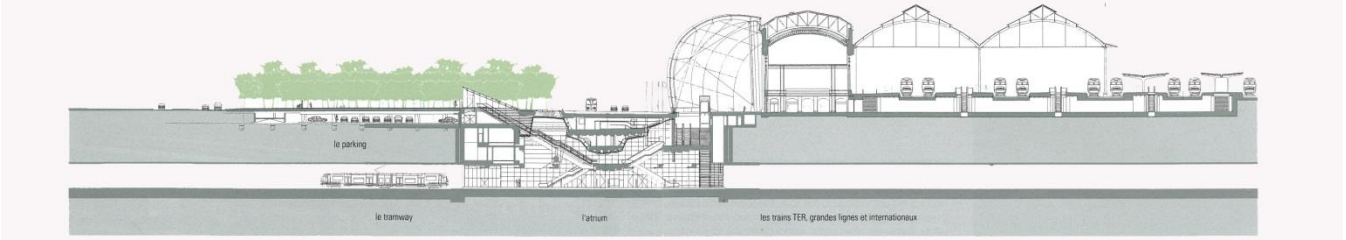


Figure 3-4. Integration with urban form and movement patterns at Waterloo station. Source: (Edwards, 2011..p.29)

The interiors of interchange must be designed to accommodate large volumes of arriving and departing passengers. Different types of movements are generated by boarding passengers, informal travellers and cross movements and all need sufficient space allocations. Edwards suggests that the most efficient and convenient configuration of transport modes is a right angled configuration.

Legibility

The interchange should be easy to locate. This can be achieved by ensuring that it is well integrated with the existing urban form/grid network and movement patterns. It should also be places in areas where the hierarchy of streets and transport modes complement each other well (Edwards, 2011). A unique building form makes the interchange stand out within the built fabric and enables it to be easily identified.

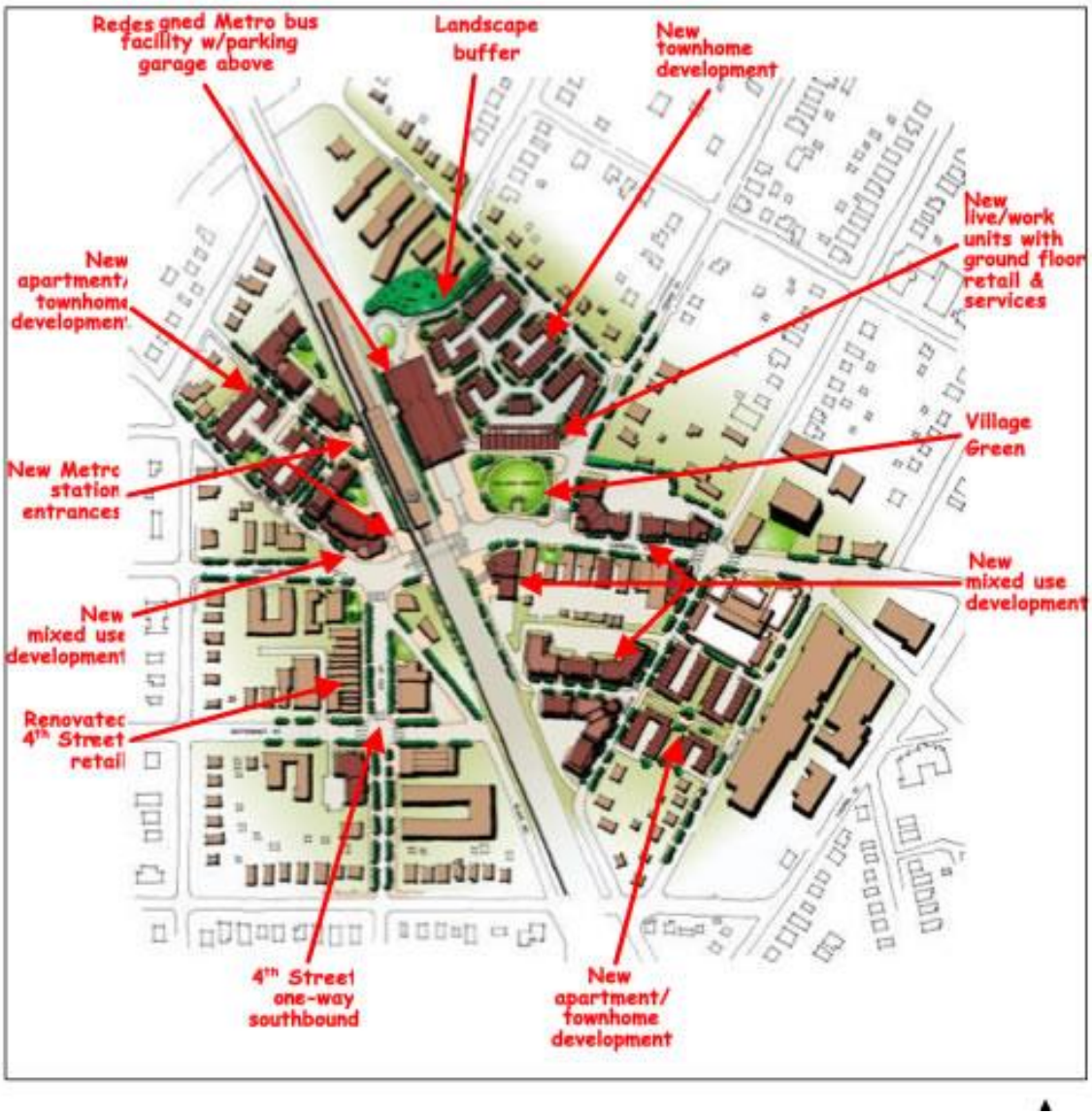


Figure 3-5. Legible form and hierarchy of movement paths. Source:

On the interior commuter orientation is maintained by ensuring that all available modes are visible. Links to the various modes need to be well lit and ventilated and consider the different levels of mobility of people, that is, some are able-bodied while others are disabled.

Figure 3-6. Section showing various modes accommodated. Source: www.city-trans.com

Comfort

User perceptions are essential to the acceptance and usability of public transport. Providing the commuter with a good travel experience plays a big role in determining the success of transport interchanges. The interchange should be welcoming to commuters and building users and provide an uplifting experience. Comfort and legibility are enhanced by use of natural lighting and a balanced use of a wide variety of materials and textures. Material and texture also help with way-finding or directing traffic and movement. Voluminous interiors ensure adequate ventilation and perception of scale the quality of spaces affect user comfort which in turn induce perceptions that have a direct impact on the decision to linger within, avoid or abuse a space.

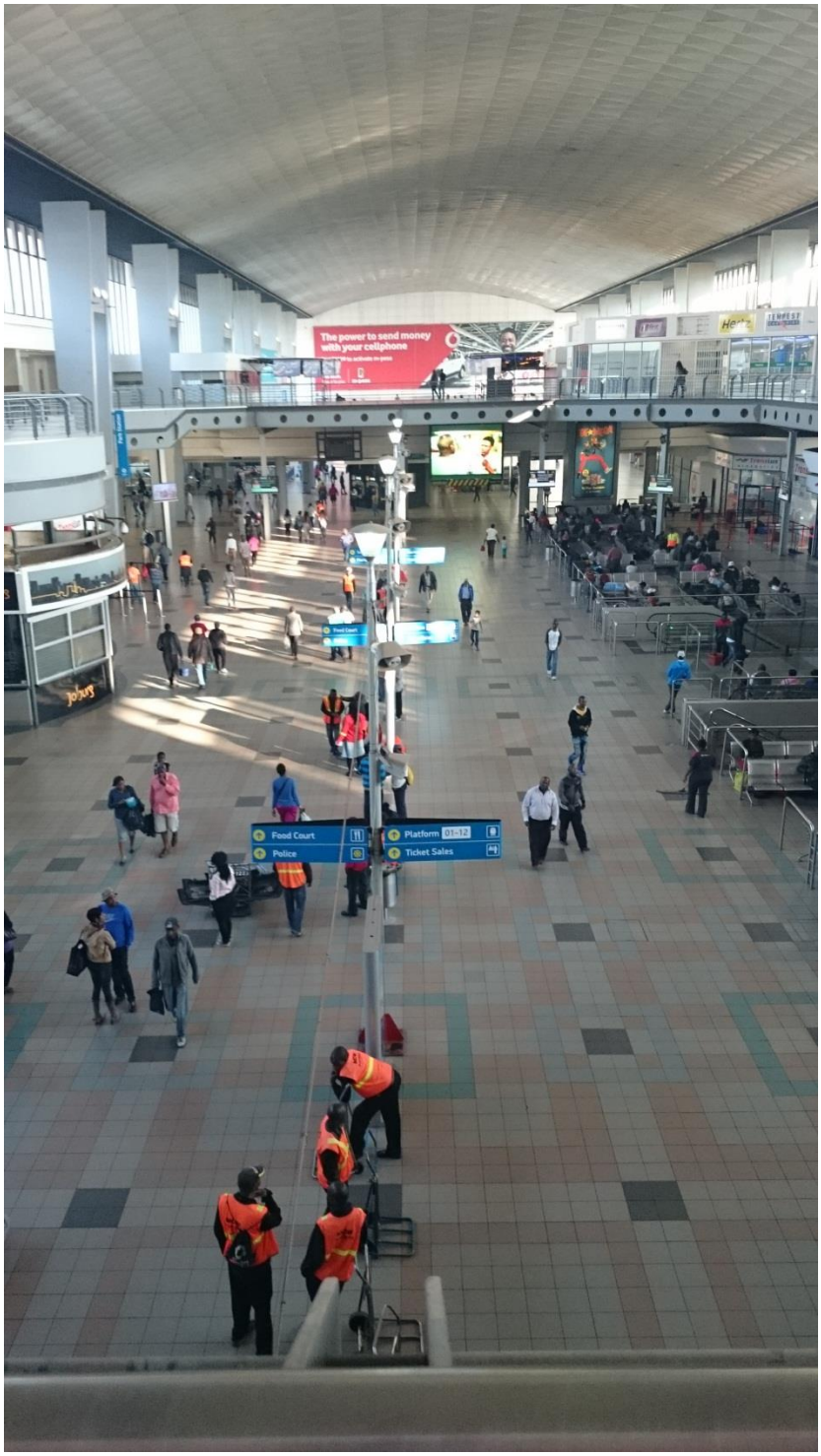


Figure 3-3. Spacious, well-lit and ventilated arrival and departure hall at Park Station, Johannesburg. Source: Author 2015

The volume of spaces needs to be in proportion and relate well to human scale. Variations in room or spatial heights assist with the hierarchical, functional and size

differentiation of rooms. Large volumes symbolise formality while low or small volumes symbolise intimacy (Alexander, 1977). The sense of arrival and welcome can therefore be achieved using high ceiling heights while low ceiling heights can be used to articulate spaces of enclosure and intimacy. The same can be used to describe gathering and transition spaces. Richards (2012) suggests that the key factors that determine the effectiveness of transport interchanges include;

- Synchronisation of transport modes
- Clear and legible way finding and crows management
- Ease of access in and out of the interchange
- Seamless transition between modes
- Availability of parking
- Availability of commercial services for convenience of commuters

Conclusions

The earth's urban population depends on safe, efficient and comfortable transport systems. Whether we travel by road, boat, rail or air we increasingly rely on our transportation systems to get us where we need to go. Transport plays an important role in the economic and urban development of urban centres in the developing world. Large populations within urban areas rely heavily on public transportation for their daily access and mobility needs. With urban populations projected to grow there is need for provision of transport *that provides access to goods and services in an efficient and socially equitable manner and protects the natural and cultural heritages of today and generations to come*. Several strategies have been developed and implemented with the aim of encouraging a shift from high dependence on private and unsustainable means of transportation to use of public transport.

However, to ensure that the implementation process is smooth, private and public stakeholders are involved and fully cooperate, and the general public benefits, there is a need for integrated approach. ITS offers an efficient and cost effective solution to the management and operation of the urban transport. To optimise these operations however requires that the urban and architectural built forms of the interchange, the interface between the commuter and ITS, be structured in such a way enables sufficient levels of

accessibility, safety, comfort, legibility, environmental sustainability, social responsibility and overall system efficiency. The urban form also needs to promote the use of alternative modes of transportation that have otherwise often overlooked and neglected in past design practice.

Chapter 4

EXPLORING THE RELATIONSHIP BETWEEN TRANSPORT AND URBAN BUILT FORM

INTRODUCTION

This chapter attempts to trace the relationship between transport and urban form from the beginning of human settlements. The intention is to make a constructive comparison between the, almost utopian, concepts of transport, urban form and their relationship with the actual urban developmental reality of transport, urban form and their relationship from the first settlements to current age. The chapter will describe urban settlements patterns and the role played by transport in each case. Particular attention will be paid to the development of science and technology, its influence on advances in transport and how that in turn affected the shaping of cities and their inhabitants. The chapter will end with a brief discussion on how urban settlements have evolved from being people places to auto-centric spaces.

Transport and urban form

Cities exist because of the agglomeration of diverse industrial and trade activities. The compactness of city provides more networking opportunities and economic advantages than any other type or form of human settlement (Rode, et al., 2014). Transportation of goods and people plays a very important role in ensuring that urban settlements continue to be productive, viable and efficient. Innovations in transport have been driven by the desire for more efficiency. Nikolaus Pevsner in *A history of building types* (1976) explains that transport innovations such as railways in the early days were a necessary precondition for the design and construction of railway station buildings. The progressive innovative development and increased use of the trains prescribed the evolution of the architecture of railway station buildings. Likewise, car garages/urban parkades, bus stations and airports only came into existence after the introduction and widespread use of cars, buses and aeroplanes, respectively, as transportation modes.

How can the benefits of urban living be retained while limiting the deterioration of transportation? To answer this question it is helpful to trace the evolution of city form and transport. Urban form and development patterns have changed significantly since the beginning of the formation of urban settlements. These changes have been influenced by a multitude of factors some of which include: transport technology, government philosophy, social values, population size, building methods, and urban design techniques

(Crawford, 2005). Streets and roads not only enable movement of goods and people within the fabric but, more critically, define the form, functional and perceptual qualities of a city. Crawford (2005) suggests that two forms street networks exist; gridiron and loose radial arrangements. He believes that the change in street patterns has made cities, over a 500 year period, evolve from rich to poorer environments.

Ancient urban settlements

From the earliest days of documented human history, humans were hunter gatherers who led nomadic lifestyles and established temporary settlements in areas where water, animals and other natural resources were in abundance. Mumford (1962) posits their movements usually followed game trails and foot was the means of movement. Over time trails became tracks then paths which formed networks that were largely organic, followed the natural contours of sloping sites and were held at maximum grade to near its lowest possible practical value. Flat terrain paths avoided drainage features and soft soils in favour of areas with firmer and drier soils (Crawford, 2005). The domestication of plant and animal species, improvement of building methods and techniques, and the development of crop cultivation led to the establishment of semi-permanent settlements.

The surplus production of storable goods, advanced systems of education and writing, more complex social organisations and technological innovations such as the potter's wheel, loom and metallurgy provided the conditions which marked the beginning of the urban revolution (ibid). As the settlements grew they formed clusters along major river systems. With time these clusters were agglomerated into bigger and more complex urban societies like the ancient civilisations of Mesopotamia and Egypt, the Indus Valley, Meso-America and Greece and Rome. The dualism of the word growth qualifies the process of urbanisation to be defined in two senses. Hall et al (1973) make the differentiation between the two as - in a physical sense – the extensive use of land for or buildings for urban purposes and, in a functional sense, the growth of social, economic and cultural activities and characteristics of an urban area.

The physical elements of an urban settlement can be divided into three categories; pathway networks, buildings and open spaces. Pathways networks carry the flows of

people, goods and services. Ancient city paths were narrow and designed for animal drawn carts and human foot traffic. Buildings provide(d) shelter to accommodate human activities. They fill(ed) in spaces between paths giving the paths defined edges and a character. Open spaces add(ed) to the quality of urban life with hard spaces like plazas and courtyards and soft spaces like parks, gardens and lawns providing the location for social and outdoor recreational activities. Successful cities from ancient to modern times pay particular attention to the arrangement of these elements to ensure that they are compatible with the daily needs and operations of their inhabitants.

Ancient civilisation urban settlements displayed both organic and regular types of urban form. The organic networks were predominant in the residential quarters of the city while the more regular and planned networks were common in the redeveloped citadel. The Greek and Roman civilisations played a major role in influencing the manner in which modern cities were built and operate. Greek urban centres grew slowly from the archaic villages characterised by irregular and organic forms. With increases in population these urban centres began to suffer problems of overpopulation, economic problems, shortage of arable and productive land and rising political tension. Between 750 and 600 BC many Greeks left mainland Greece in northern, southern, eastern and western resettlement expeditions which led to the establishment of the Greek Empire. These new colonies were consolidated and assimilated by adopting Greek culture, traditions and religions. Greek town planners used the gridiron as the basis of a systematic approach to organising conquered towns and cities (Morris, 1972).

Crawford (2005) believes that this method of planning was representative of the rulers' power and their will to impose a chosen order; a tactic that would continue to be used by future empires. The form taken by a city is usually a clear expression of the values of the civilization that built it. The dictatorial concept of society believed and practiced by the Greeks was therefore reflected in the gridiron patterns of their colonies (Zucker, 1959). For the most part however the gridiron method of (re)planning cities restricted human movement, changed the culture and tradition of the place through reconfiguration of urban blocks and (re)occupation of open spaces (Kostof, 1991). This, Kostof argues, was a way of enforcing public order and limiting temptation to obstruct passage or shield

insurrection behind barricades (ibid). As the Greek Empire expanded it encountered resistance in some parts. One such was Rome where the Greeks lost several colonial battles. It was from there that the Romans garnered strength and began conquering Greek towns in the process expanding and establishing the Roman Empire.

The Roman civilisation is believed to have risen from an Italian monarchy; when it resisted Greek conquest, to Republic; when it greatly influenced global modern government, law, politics, engineering, art, literature, architecture, technology, warfare, religion, language and society, and then Empire; when it was in control of the lands around the Mediterranean and beyond. Its domain extended from the Atlantic to Arabia and from the mouth of the Rhine to North Africa, and achieved technological and architectural feats, such as the construction of an extensive system of aqueducts and roads, as well as large monuments, palaces, and public facilities. Military necessity, maintenance of order and control, capitalist expediency, religious symbolism, aesthetic preference and simple haste were some of the motivations the Roman Empire established cities in much the same way the Greek had been establishing their colonies. Cities such as London and Paris, although having transformed in later periods, trace their origins to the Greco-Roman urban and architectural design principles (Zucker, 1959; Kostof, 1991).

Medieval and Renaissance urban settlements

The dark and middle ages, encompassed by the term 'medieval' is the period in ancient civilisation that began after the fall of Rome midway through the 6th century and ended with the beginning of the late Renaissance of the 15th century (Zucker, 1959; Morris, 1972; Crawford, 2005). Little information is available on this period and very few towns were established during this long period compared to the Greco-Roman period. The medieval period was characterised by the intellectual, scientific and creative recession that befell western civilisation due to the extinguishing of the 'light of Rome' (Mommsen, 1942).

Late into the 14th and beginning of 15th century urban development began to pick up pace in what is generally agreed to be the early Renaissance. The early towns and cities developed during this period were, by and large, based on Roman urban design. Renaissance design had not made a strong enough impact at urban scale and thus rather dormant. Local social and physical conditions affected the form of these new developments and the towns that grew around existing fortifications, churches, and villages, established during the Roman Empire, era were less regular while newly developed towns were more regular (Zucker, 1959). The appearance of the towns of this period of slow Renaissance growth was more organic than regular. Streets evolved slowly, were usually slightly curving, jogged, tapered, and were arranged by the people who used them to suit their needs and desires. Major streets converged on main civic buildings or space, such as the church, town hall, markets, or plazas (Crawford, 2005).

Plate 4-1. Curved straight, walkable street. Source: (Crawford, 2005)

Although seemingly random and haphazard medieval city urban form was designed in a way that catered to the needs of the people inhabiting them conformed to the configuration of the terrain (Sitte, 1965; Kostof, 1991). A network of narrow alleys, primarily serving pedestrians, fed into principal roads. The results of this gradual adding

onto the city over centuries by different groups of inhabitants with different needs gave the inhabitants opportunities to reflect and correct faults; a sequence Alexander (2005) credits for great cities. Medieval urban form shows a great sensitivity to the creation of good space. Some authors, however, feel that the absence of a single brilliant master plan represents poor urban design; a position Crawford (2005) equates to the Great one casting his pearls before the swine.

Late Renaissance urban settlements

Into the 15th and 16th centuries - period called the late Renaissance - urban areas experienced rapid growth. Most old town extensions were planned using the rigid grid while new towns in parts of southern Italy and the New world were fully gridded and usually had a square in the centre (Kostof, 1991). Architects and town planners conceived the city as a piece of architecture and strongly desired to give it an aesthetically pleasing and functional order. New palaces, courts and civic buildings were constructed and grand scale was highly sought after in public space. Long and wide avenues, radial street networks, monumental squares and geometric parks and gardens became the order of urban design. The application of rigid rules by one overarching authority reflects the authoritarian thread that ran through this era of increasing powerful monarchs. The resultant urban design was beautiful at first glance but lacked the ability to evolve and was often characterised by cool static space.


Plate 4-2, 4-3. Comparison of medieval and renaissance city streets. Source (Crawford, 2005)

Morris (History of Urban Form: Prehistory to Renaissance, 1972) suggests that the; preoccupation with symmetry, creation of balanced axial compositions with central

motifs, placement of monumental buildings, obelisks, and statues at the ends of long, straight streets, and creation of primary straight streets for carriage travel, resulted in repetitive and monotonous urban form. Urban traffic patterns became the basis for street design and streets were grouped under three main categories; traffic space, residential space and pedestrian space. Traffic space constituted the main urban traffic routes and was shared with pedestrians. Residential space was meant to service local traffic only and was predominantly composed of recreational space. Pedestrian space was reserved for pedestrian only and carriage traffic was often excluded (ibid). Traffic and the prevailing Renaissance aesthetics and ideas of street design were main factors that dictate urban form. As the period progressed the gridiron was increasingly used in laying out cities and reinforced the architectural aesthetic uniformity considered fashionable at the time; a stark contrast to the old and much favoured organic and romantic street patterns and multi-faceted edge (building facades).

Over all medieval urban street design and arrangements were considered better than the monotonous results of the Renaissance methods. Human intuition of the medieval period rather than the systematic mechanisation of renaissance inspired the crystallizations of the human spirit in place (Zucker, 1959; Morris, 1972).

Baroque urban settlements

Rene Descartes was arguably the greatest driver of the Baroque movement. The baroque movement has been influential since the early mid-17th century well into the 20th and 21st centuries. During this time the changes in street and urban design have not been as vast and radical as the changes that occurred in the shift from medieval to renaissance movements. As a reflection of Cartesian logic straight lines dominate Baroque planning and as cities grew, wheeled transport concerns received more importance. Crawford (2005) links this expression to the core values of the wealthy rulers of the nation-states and absolute monarchs. Influential individuals with the desire to exercise their power imposed their ideas and plans on a site and topography and local context, although accurately ascertained, were suppressed or dramatized depending on their usefulness to the intentions of the designer (Kostof, 1991). This actively caused a shift in the manner in which urban space was regarded. Avenues and boulevards, designed and built straight

and wide to imbue a high sense of dignity and majesty, and facilitate the movement of wheeled vehicles such as coaches and rail street cars, became the most important urban design elements in the baroque city (Morris, 1972). In other instances straight diagonal streets were added to strike through a regular grid reflecting the commitment of the movement to straight streets. In comparing the differences between baroque and renaissance design Morris (ibid) and Zucker (1959) note that Renaissance intended to;

- Portray beauty and clam
- Present a perfect picturesque scene
- Reveal nothing uneasy, agitated or forced
- Make people experiencing the space linger longer in its presence

Baroque on the other hand intended to;

- Overwhelmingly impose its presence
- Have a brief but effective impact on the observer
- Impress and offer nothing more beyond that

It is no wonder some of the cities built by the current and recent past empires exhibit strong characteristics of baroque planning for example Washington DC and beautiful city movement in 20th century USA and British colonies where the motor vehicle, the symbol of power, success and freedom dominates.

Industrial urban settlements

The 18th century brought about changes in the socioeconomic structures of urban societies which in the long run had severe impacts on the course of urban development. Trade and manufacturing had been common in human settlements since the agrarian age. Rural populations, as the managers and primary producers of raw material such as wool and cotton used in the textile industry, provided most of the manufacturing labour. The desire to minimise costs and production time, and increase profits led to the invention of specialised machinery. As the manufacturing industry grew and became more profitable than the agricultural industry there was a gradual net movement of populations from rural to urban centres, the location of production factories. The incoming populations were often housed on the outskirts of factory and mill districts in overcrowded and mass

produced housing. Commerce assumed primacy over religious, political and cultural factors as the driver of urban form and this had an overall negative impact on city design, signalling the decline of design skills of ordinary people (Hale, 1994). This transition from the agrarian society to industrial society is what is commonly referred to as the industrial revolution. The first revolution took place in Europe from the mid-18th century to the early 19th century and many other nations soon followed that pattern of development (Pollard, 1981).

Architecture and urban design during the industrial age followed structural concepts. Logical and functional approaches took precedence over imaginative directed creative processes as had been seen in the previous epochs. Simplicity was chosen over the richness and variety of expression. The gridiron expressed itself more than ever in the form of straight lines and rectangularity, and streets soon became more important than the square within urban settlements (Zucker, 1959). Technological innovations such as the railroad, steam engine, and horse cars of 1830's, cable cars and electric trolleys of the 1870's and 1880's enable the rapid expansion of the typical urban form and also spurned extensive changes in street design. Streets were made to be so wide that squares could only exist by being made wider. Sitte (City planning according to the artistic principles, 1965) believes this made it difficult for building edges to create a sense of enclosure; a basic human desire. The 'faulty closure of the sides of the street' effect, primarily caused by extensive width of streets, sacrificed the comfort of human scale enclosure for transport needs. This situation would worsen when motor vehicles began to dominate urban space (ibid).

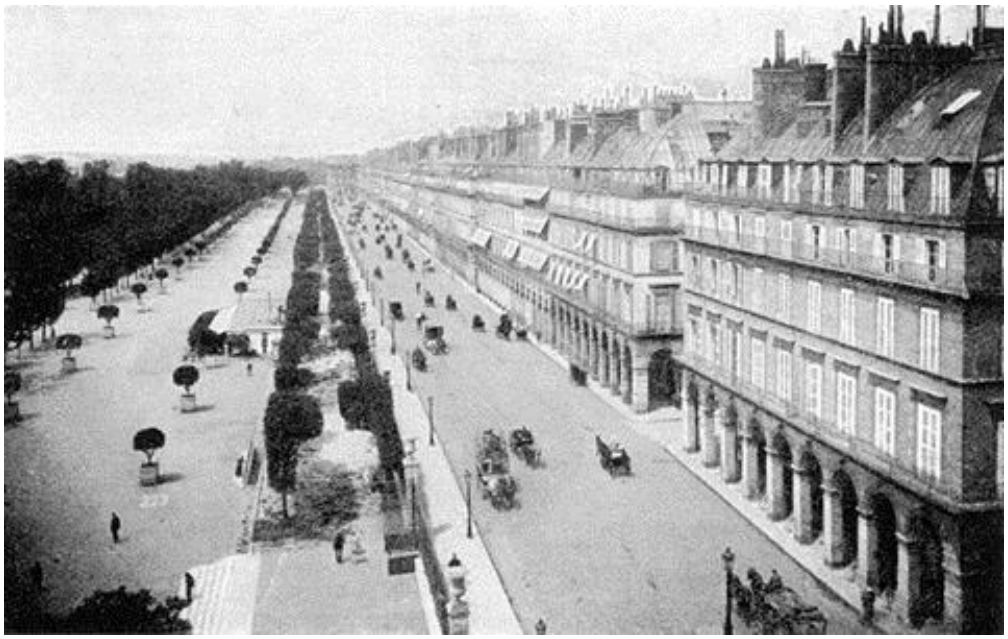


Plate 4-4. Wide boulevard designed for street cars in Early Paris. Source: (Crawford, 2005)

Modern urban settlements and the advent of the automobile

Modern architecture is purported to have started a century after the beginning of industrialisation largely as a reaction to the industrialisation and the mass production of goods negatively affecting the world (Crawford, 2005). By the 20th century modernism was well on the course of breaking away from the design thought of all previous eras and reinventing culture to suit what was perceived to be the dawning new age. Technological innovations were expected to end the hunger, clean up urban squalor and eliminate urban 'ugliness' (Crawford, 2005). Architecture was widely used a tool to drive this change and from this several movements such as the Bauhaus movement rose to prominence. The Bauhaus movement introduced an uplifting, clean-cut, minimalist type of architecture. During this period the motor car was at the beginning phase of its modern evolution. It was held in high esteem and regarded as an icon of the era. The motor car was regarded as the invention that would bring freedom to all and wedded to modern architecture an urban design. It is reported that Le Corbusier often specified that a motor vehicle be parked in from of his buildings during photo-shoots. It is this strong connection to the car that led to radical schemes proposing the demolition of vast areas of urban land and imposing broad highways and skyscrapers.

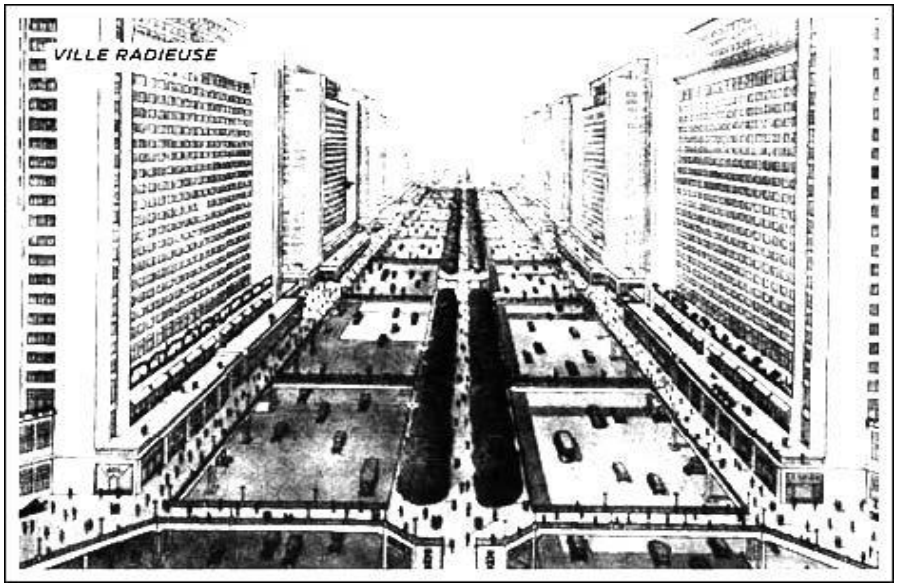


Figure 4-1. LeCorbusier conceptual sketch for a utopian city. Wide boulevards flanked by tall glass towers. Source: Unknown

The construction of developed world cities around the private motor car was further encouraged and facilitated by flawed urban development policy. The accommodation of the demands of mass motorisation significantly reshaped the urban realm with extensive road and highway building being undertaken to provide support for the use of the automobile. It is reported that from 1960 to 2010 private vehicle transportation has grown rapidly in cities around the world with registered cars and registered trucks and buses having increased from 100 million to 700 million and 30 million to 300 million, respectively (Davis, Diegel, & Boundy, 2011; VanAudenhove, Korniichuk, Dauby, & Pourbaix, 2014).

Plate 4-5. Spatial injustice in modern urban settlements. Source : www.wikipedia.org

The right to space

Urban transportation in the 21st century is increasingly becoming characterised by high travel kilometres as more and more people depend on the motor car for their travel needs. This increase in car ownership has been met by a decline in public transit patronage and decline in public transport service. The proliferation of motor vehicles has also caused a horizontal expansion of cities, a development pattern commonly known as urban sprawl. Sprawl, the anti-thesis of the ideal compact and self-sufficient city form, has been perceived as a negative form of urban development which compromises the ability of the non-drivers to easily reach suburban oriented destinations and resources. This adversely affects the social, economic aspects of society and often leads to negative environmental consequences. Sprawl is often perceived in such negative light because of (Longley, Batty, & Chin, 2005):

- the un-aesthetic forms of development it produces (e.g informal and scattered settlements)
- poor access to services for those with limited mobility such as the young and elderly;
- increased trip lengths and congestion;
- increase in fuel consumption due to low densities;
- overwhelming dependence on automobile use;
- higher costs of provision of neighbourhood infrastructure;
- increased loss of agricultural land and open space.

The domination of urban space by the motor car has also had negative effects on the quality and quantity of urban space that, ideally, should be reserved for use by humans. This is evident in transport evaluation processes which are responsible for urban traffic planning and influence urban design decisions. Where the private car is dominant, evaluation is based on vehicle travel conditions and assesses factors such as traffic speeds, congestion, delay and road-way levels of services (LOS). The result is the improvement of the transport system by focusing on improvement of roadways, for example road widening or conversion to one way use, and expansion of roadway network. Where mobility for people is the basis for evaluation rideshare and public transit improvements are made.

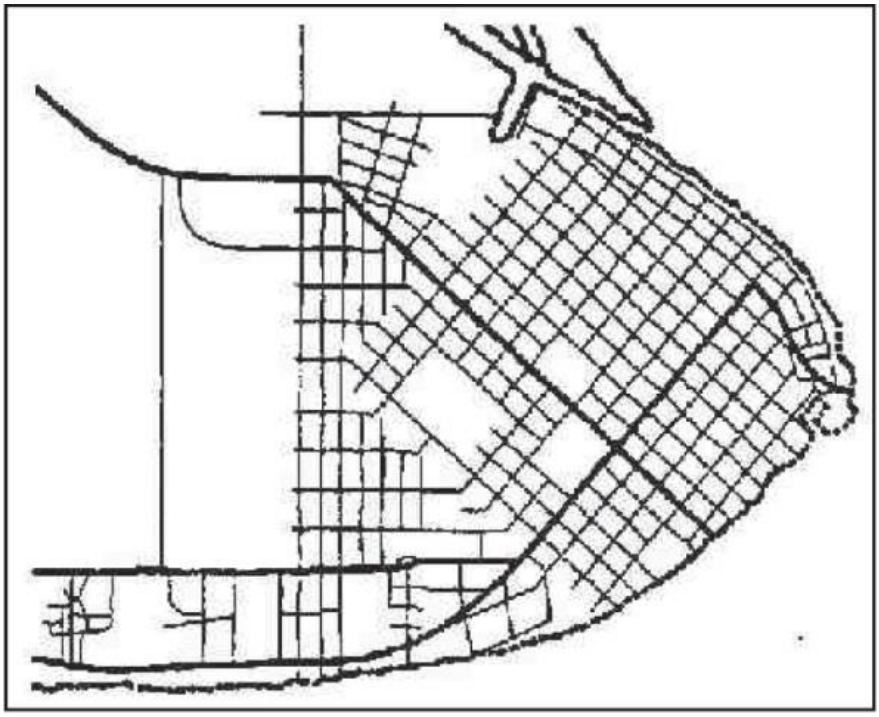


Figure 4-2. Dense, neighbourhood scale urban form that provides high connectivity for NMT in Savannah, Georgia. Source (Cervero, 2004)

When the focus is on people and evaluation is based on enabling their access to desired destinations, goods and services as easy, comfortable and fast as possible, improvement options do not only focus on roadway and mobility improvements but equally, and more importantly, ensure the improvement of urban form to optimise walking and cycling, and increase density and variety of land-uses, to substitute the need for motorised travel (Litman, , 2015). Accessibility based planning and design therefore drive development of urban transport systems that have less negative effects on the social, economic and environment aspects of urbanity (ibid).

	VEHICLE TRAVEL	MOBILITY	ACCESSIBILITY
Definition of transport	Vehicle travel	Person and goods movement	Ability to obtain goods, services and activities
Measurement units	Vehicle miles	Person-miles and ton-miles	Trips, generalised costs
Modes considered	Automobile and truck	Automobile, truck and transit	Automobile, truck, transit, cycling and walking
Common indicators	Vehicle traffic volumes and speeds, roadway levels of service, costs per vehicle-mile, parking	Travel distance and speeds, road and transit level of service, cost per person-mile, travel convenience	Quality of available transportation choices. Distribution of destination. Cost per trip
Consumer benefits considered	Maximum motor vehicle travel and speeds	Maximum personal travel and goods movement	Maximum transport choice and cost efficiency
Consideration of land use	Treats land use as an input, unaffected by transportation decisions	Recognises that land use can affect travel choice	Recognises that land use has major impacts on transportation
Favoured transport improvement strategies	Roadway and parking improvements to increase capacity, speed and safety	Transportation system improvements that increase capacity, speeds and safety	Management strategies and improvements that increase transport system efficiency and safety
Transport demand management	Generally considers vehicle travel reductions undesirable	Supports TDM strategies that improve personal and freight mobility	Supports TDM whenever it is cost effective

Table 4-1. Comparison of three different perspectives used to measure transportation (Litman, Evaluating criticism of smart growth, 2015)

As eluded to earlier, the car itself is not bad. Bannister et al., (1993) suggest that it should not be banished completely but instead incorporated and integrated into the transport network; after all the car provides a critical link between the sprawling suburbs and the public transport hubs, something public transport does not do as well. The aim rather should be to decreasing the dependence on the motor car by increasing the investment in public transportation infrastructure and services to ensure that it reaches the high standards in quality, comfort and efficiency expected and increasingly demanded by the

commuting public. The alternative to the highly intrusive and unsustainable car and motorised transport is public transport and non-motorised transportation such as walking and cycling. These are the most sustainable modes of urban transportation and should be given priority in urban policy and development plans.

Conclusions

Transport and urban form exist in a symbiotic relationship – a classic chicken and egg dilemma. Bannister (2005) however believes that built form is a stronger influencer of transport (mode choices and/or transport technologies adopted). The built form also influences travel characteristics such as trip frequency, journey lengths and the resultant energy consumption and emissions. Early city urban forms were compact and dense and this enabled the use of non-motorised transportation in the transportation of people and goods. As urban social and economic structures evolved there was need for faster, more comfortable and reliable means of transportation. The greater the efficiency – speed, comfort and reliability – of these services, the greater the economic benefits for all through economies of scale and networking advantages (Rode, et al., 2014).

Motorised transportation is the main mode of movement for people and goods and most cities that are not dependant on motorised transportation for the majority of movement of people and goods are relatively poor and strive to change this situation. This 'developed' state, as evidenced in industrialised or first world cities around the world, comes with the highest travel times, greatest congestion and worst pollution. For rapidly developing cities it is therefore of great importance to ensure that development takes a course that does not erode the social, economic and environmental fabrics of urban society.

Reducing the demand for transport at the origin is one of the most efficient ways to address the urban transport challenges. Medieval cities were built for walking and this necessitated the close proximity of live and work places. As human settlements developed and became more complex transport technologies advanced. Rail, for example, made spatial division of labour possible and allowed for the expansion of cities. Personal vehicle and mass transit followed and these enabled the further expansion of cities and increased average travel kilometres, traffic volumes, accidents, energy consumption,

environmental pollution and land consumption through sprawl or suburbanisation (Greene & Wegener, 1997). To curb these problems and return to the sustainable pathway there is a need for better transport demand management and this can be done by;

- promoting high density, mixed land use
- substituting travel through the use of telecommunications
- increasing use of advanced transport systems
- giving priority or right-of-way to high-occupancy, NMT, and energy efficient modes of transport

Chapter 5

THE ARCHITECTURE OF URBAN PUBLIC TRANSPORT: REVIEW OF MODERN BEST PRACTICE

Introduction

"*An automobile is a machine for mobility. A city is a machine for accessibility. When people say, "location, location, location," they really mean "accessibility, accessibility,accessibility*."

-T. Litman (2015)

Modern technologies of the 21st century have not yet been fully understood or adopted into the urban realm especially into the developing world. As such identifying the physical urban architectural forms of intelligent transport systems is difficult because these systems operate in a virtual realm that is unseen but connected to visible urban processes (Shephard, 2009). Expecting to find examples of intelligent transport system physical architecture is rather naïve and what this section of the research study aims to do is to explore the social and economic aspects, the common point between urban commuters and intelligent transport systems. By understanding this relationship planning and design professionals and practitioners may be enabled to articulate a meaningful architectural and urban fabric.

Urban form efficiency: Curitiba Metropolitan Urban Transport Framework

Introduction and Background

Situated 400km from Sao Paolo and in Brazil's southern Parana state, Curitiba is a metropolitan region comprised covers an area of about 432sqkm and has a population that sits just over 3,300,000 inhabitants. The urban planning and policy making in Curitiba have made it one the world's leaders in modern urban development, management, urban public transport and natural environmental sustainability since the late 1970's.

Urban transport system

Curitiba's urban public transport system has been widely published and is highly emulated globally. The bus and urban planning systems have become leading examples of successful integrated urban and transport planning (Logan, 2012). Curitiba has a modern BRT system that was developed as an integral component of an overall master

plan where the city ensured that land use planning and transportation complement each other. The system has also been reported to be highly socially and economically sustainable as more than 70% of the population use and can afford the bus service (Peinaar, Krynauw, & Perold, 2005).

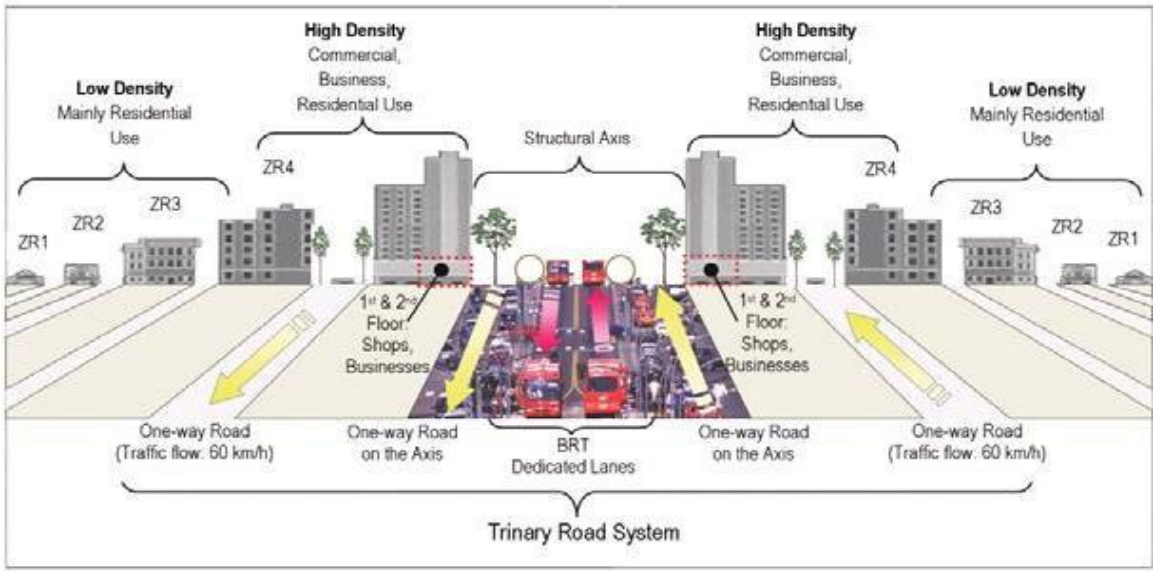


Figure 5-1. Trinary road system. Source: www.wikipedia.org

The structure of the transport system is based on the trinary road system in which a central bus way is anchored by high density development. Development grows along five principal axes or corridors the central bus way is also supported by a smaller or narrower streets and a one-way arterial route (Logan, 2012).

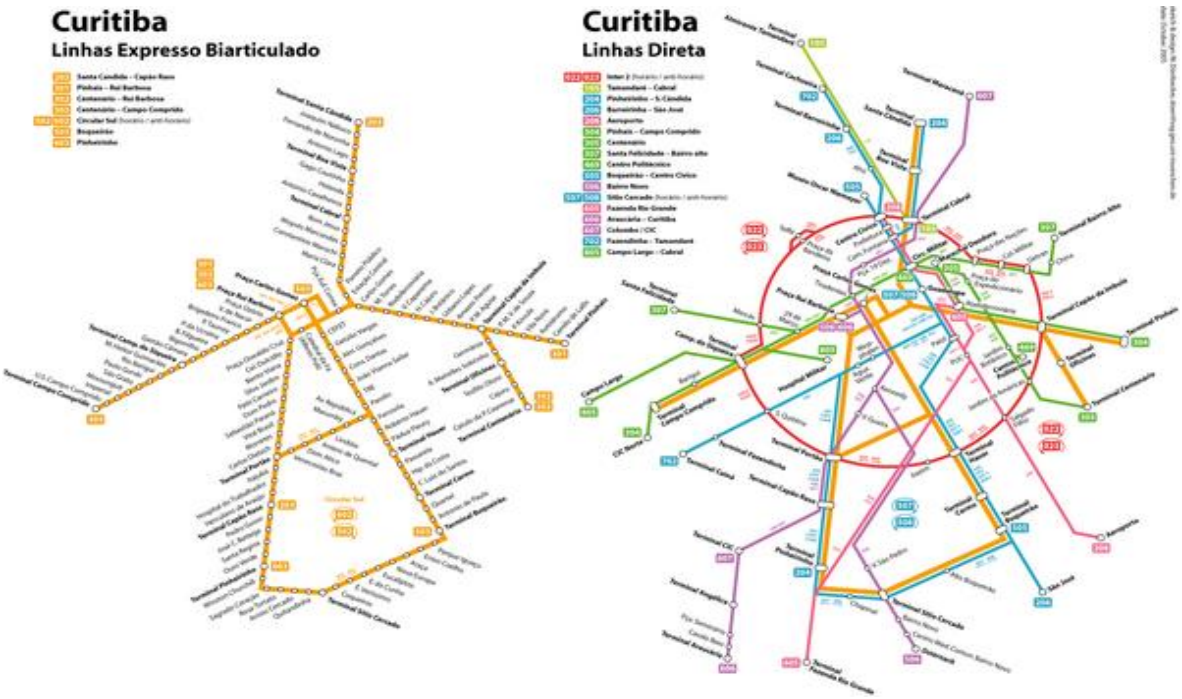


Figure 5-2. Curitiba transit system. Source: www.curitiba.info/map-of-curitiba

Curitiba's BRT travel demand is further increased when the BRT system lines reach and cross the central business district where traffic management strategies such as dedicated bus lanes, private car parking restrictions and street pedestrian zones are strictly enforced. Secondary feeder services are integrated into the bus way system at interchanges and stops (TRCP, 2002). In the case of most African cities where commuter omnibuses form an integral part of the transport system, they will constitute the feeder system and be integrated into the CBD or other specified area BRT system. This helps prevent potential clashes between private transport operators who operate the urban-suburban routes and city operators who operate the CBD area.

Several guidelines have been identified as key to the integration of transport and land use in Curitiba. These are;

- Promotion of a linear urban form through integration of public transport, road networks and land use along major corridors
- Decongestion and preservation of the central business district of urban core
- Citywide urban land use management
- Creation of employment opportunities and realization of urban land use aims by providing economic support structures

- Urban infrastructure improvement (Rabinovicth & Leitmann, 1993)

Several points have also been developed by the Transit Cooperative Research Programme which outlines the requirements for a successful urban transit system. The requirements include; a well-used system that prioritises public transit services, a system that is financially viable for both operators and users, a system that increase traffic flow efficiency and provides good access to urban destinations and resources, and a transport in which land use planning provides a high passenger demand (TRCP, 2002). As far as urban precinct integration is concerned Curitiba exhibits good urban framework within which the BRT functions. Accessibility is increased to the system thank to the implementation of;

- Pedestrian priority zones in which inner city streets are open only to non-motorised transport modes such as walking and cycling
- A good mix of land uses vertically and horizontally; retail, residential and office and public space

Plate 5-1, 5-2. Typical BRT stop in Curitiba urban transport system. Source: www.wikipedia.org

Transport mode integration: Stratford Transport Interchange

Background and introduction

The Stratford terminus in London, United Kingdom, was developed by London Underground and Stratford Development Group. The building's architectural design was handled by Wilkinson Eyre Architects. Work on the project commenced in 1996 reaching final completion in mid 1998. The brief called for the creation of "*a single major space to serve the various train lines and unify the disparate identities of the respective train services"*. In addition the terminus was to cater for future transport expansion projects. A new external

civic square, clock tower to celebrate British railway transport heritage, and road improvements were part of the project design objectives. The terminus was designed to serve train, bus, taxi (meter cab), and bicycle modes. It also improved pedestrian links to the town centre and nearby residential areas.

Building image

The terminus is 100m x 35m and is 14m high. Keeping in line with the objective of rejuvenating the area the terminus has a strong external image portrayed through the use of stainless steel, glass, self-finished materials like the polished terrazzo floor tiles and prefabricated elements.

Plate 5-4. The elliptical quadrant section. Source: www.wilkinsoneyrie.com

The combination of these elements and the unique upward curving roof shape which springs from an embankment and projects over the main 100m long glass façade give the terminus a strong landmark building status that is robust and is easy to identify and reference.

Spatial planning

The terminus straddles a couple of north-south rail lines and sits parallel to a couple of other east-west running lines. The terminus' main entrance faces a public plaza that serves as the main arrival space for the bus, bicycle, taxi and pedestrian modes.

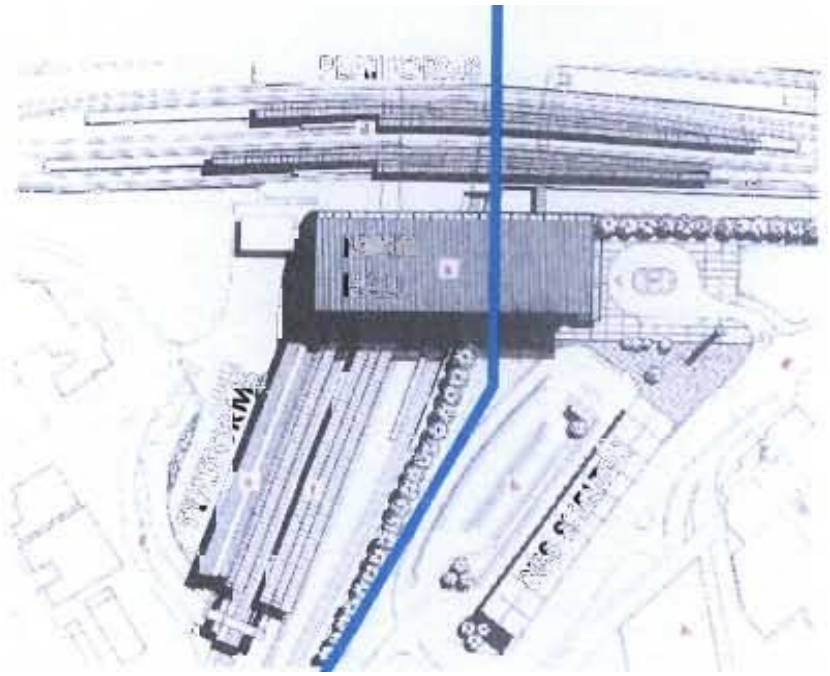


Figure 5-3. Spatial plan and zoning of the interchange precinct (Davey, 1999)

The plaza provides

- sufficient space for efficient movement between the main terminus and other transport modes
- reception area for arriving commuters and gathering space for (in)formal social and recreational purposes.

A plaza or large open 'forecourt' would/can also be used for informal economic activities in countries where informal trade is common or permitted. The plaza also acts as a directional marker as it orients commuters to the terminus' main entrance.

Figure 5-4. main pedestrian links and plaza. Source: www.queenelizabetholympicpark.co.uk

Circulation

The main components of the building's accommodation are the ticketing hall, retail and office spaces and commuter concourse(s). The ticketing hall and retail and offices surround the main entrance. These spill out onto the main (lower) concourse which is split in two by the north-south lines. Lifts, and stairs and escalators with good width and gentle gradients provide access to the upper concourse which runs the entire 100m length of the building, is at the same height as the embankment which carries the east-west rail lines, and enables commuters to access the north-south rail platforms. Access to the east west rail lines platforms is through a tunnel that is entered from the lower concourse. The simple rectangular shape of the floor plan allows for maintenance of good sightlines and lighting and this increases security and efficiency of movement.

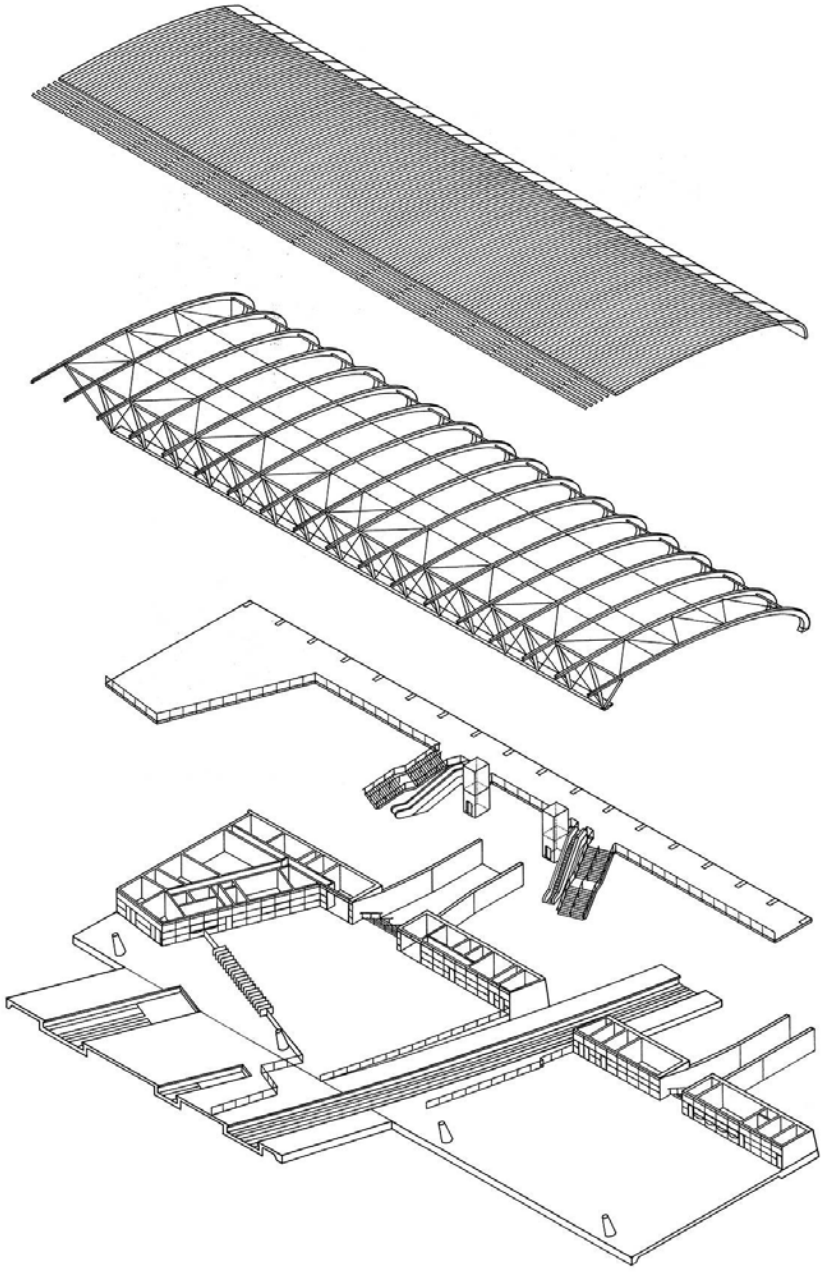


Figure 5-9. axonometric projection showing north-south rail line, lower and upper concourses and terminus superstructure elements: www.wilkinsoneyrie.com

Architectural technology and environmental sustainability

Curved plate girder ribs placed at set intervals are the main structural component of the roof. The lower end of the girder rib trusses are anchored against the embankment and curve upwards across the 35m width of the building and rest on 8m deep trusses that run

along the length of the building. These trusses carry the load of the glass curtain wall. The interior roof ceiling panels are made of a reflective metallic silver material which brightens the space during the day and reflects flood light into the interior at night thus maintaining high levels of lighting at night.

Three side of the building are glazed; the main southern façade and the two narrow ends of the building. This extensive glazing allows natural light to flood the double volume space during the day and gives the interior a welcoming, bright and airy feel. Solar heat gain is kept to a minimum low by the projecting roof and its brie solei sun louvers and extensive overhangs on the east and western sides. The building is naturally ventilated by means of glazed vents in the lower end of the roof which naturally draw in air draughts up into the double volume and out though opening in the main glass façade.

Fig 5-3. View of arrival outdoor plaza. Source: www.123rf.com

[RE]defining public transport: Southern Cross Transport Interchange

Introduction

Southern Cross Station (SCS) is located in the Australian city of Melbourne along spencer street between Collins street and La Trobe street in the western central business district.

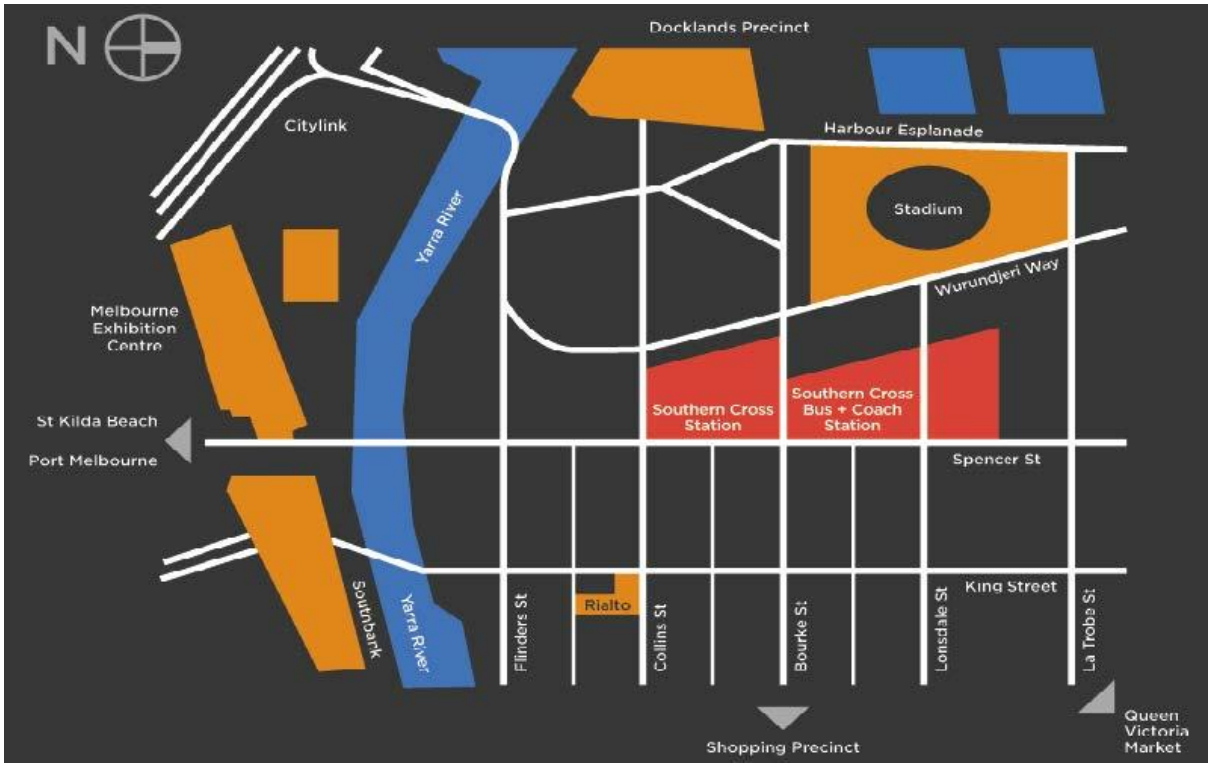


Figure 5-5. Souther Cross Station urban precinct. Source: www.southerncross.au.net

SCS accommodates rail, bus, tram and meter taxi transport modes. Rail transport runs overland regional services to Sydney and Adelaide, and a central business district underground city loop service. Buses service the outer Melbourne region and an airport shuttle (www.southerncrossstation.au.net). The station is estimated to carry a daily passenger volume averaging just above 4000.

History and background

SCS first opened its doors to the public in 1859. It originally operated as Batman's Hill Railway Station then Spencer Street Station before being called SCS (Brown, 2002). Country platforms that serve the regional rail service were built between 1888 and 1894 and laid out at an angle to Spencer St as they are today (Brown, 2002). The original iron

sheds were replaced in 1960 when, at the inception of an interstate railway link to Sydney, work on the Spencer street station design began (Brown, 2002). A 415m main platform and addition of a double viaduct were the main new features of Spencer street station.

Plate 5-5. Batman hill station in 1889. Source: www.wikipedia.org

Building image

From the 1970's the western Melbourne docklands had a bad reputation as dirty and dangerous after the shipping industry pushed south from the area (Roke, 2007). It was not long thereafter that the Melbourne Docklands Redevelopment Scheme revitalised the area with the addition of new residential projects, several public buildings and recreational facilities such as the Etihad stadium (Roke, 2007). The spencer street station however acted as a buffer zone between the western city's edge and wastelands close to the harbour esplanade (Raisbeck, 2007). The current building design bridges the void in the urban fabric between the new Docklands and the old CBD. The civic duty of the building in accommodating all of Melbourne's public transport services; local and regional trains, bus terminus, airport shuttle and 800 car parking space; is well addressed and clearly articulated (Roke, 2007).

Plate 5-6. Internal concourse at SCS. Source: www.flickr.com

Spatial Planning

The train platforms were shifted north to create space that the architects could use to activate the street edges by inserting public spaces along the streets.

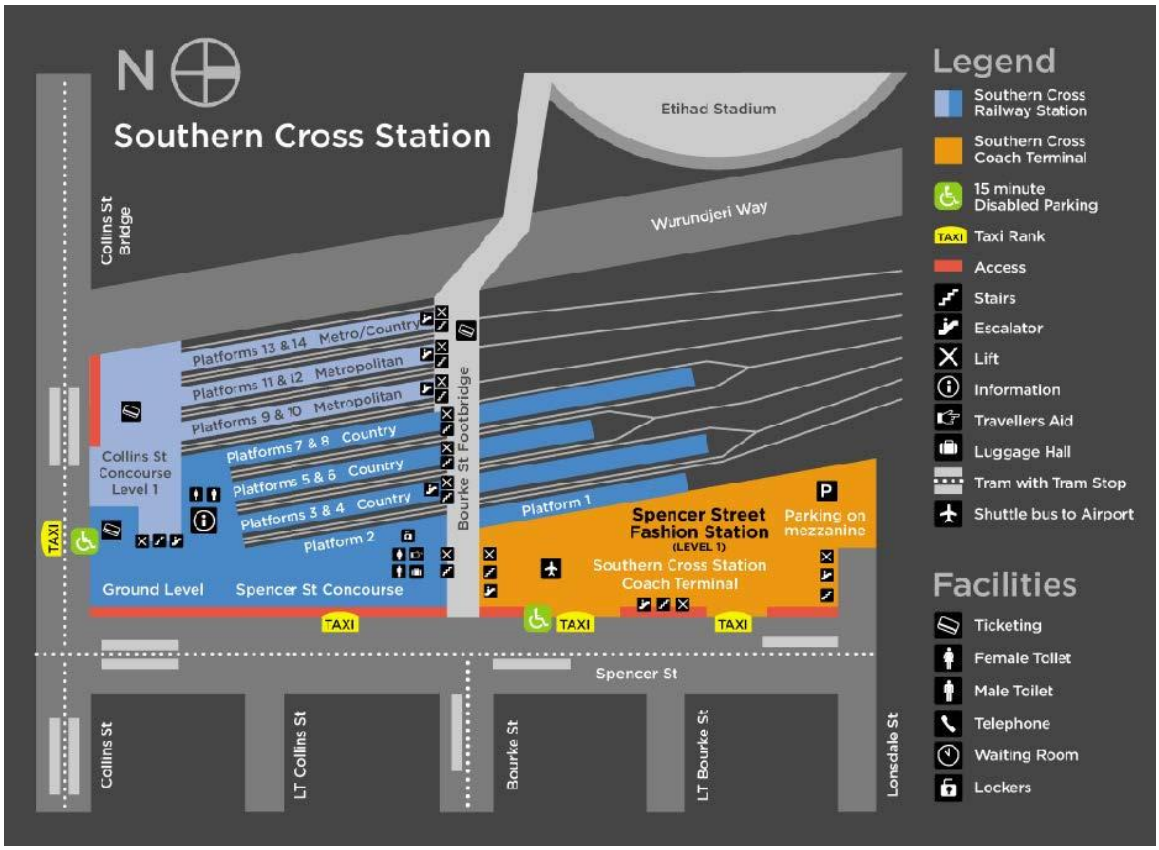


Figure 5-6. Planning at SCS. Source: www.southerncrossstation.com

The shift also enabled the creation of a pedestrian concourse which, at natural grade, allows for;

- Celebration of the main entrance at corner spencer and Collins streets
- The seamless transition from street to station
- A well lit and uncluttered space that reinforces public safety (Raisbeck, 2007)

Administration and retails activities form part of the accommodation at SCS. The administration activities are housed in raised bright yellow pods with retail space taking up the spaces below the raised pods. The raised pods also provide good surveillance through the station and onto the train platforms (Raisbeck, 2007).

Plate 5-7. Raised administration pods above the concourse. Source: (Roke, 2007)

The façade treatment at SCS allows for natural lighting, smooth transition between inside and outside, visual connection to the city while the roof's large overhangs avoid the internal spaces from overheating.

Plate 5-8. Corner view showing transparent façade and roof overhangs. Source: (Raisbeck, 2007)

Architectural technology and environmental sustainability

The SCS is a highly environmentally sustainable building whose impressive roof structure provides adequate shading and cooling for the vast civic space it covers. The environmentally responsive roof is oriented in such a way that it responds to the prevailing winds. It acts as a filter for the harmful fumes produced by the vehicle diesel engines. The aluminium domes of the desert dune shaped roof collect the hot grimy air from the track area below and extract the air through louvred venturi caps (Roke, 2007). This system enables an effective passive ventilation and cooling system. Spine trusses that run along the entire length of the building, corresponding to the structure below, provide natural lighting deep into the space.

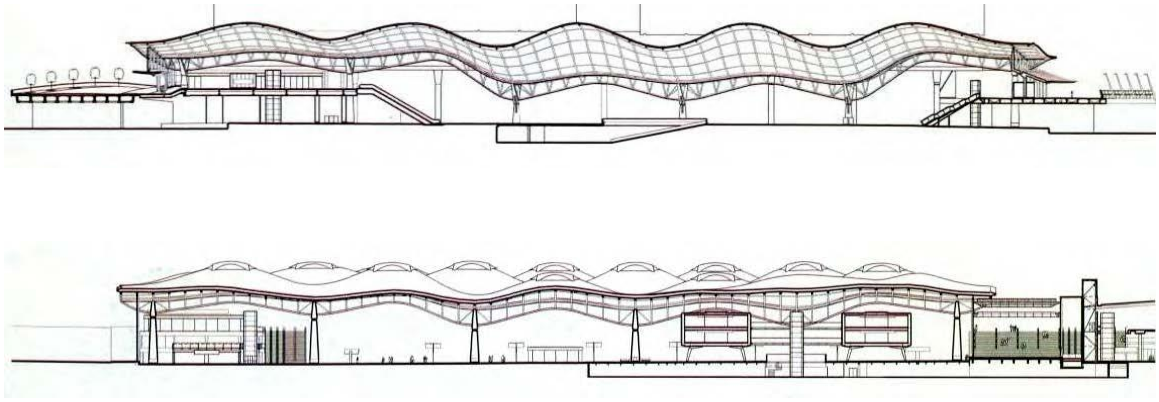


Figure 5-7. Longitudinal cross sections. Source: (Roke, 2007)

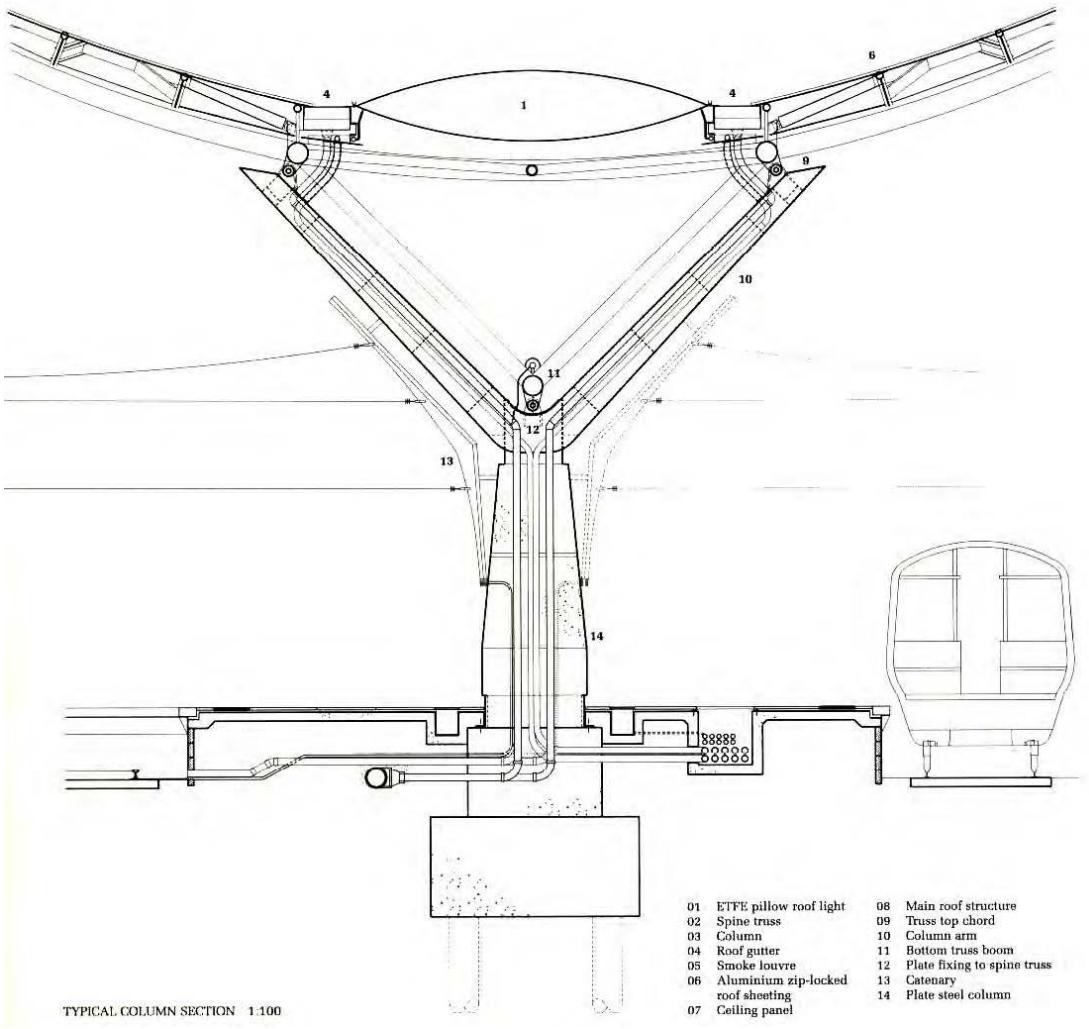


Figure 5-8. Section through the roof structure. Source: (Raisbeck, 2007)

Storm water harvesting is another environmental sustainability feature of the SCS roof. Grimshaw (2008) estimates that the 34000sqm roof creates a annual saving of about20 million litres of water. The water is collected from the roof and channelled down to ballast tanks below the station from where is pumped up and used for cleaning, ablution water management and watering plants and landscaping (Roke, 2007).

Conclusions to Precedent studies

The precedent studies discussed have exemplified the elements required for the successful design of a transport interchange at both urban and building scales. Despite the vastly different contexts in which each case is situated they are successful in providing meeting the minimum operational standards of commuter comfort, safety and efficient transport mode operational standards. It is apparent that physical and socioeconomic

contexts play an important role in shaping the transport interchange urban and building typology and this in turn will shape the travel behaviour and travel characteristics within the urban realm. Transport buildings need to offer safety and functionality, strike a balance between aesthetics and practical functionality, form an integral part of the urban form, appropriately respond to the sociocultural, economic and environmental contexts, and promote the use of sustainable transport modes. They also need to be designed to be environmentally sustainable and this is an important aspect to be emulated especially in the African context. The dynamics of the African urban context are different from the international precedent reviewed. It is important to take a closer look at best practice in the African context.

Chapter 6

URBAN PUBLIC TRANSPORT IN THE AFRICAN CONTEXT: CREATING CONNECTED TRANSPORT NETWORKS

INTRODUCTION

An efficient public transport system enhances urban mobility, reduces congestion and has minimal damage to the urban and natural environments. Urban transportation in developing African cities fails to achieve these goals owing to a number of factors including;

- Prevalence of low capacity mini-bus or commuter omnibus taxis
- Poor vehicle fleet maintenance
- Operator rivalry
- Inadequate financing for investment in public transport infrastructure and services
- Lack of integrated land use and transport planning
- Lack of urban transport development frameworks

Colonialism (and colonial hangover) also negatively affected urban transport systems in most African cities. Racial segregation and restriction on movement led to the separation of facilities as healthcare and education from places of residence that in turn created complex land use and transport demand patterns.

South Africa is among notable African nations prioritizing the reconfiguration of public transport in urban areas by increasing capacity, extending service areas and deployment of travel demand strategies aimed at containing the use of personal transport in urban areas. Sections comprising of case studies on the built form and transport systems in Johannesburg and Harare and presentation of findings from the case studies respectively follow this introduction. This section of the research study will introduce and analyse Harare's urban form and transport systems.

CASE 1: Johannesburg

Background

Johannesburg has been selected as a case study owing to colonial similarities with Harare and as a developing success story of urban transport planning strategies and transport technologies adopted to address urban transport bottlenecks and enhancement of connectivity of transport modes.

Global solution for local challenges: Rea Vaya bus rapid transit system

The Rea Vaya Bus Rapid Transit System played and continues to play an important role in the transformation of the city of Johannesburg to a globally recognised world class African city. Prior to the introduction and implementation of the bus system minibus taxis were the only means of public transport available commuters who lived in peripheral suburbs and townships and needed to commute to or connect via CBD to get to their places of work. With issues of lack of transport priority for public transport and lack of efficient road infrastructure traffic efficiency was compromised and more and more commuters turned to private or personal transport. This increased the levels of congestion, pollution and social marginalisation of the majority who depended on public transport to access destinations and resources.

Planning

These challenges caused by the increased use of personal transport led to the introduction of the Integrated Transport Plan (ITP) which sought to connect residential, cultural and commercial nodes of areas in an integrated urban framework. The framework was designed with the intention of ensuring that up to 85% of the urban population would live or work within 500m of a BRT stop or bus route. The bus route network stretches a total of 300km providing connections between and to all important urban activity nodes within the Johannesburg Metropolitan area (Manning, 2009).

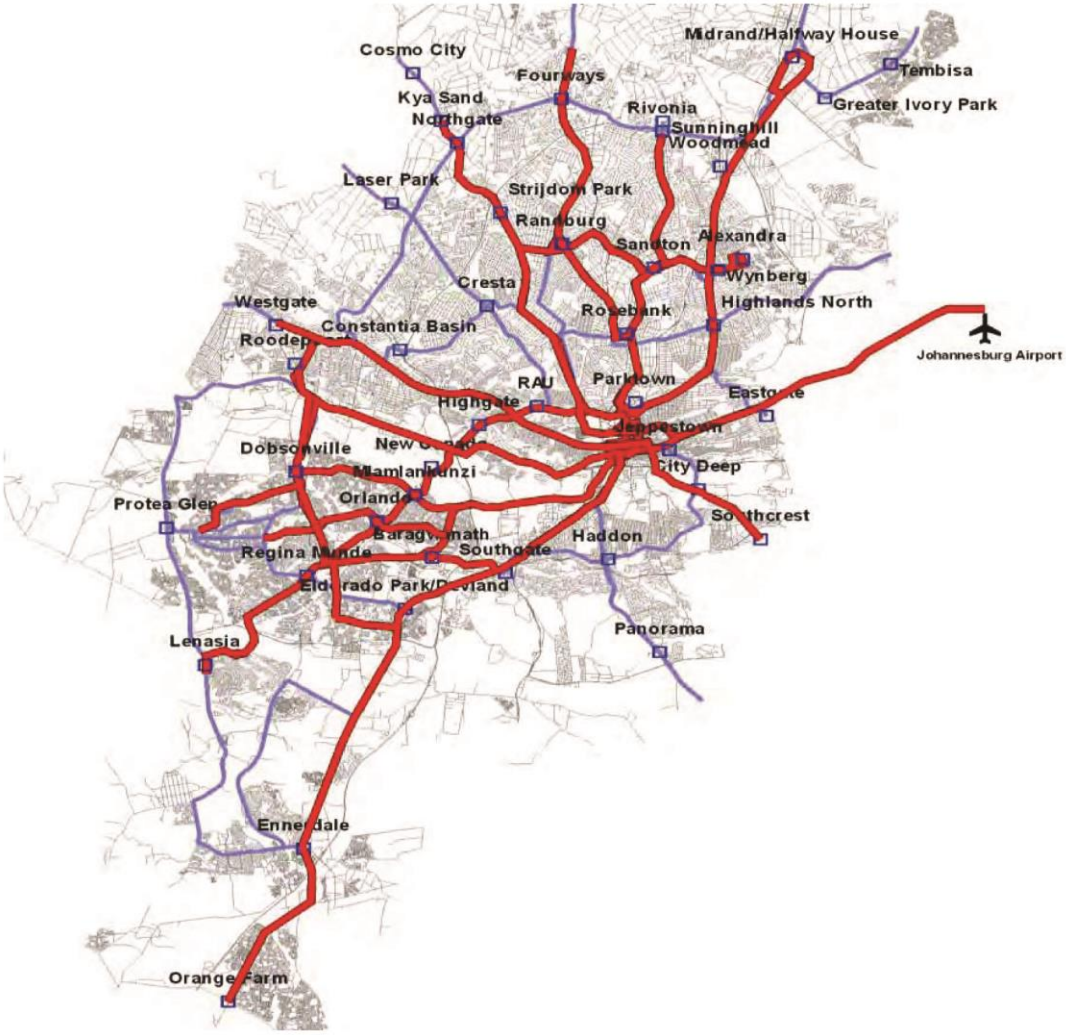


Figure 6-4. The BRT route map of the Johannesburg area. Source: Unknown

The framework also enabled commuters to have access to a wider variety of travel options and be able to move from one destination to another with greater efficiency and, more comfort and safety. Another important aspect of the ITP was the provision for integration with the existing minibus taxis (industry) for it formed an important social and economic aspect of urban transport.

Plate 6-8. Map of Rea Vaya bus route. Source: Author

Socioeconomic impact

The Rea Vaya BRT has made a tremendous impact on the local socioeconomic networks. A substantial number of employment opportunities have been created with many of the people coming from the taxi industry. The Rea Vaya BRT has also given public urban transport a new image and disproved previous notions of public transport being dirty, low quality, unreliable and unsafe.

BRT station/interchange architecture

The Rea Vaya station buildings were designed to give a new and world-class image to urban public transport and meet international standards for operation of the advanced transport systems and enable efficiency of commuter movement and circulation, comfort and safety.

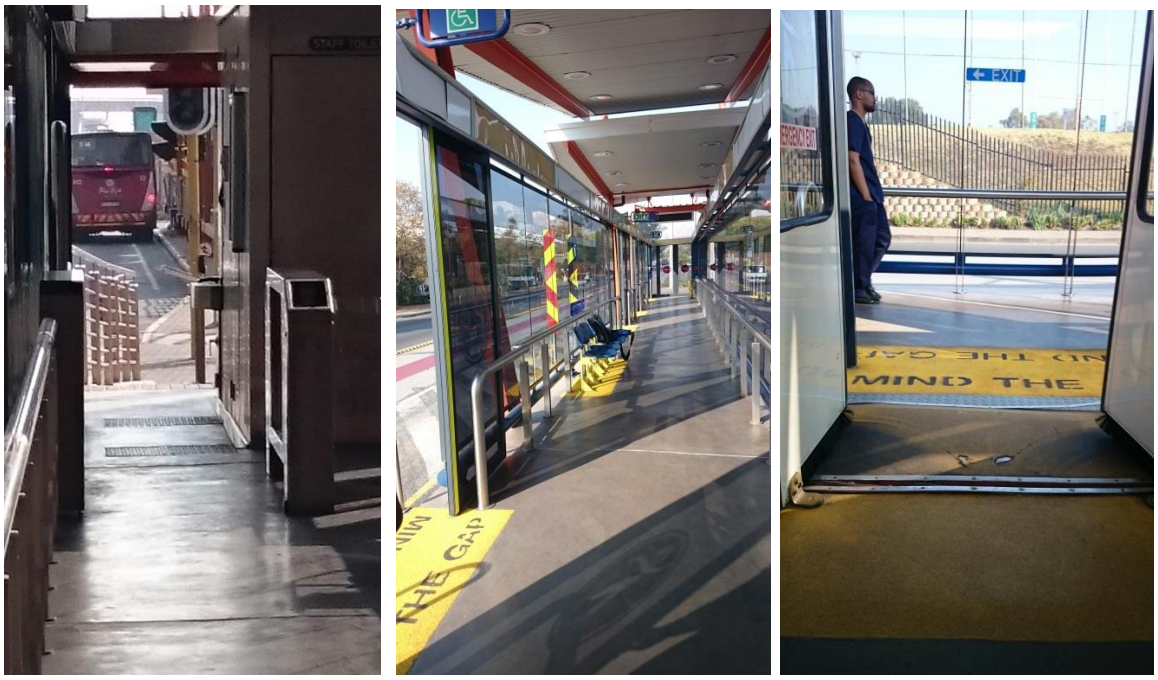


Plate 6-9, 6-10, 6-11. Efficiency, comfort and safety; core building elements. Source: Author

Expression of structure, functionality and detail was the main concept in deriving the building designs. To enhance the architectural aesthetics and sociocultural relevance African art, sculptures and murals adorn the buildings and their immediate surrounds (Manning, 2009).

Expression of detail and structure. Source: author

Plate 6-12, 6-13, 6-14. The use of art and sculpture to enhance architectural aesthetics. Building structure houses advanced ticket collection systems. Source: Author

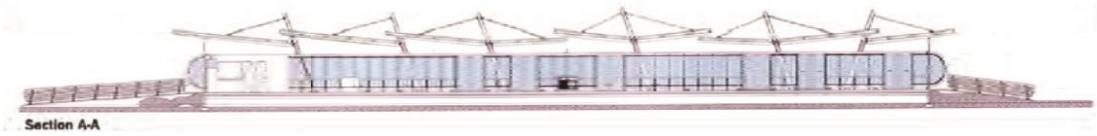


Figure 6-5. Section through BRT station building. Source: (Manning, 2009)

Smart, sustainable, efficient: The Gautrain Integrated Transport System

Introduction and Background

South Africa's Gauteng province is a powerhouse in the country's and the African region's economic network. The province has a vast rail network which covers a large proportion of Gauteng's geographical area. This rail network, covering less than 2% of South Africa serves more than 50% of the national population (Jensen, 2003). For a while, however, it did not run through highly densified and developed areas where the majority of the population lived and/or worked and this presented major challenges such as poor accessibility, negative travel choices and characteristics, and low economic productivity as the economy, population and region expanded. In 2003 roads in the Johannesburg-Pretoria corridor carried more than 150000 vehicles per day and traffic was expected to grow at a rate of 7% per annum (Jensen, 2003). Economic growth was accompanied by increases in traffic congestion and this carried on until the economy was negatively affected.

The Gauteng provincial government then planned and set out to implement a new rail transport system and network that would link Johannesburg, Pretoria and the O.R Tambo International Airport. The Gautrain Integrated Transport System (GITS) was the first integrated rapid rail and bus transport system in Africa. GITS was an initiative to induce a shift in urban travel patterns attempting to push commuters from personal transport and pull them towards public transport by improving the quality and increasing connectivity and efficiency of public transport and the urban transport network. The system's main objectives were to offer;

- Security and speed of service
- Reliable and efficient service
- Predictability of service
- Commuter/passenger safety and comfort

Planning

GITS consists of three main services namely; North – south commuter line, East west line and an airport express service (Eickler, 2008). It is also integrated with a Gautrain feeder bus service and the Gauteng Metrorail system. Construction happened in two

phases. The first phase, completed and opened in 2010, linked the main development nodes in Gauteng province and consisted of four stations along a 20km stretch. The second phase was completed and opened to the pubic a year later and consisted of a route linking Rosebank station in Johannesburg to Hatfield Station in Tswane, Pretoria. This effectively connected the Johannesburg, Ekurhuleni and Pretoria metropolitan areas (Jensen, 2003).

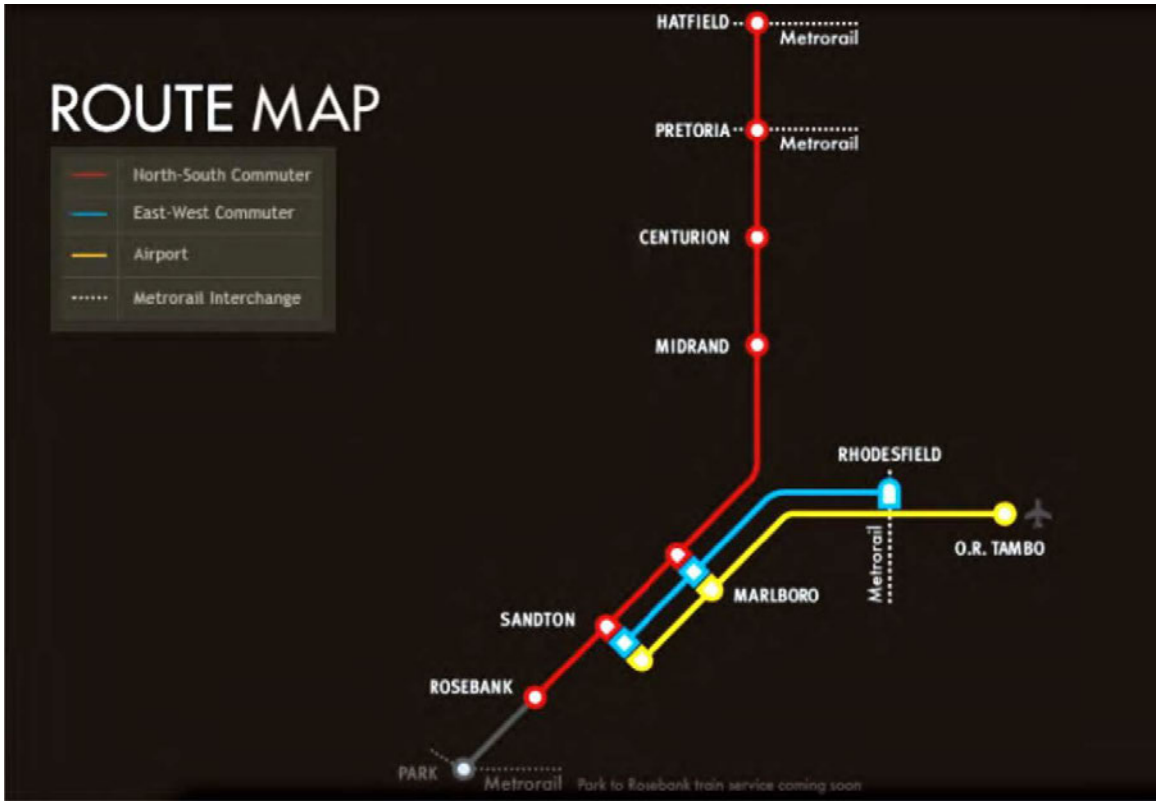


Figure 6-6. Gautrain route map. Source: www.gautrain.co.za

Advanced Systems Technologies

GITS broke new ground in terms of the application and widespread use of ITS or advanced transport systems in urban transport on the African continent. Several advanced transport systems were implemented in GITS to ensure its effective functionality, efficient operation and interoperability with other existing urban transport systems. These systems have collectively redefined the public transport in Gauteng and made immense contributions to the reduction of urban transport related challenges which have been set out extensively in the course of this research study. The main systems in operation in the GITS include;

- Centralised traffic control (CTC)
- Automatic vehicle protection (AVP)
- Automatic fare collection (AFC)

Centralised traffic control

The centralised traffic control system provides for central control and management of the GITS. Operational personnel are supported by being given operational information and processing of requests during operation. Any abnormalities in the system are relayed to the controller/operator and the problems attended to. The CTC system also enables the supervision and control of rail and feeder bus traffic and vehicles allowing for the relay of information relating to estimated arrivals, departures and any delays to system commuters (Gautrain, 2009). This system allows for overall efficient operation of the transport network.

Automatic vehicle protection

Commuter, vehicle, and infrastructure safety are important aspects to ensuring the sustainability of the GITS. To ensure that the assets are secured and well protected and to reduce the rates of public transport related accidents, AVP systems are used. These systems monitor train and bus movements and warn the drivers of over speeding situations or when approaching stop signals. At higher speeds than the posted speed limits the train's braking system is automatically applied to slow the train down. This system enhances the safety of commuters and other transport network users and limits accidents due to human error.

Automatic fare collection

Maintaining the economic viability of a complex and technologically advanced urban transport system as GITS is of high importance. AFC systems enable the GITS to;

- Provide affordable and convenient access for all members of society to railway, feeder bus and parking services
- Facilitate revenue collection via fare media such as smart cards and smart phones
- Promote the use of public transport over personal transport through discounted fares and park-and-ride patrons

- Facilitate the control and management of economic and business performance through product management and information reporting
- Provide opportunities for integration and interoperability with other transit systems and modes (Gautrain, 2009)

The GITS automatic fare collection systems are operated with contactless smart cards (CSC) which enable commuters to load a variety of different trip products that range from single to monthly tickets. The CSCs also enable commuters to minimise delays caused by long queues and ticket purchases and payments. People requiring extra space, for example, people with disabilities, luggage or children, are considered and their needs met by the provision of wide entry gates activated by CSCs (Gautrain, Fares and Ticketing, 2009). CSCs offer commuters the convenience of being able to purchase the cards from off-station sites and selected retailers through a wide range of payment options which include debit or credit cards, cash and coins, and direct deposits. CSCs operate using radio frequency identification (RFID) technology which enable commuter to hold their smart cards against card readers located at station entrance and exit points, inside buses, and parking areas. The CSCs can also be integrated with other urban transit systems and this means that commuters can use the cards to access the Gautrain feeder bus service Johannesburg Metrorail. This service can be extended to other modes in the future for example, bicycles at bike hiring stations. The interoperability of CSCs enables seamless travel and increased convenience, safety, and improved access to public transport for all urban commuters (Gautrain, 2009).

Socioeconomic impact

GITS has established itself as a benchmark project for the social and economic empowerment of South Africans. From the onset GITS set out socio-economic development obligations which the Independent Socio-Economic Monitor (ISEM) states to be;

- Increasing black shareholding
- Increasing procurement from and sub-contracting to black entities (Bes)
- Increasing procurement from and sub-contracting to new BEs
- Increasing procurement and sub-contracting to SMMEs

- Expanding use of local content
- Job creation
- Increasing training South Africans (Gautrain, 2013)

Thousands of opportunities have sincs been created through investments in the welfare of people. According to the MEC for Roads and Transport, Dr Ismail Vadi,

"Gautrain contributed to the creation many employment opportunitites which have facilitated skills transfer, human resource development and increased equality for the disabled, women and youth." (Gautrain, Gautrain Surpasses Socioeconomic Development Obligations During Construction, 2013).

From the beginning of project implementation more than;

- 75000 direct and indirect jobs have been created
- 550 companies have benefited
- R 3.3 bln generated (Jensen, 2009)

By the end of 2012 the number of direct and indirect jobs had increased by more than 50000 and increased numbers of companies and previously disadvantaged people that benefitted. These stats and figures prove GITS' socio-economic sustainability and its status as a project which makes important and significant contributions to the local and national economies and people's welfare (Gautrain, Gautrain Surpasses Socioeconomic Development Obligations During Construction, 2013).

Station buildings design

The master architects for the GITS stations produced a system of 13 detailed design packages relating to different packages of work and covering all the construction disciplines. Generic concepts and details were generated to ensure that each station design was coordinated to meet the aesthetic requirements of the GITS Gautrain System Identity (GSI). The GSI consists of guidelines, drawings and specifications that ensure system-wide architectural design conformity and uniformity which helps in station architecture brand reinforcement and identification (Gautrain, 2009). Some of the

elements used in the packages include signage, entrance structures, finishes. The design package or toolkit enabled the architects to give each station its own unique, but overall system compliant, design identity (Gautrain, 2009).

There are three main architectural typologies in GITS station architectural design;

- Underground station
- At-grade or ground level station
- Elevated station

Station planning and circulation

According to Tom Steer of Gautrain Architects Joint Venture (GAJV) components such as ticket offices, station control rooms, and payment stations are common to all stations although each typology and station has its own accommodation schedule and has its spaces designed and arranged safely and in line with rail track alignment (Gautrain, 2009). The feeding of commuters onto platforms was the main determinant of station building layout. In the Midrand Gautrain station, for example, commuters circulate beneath the rail tracks to get the platform while in the Marlboro station commuters circulate above the rail tracks to get to the platforms, although both stations are at-grade stations. Each station in the GITS is linked to ancillary services and function. Typical ancillary services include;

- Park and ride facility
- Feeder bus rank
- Kiss-and-ride facility ((car) drop-off facility
- Short term facility
- Concourse paid and unpaid areas
- Transfer links that lead to train platforms
- Train platforms
- Bicycle ranks along paths that lead up to the station building (Gautrain, 2009)

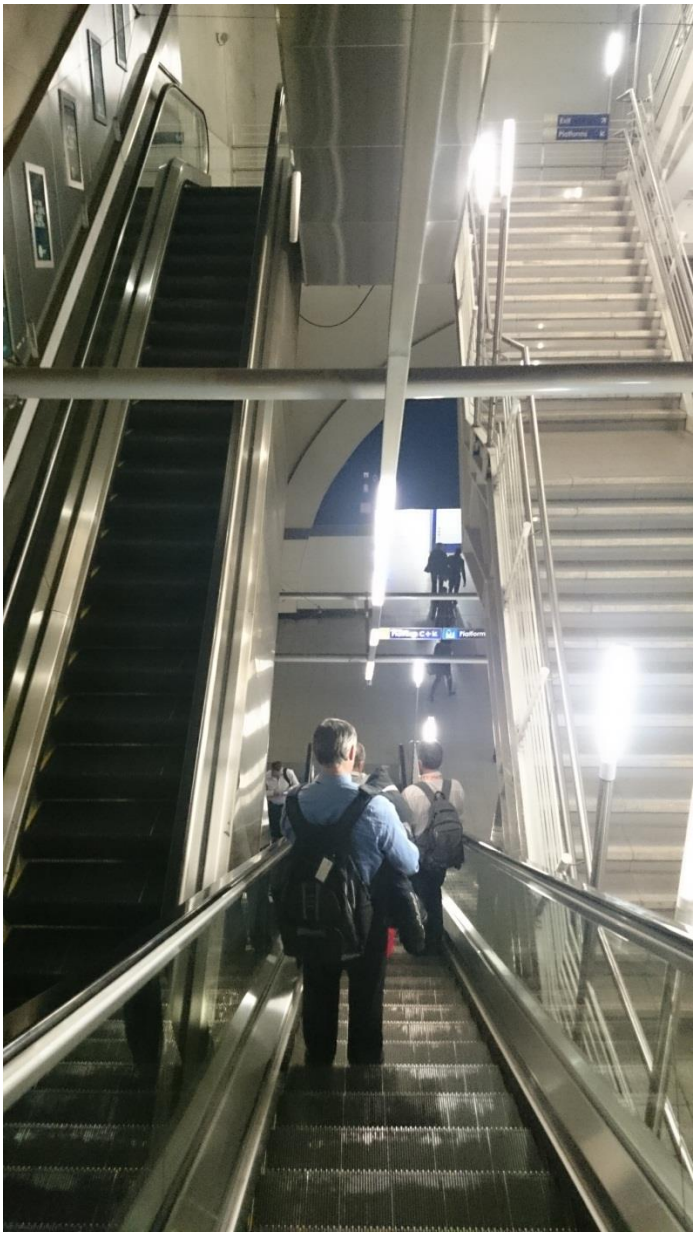


Plate 6-15. Vertical circulation at the Sandton Gautrain station. Source: Author

Design aesthetics

Expression of three dimensionality was an important aspect in the design of the Gautrain stations. Inspiration for the designs was garnered from the fragmented communities of Gauteng and the need to link them. The architects made notes of the paths that link these communities and the activities that happen along them. Of particular interest along these paths were nodes where communities gathered to barter and socialise. These nodes normally occurred under large trees which provided good shade and a means of identification within vast landscapes (Gautrain, 2009). In the station design trees are

conceived as a symbol of protection and point of unity. The tree structures rare depicted by columns and the tree canopies are depicted by the wavy roof forms at the station entrances.

Plate 6-16. Wavy roof celebrates entrance as at the Sandton Station. Source: Author

Plate 6-17. Typical tree column as at Rosebank station. Source: Author

Materiality

The material and finishes of the station designs were carefully chosen to represent and celebrate the diverse range of materials available in South Africa. Maintenance friendliness, durability and colour neutrality, for backdrops that make signage legible, were the main material selection criteria (Gautrain, 2009).

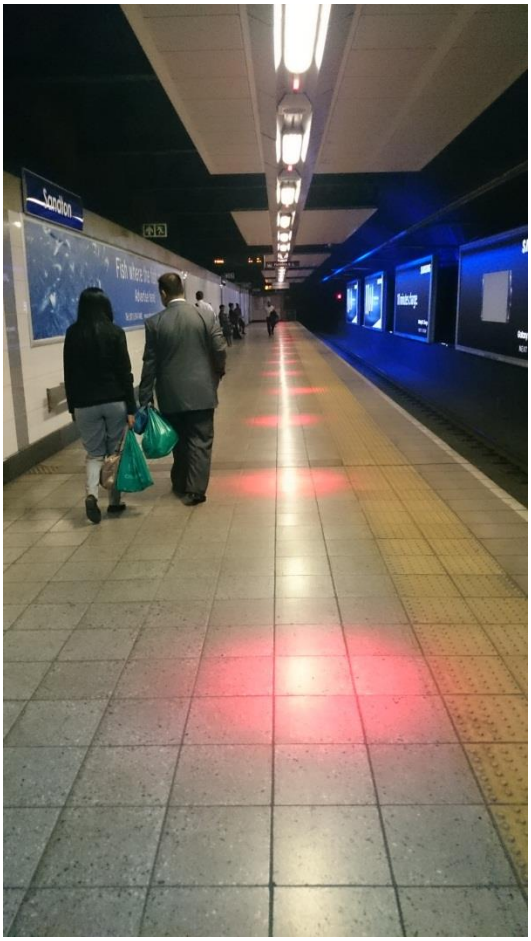


Plate 6-18, 6-19. Textured and neutrally coloured material enhance signage path legibility. Source: Author

Elements of the design above ground level were constructed using transparent material to aid with the legibility. Transparency of materials, especially the glass façade, aided with the enhancing of natural lighting to better improve interior comfort (Gautrain, Gautrain Station Architectural Design, 2009).

Plate 6-20. Transparent facades aid with station legibility and user/commuter comfort. Sandton station Source: Author

The use of steel and glass also gave the station architecture a lightweight look and feel that was not too overbearing on the observer or user of the building and projected a modern and minimalistic aesthetic; a much welcome departure from the heavy transport architecture of bygone centuries. The lightweight material also helped with the creation

of warm and welcoming entrance atmospheres (Gautrain, Gautrain Station Architectural Design, 2009).

Plate 6-21. Station entrance at Park station in central Johannesburg. Source: Author

Plate 6-22. Use of steel and glass creates a lightweight and modern feel. Park station. Source: Author

Case 2: Harare

Harare Urban form

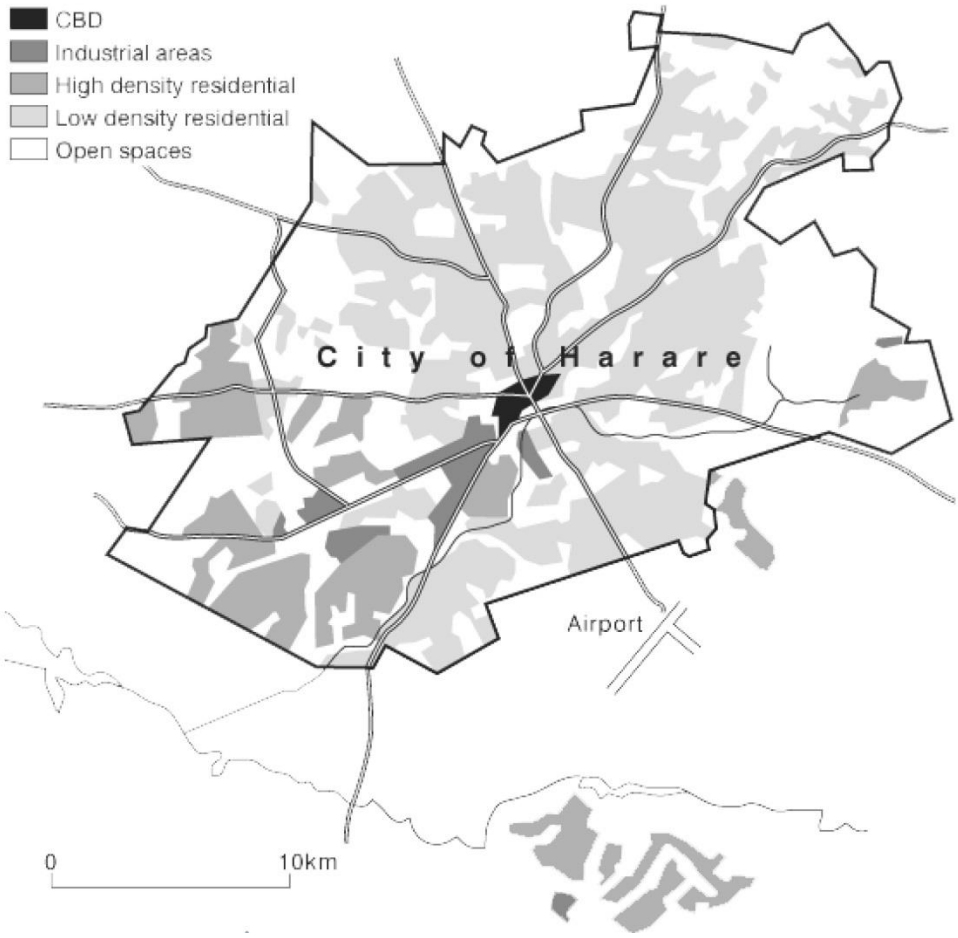


Figure 6-1. Greater Harare showing main trunk routes and districts. Source: unknown

There are three types of cities in the global system: informal hyper-growth; dynamic growth; weakening mature (Zegras, 2005). Within this global city framework Harare lies in the informal hyper-growth category typically characterized by a rapid population growth, rapid rate of economic expansion and a large middle-age group and environmental challenges. Harare urban's population was enumerated at just fewer than 2.1 million in the 2011 national census (ZimStats, 2012). The majority of the inhabitants of Harare live in sub-urban districts surrounding a central business district. Harare urban form is largely mono-centric as the CBD is the single largest attraction and place for

socioeconomic activities. Travel plays an important aspect in the lives of Harare's inhabitants and the day to day functioning of the city.

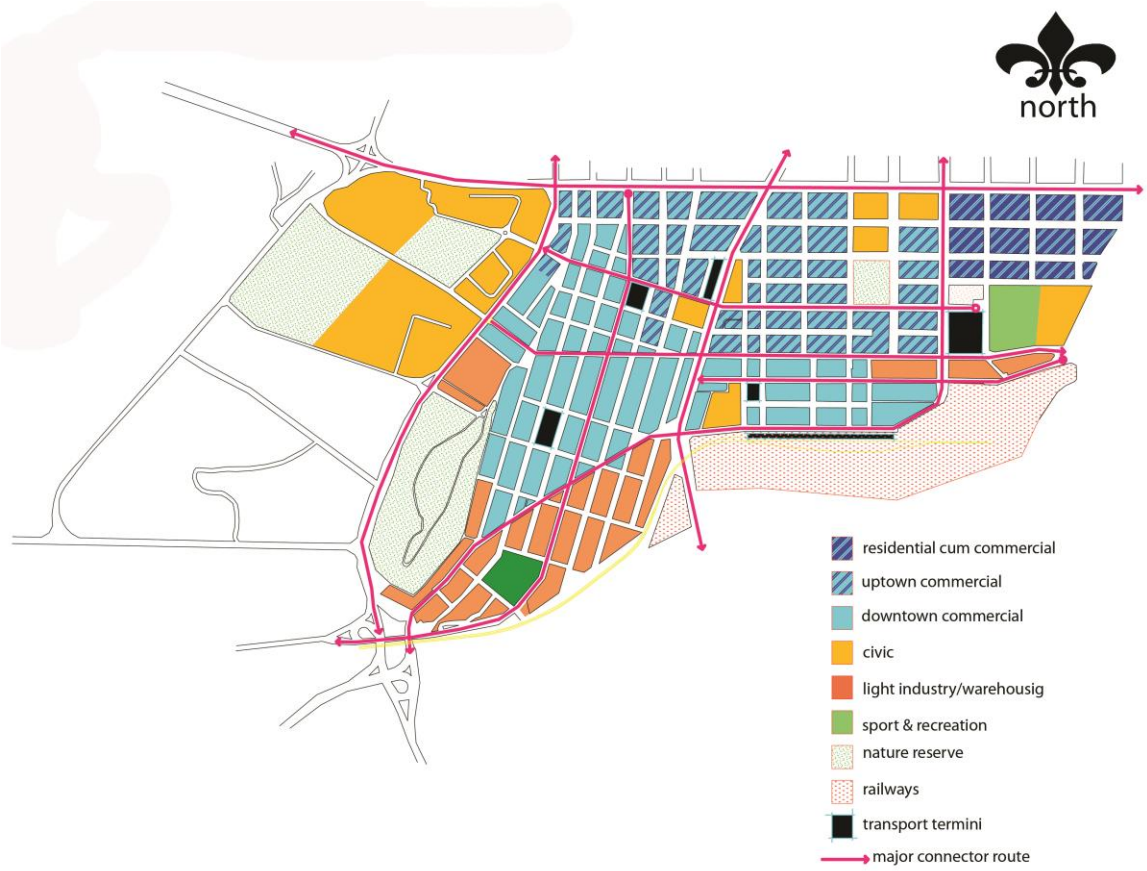


Figure 6-2. Harare CBD land use planning diagram. Source: Author/City of Harare

The provision of transport services in Harare spans more than 7 decades. Management of transportation services has shifted between central governments, local authorities and private enterprise in that period. Throughout this period the urban form and infrastructure of the city have largely remained the same. The rates of population increase and transport demand have increased and this is reflected by the increasingly high levels of congestion and pollution. The following is a brief historical timeline of Harare's urban transport provision services.

Transport provision in Harare: an historical timeline

1930 -1949

This decade marked the beginning of provision of public transportation services in Harare. The local municipal authority started its first bus service operations in 1942 after

unanimous approval by ratepayers' vote. The purpose of this pioneering move was to provide cheap, continuous and reliable transportation services for all members and sections of society (Jordan, 1983). An application for extending the services to peri-urban areas was lodged in 1948 and concessions granted to private operators on condition that they do not encroach upon the city bus service jurisdiction (Jordan, 1983).

1950 – 1979

Municipal and private operators involved in legal battles over claims by council of contravention of the concessions specifically encroachment into city bus service jurisdiction. Court ruling in favour of private operators disgruntled the city authority and pushed it to argue for the establishment of a bus monopoly on the grounds that;

- urban commuter services formed a vital component of the social and economic life of city thus had to be in control of a civic operator
- Urban transport services play a key role in town planning and the co-ordination of the two would be better off in the hands of a capable authority
- The urban poor and marginalised needed special protection against the profiteering nature of private enterprise
- Capital expenditure, operating costs, control of supply and demand, efficiency, safety and convenience would be better managed under municipal operation

Plate 6-1. Salisbury City bus service circa 1966. Source: flicker.com

The city however recognised that banning private operators would affect services to the peri-urban areas. It went on to enforce new laws and penalties for infringing the city service monopoly. The financial burdens of the managing an urban monopoly bus service proved too heavy for the city and by 1955 it sold its entire fleet to one private transport operator under a franchise agreement that was supposed to run until 1987. The private-public partnership gave the private operator (Jordan, 1983). All stakeholders from commuter, private operators and city authority benefited from the agreement. This reflected in the rise in public transportation use by the public and a rapid expansion of the bus network, services, efficiency and economic viability.

1980 – 1989

This decade was the most significant period in the transformation of transport provision services in Harare. After gaining independence the daily demand for public transportation increased (Mbara & Maunder, 1997) due to the relaxation of rural-urban migratory laws and influx of rural populations into urban areas. The denial of a justified urban bus service fare increase application affected its operational profits and the quality of service from that point on. Local authority, bound by the conditions of the public-private concession, began to subsidise transport services. Central government interference in the form of an instruction to city to cease all subsidy payments sounded the death knell for the private operator.

Harare United Mercedes R342 at Rezende Street Bus station, 1984

Plate 6-2. City operated bus service. Source: unknown

Quality of service, efficiency and operations were severely affected that by 1983 central government;

- Authorised the operations of 'emergency taxi' (privately owned and operated station wagon vehicles) as a solution to ease the growing public transport demand
- Took over power of fare structuring and acquired majority ownership of the bus company and controlled them under the Zimbabwe United Passenger Company; a move made to facilitate government participation in the public transportation sector

This move was viewed by some scholars as a way of redressing the economic imbalances existing in the economy at the time (Mbara T. C., 2006). Emergency taxi transport was envisioned as a (readily available) alternative mode that would supplement the failing urban bus service. The emergency taxis operated between peri-urban areas and beyond limits of the urban core restricted to public transport. This enabled commuters access not previously provided by the official public transport services. Pirate taxis were fundamentally a car sharing service whose existence was enabled, tolerated and perpetuated by a private-car oriented urban form. Although this informal mode of

transport generated a lot of employment opportunities and provided commuters a cheaper alternative mode of transportation the necessary transport infrastructure was not provided at transport termini.

Plate 6-3. Pirate / emergency taxi. Common throughout Africa in the early 80's. Source: www.blogspot.com

1990 – 1999

The emergency taxi fleet had grown to 2600 midway through 1993 (Mbara T. , 1994) when government officially deregulated the public transportation industry through passing of the Economic Structural Adjustment Programme (ESAP). This move, similar in intent to the franchise agreement between the municipal authority and the private bus company 40 years earlier, allowed mid-high occupancy vehicle to take over the pirate taxi role. They however suffered similar restrictions as the bus service and could not provide cross or inner city services. By the beginning of 1996 emergency taxis were banned from the streets and more than 2000 commuter omnibuses were in operation and poised to dominate provision of transport services. Public transport vehicle volumes increased and a considerable reduction in passenger waiting times at bus station was recorded. The physical infrastructure remained the same and was not improved or expanded (Mbara T. C., 2006).

2000-2009

This period in the history of transport provision in Harare was marked by record high levels of national inflation and economic stagnation. The public transport sector was one of the most affected due to the limited supply of fuel and this affected commuter travel patterns. This period saw the (re)emergence of the informal transportation sector characterised by commuter coping strategies such as illegal hitchhiking/carpooling/ride sharing/lift club services and walking or cycling (Mbara T. C., 2006). These alternative modes of transport were viewed in much negative light as they did not 'fit in' a car oriented urban form. This period was also marked by an increase in private car ownership as the public transport sector had simply failed to provide a safe and reliable service.

2010 to 2015: the era of disconnection

Urban public transportation services operating in Harare today can be classified into two groups. The first is the formal transportation services provided by metered taxis, commuter omnibuses and the recently launched, and barely functional, city shuttle. The second group is the informal transportation services which constitute a modern variant of the emergency taxi, hitchhiking, informal car sharing and walking. Cycling is still a very unpopular mode of transport within the CBD. Broken traffic signals, and street and information signs, dilapidated public transport termini shelters and badly damaged roads are common sights in Harare. These factors make an immense contribution to lowering the quality and reliability of public transport thus pushing the public towards personal and other modes of transport (Mbara T. , 2015). The few physical planning and design measures implemented have been targeted at increasing personal vehicle volumes on roads and not providing mass transit services that nip traffic related problems in the bud.

Plate 6-4. Dilapidated public transport termini shelters. Source: Author

Public transport termini maintenance and design, a responsibility of the local Municipal authority (ibid), has received very little attention and no infrastructure upgrades have happened since the beginning of the 1970's when the current stock of termini was constructed. Existing termini are not designed to cater to the dynamic patterns and systems of mobility in modern-day Harare. Statistics from the traffic safety council of Zimbabwe (TSCZ in Mbara 2015) indicate that the majority of Harare's fatal traffic accidents involving pedestrians, cyclists and commuter omnibuses occurred in the vicinity of public transport termini.

Plate 6-5. Coppacabana (western CBD) Commuter omnibus terminus. Source: Author

Low carrying capacities of the termini force transport operators to take over streets adjacent streets and illegally convert them into taxi holding space. This affects traffic flows, tarnishes the city image and continues to be a major spanner in the process of creating reliable, efficient and sustainable services especially during peak traffic periods and inclement weather days.

Plate 6-6. Cross city pirate taxi tputs. Source: www.wkipedia.org

Figure 6-3. Urban public transport routing. Source: Author

The history of public transport provision in Harare is eerily similar to London, Great Britain in the 1930's, when the granting of licenses to private operators was unregulated and lacked a clear method. This led to serious competition between (the city and private) operators and resulted in instances of public transport Vehicle Street racing, fare-cutting and cutting-in (along roads and at termini). This wasteful competition caused traffic congestion, increased rates of accidents, led to infrastructure dilapidation and posed a serious threat to commuter safety. A direct result of this was the decline in the quality and efficiency of public transportation services, and dishonouring of the interests of the general public (Jordan, 1983). To steer clear of the calamity that awaits at the end of such a path inclusive urban design, introduction of mass transit systems, promotion of non-motorised transport modes and densification through mixed land use planning need to be implemented (Dube & Chirisa, 2012).

Plate 6-7. Fourth (eastern CBD) public transport terminus. Source: www.wilipedia.org

Discussion of findings

The preceding sections presented case studies of urban transport systems of Johannesburg and Harare. The aim was to examine urban transport in Harare relative to Johannesburg that has made great strides in implementing ITS. This section presents a discussion of findings from the studies.

Transport infrastructure

The successful development of ITS in Johannesburg can be attributed to the design and configuration of its mass public transport infrastructure. Lanes dedicated for the movement of Rea Vaya buses ensure that buses do not inconvenience the flow of traffic and similarly the buses are not inconvenienced by regular traffic. Bicycle lanes also ensure the promotion of cycling as a safe and reliable transport mode. The pedestrian sidewalks are designed to provide maximum protection for pedestrians and to make walking comfortable.

In Harare however, there is minimum separation of transport modes on streets and space for motorised transport (cars and buses) is disproportionately higher than that for non-motorised transport. There is thus a preference of use private cars as they are the most efficient transport. This, however, results in high congestion levels and unsafe conditions for non-motorised transport modes whose movements often overlap onto streets.

Furthermore, traffic control signals were aligned with the infrastructure layout in Johannesburg. This had twofold advantages. It ensured the mass transit system had unhampered passage at intersections and as such would achieve the intended timeliness of the mass transport system. By extension, the smooth passage of buses at traffic intersections also contributed to the aversion of congestion at intersections. The absence of a similar priority system in Harare (also linked to the absence of dedicated lanes) implies that passenger movement through mass transit system is compromised as vehicles contest for space in the traffic maze.

Findings from the study also show that transport interchange buildings are designed to accommodate the myriad of social and economic activities that occur when large

numbers of people are moving. In Johannesburg, the park station interchange building is an example where the social and economic activities that supplement movement of people are accommodated activities. In Harare, however, none of the existing transport interchange termini were intentionally designed to accommodate social and economic commercial activities. In fact, social and economic activities have organically encroached into the termini spaces in a manner which is unregulated and unstructured. There is an obvious lack of sense of belonging, place and identity. Interchange buildings therefore need to respond appropriately to avoid losing contextual essence which gives them relevance and the sense of place and identity (Frampton, 1985).

Transport services provision and management

In Johannesburg, the municipal authority is actively involved in the provision of transport services. The city of Johannesburg is the owner and operator of the ReaVaya BRT and is responsible for the entire system operations and maintenance. This has enabled the city to maintain transport services at a standard which is in line with its mandate for service provision to all citizens at fair and affordable prices. The city authority is also involved in the monitoring of the metrorail and Gautrain services provided by the state-owned PRASA and privately owned Bombela Concession Company, respectively. The city is also involved with the various bus and minibus companies that operate within Johannesburg.

In Harare however, bus and minibus transport services are the only available option and these are owned and operated privately. The city has little control and input over standards of operation of services and quality of infrastructure. The commuters are therefor left at the mercy of profit oriented private operators. Although local government's participation in the provision of services could crowd out private operators that they often seek to empower, the municipal authority is not expected to operate on profit maximization and could also use its services as the benchmark of transport services within the city. Further to this

Integration of transport services

The routing of transport services in Johannesburg is well-integrated. This provides seamless movement and transfer of commuters within the system. In Harare on the other hand, there are several areas of disconnection in the routing of transport services available. Commuters do not experience convenient and seamless transfer and connection between modes. This has paved way for the proliferation of informal taxis to fill in the gaps. Although informal taxis offer a valuable service that completes the circuit and makes travel more convenient for commuter, the type of vehicle typically used and the manner in which they operate exacerbate the congestion, pollution and public safety challenges. Bus and rail transport services are not active and this prevents the city from making use of mass transit; a viable solution for reducing vehicle populations in circulation.

Chapter 7

FINAL RECOMMENDATIONS AND CONCLUSIONS

Introduction

This study was aimed at understanding public transport system in Harare in the backdrop of the deteriorating public transport infrastructure, traffic management related challenges and the changed demographics of the city. Through understanding the linkage between urban built form and ITS, the study also aimed to contribute towards the design of an ITS in Harare. This chapter presents a summary of the research, conclusions and recommendations from the study.

Summary of findings

This section presents some of the findings from the study. Findings show that congestion and other traffic related problems in Harare's CBD arose due to the mismatch between the capacity of existing infrastructure and volume of vehicular and pedestal traffic. Traffic volume within the city increased following the removal of travel restrictions after independence and the collapse of the mass transport system in the new millennium. Furthermore, the design and location of termini in the city also contributed to the inefficient movement of traffic in the city. Interchanges were also found to be disjointed from the wider social and economic systems. Consequently, vendors have encroached into the termini and continue to affect the movement of people and functioning of transport services. If incorporated as commercial spaces, transport infrastructure in Harare could contribute to the city's built form as seen in the case of Johannesburg.

The city of Harare is limited to the provision and maintenance of transport infrastructure and the regulation of transport services in its jurisdiction. Had the city council been involved in the provision of mass transport services, there is a possibility it would have reduced transport problems in the city in periods of economic decline where private operators struggle to maintain operations. Finally, the basket of transport forms in Harare has remained the same over decades. In Johannesburg on the other hand, railway has been added to the urban transport network. The addition of railway to urban transport in Johannesburg has on the other hand has reduced the burden on road-based transport, enhanced the efficiency of transport services in the city and contributed to the generation of the urban built form.

Recommendations

Urban planning

There is need for identification of the major nodes within the central business district. Densification of nodes should happen through varying of the land uses within each node. Nodes need to be designed so that they are walkable. The nodes must then be connected using the major connector streets. Transport modes on the street should be separated to avoid interruptions that occur when there is no modal separation

Transport mode integration

All modes of transport, walking, cycling, driving, buses and train should be integrated to allow commuters a variety of travel options. Integration can be maximised by ensuring that all major nodes and traffic corridors are well serviced by both non-motorised and mass transit and have sufficient space to ensure safe and efficient operation of modes.

Interchange building design

The interchange points within the transport network should be designed to serve the functional process of enabling commuter to connect and transfer transport modes. In addition the interchange buildings should accommodate the various social and economic activities that take place in around and its edges. A sense of place should be infused in the interchange building so that they become dwelling places and make travel by public transport very convenient.

Efficiency, legibility, comfort and environmental sustainability are factors that need to considered and effectively addressed when designing the interchange building. Materiality plays an important role in the tectonics of transport interchange building typologies. These enhance commuter orientation, comfort, and definition of the building as an urban landmark. Materiality also increases the sense of place and identity of transport interchange buildings making them more than just transport utility spaces. This helps with the manner in which people interact with and around a building. Building technology helps with optimising energy and environmental performance of buildings

Research Limitations

The study reports some limitations through which findings ought to be interpreted. Some places could not be visited during fieldwork on security grounds, the park station commuter omnibus terminus for instance. Similarly, the researcher had to spend limited time at some termini and had to ensure not to be seen studying structures intensively. And, passengers and other urban road users were not interviewed during the study owing to budget and logistical constraints. Nonetheless, the study is a notable contribution to literature on the use of intelligent transport systems and the appropriate urban built form for their use in Harare, Zimbabwe.

Conclusions

The use of Intelligent Transport Systems in rapidly developing urban areas is effective in reducing and limiting traffic congestion and increasing efficiency of mobility. ITS enables fair accessibility to resources and opportunities for all users of urban areas. Urban form needs to be (re)configurations at the urban and building scales in order to maximise the functionality, usability, efficiency, reliability and future expansion of ITS. Harare urban built form currently does not conform to the minimum standards for successful implementation, functionality and usability of ITS. Cities that have successfully implemented ITS, and in the process transformed their transport system efficiency, safety and reliability provide good lessons for cities that desire to embark on ITS implementation.

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APPENDICES

CITY OF HARARE

HUMAN CAPITAL DEPARTMENT
TOWN HOUSE, HARARE, ZIMBABWE
POST OFFICE BOX 990
TELEPHONE 752979 / 753000

EMAIL: hrd@hararecity.co.zw
ADDRESS ALL CORRESPONDENCE TO THE HUMAN CAPITAL DIRECTOR

25 April 2015

Tinashe Nyambuya
Howard College Campus
University of Kwazulu Natal
Durban
Republic of South Africa

Dear Sir

RE: AUTHORITY TO UNDERTAKE RESEARCH: TINASHE M. NYAMBUYA

This letter serves as authority for Tinashe Martin Nyambuya to undertake his research project on: **INTELLIGENT TRANSPORT SYSTEMS AS GENERATORS OF BUILD FORM: TOWARDS THE DESIGN OF A TRANSPORT INTERCHANGE IN HARARE.**

This is in partial fulfilment of his Degree in the Master of Architecture program with the University of Kwazulu Natal in South Africa.

The City of Harare has no financial obligation and neither shall it render any further assistance in the conduct of the research. The researcher is however requested to avail a copy of the research to the undersigned so that residents of Harare can benefit out of it. The research should not be used for any other purpose other than for the study purpose specified.

[redacted]

HUMAN CAPITAL & PUBLIC SAFETY DIRECTOR
CD/

"HARARE TO ACHIEVE A WORLD CLASS CITY STATUS BY 2025"

Interview schedule

Person interviewed:

Deputy Director of CoH Traffic Planning Department

The current urban transport termini and transport network are from the early 1980's. with the high rates urbanisation that has taken place since then are there any plans to upgrade the systems?

The City Of Harare (CoH) has taken note of the increase in traffic volumes and the CoH has come up with a plan. We are currently looking at upgrading the existing transport termini while we are looking and waiting for investors to partner with us. The long term vision is to have a (massive) public transport system for Harare that is:

- Cost effective
- Meets the standards of international as other developed nation cities are doing or have done
- A system that other countries have adopted

At the present moment there are two main tiers of transport systems;

- CBD (cross town trip)
- Urban-suburban trips

Shuttle services

Service 1: albion/Cameroon str – Mugabe – Fourth – (fifth) – J. Moyo – (Angwa) –

Service 2: Market Sqr – Bank str – Angwa – mugabe – Fourth

The shuttle doesn't have a start or finish point.

There pick drop points at specific points within the systems

Commuter omnibus services

Four main termini that accommodate urban-suburban commuter omnibus services;

Copacabana – north and north western suburbs

Fourth street – eastern and north eastern suburbs

Charge office – south and south eastern suburbs

Market square – south western suburbs

In the proposed upgrade designs is provision primarily for transport services or are there plans for social and economic activities?

Unfortunately our economy has become a bit informal in the sense that there are a lot of informal businesses sprouting and people either go into vending or operate small passenger vehicles that are giving us problems. We intend to establish separate retail areas and facilities for the informal traders.

What problems does urban informality present within the transport sector?

The main problems being presented by informality are congestion, reckless driving, unregulated and unregistered/illegal operation, and touting. These are private vehicles operating without licenses. It poses a danger to public safety.

Have any efforts been made to integrate these informal services into the formal transport network or structures?

At some point the City of Harare (COH) engaged the commuter omnibus (kombi) drivers and their conductors with questionnaires on how best they could work together, take some of their ideas and come up with a total/complete package. Infrastructure development is also done with the input from stakeholders; City of Harare (CoH), Commuter Omnibus Owners' Association (COOA).

Is the location of transport termini correct?

Location of our existing termini is alright. These termini are located strategically in line with CoH vision for Harare transport. Even the master plan coming in operation will take into account these and other places reserved for urban transport.

Is the CoH considering the introduction and use of alternative modes of transport?

The (bus and kombi) current public transport system has to be augmented by other systems that shall be put in place. We are aiming at making use of existing modes such as rail. Rail died a natural death due to the financial and administrative challenges faced by the National Railways of Zimbabwe (NRZ). Rail served south western and south eastern suburbs/townships providing morning, afternoon and evening services. In the long term

if the bus system is developed together with the rail system Harare urban transport will improve drastically and become more efficient. At the moment it's either private vehicles or the kombis which are the most preferred modes of transport and the least efficient (account for most congestion and pollution). With respect to kombis, if we had large passenger vehicles to carry large(r) volumes of commuters per trip the public transport and traffic congestion situation would highly likely improve.

Would kombi operators be happy to compete with and potentially lose business to city-managed transport services?

If they cooperate with the CoH traffic plans they stand to benefit more. There are programs to accommodate all transport providers. The average fleet size of private kombi operators is 3. They will be given the option to trade in their vehicles for government recommended mass transit vehicles. Their operational carrying capacity will remain the same if not improve and there will be less vehicles on the roads. It's a private operator-city win-win situation. CoH is trying to come up with solutions that fit local problems. The mere imposition of (raw) foreign ideas will make local stakeholders skeptical.

Is CoH making any efforts to embrace and implement technologically advanced systems in improving management and efficiency of the urban transport system?

Yes, CoH embrace technology. Traffic management as well it's the system hasn't been computerized. Even if we want to introduce a modern system we still have to understand that same system as it has been implemented elsewhere for example in our twin city(ies).

Is the CoH considering implementation of advanced transport technologies, eg smart card systems, in future transport plans?

That system is already being used on a trial basis by City Parking. As CoH we don't live in isolation. This is a global world so we will be as cooperative and open to modern technologies and solutions to urban transport.

Does the CoH Traffic Planning department have a [collaborative] relationship with the City Architects' department; at least as far as Traffic Planning project(s) implementation is concerned?

Where there are projects (that need input from other department/divisions of CoH) we form a Project Implementation Team (PIT) which is normally comprised of Traffic planning, Town planning and City Architects. This is so that all aspects (of city management and design) are taken into account and considered holistically.

Thank you for your time