Built Environment

City Futures Research

Wayfinding at night

Literature review

Final report

June 2017

Wayfinding at night: Literature review

by Aida Afrooz, Parisa Kalali, Simone Zarpelon Leao, Chris Pettit

City Futures Research Centre

Faculty of Built Environment

UNSW Australia

www.cityfutures.net.au

Published by: City Futures Research Centre, UNSW Australia

This report is based on research undertaken with funding from the City of Sydney Council.

The researchers would like to thank Carmela Ticzon for her assistant.

Any opinions expressed in this report are those of the authors and do not necessarily reflect the views of UNSW Australia or the City of Sydney Council.

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Executive Summary

The City of Sydney Local Government Area is located in the Sydney Metropolitan Area and encompasses the Central Business District (CBD). As a CBD, the City of Sydney attracts extensive flows of pedestrians even late at night.

This study was undertaken by the City Futures Research Centre, UNSW Australia, with the support of the City of Sydney Council. The key purpose of this report is to develop a comprehensive literature review of night-time wayfinding research and practice to inform future decision-making in the City of Sydney. Accordingly, this report:

- Outlines the common wayfinding practices based on national and international practices
- Highlights the new and emerging technologies in wayfinding; and
- Identifies wayfinding strategies and components which can enable different users to navigate through the built environment more effectively at night.

This report can support Sydney's future developments such as the Sustainable Sydney 2030 vision—A city for walking and Cyclists, a city with night-time economy, a lively and engaging city centre, a cultural and creative city—and action plans like Walking Strategy and Action Plan (City of Sydney 2015b), Tourism Action Plan (City of Sydney 2013b), Open Sydney: Future directions for Sydney at night (City of Sydney 2013a), and Sydney night-time economy roundtable (NSW Government 2016). Moreover, this report can act as a supplementary document for the Legible Sydney: Wayfinding strategy report (City of Sydney 2012) to improve the City's wayfinding system at night, particularly by means of advanced technology.

Across the world many governments have sought to make cities more legible as well as more pedestrian friendly. Examples include the Legible London, Legible Dublin (Dublin City Council 2004) and Walk New York City Strategy (City of New York n.d.). Central London Partnership (CLP) is providing people with a user-friendly wayfinding system that gives them the confidence to get 'lost' in the city and get back on track (Central London Partnership 2006). These practices have recommended an enhanced signage system. There are some studies with performance metrics, but are very limited in scope and have been only applied to small sampled studies. However, there is still a lack of a comprehensive framework to integrate performance metrics to benchmark wayfinding systems for the built environment. Some reasons for this gap can be attributed to the fact that most wayfinding projects are focusing on specific wayfinding approaches, particularly signage design, rather than considering the integration and interplay of varied aspects of the wayfinding system.

Wayfinding involves the interaction between people and the built environment. However, most practices only consider one of these groups; either the design of the built environment or the target users. It is difficult to measure dimensions of the interrelation between built environment and users at the same time. On the one hand, people's

wayfinding performance may vary based on their age, gender, ethnicity, spatial ability, and many other individual differences (e.g. Afrooz 2016, Carpman and Grant 2012, He et al. 2014, Lynch 1960). On the other hand, the assessment of the built environment in terms of wayfinding is based on many aspects, mostly qualitative, which are not easy to measure such as legibility, connectivity, flexibility, consistency and many more. Measuring all these aspects requires a comprehensive assessment of the built environment which depends on the context. Moreover, contemporary wayfinding technologies involve not only infrastructure implemented by local governments, but a variety of personal options available to citizens via smartphones and computers connected to the World Wide Web.

Hunter et al (2016) highlight that "*the divergent fields of inquiry that inform wayfinding typically focus on a single piece of the overall puzzle perhaps missing opportunities to make connections, to learn from other fields, and to achieve insights to benefit not only their own work but wayfinding more broadly*" (p. 267) In this context, it is not possible to give a hierarchy to the applied strategies recommended by existing research and practice. For example, we cannot determine that the strategies being implemented in London outweigh those in Toronto or vice versa.

In order to partially overcome this limitation in this review, in the absence of an integrative/holistic approach to urban wayfinding, a matrix is presented in this report (see Table 3.1). This matrix intends to assist readers to select the most suitable strategies for the purpose of their projects based on a limited set of criteria, rather than rating the applied strategies.

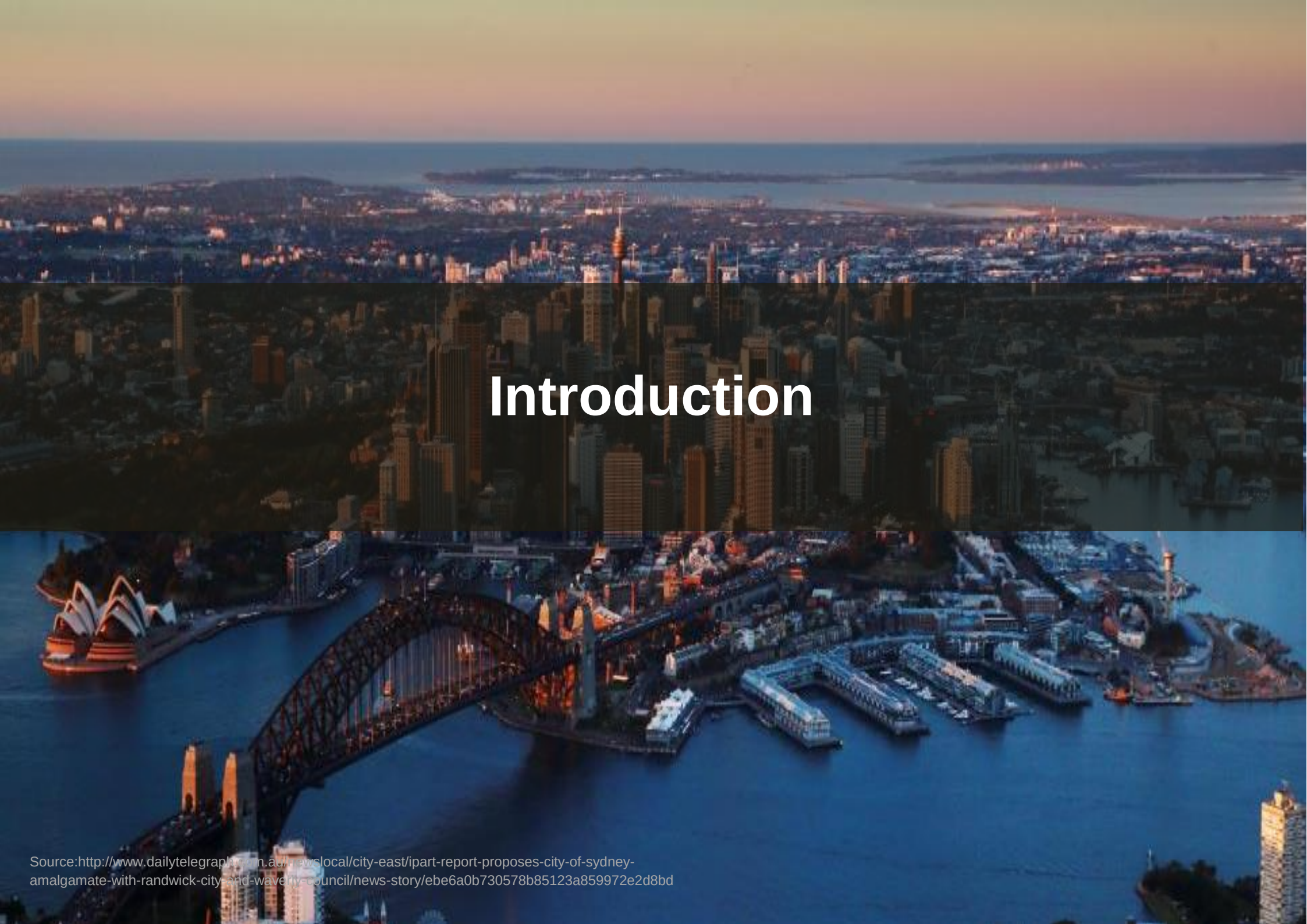
Although daytime navigation tools are usually used by wayfinders at night, there are many other reasons why people get lost at night-time specifically. Because providing wayfinding facilities in all the streets and throughout the whole City during night-time is not feasible, applying smart technologies can be a potential solution for overcoming wayfinding difficulties. In this regard, this study offers a synthesis of an ample variety of strategies with a specific focus on smart lighting system and emerging technology. Such technologies also have benefits in addressing safety concerns which are more prevalent at night-time.

This study is a comprehensive review of comparable national and international wayfinding practices. Fifty-four practices and plans were reviewed and twenty-four comparable cases to City of Sydney were described in this report. The target users are also identified. The aims, scopes, and the applied strategies of the common practices are presented. It is worth mentioning that not all the reviewed case studies include wayfinding practices nor are applied at *night-time*. This report extends to review the smart cities strategies which are applicable for the context of this report (i.e. wayfinding at night for an urban area). This gives a unique characteristic to the report which differentiates it from other existing wayfinding literature.

The report synthesises key insights and strategies of reviewed practices that may be considered for City of Sydney to enhance its existing wayfinding system at night for target users. General considerations for City of Sydney are classified into five contextual urban elements namely, streets, intersections, parks and waterfronts, squares and landmarks. A wide variety of wayfinding components are considered to enable City of Sydney's wayfinding system to be inclusive and meet the needs of different types of users, including residents, visitors, commuters and users with disabilities. Finally, a

benchmark for evaluating wayfinding practices is suggested in this report.

Implementation of the identified strategies can provide City of Sydney with remarkable opportunities to enhance the wayfinding system while utilising the most energy efficient and low-cost methods. The identified strategies can assist City of Sydney to improve its legibility and welcoming atmosphere particularly at night-time with the aim of a sustainable smart city which has a flexible wayfinding system at different times of the day and different types of events.



Introduction

Source:http://www.dailytelegraph.com.au/news/local/city-east/ipart-report-proposes-city-of-sydney-amalgamate-with-randwick-city-and-waverly-council/news-story/ebe6a0b730578b85123a859972e2d8bd

1. Introduction

Although daytime navigation tools are usually used by wayfinders at night, there are certain concerns which become more pronounced during night-time, including concerns for personal safety (particularly for women) and the propensity of getting lost more easily (see 1.5). Darkness and disorientation are two fears of humans. This report attempts to enhance wayfinding at night by reviewing the common wayfinding practices regarding two themes; “lighting at night” and “emerging technology in wayfinding”.

There are many factors affecting the wayfinding process. These factors can relate to people (users), environment (context), and information (emerging technology). Factors that are related to people include: prior knowledge of the site, the level of familiarity with the environment, emotional state, ability to read and understand maps, gender, etc. (see Chen et al. 2009, Lin et al. 2012, National Health Service (NHS) 2007). Environmental factors include complexity of the site, visual accessibility, and landmarks. Finally, information factors include position, legibility, and accuracy (National Health Service (NHS) 2007).

This report covers three categories of users namely, residents, visitors, and commuters (see 1.6). Night-time wayfinding is reviewed as the context, and the most applicable emerging technologies are reviewed with respect their effectiveness in informing pedestrians.

This introductory chapter outlines the purpose of the study (section 1.1). The structure of the report is explained in the methodology section (section 1.2). Section 1.3 and 1.4 describe the scope and the significance of the study, respectively. Definitions, components and principles of wayfinding are described in section 1.5 followed by the identification of different groups of users in section 1.6.

1.1 Purpose of the study

This report sets out ways to improve the wayfinding system at night. The primary aim of the study is:

- To develop a comprehensive literature review of night-time wayfinding research and practice to inform future decision-making at the City of Sydney.

To achieve this aim, it is necessary to conduct a comprehensive review of the common and comparable national and international wayfinding practices. Several case studies have been reviewed in this report. Additionally, the key insights of the reviewed literature are synthesised for the City of Sydney. Furthermore, the potential opportunities for enhancing the existing wayfinding strategies for the City of Sydney are identified in this study.

Accordingly, the following objectives are identified in this report:

- Outlining the common wayfinding practices based on national and international practices
- Highlighting the new and emerging technology in wayfinding
- Identifying wayfinding strategies and components which can enable different users to navigate through the built environment more effectively at night

1.2 Methodology

This research is a structured review of wayfinding strategies, guidelines and design standards. It identifies what is currently being researched and implemented globally. It also enables the City of Sydney to understand how to align wayfinding considerations with the common existing and practical strategies. The structure of this report is illustrated in Figure 1.

This study consists of two main parts:

a) Common practice review

The first part includes a comprehensive review of wayfinding practices. The common and comparable practices to City of Sydney are selected in terms of context (i.e. an urban environment), users and applied emerging technology. The reviewed practices are classified in two categories of national and international practices. This part consists of three themes namely, context, means and accessibility (see Figure 1). Wayfinding examples at night-time are reviewed as the *context*. Emerging technologies utilised for smart cities are reviewed and finally, visually and mobility impaired users are studied for the *accessibility* theme. The scope and scale (i.e. large or small scale extent) of each case study is also identified in the review.

b) Considerations

The second part presents a synthesis of the reviewed strategies and the final considerations for the City of Sydney. The trends and opportunities for the City of Sydney are identified based on the practical reviews. The reviews and general considerations for City of Sydney are classified into five contextual urban elements namely, streets, intersections, parks and waterfronts, squares and landmarks.

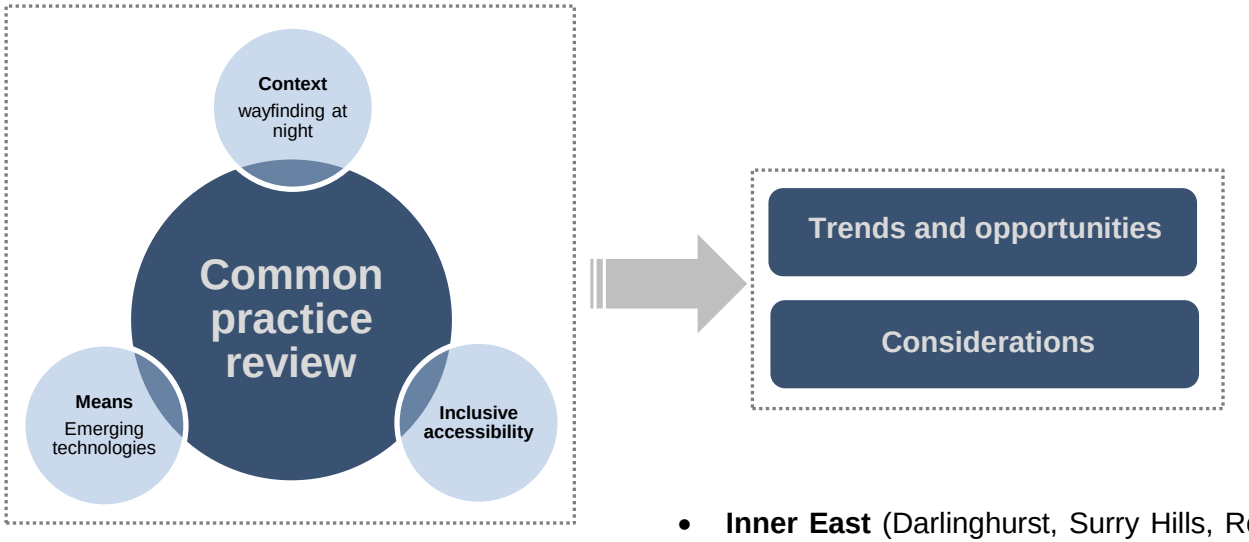


Figure 1.1: The structure of the report

1.3 Scope of the study

The scope of this study is the City of Sydney Local Government Area, which is located in the Sydney Metropolitan Area within the State of New South Wales (NSW), Australia. The study area includes the existing social and physical environments within all the eight local precincts of the City of Sydney Local Government Area (Figure 1.2). The included precincts are as follows:

- **City Central** (City Centre, Haymarket, Chinatown, Millers Point, Dawes Point, The Rocks, Walsh Bay, Circular Quay, Darling Harbour)
- **Inner East** (Darlinghurst, Surry Hills, Redfern East, Moore Park, Centennial Park, Paddington)
- **City East** (Woolloomooloo, Potts Point, Elizabeth Bay, Rushcutters Bay, Kings Cross)
- **Inner South** (Redfern, Waterloo, Eveleigh)
- **City South** (Alexandria, Zetland, Beaconsfield, Green Square, Rosebery, St Peters)
- **Inner West** (Camperdown, Chippendale, Darlington, Erskineville, University of Sydney, Newtown)
- **North West** (Glebe, Forest Lodge, Annandale – East of the Crescent)
- **City West** (Pyrmont, Ultimo, Broadway)

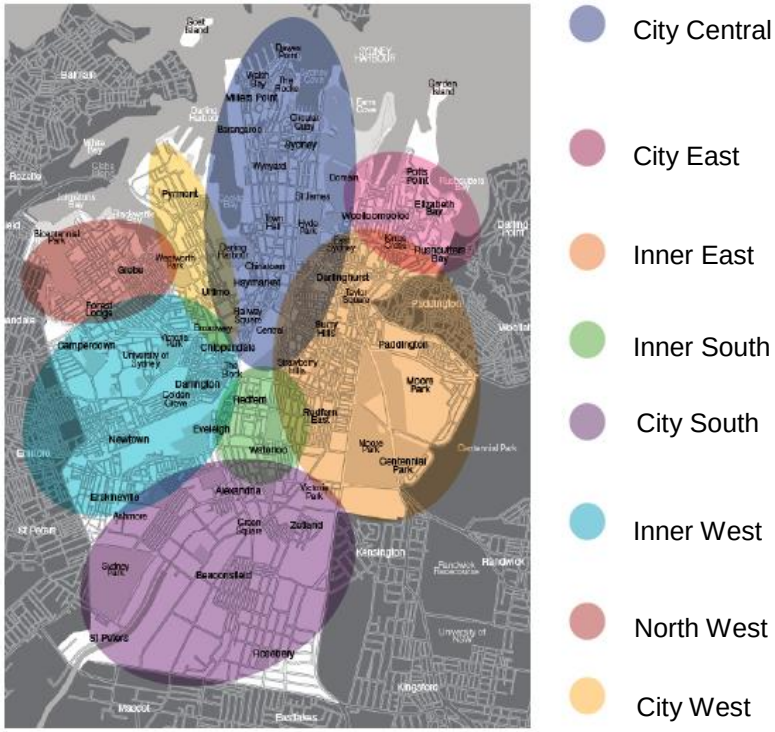


Figure 1.2: The study area for wayfinding strategy (source: City of Sydney 2012)

1.4 Significance of the study

This research plays a significant role as a supporting study for future developments in the City of Sydney. According to the vision for Sustainable Sydney 2030 (City of Sydney 2014), the future developments are required to address several strategic directions. This report provides considerations that are aligned with several strategic directions for Sustainable Sydney 2030. The strategies that are prevalently addressed in the present report are as follow:

- **A city for walking and Cyclists**: This strategy aims to give a greater priority to pedestrian and cycle movements in the city centre. It also aims to provide a safe and attractive walking network linking streets, parks and open spaces, improve health, wellbeing and sustainability. The present report can improve the walkability for pedestrians. In addition, it can enhance accessibility for people with access needs such as the visually impaired and disabled group.

- **A city with night-time economy**: Open Sydney (City of Sydney 2013a) is the City's vision for the long-term development of Sydney's night-time economy. This strategy aims to improve Sydney's function at night, provide a better balance with daytime activities, and become more inclusive of the broader population. It includes actions for making global Sydney's night-time economy better connected, more diverse, inviting and responsive to change. Sydney night-time economy roundtable (NSW Government 2016) is another action plan which aims to grow a night-time economy that has the flexibility to adapt and innovate without undermining public safety. This action plan is consistent with the aim of strengthening Sydney's reputation as a global city, by promoting night-time leisure and social activities for residents and visitors. Establishing a world class wayfinding system for visitors to access public transport hubs and major facilities is one of the main actions. Therefore, the present report can be aligned with these strategies and action plans by supporting the City of Sydney

to enhance its night-time wayfinding system and providing a vibrant, legible, walkable and inclusive City particularly at night.

- **A lively and engaging city centre**: This strategic direction aims to provide inviting streetscapes and vibrant public spaces. It is an attempt to reclaim the city centre from traffic and improve existing spaces for people to enjoy. The functions and services that are required include night-time city management, creating a more diverse and mature night-time culture and support to local businesses. This report will assist achieving this strategy and enhancing night-time legibility by reviewing national and international common practices of wayfinding and by providing considerations for City of Sydney.

- **A cultural and creative city**: This strategy aims to encourage and foster innovation and creativity. This strategy is supported in this report by reviewing the most applicable smart cities practices to the scope of this study.

In addition, this research could be a supporting study for Walking Strategy and Action Plan (City of Sydney 2015b) which aims to improve legibility and wayfinding in the City. The report can also support the Tourism Action Plan (City of Sydney 2013b) which looks for developing reasons for visit, managing visitors' navigation, and promoting tourism.

Furthermore, the current research can be used as a supplementary document for the Legible Sydney: wayfinding strategy report (City of Sydney 2012) through focusing on strategies for wayfinding at night and utilizing a wide variety of technologies in wayfinding.

Finally, an analysis of Opal Card Data (City Futures Research Centre 2016), indicates that approximately 530,000 travellers arrive in Sydney CBD daily by public transport, 245,000 of which are commuters (Figure 1.3 and 1.4). This number of daily travellers within the Sydney CBD emphasizes the significance of specific considerations for enhancing the wayfinding system and walkability in the City of Sydney.

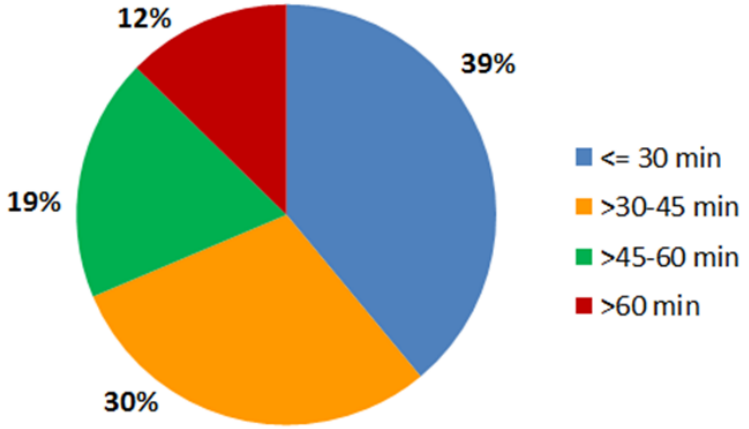


Figure 1.3: Percentage of trips using public transport to Sydney CBD by travel time. Source: City Futures Research Centre 2016

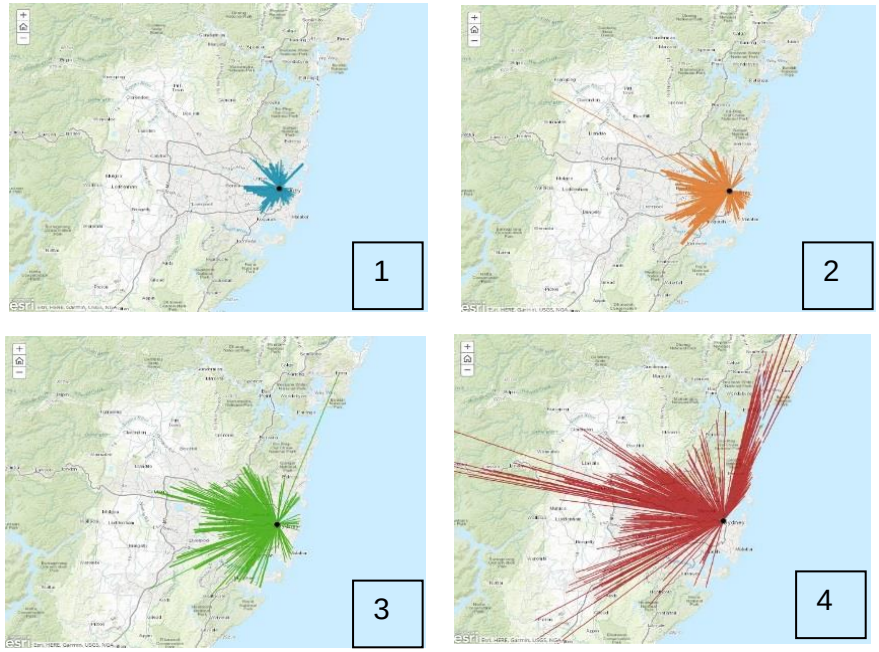


Figure 1.4: Origins of public transport trips to Sydney CBD with duration (1) ≤30 min, (2) 31-45 min, (3) 46-60 min, (4) > 60 min; Source: City Futures Research Centre, 2016.

1.5 What is wayfinding?

Wayfinding is a dynamic process of orienting and navigating through the built environment (Lynch 1960, Winter et al. 2005). It involves selecting a pathway within a network from an origin to a destination (Golledge 1999, Klippel 2010). Wayfinding is also a behaviour (Bechtel and Churchman 2002, 427) that involves many cognitive processes. This behaviour refers to the interactions between the traveller and the environment (Raubal 2001).

Wayfinding is one aspect of a cognitive process which includes all aspects of encoding, processing, and gaining information from the environment (Blades et al. 2002). The wayfinding behaviour involves the ability to learn a route and retrace it from memory (Blades et al. 2002) in order to move from an origin to a destination while maintaining orientation in spaces and around objects and people.

Wayfinding involves interaction between the traveller and the built environment (Raubal 2001). The more interactions the person has with the environment, the more comfortable they become (Parsons 2011) as their familiarity with built environment increases.

The process of wayfinding could vary for individuals depending on the purpose of the trip or their response to external environmental conditions (Golledge 1999). Wayfinding is a decision-making process (Xia et al. 2008). Decision-making for selecting a pathway can be affected by several criteria such as the least time taken, fewest turns, shortest path, or the most scenic path (Xia et al. 2008).

Landmarks are important features in the environment that play critical roles in wayfinding and orientation (Lynch 1960).They are any distinct object that can be noticed and remembered, and that can be cognitively distinct in spatial memory (Presson and Montello 1988). The available wayfinding information in the built environment can improve the legibility of the cityscape by transferring the right message to the users at the right time (Reddy and Carbonell 2006). Therefore, providing distinct landmarks as reference points or visual cues can enable people to understand the form and layout of urban places; in turn, assisting them in wayfinding.

Legibility as a visual quality of the cityscape is one of the most influential factors in wayfinding (Lynch 1960). It is defined as the

ease with which the inherent urban structure and form of a city can be read through the arrangements, quality and character of buildings and spaces (Lynch 1960). Legibility can make the collection of information and decision-making easier for the people. It can ease the wayfinding process around the city by identifying districts, landmarks or paths (Lynch 1960). A legible city can improve the user's understanding of the built environment. Legibility can enhance the user's experience and enjoyment of the city.

The legibility of information which includes positioning, understandability, and clarity of information may vary among diverse sites and places (National Health Service (NHS) 2007). People's perception of the environment can also affect wayfinding, as there is possibility that each user can experience the environment differently. Legibility can be as crucial for wayfinding at night as it is for daytime.

Wayfinding at night is fundamentally based on different factors in comparison with wayfinding during daytime. However, one important process in wayfinding (in either night or daytime) is recognizing items. That is "remembering an item in the presence of the item". This differs from recalling which is defined as "remembering an item in the absence of the item" (Arthur and Passini 1992, 31). Similar to daytime, wayfinders should be able to distinguish landmarks at night-time. The strategic integration of light sources into urban places can improve people's orientation, providing guidance and direction at night (ARUP 2015). For example, illuminating landmarks enhances people's understanding of the city and provides simple orientation. It can provide the possibility to call people's attention towards a particular destination or direction (ARUP 2015).

The improvement of night-time wayfinding systems for pedestrians can increase the opportunity for them to interact with the built environment. It can also provide them with the sense of safety and security at night. Lighting places plays a critical role in ensuring a safe night-time environment.

Emerging technologies are central to effective wayfinding. These technologies can include both passive and active technologies (CRC for Rail Innovation 2011). The passive wayfinding technologies are those that do not interact or provide feedback to the user (i.e. maps, signs, printed information, etc.). The information that is displayed by passive technologies is fixed and they do not require a power source (CRC for Rail Innovation 2011). In contrast, active wayfinding technologies interact with the users. Therefore, the information that the users receive from active technologies is tailored to their needs. Active wayfinding technologies can be also differentiated into personal devices (i.e. smart phones) and infrastructure technologies (i.e. digital kiosks) which are a part of the city infrastructure (CRC for Rail Innovation 2011).

According to some of the practices on wayfinding such as "Bristol legible city" (Kelly 2001) and "Legible London" (Central London Partnership 2006), a successful wayfinding system goes further than simply allowing people to navigate through an area. It can include improving the aesthetics of a city, decreasing street clutter, reducing traffic congestion, increasing tourism, increasing tourists and locals' knowledge of the cities, getting more people walking around the city, boosting local business and the economy by increasing passing trade, and improving public safety. Implementation of an efficient wayfinding system can be significant in terms of health and environmental benefits. Wayfinding encourages walking as an alternative method of transport, reducing

congestion, greenhouse gas emissions, air pollution and creating cleaner cities and cleaner air. Cities that have adopted wayfinding strategies have found that improving the wayfinding system helps support business, tourism, sustainable transportation and sense of place.

Safety in wayfinding

People's perception and feelings of safety in a night-time environment often differ substantially from actual risks. However, lit places are safer than dark areas in general. It is therefore necessary to rethink urban lighting and illumination as a part of wayfinding system. Their functionality can go beyond serving as add-ons for providing easier navigation or beautification; they can also have safety purposes. Therefore, a successful wayfinding system should be able to provide a required level of safety and security for all groups of users particularly at night.

Why do people get lost?

In order to enhance wayfinding, it is necessary to first understand why people get lost, and then attempt to lessen such difficulties. Carpman and Grant (2012) categorised the reasons people can get lost into two categories: things you can control and things you cannot. Things you can control are totally related to user's attitude and behaviour (Carpman and Grant 2012). Without knowing one's location in relation to other objects (sense of orientation) a person can get lost (Carpman and Grant 2012). Whereas the things you cannot control includes: challenging situations, confusing environmental features and way-finding cues, unhelpful institutional policies, brain wiring, physical sensory or cognitive disabilities (Carpman and Grant 2012). This report focuses on the elements that are related to the built environment which are out of the user's control.

1.5.1 Principles of wayfinding

According to the several successful wayfinding practices such as practices in New York (City of New York n.d.), London (Central London Partnership 2006), Toronto (Toronto City Council 2012, 2014), Cleveland (Positively Cleveland 2013), Dublin (Dublin City Council 2004), Edmonton (Applied 2016), Glasgow (Glasgow City Council 2014), and Austin (Merje 2013), there are a number of universally applicable wayfinding principles. The following principles are some of the most referred ones in the mentioned practices.

- **Legibility**: It is a visual quality of the cityscape that can ease the reading of urban structure and navigating around the city.
- **Walkability / Bikeability**: It breaks the city into walkable-bikeable areas to structure people's mental maps and promotes walkable and bikeable connections.
- **Sustainability**: It improves sustainable lifestyle and built environment through promoting walking as an alternative method of transport; reducing reliance of other forms of transport; reducing road traffic congestion, exhaust

emissions and greenhouse gases; reducing air pollution and providing cleaner air.

- **Connectivity of places**: It explains how to travel between places in the city and encourages people to consider alternatives to driving.
- **Consistency**: It allows people to consistently describe what things are called, where they are, and prevents confusion.
- **Predictability**: It fosters trust in the system and promotes a sense of care through consistent appearance, placement and references in information.
- **Flexibility**: It demonstrates the adaptation to future growth, new media and new users by creating systems and standards.
- **Inclusivity**: It provides accessibility of the broadest audience possible and meets the different users' needs.
- **Welcoming**: It communicates the image of the city and its attractions in a positive tone of voice by designing information.
- **Accuracy**: It provides information with the correct tone of voice in the right way. People are more likely to engage with it.
- **Intuitiveness**: It ensures that simple and clear information is placed at natural decision points, and structured in an intuitive way.
- **Being seamless**: It integrates core elements and rules for information across modes to connect them, and reflects the real journeys that people make.
- **Being progressively disclosed**: It relates to the rationale for distributing information along a journey in a manner that prevents information overload and provides a sense of arrival.
- **Being multi-faceted**: It allows people to collect the required information via a wide variety of options including maps, signs, landmarks, public art, lighting and different types of technology for navigation.

Components of the Wayfinding System

Wayfinding system encompasses architecture, landscape architecture, street furniture, public art, lighting, landmarks, orientation points, names, maps, signs, printed information, and different types of digital information and technologies for navigation. The design of urban places should assist the users with accessing a wide variety of the above mentioned components. In fact, a good wayfinding system is composed of a blend of art and science.

1.6 Who are the users?

A successful wayfinding system is responsive to the needs and demands of different users. It is necessary to understand what type of information different users need and how they navigate. The wayfinding system should respond to users' needs by applying components and elements that can make places direction-able. Also, the system must be able to support users in accessing these components and elements easily.

With respect to the purpose of travel, the types and needs for navigation can differ among different users because they may rely on different components and elements of wayfinding. Recreation

and Resolute travel have different aims in the wayfinding process. Four groups of users are defined in this report based on the purpose of travel and the reasons of reaching a destination, including pedestrians who are residents, visitors, commuters or users with disabilities (see Figure 1.3).

Visitors

This group includes recreational travellers who are not in a hurry and are looking for relaxation and amusement (Passini 1984). For this group of users, the process of wayfinding takes priority rather than the functional task of getting from one place to another (Airport Cooperative Research Program 2011). They are mostly explorers who are unfamiliar with the environment (Allen 1999).

Commuters

This group has similar aims to resolute travellers. Resolute travellers aim to find the way in the most efficient manner (Airport Cooperative Research Program 2011). They also tend to reach a familiar destination or are travelling along a familiar route (Allen 1999).

Residents

This group of users can either have recreation as their purpose for travel and may look for relaxation and amusement, or may aim to find the most efficient way from one point to another like commuters. Residents are usually familiar with the surroundings.

Users with disabilities

In order to improve the inclusiveness of the wayfinding system in the City of Sydney, this study also addresses users with disabilities (e.g. users with visual or physical impairment) who have special needs for wayfinding (Figure 1.5). They may have either recreation or commuting as their purpose for travel. However, it is challenging to provide wayfinding information to this group of users.

Users with disabilities face considerable wayfinding difficulties in cities and transit systems. They need facilities to feel safer, more efficient and more independent in the built environment. For visually impaired users, the alternative options for reaching the required information can be the auditory and tactile modalities (Montello and Sas 2006). Wayfinding orientation technologies can also provide them with more options to gather detailed and accurate information about the surrounding environment (Marion and Michael 2008).

Wayfinding and navigation technologies can also be effective for users with mobility impairment. New technologies can mitigate environmental factors that may hinder their travel by routing these users around the environmental barriers. Providing some information about location-based accessibility features enable these users to navigate easier (Karimi et al. 2014).

The existing pedestrian wayfinding services usually do not support accessible wayfinding for this group of users. This group requires special wayfinding needs to facilitate their travel in cities. Therefore, it is necessary to update the wayfinding system in City of Sydney and address the preferences of pedestrians with disabilities. A successful implementation of the identified wayfinding strategies will deliver significant and proven benefits to all the above-mentioned users.

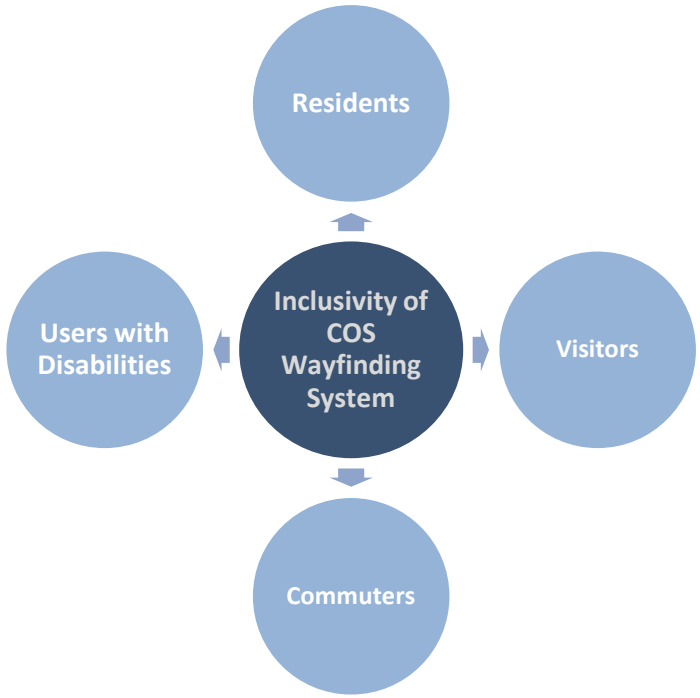


Figure 1.5: The users of wayfinding system in City of Sydney

1.7 Benchmarking wayfinding performance: a gap in the literature

The academic literature contains a large number of wayfinding studies which significantly vary in scope, aims and methods. Generally, they involve the assessment of a specific wayfinding approach within an environment, or wayfinding strategies used for a particular group with specific characteristics. Also, in terms of methods, they normally involve small samples which are part of a survey or an experiment, with limited suitability for generalisation to contexts beyond the study boundaries. Moreover, there are more studies focused on indoor environments, such as hospitals, libraries, and shopping malls, than outdoor environments. As a result, the literature in wayfinding is a patchwork of fragmented studies which provides significant evidence for specific contexts, but is yet unable to provide a holistic understanding of wayfinding in complex environments. This is for *wayfinding* in general. Specifying literature search for *wayfinding at night*, dramatically decreases the number of available studies.

Specific wayfinding methods or infrastructure whose assessments have been handled by recent scientific research include: signage (Greenroyd et al. 2017); dynamic signage (Langner and Kray 2014); lighting in signage (Lasauskaite and Reisinger 2015); auditory cues (Secchi et al. 2017); maps in several forms, such as in print and within applications (Bjerva and Sugurjonsson 2016); digital 2D and 3D maps (Lei et al. 2016); mapping assisted by voice and augmented reality (Rehrl et al. 2014); landmarks (Bala 2016), just to name a few. Mullen et al (2016) proposes a taxonomy of wayfinding technologies and a preliminary assessment of feasibility and usability issues. They argue that more research is necessary to understand the utility of these applications in larger, diverse samples, using better metrics to assess their impact (immediate and long-term goals), with a greater awareness of influential mediating factors (individual characteristics, socio-contextual factors) and potential side effects from a reliance on technology.

In parallel there is a robust body of research investigating how human characteristics affect the way people build and use strategies for wayfinding and navigation in the environment. This

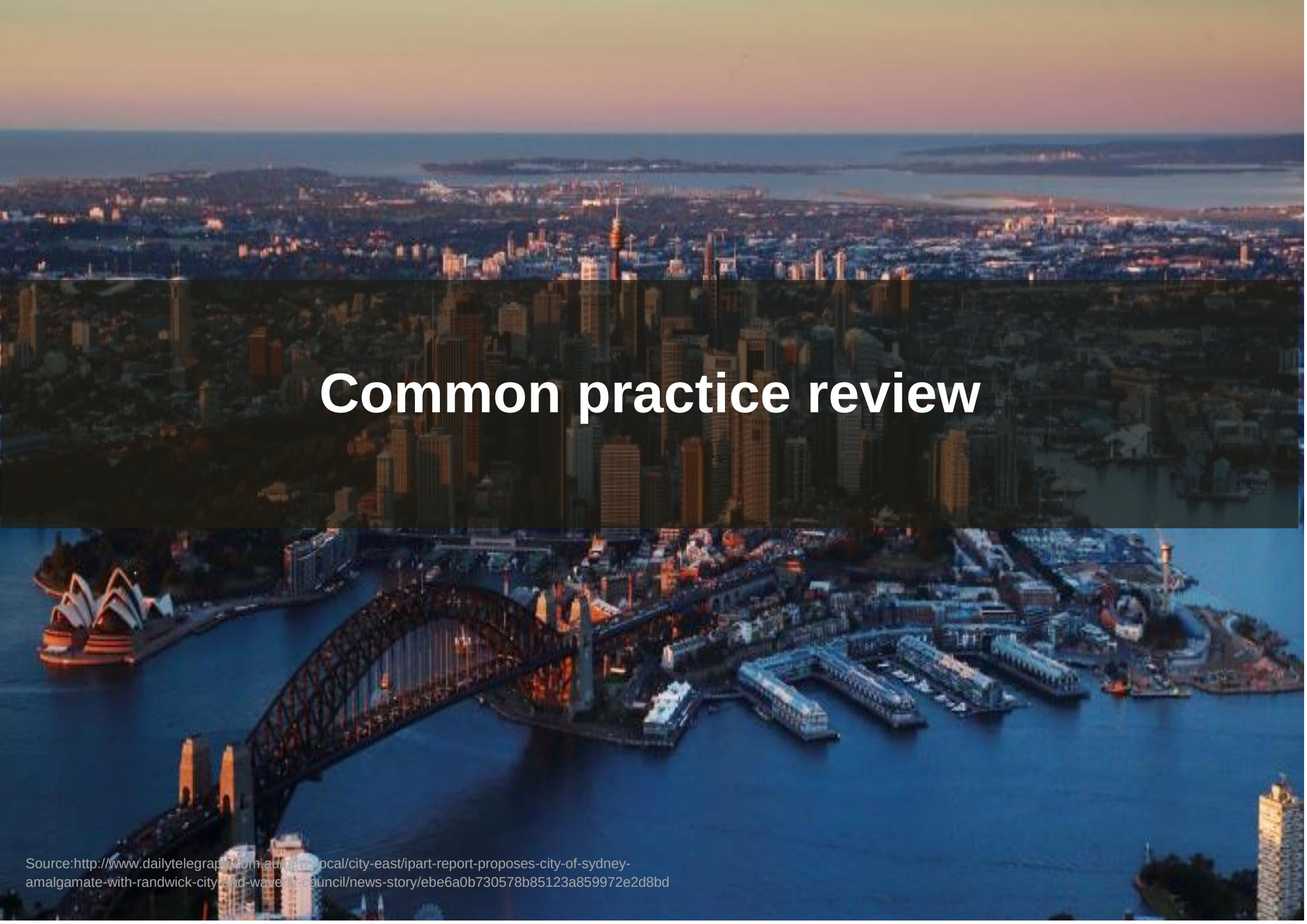
type of research look at specific groups of people who share certain characteristics, such as seniors (Mishler and Neider 2016), people with varied spatial cognition capacity (Koletsis et al. 2017), people with visual impairment (Secchi et al. 2017), etc. Another focus of wayfinding research, is on the extent of the impact of urban morphology and built environment configuration on people's navigation and wayfinding (Emo 2014, Silavi et al. 2014).

Due to the complexity of urban environments (particularly city centres), the diversity of groups using these environments, and the variety of existing and emerging technologies for spatial navigation, benchmarking wayfinding is a challenging and difficult task. Plans and programs for wayfinding proposed and/or implemented by local governments are generally not based on extensive evidence from research. When they are, they generally address specific strategies (e.g. signage), or group of users (e.g. visitors, blind). This may be due in part by the fragmented state of current knowledge and evidence on wayfinding.

However, despite most research being narrow in their goals, some researchers have already identified the need for a more holistic approach (Hunter et al. 2016, Giannopoulos et al. 2014). Such a holistic approach should benefit from the evidence produced from multiple studies within small scope, but progress filling gaps in between studies, linking the diversity of environments, wayfinding approaches, and user groups into a robust framework. Hunter et al. (2016) highlights that many of the unanswered questions on wayfinding are located in those areas in between research fields and applications. Only a holistic framework would allow for a more general and complete assessment of wayfinding strategies, and then a standardised comparison among practices. Thus, best practices could be identified, and lessons learned from them could be beneficial for places trying to improve their own performance based on evidence and assessed practices. Such benchmarking is not available at the current status of development of the wayfinding field.

In the absence of an integrative approach to wayfinding assessment, any literature review is limited to being a review of existing practices, which in large part are not fully assessed and compared to other practices—therefore, not a review of best practices. In this context, evaluations and recommendations from existing practices or developed research cannot be classified into a hierarchy of priorities or tested for complementarities of conflicts. The increasing complexity of the built environment, accompanied by the diversity of user groups, and the fast pace of emerging technologies available to local governments and individual users to assist wayfinding, calls for the need of tools for integrative and strategic planning of wayfinding infrastructure.

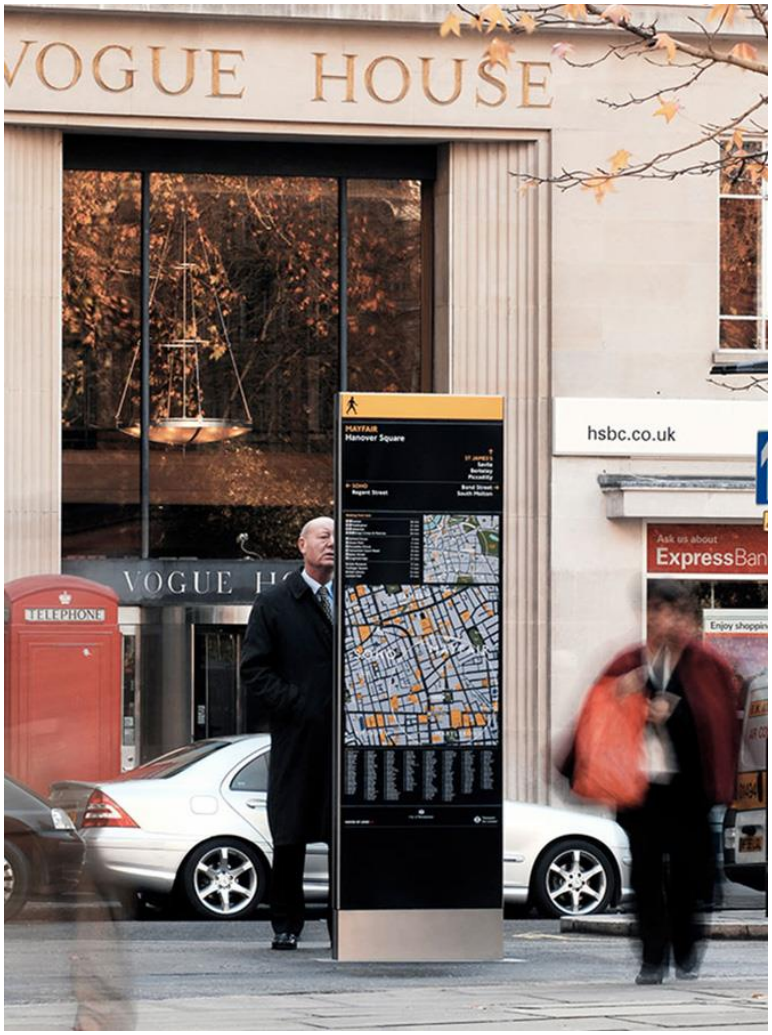
Common practice review



Source:http://www.dailytelegraph.com.au/news/local/city-east/ipart-report-proposes-city-of-sydney-amalgamate-with-randwick-city-and-waverley-council/news-story/ebe6a0b730578b85123a859972e2d8bd

2. Common practice review

The focus of this section is on two themes: lighting at night, and emerging technologies in wayfinding. This section reviews the common wayfinding practices for each theme. This review covers a comprehensive review of both national and international practices. The review aims to identify the key insights and strategies and implementations of wayfinding which can be applied for the City of Sydney. The target users of each project and the scale of the projects are identified and mentioned for each case study.



Source: http://appliedwayfinding.com/projects/legible-london/

2.1 Lighting at night

2.1.1 Existing and common international practices

1 Queen Elizabeth Olympic Park, London (UK)

Scope

'Lighting Strategy Queen Elizabeth Olympic Park' is a large-scale strategy for guiding and informing the subsequent detailed lighting design submissions for the Queen Elizabeth Olympic Park and the five new neighbourhoods (London Legacy Development Corporation 2013). This strategy acts as an aid to wayfinding and guides visitors navigate through the park during the day and night-time (Olympic Delivery Authority 2011). Accordingly, the target users are the visitors of the Olympic Park, including both visitors and residents.

- Followings are the main purpose of this strategy (Olympic Delivery Authority 2011):Maintaining higher levels of lighting during the games to facilitate wayfinding
- Ensuring safety and security
- Promoting the use of a renewable energy source
- Promoting common procurement to provide consistent look and feel
- Defining lower light levels in transformation to save energy and protect biodiversity

The Strategy has been prepared around several principles, including amenity, ambience, legibility, consistency, accessibility, safety, security, maintenance, and sustainability (London Legacy Development Corporation 2013). The specific strategies that can be applied for the purpose of this report are outlined in the following section.

Table 2.1: Lighting strategies in practice in London Queen Elizabeth Olympic Park

Strategy	Description
Using LED (Light Emitting Diode) smart technology for lighting	Advanced lighting and energy-savings technologies such as LEDs can reduce waste and provided improved quality and distribution of light. Each LED luminaire contains advanced lamp and gear technologies that include a sealed optical lens array to provide an even distribution of layered light (Olympic Delivery Authority 2011). This strategy provides the project with low-energy, long service lifer, easily dimmable and low ultraviolet component (London Legacy Development Corporation 2013).
Using nodes* and clearly highlighted destinations in combination with well-lit pathways	This strategy aims to create an environment of intuitive navigation and the creation of a strong sense of identity for the park at night. It focuses on creating a sense of spectacle, and aiding wayfinding for visitors through clearly lit routes (ARUP 2015).

* Nodes are important strategic points or places into which an observer can enter (Lynch 1960). They can be focal points, junctions, convergence of paths, breaks in transportation. These spaces are points of both convergence and divergence (Stevens 2006). Nodes are decision-making places where people slow down or stop to a make choice about what to do next or where to go (Stevens 2006).

2 Amsterdam (Netherlands)

Scope

Amsterdam has defined a number of large-scale innovative strategies for smart lighting. Followings are some of the key strategies in practice within this smart city that can be applied for wayfinding at night. These strategies can be applied in large-scale for both residents, commuters, visitors, and people with disabilities expect the visually impaired and also importantly to improve the safety of streets at night-time.

Table 2.2: Lighting strategies in practice in Amsterdam

Strategy	Description
Managing and adjusting street light by smartphone application	The GeoLight application on the smartphone is a Luminext solution that gives people the opportunity to manage street lighting themselves. It provides energy saving and safety. The light can dim after passing the area (Amsterdam Smart City (a) n.d.).
Flexible switch system for street lighting	This project aims to control the switches and dimming devices in public spaces and to facilitate the transition to a sustainable, reliable and safe energy supply. The Amsterdam pilot in 2013 (in Osdorp, Nieuw-West) forms part of the Amsterdam Smart City programme. The tests in Amsterdam and Leiden involved placing 50 'smart' light masts, to try out the flexible switch system (Amsterdam Smart City (b) n.d.).
Smart lighting	Using LED (Light Emitting Diode) technology for decreasing the costs, saving energy and increasing the durability of lighting infrastructure

Note: The technology of using Light Emitting Diode (LED) as a smart street lighting is broadly applied in other cities such as New York, London, Toronto, Vancouver, Montreal, Moscow, Copenhagen, Barcelona, Seoul, Melbourne, Sydney, and Brisbane.

3 Copenhagen (Denmark)

Scope

Copenhagen lighting master plan (Copenhagen City Council 2014) is a large-scale study for lighting the public urban spaces in Copenhagen. It has developed strategies and concepts to use light as means to promote a more sustainable, safe, social and culturally rich city experience. All the groups of users which were defined in 1.6 are the targets for this project except the visually impaired. The strategies which can be applied for wayfinding are described below.

Table 2.3: Lighting strategies in Copenhagen

Strategy	Description
Interdependence between street lighting and traffic signals	Smart technologies can be applied to link the stre lighting with the traffic signals in order to Illuminate th pedestrians' paths at the intersections with projector Applying this strategy can encourage the pedestriar to pass through the identified areas. It can provide pedestrians with safety and eas wayfinding at the intersection (Copenhagen Ci Council 2014).

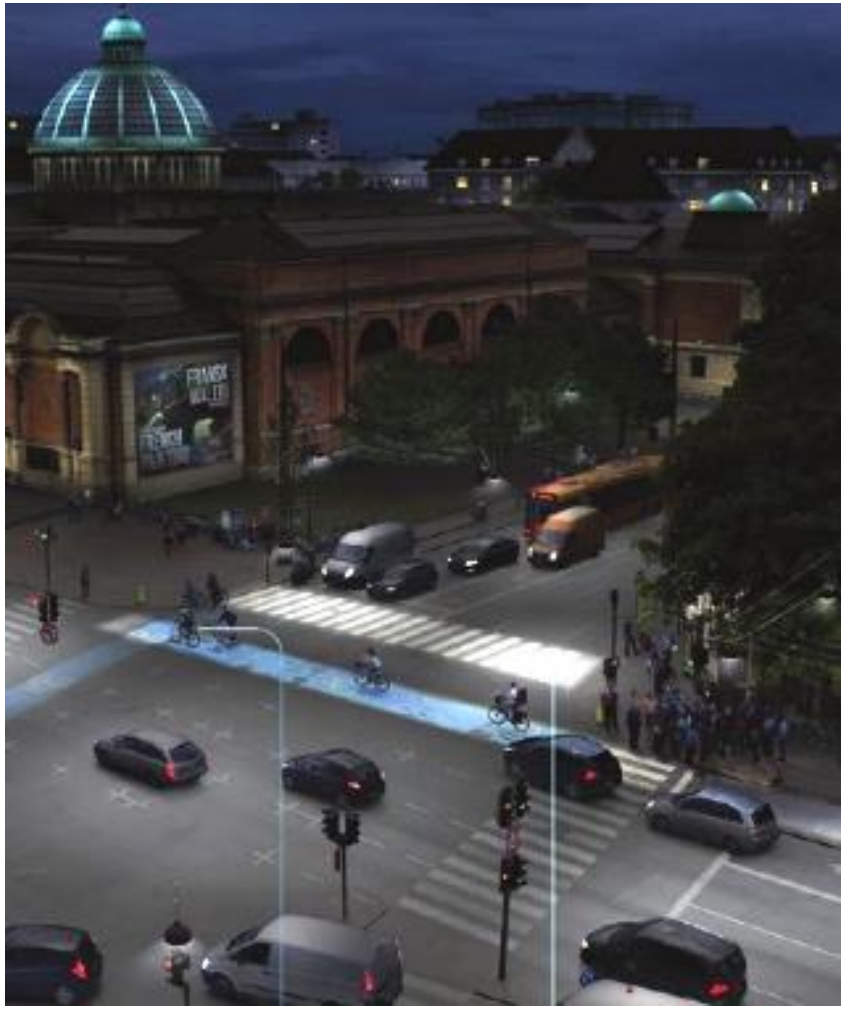


Figure 2.1: Interdependence between street lighting and traffic signals, Copenhagen. Source: Copenhagen City Council 2014.

4 Montreal (Canada)

Scope

The Montréal's Quartier des Spectacles is a small-scale project that has experimented in one of the city intersections (intersection of Sainte-Catherine and Saint-Denis streets) in order to improve pedestrians' wayfinding (ARUP 2015). This pilot project explores the potential of light projections on the pavement to create signage. Some of the key Montreal's lighting strategies, which could be applied for wayfinding at night, particularly for residents, visitors, and commuters are described below.

Table 2.4: Lighting strategies in practice in Montreal

Strategy	Description
Using light projections on the pavement to create signage	The preliminary installation, was made up of projectors suspended from towers and synchronised with the existing traffic lights at the intersection. An interplay between projections and the traffic light system is created. When lights turn red, projections change to display directions and shows pedestrians the way to major nearby places. The projections illuminated only the crosswalks, clearly indicating safe pedestrian passages across the street and through rows of animated circles (Quartier des Spectacles Montreal 2010).

Figure 2.2: Using light projections on the pavement to create signage, Montreal - Source: http://www.designboom.com/design/quartier-des-spectacles-lighting-plan/

Figure 2.3: Using light projections on the pavement to create signage, Montreal - Source: http://www.designboom.com/design/quartier-des-spectacles-lighting-plan/

5 New York (US)

Scope

'Silent Lights' is a small-scale urban lighting project located near the Navy Yard in Brooklyn. It takes the traffic noise and makes it visible, illuminating the gloomy, clamorous underpass with a pathway of peaceful lighted gates for pedestrians. The installation acts as a wayfinding element, making the inconspicuous pedestrian pathway more visible and engaging (Urban Matter INC n.d.). The key strategies which can be applied for wayfinding at night for both commuters and visitors are mentioned in the following table.

Table 2.5: Lighting strategies in practice in New York

Strategy	Description
Applying interactive lighting	Lights respond to the sounds above them, lighting up sequentially as vehicles pass overhead. Thus, the hum of the traffic becomes a tangible, reactive presence and passersby can walk beneath the multi-coloured gates to experience a moment of respite from the constant noise (Urban Matter INC n.d.). This project is embedded with 2400 LEDs and 2 microphones, controlled by an arduino mega microcontroller. There are also 5 multi-coloured gates that light up sequentially in response to ambient noise. The gates are made of various perforated metal panels clad over an aluminium frame. Each gate contains 2 sealed white acrylic boxes; these boxes house the sequence of LEDs (Urban Matter INC n.d.).

Figure 2.4: Applying interactive lighting, New York
Source: http://urbanmatterinc.com/silent-lights/

Figure 2.5: Applying interactive lighting, New York
Source: http://urbanmatterinc.com/silent-lights/

6 Barcelona (Spain)

Scope

BruumRuum is a small-scale project for an intuitive, interactive lighting installation at the Plaza de Glories in Barcelona, creating a dialogue between people and the public space (ARUP 2015). It can transform a standard urban space by day into an engaging space at night. This strategy has the potential to be utilised by all the users (except the visually impaired users) particular by residents to enhance the social activities. The potential strategies that can be applied for enhancing wayfinding at night are described below.

Table 2.6: Lighting strategies in practice in Barcelona

Strategy	Description
Applying interactive lighting	Using sensors that can capture, integrate and respond to the sounds caused by pedestrians and vehicles passing through. The lighting elements change colour in response. This is an example of social light and sound interaction (ARUP 2015).

Figure 2.6: Applying interactive lighting, Barcelona
Source: http:// www.artec3.com/bruumruum

Figure 2.7: Applying interactive lighting, Barcelona
Source: http:// www.artec3.com/bruumruum

7 Dörentrup (Germany)

Scope

'Dial4Light' is a small-scale project which has been trialled for lighting in Dörentrup, Germany. This project incorporates the early switching off the street lighting with individual community remote controls (ARUP 2015). Residents are the target of this project.

Table 2.7: Lighting strategies in practice in Dörentrup

Strategy	Description	Example
Applying community-based adaptable lighting	It enables pedestrians to adapt street light for better wayfinding. It gives pedestrians the option to turn on the illumination of individual streets for 15 minutes with a simple telephone call. Furthermore, this project is aligned with sustainability principles and saves the town up to 12 tonnes of carbon emissions per year (ARUP 2015).	 Source: http://www.travelbugholiday.com/2011/01/germany%E2%80%99s-street-lights-turn-phone/

2.1.2 Existing and common national practices

8 Melbourne (Australia)

Scope

The City of Melbourne 'Public Lighting Strategy' (Melbourne City Council 2013), is a large-scale strategy that provides direction for public and private external lighting throughout the City of Melbourne. It aims to enhance people's experience of the city after dark, while ensuring responsible energy use. Residents, visitors, and commuters can gain benefit from this project.

The main objectives of this study are as follow:

- To improve the quality, consistency and efficiency of night lighting in streets and other public spaces
- To improve wayfinding and visual comfort, as well as road safety and personal security
- To make the public spaces remain attractive, safe, comfortable and engaging after dark
- To minimise the energy consumption in the outdoor lighting
- To ensure new lighting projects provide a balance between achieving the outcomes and reducing greenhouse gas emissions
- To encourage event lighting and temporary illuminated displays
- To improve the environmental sustainability of public spaces due to the standard streetlight

This strategy is divided into five key themes as follow:

- **Designing the luminous city:** Ensuring a consistent, attractive and balanced approach to the design of lighting throughout the municipality.
- **Safety and amenity:** Providing the required levels of illumination for a safe and appropriate public realm.
- **Attracting the evening crowd:** Promoting Melbourne's growing reputation as a 24-hour city.
- **Designing a sustainable city:** Promoting efficient technology, responsible management practices and other forms of energy conservation.
- **Keeping the lights shining:** Delivering quality lighting and safety outcomes while managing operating costs and energy use

Figure 2.8: Illuminating key buildings and structures, Melbourne
Source: https://www.travelvictoria.com.au/regions/melbourne/city/

Table 2.8: Lighting strategies in Melbourne

Strategy
Use lighting to support active transport modes (bicycles, walking, and tram) should be lit where and when there is a heavy use (pick hours) and generally turned off after 1am.
A skeletal path layout for major pedestrian routes and building security lighting can be lit all night. Remote control technology should be installed to turn these off for 'starlight nights'.
Illuminate buildings and structures that are seen from distant vantage points.
Illuminate the buildings at the end of major street corridors or the buildings that face parks, gardens and other public reserves to allow a good visibility.
Illuminate and drawing attention to local landmarks in areas both inside and outside the Central City.
Accent parks' edges and main entrances with lighting.
Provide good illumination of the most popular walking routes in parks. Ensure these pathways are well connected with each other and with surrounding city streets. Do not light cul-de-sacs or routes that are seldom used.
Introduce timers or energy-efficient dimmers to lamps along infrequently used pathways. Use these controls to reduce illumination during the early hours of the morning.

Continuation of table 2.8: Lighting strategies in Melbourne

Strategy
Reinforce continuity along the rivers by lighting to support public access to the water's edge and legible pathways along the full length of each waterway.
Use white light in areas of the city with high pedestrian activity.
Continue the colour of surrounding streetlights into plazas, squares and other small parks or reserves.
Full-facade lighting, or floodlighting, should be limited to buildings that have special public significance and those that assist wayfinding. Ordinary buildings should be treated more modestly so as not to compete with these civic landmarks.

Figure 2.9: Lighting along the waterway, Melbourne

Source: https://commons.wikimedia.org/wiki/File:Melbourne_at_night.jpg

Figure 2.10: Illuminating the landmarks, Melbourne

Source: https://www.travelvictoria.com.au/regions/melbourne/city/

9 Newcastle (Australia)

Scope

'Newcastle City Council Smart City Strategy 2017-2021' (Newcastle City Council 2017) is a large-scale strategy which outlines the vision for Newcastle 2030 and highlights Council's role in working towards the delivery of this vision. This strategic plan targets all groups of users. It includes six strategic directions in addition to smart and innovative city as follow:

- Connected City
- Protected and Enhanced Environment
- Vibrant and Activated Public Places
- Caring and Inclusive Community
- Liveable and Distinct Built Environment
- Open and Collaborative Leadership

This Smart City vision for Newcastle is based on the following principles:

- **Collaboration**: Ensure organisations are working together to achieve positive change and success.
- **Connectivity**: Ensure the capacity for interconnection of people, platforms, systems and applications.
- **Efficiency**: Ensure orderly, capable, competent and valuable outcomes.

- **Openness**: Ensure access to data and a subsequent increase in acceptance, tolerance, receptiveness and understanding.
- **People**: Engage community, humanity and citizens.

Table 2.9: Lighting strategies in Newcastle

Strategy	Description
Smart lighting	LED (Light Emitting Diode) technology. Each pole can also house Wi-Fi signal points and sensors.
Interactive lighting system	Sensor-based interactive lighting to create a dynamic public domain and bring innovation to the city streets.

2.2 Emerging technology in wayfinding

2.2.1 Existing and common international practices

10 Toronto 360 wayfinding strategy (Canada)

Scope

'Toronto 360 Wayfinding Strategy' (Toronto City Council 2012) is a large-scale wayfinding system strategy for the city of Toronto which addresses the needs of all users including residents, visitors, people with visual and mobility impairments. The objectives of this study include:

- Identifying and connecting places
- Reducing reliance on the car and promoting multi-modal trips
- Stimulating economic growth
- Encouraging exploration, wandering and discovery
- Building confidence and trust to walk

The design framework is organised around five main principles as follow:

- **Consistency**: Ensuring signs are serviced regularly, and are multi-lingual as well as ensuring obstructions are removed
- **Inclusivity**: Ensuring that information is compatible with other platforms, use tactile/textured surfaces

- **Sustainability**: Removing items before implementing new elements, remove Info Pillars, provide more open data and ensure regular updates
- **Transition**: Visible address numbers, ensure routes are clear, high map contrast
- **Local Identity**: Including local landmarks

Table 2.10: Strategies for emerging technology in Toronto

Strategy	Description
Applying digital technology	Digital maps could use built-in (mobile) compass to aid orientation.
	Mobile applications should be multi-platform, including iOS (iPhone, iPad), Android (HTC, Samsung), Windows Mobile (Nokia) and Blackberry OS.
	Mobile applications should consider the use of accessibility features. Signage structures should include QR codes, RFI tags, Wi-Fi, or other technologies in support of location based services.
	Mobile devices should be enhanced by features such as compass and location based services.
	The content of mobile applications may include system identification, map-based navigation and multimodal journey planning, find / search functions, customizable options (user profile, mode, district, events), up to Tier 4 shop-to-shop locator, partners and sponsors, information made available in alternative media.

Considerations for users with disabilities

The Toronto 360 wayfinding study, considers number of strategies for improving accessibility for the disabled users. According to these strategies, all signage should be located in such a way that it can be easily accessed by someone who is standing or using a wheelchair. All essential information is suggested to be located between 90cm and 140cm from the finished ground level. 'Toronto 360 Wayfinding Strategy' also recommended considering alternative media or materials for a range of users such as the elderly and visually impaired (Toronto City Council 2012).

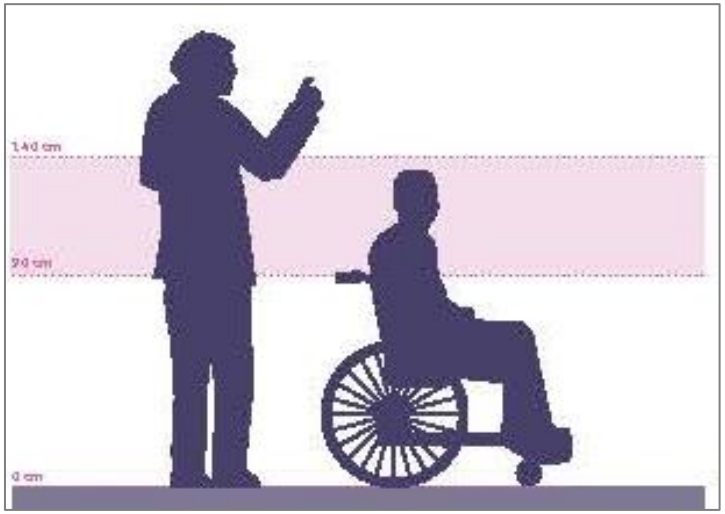


Figure 2.11: Height limit of signage for the users with mobility impairment - Source: City of Toronto 2012.

Figure 2.12: Alternative materials for users with visual impairment
Source: City of Toronto 2012

'Toronto 360 Wayfinding Strategy' also recommended a set of general strategies which can be adapted for the users with disabilities. Displaying walking distances in metres (up to 900m) with a walking time catchment of 5-10 min/400-800 m, is one example of these strategies. It is also highlighted that physical and or visual obstructions should be avoided and the existing obsolete structures in the public right-of-way should be removed. Signs should avoid physical obstructions within open space or public right-of-way (Toronto City Council 2012).

The city of Toronto has a separate strategy for pedestrians with low or no vision, or who are deaf-blind. It is called 'Accessible Pedestrian Signals' (City of Toronto (a) n.d.). This audible pedestrian signals, is a consideration by Toronto City Council that is linked to the visual pedestrian signals. It advises pedestrians with low or no vision, or who are deaf-blind when they have the right-of-way to cross at a signalised intersection and in which direction they may cross the intersection (City of Toronto (a) n.d.). The City of Toronto has over 600 signalised intersections equipped with accessible pedestrian signals.

Two audible tones are used to indicate the direction in which the pedestrian has the right-of-way:

- A **cuckoo** sound (accompanied by the walking person display) indicates that the pedestrian can cross in the north or south direction.
- A **chirp** sound (accompanied by the walking person display) indicates that the pedestrian can cross in the east or west direction.

This signal can operate both automatically and manually. In case of manual operation, the pedestrian pushbutton must be pushed and held for at least three seconds to active the audible sound. In addition to the "cuckoo" and "chirp" sounds, some signals are equipped with a continuous tone called a "locator tone". This tone is emitted from the pushbuttons to assist pedestrians, who are blind or visually impaired, in locating the pushbuttons (City of Toronto (b) n.d.).

There are also a set of general strategies which can be adapted for wayfinding at night. It is recommended to improve route legibility through supporting the implementation of lighting to ensure adequate lighting along major pedestrian routes. Furthermore, panels and totems can be Illuminated for better visibility at night (Toronto City Council 2012).

Considerations for Visitors

To respond to the needs of visitors, 'Toronto 360 Wayfinding Strategy' recommends providing this group of users with pocket maps at visitors' welcome and entry points (e.g. airports, hotel concierge, convention centres). The pocket map may content system identification, mode identification, context map citywide (thematic) or area map, activity or mode-relevant information, partners and sponsors, and information regarding alternative media (Toronto City Council 2012).

11 Toronto parks and trails wayfinding strategy (Canada)

Scope

'Toronto Parks and Trails Wayfinding Strategy' (Toronto City Council 2014) is a large-scale study for improving wayfinding in parklands managed by the City of Toronto. Residents, visitors, and commuters can gain benefit from this project.

The main objectives of this strategy are:

- Improving identification, orientation and navigation
- Encouraging visiting, exploring and appreciation
- Raising awareness of what parks have to offer
- Improving perception of park user safety
- Improving confidence to walk and explore

This study is based on several wayfinding principles. The main principles are as follows:

- **A user-based approach:** The user experience is the primary consideration for any sign design decisions.
- **Simplicity:** Signs should be as simple as possible, and avoiding non-essential information (i.e. marketing brands, logos, names of organizations, etc.).
- **Consistency:** A consistent approach to wayfinding elements and information is required across parks.
- **Placement:** A balance between information and clutter needs to be considered at a local level.

- **Visual language and identity:** Reflect Toronto parkland's unique voice and design information and products to communicate parkland attributes.
- **Integrate with surroundings:** The connections between parks and their surrounding areas should be improved.
- **Modular and easily updateable:** Signage products should be flexible and adaptive depending on information need and park type.

Table 2.11: Strategies for emerging technology in Toronto

Strategy	Description
Applying digital technology	Digital applications in conjunction with either smartphone and/or wearable technology.
	Global Positioning Services (GPS) for location and context information. Standard GPS would provide the service with a location, and would offer context information for the routing service.
	Near Field Communications (NFC). It can be used as a standalone tool to offer the user highly location-specific information (to inform about a specific point of interest, or perhaps to alert users to a hazard). This is a low-cost option and would enhance the environment, rather than acting as a standalone service.
	Radio-frequency Identification (RFID) for point specific information
	Bluetooth beacons for location specific information delivery. It can provide the users with general point of interest information when they are within the proximity of the transceiver. This means that users could be provided within information even if they are not walking on a particular pathway.

12 Legible London (UK)

Scope

'Legible London' (Central London Partnership 2006) is a large-scale wayfinding study for pedestrians including residents, visitors and commuters. It covered the Congestion Charging Zone (CCZ) in London, but the principles and proposed solutions in this study are applicable to all 33 London boroughs.

The main objectives of this study are as follows:

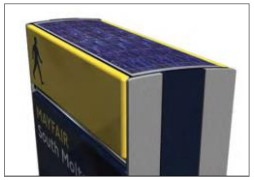
- To identify a common solution to wayfinding and outline the principles of a pedestrian signage system that encourages walking
- To take into account the viewpoints of all stakeholders
- To make London easier to understand for pedestrians
- To design any effective signage system
- To be mindful of what matters to different kinds of walkers in our city including residents, visitors or commuters

Below are the main wayfinding principles which have been addressed by this study:

- **Walkability**: Providing a better service for pedestrians to encourage walking.

- **Legibility**: Providing a wayfinding system which has a pedestrian- focused details and facilities with legibility.
- **Connectivity of places**: Connecting areas, regions and transport systems.
- **Inclusivity**: Responding to the needs of many different groups of walkers: visitors, locals, visitors and customers.
- **Multi-faceted approach**: Achieving a substantial increase in walking in London.
- **Being progressively disclosed**: Providing enough information and not too much.

Table 2.12: Strategies for emerging technology in London

Strategy	Description	Example
Applying digital technology	Digital devices (i.e. Digital kiosks and digital smart totems) Note: The use of digital kiosks and touch screen information consoles have been recommended in other similar studies like 'Legible Bristol' (2001) as well.	
	Technologies including GPS/GPRS	
	Online journey planning information (i.e. TfL's (Transport for London) journey planner or visitlondon.com)	
	Online journey planning tube map	
	Use the technology of solar panels on the top of the signs for viewing at night	 Source: AIG London Ltd 2006

In order to address the inclusivity and the needs of the users with disabilities, this study has some considerations for the height of interactive elements for wheelchair users. In terms of the users with visual impairment, it considers the size, contrast, clarity and avoidance of reflectivity of the signage (Central London Partnership 2006).

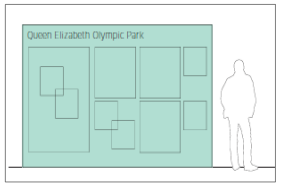
13 Queen Elizabeth Olympic Park, London (UK)

Scope

'Queen Elizabeth Olympic Park wayfinding strategy' (Applied 2013) is a large-scale study. The target users are the visitors of the Olympic Park, including both visitors and residents. The objectives of this study are as follow:

- To create a safe and accessible environment
- To create an uncluttered and legible landscape
- To promote an integrated experience of the Queen Elizabeth Olympic Park and reinforce the brand identity
- To improve connectivity for local visitors from the surrounding neighbourhoods

Table 2.13: Strategies in practice for emerging technology in London Queen Elizabeth Olympic Park

Strategy	Description	Example
Applying digital technology	Digital signage and wander walls which can provide real-time information and scrolling updates (Applied 2013).	 Source: Applied 2013
	Digital and audio wayfinding tool for users with visual impairment (London Legacy Development Corporation 2013).	

14 Smart London (UK)

Smart London Innovation Networks (SLINs), run by the Institute for Sustainability in partnership with the Mayor of London's Office, are created to support the development visions for "smart city" innovation, address resource pressures and create new economic and research opportunities (Smart London innovation networks 2015). These networks provide a platform for the public and private development organisations delivering London's largest and most ambitious development districts. The aim of these networks is to showcase the exemplar developments, enable collaboration, sharing of best practice and bringing new smart city innovation to market.

In terms of smart wayfinding, these networks sought smart innovations which would help residents, visitors, businesses and developers better connect with their surroundings. Based on a public competition and its assessment process, six innovations were selected as the best and most recommended innovative solutions for London's smart wayfinding system (Smart London innovation networks 2015). The selected innovations which could be applied in wayfinding are as follow:

Table 2.14: Strategies for emerging technology in London

Innovation	Description
Colocator (Crowd Connected Ltd)	It is an insight platform offering districts real time visualisation and analysis of people movement. Colocator fuses observations from multiple smartphone sensors to generate location data. It takes real-time data from cellular, Wi-Fi, Bluetooth and GPS to be used as operators with real-time visualisations and analysis of people movements and behavioural patterns across an area. A web based console provides region occupancies, event attendance figures, dwell time estimates and configurable alerting. Data is harvested from applications and the required code can easily be dropped into an existing application. The system can continue to track devices in real time when they are offline. Applications can be built using this solution for navigation and wayfinding; for example, utilising the push notification mechanism. Colocator can be used as a basis to develop new smart application features, for example automatically directing users to underutilised facilities.
Flybits Smart City Solution (Flybits Inc)	Flybits Smart City Solution is a smart wayfinding personal mobile application which offers a smart wayfinding solution for district users and actionable insights for district managers using real-time data. It combines contextual information for end users with actionable insights for district management, such as disruption of service notifications and consumer behaviour. The user side application utilises patented context-aware technology to power delivery of mobile applications and services that respond and adapt to a user's unique context, interests, environment and more. Features include Augmented Reality wayfinding and navigation and information and services related to district venues and events. Furthermore, the Flybits Smart City Solution offers a dynamic rendition of services for district operations and management, including notification of disruption of service, or access to the security camera system.

Continuation of table 2.14: Strategies for emerging technology in London

Innovation	Description
Smart Wayfinding (Maynard Design)	It is a combination of digital and physical elements providing wayfinding to district users, including fixed milestones with digital displays and an application for residents and visitors. The solution is designed to help reinforce a sense of permanence, whilst providing the flexibility to adapt to the changing requirements of the district and its events, spaces and activities. The Smart Wayfinding solution also allows managers to monitor pedestrian movement across the district. The physical milestones are an important component to enable accessibility to all demographics and provide a non-discriminatory solution for all user groups including children and the elderly. The solution is designed to improve navigation and wayfinding by providing a personal experience through the harnessing of live, user focused data feeds. The sharing of site wide data encourages visitors to engage more actively with their surrounding environment. A QR code connects the user with the digital application. The adaptability of this solution could complement existing wayfinding products.
BriteLocate3D (Briteyellow Ltd)	It is an interactive 3D indoor and outdoor positioning and navigation virtual reality in the form of personal mobile application. It combines high resolution 3D visualisation with precise location accuracy to help visitors and residents navigate around the district whilst allowing district managers to monitor use of public space and engage with users.
MappedIn Wayfinding (Industry Touch)	It is a user-friendly wayfinding solution with a centralised web-based Content Management System (CMS). The CMS allows district managers to control and instantly edit every component of the wayfinding maps and deliver this to kiosks, mobile users and websites.

Continuation of table 2.14: Strategies for emerging technology in London

Innovation	Description
TriceKit (Area360)	Tricekit is a software development kit (SDK), with core features including indoor positioning, wayfinding, analytics and a prediction engine. TriceKit is a SDK platform on which to build applications. The platform enables location based and behavioural content delivery which is accessible, contextual and enabled, to predict the needs of end users and individually tailor experiences. It also provides real-time analytics on district user movement. User data is collected from mobile applications and from databases and includes demographic information, application engagement and user movement within an area. It can aggregate any touch point data, e.g. from mobile applications, geo-location, social media, on-site activity. TriceKit uses algorithms to provide customised information to its end users. District managers can access real-time analytics on visitor and resident movement. A customised application could be developed if required.

15 Cleveland (US)

Scope

The 'Seamless Cleveland' (Positively Cleveland 2013) is a wayfinding master plan for the City of Cleveland. It is a large-scale study which proposes how the city can be joined together into a seamless system that supports visitors along their journey. This wayfinding master plan aim to improve the visitors experience in Cleveland and provide a better connection between the visitors and the elements of Cleveland's world-class destinations.

This study has six core objectives as follow:

- To connect Cleveland visitors using signs, maps and technology
- To improve visitor first impressions in a cohesive, consistent manner
- To allow visitors easily purchase tickets for multiple attractions
- To provide Cleveland visitors with an authentic Cleveland experience through the eyes of local residents
- To make public transportation a preferred mode of transportation
- To attract visitors to Cleveland through signature events

Table 2.15: Strategies for emerging technology in Cleveland

Strategy	Description	Example
Applying digital technology	Downloadable suite of maps available online on the Positively Cleveland's website (http://www.thisiscleveland.com/).	
	Digital units (kiosks, screens or temporary signage) showing real-time information on the street.	 Source: (Positively Cleveland 2013)
	Satellite navigation/ GPS capabilities and downloadable applications for mobile devices such as smartphones.	

These objectives are integral aspects of a wayfinding project and provide some guiding principles:

- **Being seamless:** Integrating information across transportation.
- **Consistency**: Use the same references, codes and language throughout a journey.
- **Coherence**: Providing a single system which offers an interconnected and coherent view of the total information.
- **Compelling:** Ensuring the efficiency, reliability, attractiveness and the usability of information.

- **Inclusivity:** Providing information for different groups of users with a particular focus on people with disabilities.

16 Austin (US)

Scope

'Downtown Austin wayfinding master plan' (Merje 2013) is a large-scale wayfinding study for City of Austin, Texas. This study aims to create an overall wayfinding philosophy for Downtown, identifying a variety of possible wayfinding tools including the integration of technology elements, environmental cues, materials, signage, landscaping, lighting and public art. The target users are resident, visitors, commuters and people with disabilities.

The main objectives of this study are as follow:

- To create a public outreach plan that promotes the wayfinding system
- To enhance pedestrian travel and accessibility
- To promote Downtown Austin as a friendly, well-planned, organised and safe environment
- To support multi-modal transportation and sustainable initiatives
- To develop a plan for long-term management and maintenance

Below are the main wayfinding principles which have been addressed in this study:

- **Being seamless:** Integrating a variety of wayfinding tools.
- **Inclusivity:** Providing information for different groups of users (designed for first time
- Visitors, while keeping in mind the needs of frequent visitors).
- **Connectivity:** Establishing connections between destinations and travel modes

Table 2.16: Strategies for emerging technology in Austin

Strategy	Description
Mobile Applications	Mobile Applications can include the following potential features: • Map-based location services with GPS • Transportation Mode Option (auto, bike, walk, transit, car-share, bike-share) • key sights and attractions • Events calendar and live entertainment schedules • Traffic Reports • Current construction delays • Multiple languages - cultural tourism
Interactive kiosks	This element can be 2 or 3 sided and provide downtown and citywide orientation maps, directional information, real-time information. While static in nature, the panels can offer access to technology through QR Codes, text message information and maps.
Information panel	This element can contain text messaging, internet links and destination information.

Continuation of table 2.16: Strategies for emerging technology in Austin

Strategy	Description	Example
Text message maps	Static orientation maps (at bus shelters, kiosks or on signs) can include a "text message number". When keyed in, the user receives a return text message with information about the destination functioning much like Capital Metro's system to receive bus schedule information. This strategy has been also applied for better wayfinding in the City of San Rafael, California, US (San Rafael City Council 2016).	 Source: Merje 2013
Solar panels	Solar panels can be used to provide power for illuminating signs and information kiosks.	 Source: Merje 2013

Continuation of table 2.16: Strategies for emerging technology in Austin

Strategy	Description
Pre-visit technologies which provide the users with information prior to beginning their journey and encourage exploration	These pre-visit technologies include, Google Maps, tourism websites, GPS navigation with the following features: • Destinations listed by category • Interactive Map powered by Google Maps • Connect to Google Places • Street Closings / Construction updates • Downtown amenities (ATM's, restrooms...) • Search features • Trail Information • Event Information • Shopping / Dining information & discounts
Portable landmark technology hubs	These hubs cab be Located at key gathering points to provide real-time data and downloadable information.
QR codes	QR Codes help visitors connect to specific information through scanning technology. Visitors can scan codes using a free application on their mobile phones and then will promptly directed to online information wayfinding options.

Figure 2.13: Portable landmark technology hubs, Austin
Source: Merje 2013

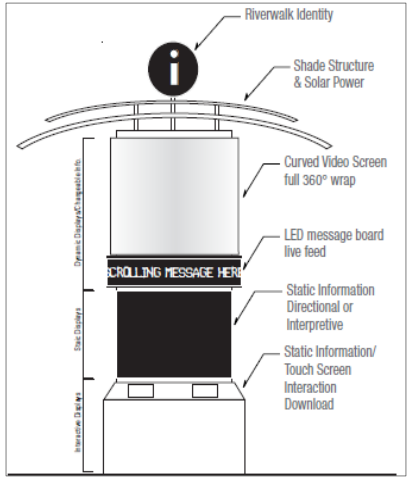


Figure 2.14: Interactive kiosk, Austin
Source: Merje 2013

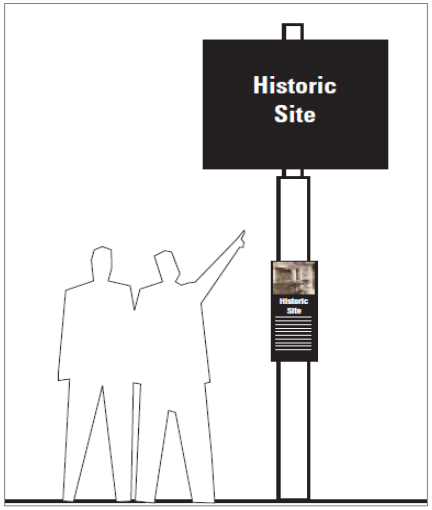


Figure 2.15: Information panel, Austin
Source: Merje 2013

Downtown Austin wayfinding master plan (Merje 2013) has a number of considerations for the users with disabilities:

- The wayfinding website should provide specific and accurate information for people with disabilities, including unique conditions around Downtown or at an individual destination.
- Lettering size should be legible at typical viewing distances (e.g., from a wheelchair, or for the users with visual impairment).
- Sign messages and backgrounds should have minimum contrast of 70%.

- The “International Symbol of Accessibility” should be used to identify special amenities such as entrances and routes.
- Kiosks, interpretive signs and information hubs should be designed to be accessible to users in wheelchairs.
- Pedestrian signage shall provide alternate accessible routes for streets that present accessibility issues.
- Temporary signage should include information to assist with accessibility where construction or other temporary obstacles create barriers, closed sidewalks or pedestrian detours.
- Tactile maps can be considered for people with visual impairment.
- Audible technology can be considered as part of information hub kiosks for the use of visually impairment people.
- Technology and support tools such as printed material and brochures can assist the users with hearing impairment.

Note: The abovementioned sets of wayfinding strategies for Austin overlaps with some recommendations by some other wayfinding studies; example of Merje (Environment and Experiences); such as the ‘wayfinding and signage program: Wayfinding Analysis for City of Santa Cruz’, California (Merje 2001) and ‘Wayfinding Analysis for Portsmouth’, New Hampshire (Merje 2014).

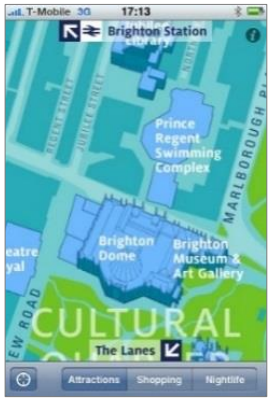
17 Brighton (UK)

Scope

‘WalkBrighton’ is a large-scale project designed by the Applied Information Group which aimed to improving the pedestrians’ wayfinding (Applied Wayfinding n.d.).

The company adapted the wayfinding system and developed an iPhone application to support the pedestrian wayfinding system. The advantage of WalkBrighton’ project is the use of the same look and feel as the hardware which allows the two systems works seamlessly together informing the pedestrians where they are and where they want to go (designworkplan n.d.).

Table 2.17: Strategies in practice for emerging technology in Brighton

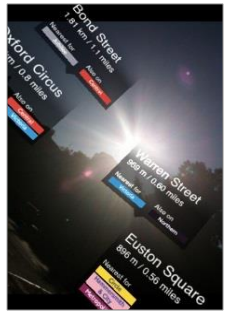
Strategy	Description	Example
Applying wayfinding application named 'WalkBrighton'	This wayfinding application includes the following details: crossings, railings, ramps and footpaths with details, individual shops, bars and public services. 3D illustrations of key landmarks help pedestrians place themselves in the map (designworkplan n.d.).	 Source: http://designworkplan.com/wayfinding/iphone-navigation.htm  Source: http://appliedwayfinding.com/projects/walk-brighton/

18 New York (US)

Scope

'Nearest Tube' is one of the first augmented reality iPhone applications nowadays available (designworkplan n.d.). This application can be applied in large-scale within the city with the aim of improving the pedestrians' wayfinding process.

Table 2.18: Strategies in practice for emerging technology in New York

Strategy	Description	*Example*
Applying wayfinding application named 'Nearest Tube'	Pedestrians can point their iPhone into the environment and the application will show them where the nearest tube station. It is also available for many other cities such as London, Barcelona, San Francisco, Chicago, Madrid, Paris, and Tokyo (designworkplan n.d.).	 Source: http://designworkplan.com/wayfinding/iphone-navigation.htm

19 Amsterdam (Netherlands)

Scope

Amsterdam as a smart city has innovative strategy for emerging technology in wayfinding which is described below.

Table 2.19: Strategies for emerging technology in Amsterdam

Strategy	Description
Crowd management technology	Crowd management technology used various techniques as trial to get a picture of pedestrian flows in real-rime, predict congestion, and manage slow-moving traffic. Cameras, social media, data, GPS, Wi-Fi and Bluetooth are used for this purpose. It allows people to pay for their bus journey, parking space, or train ticket in advance. Because they register when they pay and enter their postal code at the same time, the government knows where they come from. Using a postal code matrix, the government send travel advice to visitors by e-mail which are based on traffic intensity and historic data. In this way, government can guide people to take certain routes, and that prevents traffic congestion (Amsterdam City Council 2016).

20 India

Scope

'SafetiPin' is a large-scale GIS map-based safety application which contains location based tracking feature. It works to make the communities and cities safer by providing safety-related information collected by users. This application provides information about infrastructure to promote safety to citizens and stakeholders including the government and NGO's (Active Learning Solutions Pvt Ltd n.d.)

Citizens can view and contribute information and comments on audits, harassment, hazards and places. They can report problems such as broken lights, bad roads. Moreover, they can find useful establishments nearby such as 24 hour pharmacies, hospitals, banks, filling stations, restaurants, hotels, etc. more quickly. When travelling, the users can view audits to view safe and unsafe locations, and plan their routes accordingly with the help of the GIS service. Government can also use this application to access some useful information such as non-functioning streetlights, to track level of service and hence the improvement of amenities. This application can be used for wayfinding system as well. The options of this application can be added to the wayfinding applications in order to enhance the safety of different groups of users especially at night time (Active Learning Solutions Pvt Ltd n.d.).

Table 2.20: Strategies for emerging technology in India

Strategy	Description
Applying application named 'SafetiPin'	Within this application, the safety audits are conducted on the basis of a set of 9 parameters that together contribute to the perception of safety: • Lighting in the Area • Openness of the Area • Visibility in the Area • People Density • Security • Walk Path • Transportation in the Area • Gender Diversity in the Area • Feeling Each audit results in a pin on the specific location where the audit was performed and also records the time and date for the users' reference.

Figure 2.16: SafetiPin map-based information, India
Source: http://www.safetipin.com/site/about

Figure 2.17: SafetiPin application, India
Source: http://www.safetipin.com/site/about

21 Tel Aviv (Israel)

Scope

Sidekix is a large-scale map-based application which offers urban navigation on foot and shows interesting routes and places to the users (Lifehacker 2016). This application is currently being used in 14 other major cities including London, New York, Paris and San Francisco (NoCamels 2016). It is particularly useful for common tourist destinations.

Moreover, the Sidekix application offers options of streets that are well lit at night and allows the users' contacts to monitor the users walks in order to make them feel safer while exploring a new area (NoCamels 2016). Therefore, Sidekix can be a useful wayfinding application for visitors and other users during the day and night.

Table 2.21: Strategies for emerging technology in Tel Aviv

Strategy	Description
Applying application named 'Sidekix'	It is the only navigation application that offers walking routes based on interest, not just distance (Sidekix n.d.). It creates a route that incorporates other locations like cafes and restaurants (Lifehacker 2016). This application enables the users to personalize their route by tailoring it to their needs.

Figure 2.18: Sidekix navigating application, Tel Aviv
Source: http://nocamels.com/2016/06/sidekix-app-tailors-navigation-interests/

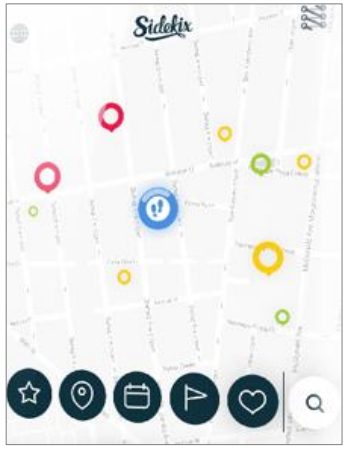


Figure 2.19: Sidekix map-based application, Tel Aviv
Source: http://nocamels.com/2016/06/sidekix-app-tailors-navigation-interests/

2.2.2 Existing and common national practices

22 Adelaide (Australia)

Scope

'Smart Move: The City of Adelaide's Transport and Movement Strategy 2012-2022' (Adelaide City Council 2012) is a large-scale study which outlines Council's desired transport and movement outcomes for the City, and the strategies to achieve these over the next ten years.

The main aims of this strategy are:

- To create a people-friendly City by improving conditions for pedestrians, cyclists and those using public transport
- To give greater priority to pedestrians and provide them with easy, comfortable and safe walking paths
- To improve pedestrian connections and navigation
- To create a better and safer environment for pedestrians during the day and night
- To create a better and safer environment for pedestrians during the day and night
- To make the City more accessible and meet the needs of all users

Table 2.22: Strategies for emerging technology in Adelaide

Strategy	Description
Applying digital technology	Real-time information on the internet, mobile phones, and signage.
	Touch screen kiosks at key locations for pedestrians.
	Mobile phone text alerts about the real-time and location specific information.

23 Brisbane (Australia)

Scope

“Brisbane Access and Inclusion Plan 2012-2017” is a large-scale study that aims to improve facilities and services accessible to all residents and visitors, people with disabilities, carers, seniors, people with temporary impairments or parents with young children (Brisbane City Council 2012).

The main aims of the Brisbane Access and Inclusion Plan are as follow:

- Eliminate direct and indirect discrimination in the provision of Council’s services to Brisbane’s residents and visitors.
- Eliminate physical access barriers in Brisbane’s public buildings and public spaces.
- Provide better customer support, safer public and work environments and more efficient and effective services.

Table 2.23: Strategies for emerging technology in Brisbane

Strategy	Description
Deploy night-time wayfinding systems utilising digital components	Personal mobile wayfinding applications
Smart screens	Interactive smart screens around the CBD to provide information and help people find out the latest on what's going on in the city.

Brisbane Access and Inclusion Plan 2012-2017” has a set of strategies in order to improve inclusivity and provide services accessible to all residents and visitors with or without disabilities. Accordingly, it has a considerable focus on the importance of using tactile ground surface indicators, Braille trails and Braille signage to response the needs of users with visual impairment. It also recommends the use of audio facilities like audio signals for safety and direction at signalised pedestrian crossings. Similarly, it recommends the use of visual facilities for the users with hearing impairments (Brisbane City Council 2012).

24 Newcastle (Australia)

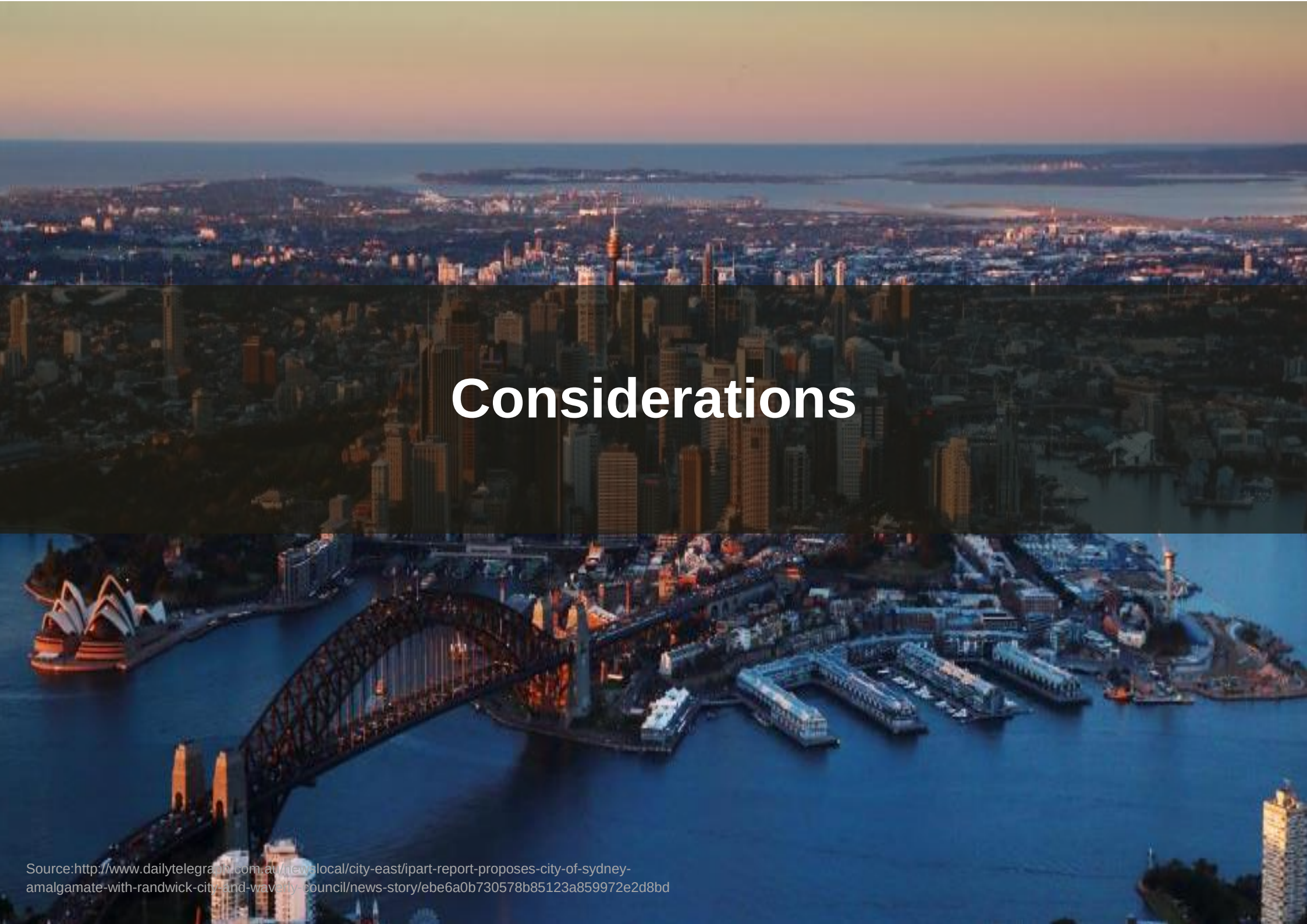
Scope

The scope, principles and strategic directions of 'Newcastle City Council Smart City Strategy 2017-2021' (Newcastle City Council 2017) has been stated in section 2.1.2.

Table 2.24: Strategies for emerging technology in Newcastle

Strategy	Description
Applying digital technology	Mobile web devices which shows path gradients, accessible paths of travel and accessible premises in the city
	Digital displays
	Public audio-visual consoles

Considerations



Source:http://www.dailytelegraph.com.au/newslocal/city-east/ipart-report-proposes-city-of-sydney-amalgamate-with-randwick-city-and-waverley-council/news-story/ebe6a0b730578b85123a859972e2d8bd

3. Summary and considerations

According to the comprehensive review of common and comparable national and international wayfinding practices, the specific considerations for the City of Sydney are defined in this chapter. The current chapter presents the synthesis of the key insights and reviewed strategies and implementations which can be applied for wayfinding at night for the City of Sydney.

Following the reviewed practices, sets of wayfinding considerations are described based on the wayfinding components. These identified strategies could be implemented as separate or integrated project/s for the City of Sydney. The considerations are classified into five categories; streets, intersections, parks and waterfronts, squares, and landmarks. The opportunities and advantages of implementing the considerations are highlighted in the last section of this chapter.

3.1 Wayfinding strategies

For the convenience of the reader, Table 3.1 summarised the synthesis of the common reviewed wayfinding strategies and implementations. The presented strategies are classified based on the two main themes of this report namely; “lighting at night” and “emerging technology”. In addition, the matrix highlights the following details:

- Scale of implementation (small or large scale): It is identified whether the strategy can be implemented in large scale (throughout the City) or in small scale (in specific places within the City).
- Type of technology (active or passive); indicates whether the identified technology is in direct interaction with the users or not.
- Users; a group of users who can gain benefit from the implementation of each strategy. The strategies that are responsive to the needs of each group are identified.

Table 3.1 can be used as a matrix to identify the most commonly applied strategies within the specific site and for specific users. For example, the reader can discern the most commonly applied strategies to enhance wayfinding at night for users who belong to the visitors group. It is also possible to limit the strategies to either emerging technology or lighting at night. For instance, one can identify the most commonly used strategies in wayfinding to encourage active use of technology for visually impaired users.

Table 3.1: The common practices wayfinding strategies; column 1 differentiates the main themes of the report, column 2 indicates the common applied strategies; column 3 specifies the scale of the applied strategies (small or large scale); column 4 identifies the type of technology (either active or passive); column 5 specifies the users (residents, visitors, commuters, or users with special needs such as physical disabilities (physical and visual impairments); column 6 indicates the options that could be doable at the lower end cost.

Theme	Strategy	Scale		Type of technology		Responsive to users					Low cost options*
		Small scale	Large scale	Active technology	Passive technology	Residents	visitors	Commuters	Users with disabilities Visual	Users with disabilities Physical	
Lighting at night	Smart lighting (Using LED - Light Emitting Diode - technology)	●	●		●	●	●	●	●	●	●
	Flexible switch system for street lighting		●		●	●	●	●	●	●	●
	Manageable and adjustable street light by smartphone app	●		●		●	●	●	●	●	●
	Interdependence between street lighting and traffic signals	●			●	●	●	●	●	●	
	Using light projections on the pavement to create signage	●			●	●	●	●	●	●	
	Interactive lighting (integrative and responsive to the sound)	●			●	●	●	●	●	●	
	Illuminated signs and totems	●	●		●	●	●	●	●	●	
	Lighting the major pedestrian routes		●		●	●	●	●	●	●	
	Illuminating buildings and structures that are seen from distant vantage points	●			●	●	●	●	●	●	

*Low cost option has been added by authors and there is not an accurate assessment for it.

Continuation of table 3.1: The common practices wayfinding strategies; column 1 differentiates the main themes of the report, column 2 indicates the common applied strategies; column 3 specifies the scale of the applied strategies (small or large scale); column 4 identifies the type of technology (either active or passive); column 5 specifies the users (residents, visitors, commuters, or users with special needs such as physical disabilities (physical and visual impairments); column 6 indicates the options that could be doable at the lower end cost

Theme	Strategy	Scale		Type of technology		Responsive to users					Low cost options*
		Small scale	Large scale	Active technology	Passive technology	Residents	visitors	Commuters	Users with disabilities Visual	Users with disabilities Physical	
Lighting at night	Illuminating the buildings at the end of major street corridors or the buildings that face parks, gardens and other public reserves	●			●	●	●	●	●	●	
	Illuminating and drawing attention to local landmarks in areas both inside and outside the CBD	●			●	●	●	●	●	●	
	Accent parks' edges and main entrances with lighting	●			●	●	●	●	●	●	
	Illuminating the most popular walking routes in parks	●			●	●	●	●	●	●	
	Illuminating along the edge of waterfronts	●	●		●	●	●	●	●		
	Using white light in areas of the city with high pedestrian activity		●		●	●	●	●	●	●	
	limiting full-facade lighting or floodlighting to buildings that have special public significance and assist wayfinding		●		●	●	●	●	●	●	●

*Low cost option has been added by authors and there is not an accurate assessment for it.

Continuation of table 3.1: The common practices wayfinding strategies; column 1 differentiates the main themes of the report, column 2 indicates the common applied strategies; column 3 specifies the scale of the applied strategies (small or large scale); column 4 identifies the type of technology (either active or passive); column 5 specifies the users (residents, visitors, commuters, or users with special needs such as physical disabilities (physical and visual impairments); column 6 indicates the options that could be doable at the lower end cost

Theme	Strategy	Scale		Type of technology		Responsive to users					Low cost options*
		Small scale	Large scale	Active technology	Passive technology	Residents	visitors	Commuters	Users with disabilities		
									Visual	Physical	
Emerging Technology	Global Positioning Service (GPS)		●	●		●	●	●	●	●	
	Online journey planning maps (i.e. Google Maps, Tourism Websites, etc.)	●	●	●		●	●	●		●	
	Mobile applications	●	●	●		●	●	●	●		
	Near Field Communications (NFC) offering the location-specific information		●	●		●	●	●	●	●	
	Radio-frequency Identification (RFID) for point specific information		●	●		●	●	●	●	●	
	Bluetooth beacons for location specific information delivery		●	●		●	●	●		●	
	Text message maps		●	●		●	●	●		●	
	QR codes		●	●		●	●	●		●	
	Interactive kiosks and smart totems		●	●		●	●	●	●	●	

*Low cost option has been added by authors and there is not an accurate assessment for it.

Continuation of table 3.1: The common practices wayfinding strategies; column 1 differentiates the main themes of the report, column 2 indicates the common applied strategies; column 3 specifies the scale of the applied strategies (small or large scale); column 4 identifies the type of technology (either active or passive); column 5 specifies the users (residents, visitors, commuters, or users with special needs such as physical disabilities (physical and visual impairments); column 6 indicates the options that could be doable at the lower end cost

Theme	Strategy	Scale		Type of technology		Responsive to users					Low cost options*
		Small scale	Large scale	Active technology	Passive technology	Residents	visitors	Commuters	Users with disabilities Visual	Users with disabilities Physical	
Emerging Technology	Portable technology hubs	●		●		●	●	●	●	●	
	Digital wander walls	●			●	●	●	●	●	●	
	Digital signage		●		●	●	●	●	●	●	
	Information panel		●		●	●	●	●	●	●	
	Tactile signage		●		●				●		
	Audible information at technology hubs, digital Kiosks, smart totems, digital signage and digital wander walls		●	●					●		
	Audible pedestrian signals		●	●					●		
	Using solar panels for illuminating signs at night		●		●	●	●	●	●	●	●

*Low cost option has been added by authors and there is not an accurate assessment for it.

3.2 Wayfinding system: considerations, emerging trends, and opportunities for City of Sydney

The following considerations are classified based on different contextual elements namely, streets, intersections, parks and waterfronts, squares, and landmarks. These considerations are based on the wayfinding principles which were identified in the reviewed practices. A wide variety of components including urban furniture, urban infrastructures, the printed and digital wayfinding elements are orchestrated to work together to address the most significant principles of wayfinding systems in City of Sydney. Figure 3.1 summarizes these principles.

Figure 3.1: Key wayfinding principles

3.2.1 Streets

A set of considerations that can be applied for the main streets and major walking paths in the City of Sydney are suggested in this section. Accordingly, an application for monitoring pedestrians' movements to identify the major walking paths for pedestrians is suggested. The mobile application can offer real-time data of people movement including some visualisations and analyses. The outcome of the proposed mobile application could be the identification of hot spots in the City, pedestrian flows and their distributions in open spaces in real-time, and predictions of potential congestions. Therefore, it can enable the Council to manage a better and efficient wayfinding system for identified areas. This application can track the pedestrians' movements via their smartphone sensors (i.e. Cellular, Wi-Fi, Bluetooth and GPS) to generate location data.

The considerations for wayfinding systems for main streets and major walking routes are as follows:

- **LED (Light Emitting Diode) technology:** This strategy provides the wayfinding system with low-energy consumption. This consideration is aligned with the strategies in the Sydney Lights: Public Domain Design Codes (City of Sydney 2015a) to promote sustainability and has been implemented in the City of Sydney.

- **White light (including warm and cool spectrum) in major pedestrian routes:** It is more useful than yellow light for orientation and wayfinding as the human eye is more sensitive to white light than yellow light at low levels of illumination at night (Melbourne City Council 2013). The full range of white light spectrum is important for mental health, with different parts of the spectrum having positive impacts at different times of day (ARUP 2015). Moreover, the white light reveals the natural colours of surfaces, and provides a more accurate sense of the size and shape of objects. Therefore, less illumination is needed when white light replaces yellow which can be a help to energy efficiency (Melbourne City Council 2013). This consideration is aligned with the recommended strategies in the Sydney Lights: Public Domain Design Codes (City of Sydney 2015a).

- **Flexible switch system for street lighting:** This strategy enables the Council to manage the lighting system (i.e. switching the lighting modes and increasing or decreasing the brightness) in different hours of the day and during the events. It is effective for reducing energy consumption and costs. Automating the lighting and implementation of flexible and controllable lighting has also been recommended in the Sydney Lights: Public Domain Design Codes (City of Sydney 2015a).

- Placing **lights on the ground** along the centreline or **along the edges of the paths** that are specifically for the pedestrian flows: Illuminating paths can help identify the barriers of the paths, emphasize important directional turns, and better wayfinding at night. It also improves the quality and safety of dark paths. These lights can run on a timed system connected underground and powered with solar energy. With advanced enough technology, they could flash, change colour, or become brighter or dim.

- **Establishment of a luminance hierarchy** to promote legibility and avoid visual fatigue. This consideration is aligned with the recommended strategies in the Sydney Lights: Public Domain Design Codes (City of Sydney 2015a).

- **Interactive lighting:** It is integration between the traffic, crowd and other built environment related noises and the lighting system. Sensors which are responsive to the environmental sounds (i.e. the sounds of vehicles) can be applied for lighting up the specific areas along the streets or dark spaces under the bridges. This lighting can apply with directional design to provide the pedestrians with ease of wayfinding, specially the commuters. This innovation can be applied in combination with public arts to attract visitors as well.

- **Illuminating the buildings at the end of major street corridors:** It makes the buildings located at the end of the street as a landmark and provides legibility for pedestrians passing through the street.

- **Manageable and adjustable streetlight:** This technology enables the pedestrians who are passing through the dark and quiet areas to manage and adjust the light during the time they are passing through those areas simply by using their mobile phones. The lights can be increased by dialling a specific number and can dim after the pedestrian has passed the area. This strategy is effective for reducing the cost of lighting, providing energy saving and safety at night.

- **Online journey planning maps:** Online maps can be provided by Google Maps, tourism related websites, etc. These websites can include useful features for visitors such as destinations listed by category, street closings, construction updates, and provide some information relating to key purposes of trips; such as events, shopping and dining. These planning state aids can be useful not only for visitors, but also for the residents and commuters.

- **Mobile applications:** Smartphones, disregarding the negative effects on users' cognitive maps (Afrooz 2016), can ease the wayfinding process, through providing different groups of users with the following facilities:

  - Global Positioning Service (GPS): It provides the service with a location and offers contextual information for the routing service.

  - Near Field Communications (NFC): It offers location-specific information. It can inform the user about a specific point of interest, or alert them about a hazard. This is a low-cost option and would enhance the wayfinding for different groups of users.

  - Radio-frequency Identification (RFID): It can be used for point-specific information.

  - Bluetooth beacons: It provides the users with general point of interest information when they are within the proximity of the transceiver. This location specific information delivery could be provided even if the users are not walking on a particular pathway.

  - Text message maps: Digital and non-digital wayfinding elements such as totems, kiosks, signage, information panels can be included a "text message number". When keyed in, the user receives a return text message with real-time information about the area.

  - QR codes: These codes can help the pedestrians connect to specific information through scanning technology. Users scan codes using a free application on

their mobile phones and are promptly directed to online information wayfinding options.

- **Interactive kiosks and smart totems:** They can provide useful real-time information, orientation maps and directional information. They can offer access to technology through QR Codes and text message information as well. The interactive kiosks and smart totems should include touch screen, maps, slogans and the opportunity to access the additional resources. These digital units need to be well lit to ensure optimum legibility at night. Solar panels can be used for illuminating signs at night. The interactive kiosks and smart totems can provide both the residents and the visitors, who are not familiar with the city and routes, with a wide variety of information. In order to respond to the needs of visitors, pocket maps are considered to be available at kiosks and totems.

- **Digital signage:** This signage can provide real-time wayfinding information.

- **Information panels (screen display):** These panels can contain text messaging, internet links and destination information.

- **Digital wander walls:** These walls are portable notice boards. They can be used during specific events (i.e. Vivid Sydney). The digital wander walls can provide real-time information and inform pedestrians what's on at the event and which routes are accessible during the event.

- Implementation of **signage** requires some consideration for better visibility at night for users with visual impairment. Therefore, the signage should:

  - Be well lit to ensure optimum legibility at night, without glare. The lights can be placed on or under signs. Solar panels can be used for illuminating signs at night.
  - Be designed with light reflective material.
  - Have sufficient contrast between the sign and the background environment or the surface on which it is located.
  - Have sufficient contrast between text and sign background to be legible especially for users with visual impairment.
  - Have a suitable size in relation to reading distance. The size of the message on the signage should be also suitable for users with low-vision.
  - Be fixed in such a way that neither the sign nor its supports become a hazard to the users with visual or mobility impairment.
  - Be placed (both in terms of location and elevation) close enough to the pedestrian path. It should be located in such a way that someone who is standing or using a wheelchair can access it.
  - Be visible but not distracting, informative but not unwieldy, and concise but not confusing.

- **Wayfinding application**: Such an application can present an interactive 3D positioning and navigation system. It can combine high-resolution 3D visualisation with precise location accuracy to help visitors and residents navigate around the City. 3D illustrations of key landmarks can also help pedestrians envisage the area. This wayfinding application can include the details such as crossings, railings, ramps and footpaths, individual shops, bars and public services.

- Clear demarcation of pedestrian footpath: Inground lights can be utilized along the footpath to clearly separate the footpath from the cycle pathways in order to minimise pedestrian and cycle conflicts.

Furthermore, such applications can be provided with location-specific information. It can be designed in a way that can show the pedestrians a specific place like the nearest train station or a landmark. The application can allow users to find that specific place by pointing their iPhones into the environment and the app will show them where that place is located.

Considerations for users with visual impairment

- Audible information on digital wayfinding elements: This information can be provided at technology hubs, digital Kiosks, smart totems, digital signage, information panels and digital wander walls. It can provide the visually impaired users with real-time information.

- Remote infrared audible signage (talking signs): The remote infrared audible signage system can provide effective wayfinding information for people who have visual impairments or cognitive disabilities. It can be applied to enhance independence and efficiency of abovementioned users in travel. The remote infrared audible signage system is composed of a small infrared transmitter that emits a repeating voice message over a directional light beam to a handheld receiver carried by the pedestrian user who has visual impairment or cognitive disabilities. The infrared system greatly reduces the need for travellers to get assistance from others or to remember distances, directions, and turns. Due to the advantage of this system in direction selectivity, it can ensure that people using the device get constant feedback about their relative location to the goal as they move towards it (Bentzen et al. 1999).

- Tactile signs: These signs can be applied for the use of people who have sufficient vision to locate a sign but not to distinguish individual characters. They should be embossed and not engraved. The braille subtitle in tactile maps can help the users with visual impairment better understanding of the tactile signs representation (Almeida et al. 2015).

- Reflective paint on street edges: The reflective paint can be applied for the use of people with low-vision. It can enable them to distinguish the edges of the street at night and provide them with safety.

Considerations for users with mobility impairment

- Meter Markers: The simple addition of the distance mark to the main public places can provide mobility impaired users with more information about their distance to a specific public place such as main squares, train stations, landmarks, etc.

3.2.2 Intersections

Sets of considerations for the main junctions and decision points are suggested in this section to be applied specifically for "intersections". The considerations for wayfinding system in these areas are as follows:

- **Signage with light:** Light projectors synchronised with the traffic lights at the intersection can be used to create signage on the pavement. At the time that lights turn red, projectors can change to display directions and show pedestrians the way to major places nearby. The projectors can illuminate the crosswalks, closest bus stops and train stations and clearly indicate safe pedestrian passages across the intersection. It can be useful for both visitors and commuters.

- **Illuminating the pedestrians' paths at the intersection with projectors:** Smart technologies can be applied to create an interdependence between intersection lighting and traffic signals. It can encourage the pedestrians to pass through the marked paths and provide them with safety and easy wayfinding at the intersections. It is useful for all groups of users specially the commuters.

- **LED (Light Emitting Diode) technology:** This strategy provides the wayfinding system with low-energy consumption. This consideration is aligned with the strategies in the Sydney Lights: Public Domain Design Codes (City of Sydney 2015a) and has been implemented in the City of Sydney.

- **White light at intersections:** As mentioned earlier, the human eye is more sensitive to white light than yellow light at low levels of illumination at night. The white light reveals the natural colours of surfaces, and provides a more accurate sense of the size and shape of objects (Melbourne City Council 2013). Therefore, the white light provides the pedestrians with safety while they are passing through the intersection. Less illumination is also needed when white light replaces yellow which can be a help to energy efficiency. Implementation of warm and cool spectrum of white light has been also recommended in the Sydney Lights: Public Domain Design Codes (City of Sydney 2015a).

- **Flexible switch system for intersection lighting:** This strategy enables the Council to manage the lighting system (i.e. switching the lighting modes and increasing or decreasing the brightness) in different hours of the day and during the events. It is effective for reducing energy consumption and costs. Applying controllable and flexible

lighting system is one of the strategies in the Sydney Lights: Public Domain Design Codes (City of Sydney 2015a).

Considerations for users with visual impairment

- Audible pedestrian signal: As mentioned in the previous section, this technology can be applied for pedestrians with low or no vision, or the deaf-blind. The audible signal can be linked to the visual pedestrian signals for advising pedestrians when they have the right-of-way to cross at a signalised intersection and in which direction they may cross the intersection. Two audible tones can be used to indicate the direction in which the pedestrian has the right-of-way; a cuckoo sound and a chirp sound (see section 2.1.1 for details)

- Remote infrared audible signage system (talking signs) can provide effective wayfinding information for people who have visual impairments or cognitive disabilities. It is composed of a small infrared transmitter that emits a repeating voice message over a directional light beam to a handheld receiver carried by the user (Bentzen et al. 1999).

This audible signage system can provide two types of information for pedestrians. Firstly, it tells the users where they are located (it is comparable to the information posted on the visual signs at each intersection). Secondly, it identifies the condition of the traffic signal for the users by repeating some messages like "Wait" and "Pass the street". Some extended information like "mid-block crossing" or "use of pedestrian activated signal at island for walk signal to cross second half of street" can be added to the message. Remote infrared audible signage can be merged with mobile technology to access an information database stored on a remote server (Crandall et al. 1998). The audible pedestrian signals can be applied to enhance independency of the users who have visual impairments or cognitive disabilities.

- Reflective paint on intersection edges: The reflective paint can be applied for the use of people with low-vision. It can enable them to distinguish the edges of the intersection at night and provide them with safety.

3.2.3 Parks and waterfronts

The following sets of considerations are suggested for "parks and waterfronts":

- **Lighting the major and most popular walking routes in parks:** The major routes can be identified by the Council with the use of an application for monitoring pedestrians' movements in the parks. This lighting can be designed by using white light LED (Light Emitting Diode) technology. It provides the pedestrians with clear vision at night and can help in saving energy. This consideration

has been identified within the Sydney Lights: Public Domain Design Codes (City of Sydney 2015a).

- **Small sources of light along the routes that are not popular for walking:** The routes that are not popular for walking can be facilitated by placing small sources of light on the ground through the centre or along the street edges. These lights can be run on a timed system connected underground and powered with solar energy. They can also flash, change colour, or become brighter or dim, by using advanced technology. This lighting system can help the pedestrians who pass through these routes with easy wayfinding and higher safety at night.

- **Flexible and manageable lighting system:** Lighting large areas like parks should have a considerably high cost for the Council. Therefore, applying a flexible lighting system able to manage the lights (i.e. switching the lighting modes and increasing or decreasing the brightness) in different hours of the day, can help to reduce energy consumptions and costs. With the use of advanced technology, the lights can be also managed by pedestrians and based on their needs. It enables the pedestrians who pass through the park at night, to increase the light by dialling a specific number and providing safety and better wayfinding in parks during the night-time. The light can dim after passing the area. The consideration of flexible lighting system is aligned with the Sydney Lights: Public Domain Design Codes (City of Sydney 2015a).

- **Accenting parks' edges, main entrances with lighting:** It makes the park more legible for pedestrians and enables them to find their ways toward the entrances or edges easily.

- **Illuminating the buildings that face parks:** It improves the legibility and enables the pedestrians to identify the park area.

- **Illuminating along the edge of waterfronts:** The lighting can be provided by white light, flexible and manageable LED (Light Emitting Diode) technology to make the waterfront area more legible and safe at night.

- **Wayfinding aids** such as interactive kiosks, smart totems, digital/non-digital signage, information panels, tactile signs, and audible information on digital wayfinding elements can be applied in parks and waterfront areas with the same characteristics and details that has been considered to operate on streets.

Note: For the details of wayfinding elements please refer to the section 3.2.1.

3.2.4 Squares

Following considerations are suggested for “squares”:

- **Interactive lighting:** The integration between environmental sounds and the lighting system can be applied both as a wayfinding element for the use of commuters and as public art to attract visitors. Sensors which are responsive to the traffic, crowd and other built environment related noises can be applied for lighting up squares. This lighting can apply with directional design to guide the pedestrians specially the commuters toward the nearest main public spaces.

- **Signage with light:** Light projectors can be used to create signage on the pavement within the square. The projectors can display directions and show pedestrians the way to major nearby places or landmarks. It can be useful for both visitors and commuters.

- **Lighting square** with white light, flexible and manageable LED (Light Emitting Diode) technology to make the square area more legible and safe at night. It can help save energy as well. This consideration is aligned with the recommended strategies in the Sydney Lights: Public Domain Design Codes (City of Sydney 2015a).
  Note: For the details of the flexible and manageable lighting system please refer to the section 3.2.1.

- **Illuminating buildings that face squares:** It improves legibility and enables the pedestrians to identify the square area.

- **Portable landmark technology hubs:** These hubs can be located at key gathering points within the square to provide real-time data and downloadable information. Audible information should be available in these hubs for users with visual impairments.

- **Wayfinding aids** such as interactive kiosks, smart totems, digital/non-digital signage, information panels, tactile signs, and audible information on digital wayfinding elements and pedestrian signals can be applied in squares with the same characteristics and details that has been considered to operate on streets.

Note: For the details of wayfinding aids please refer to the section 3.2.1.

Considerations for users with mobility impairment

- Meter Markers: The simple addition of the distance mark to the main public places can provide the mobility impaired users with more information about their distance to a specific public place such as main stations, landmarks, etc.

3.2.5 Landmarks

Followings are the considerations to enhance wayfinding system in terms of landmarks:

- **Illuminating buildings and structures that are seen from distant vantage points**

- **Illuminating local landmarks in areas both inside and outside the CBD**

- **Limiting full-facade lighting or floodlighting to buildings that have special public significance and assist wayfinding**. Studies show that the most prominent parts of the buildings that attracted wayfinders' attention are the colour and materials of the building, and windows shape and patterns (e.g. Afrooz 2016). Since colour and materials of the buildings are not very visible at night-time, it is suggested to illuminate the specific patterns of facade of the key landmarks at visual cues for travellers at night. These lighting considerations are aligned with the recommendations of the Sydney Lights: Public Domain Design Codes (City of Sydney 2015a) in order to emphasize the identity of heritage sites and landmarks as well as providing distinctiveness for the mentioned sites.

3.3 Suggested approaches to implement wayfinding strategies

This section suggests some approaches to plan wayfinding at night. For example, when the goal of the project is enhancing the wayfinding for low-vision users at night-time, defining the scope of the project should be done prior to the assessment of the current situation. If needed, some surveys can be conducted to understand the demand of this group of users and identify where in the city they encounter difficulty finding their way around. Appropriate strategies for the target group can then be defined after the formulation of the design concepts. Finally, conducting a cost analysis can illustrate the feasibility of the design.

Aims and scope of the project: The first stage in implementing not only wayfinding strategies but also any built environment related projects is to identify the goals and the scope of the case study.

After identifying the geographic region of the case study, the existing situation of the site is required to be assessed:

Phase 1 – Assessing the existing situation: This phase may include reviewing the current wayfinding elements such as signage, and current wayfinding apps, analysis of existing sign messaging protocols, on-site observation, and surveys of the target group including residents, visitors, and travellers with special needs. At the end of this stage a conceptual design can be articulated. Some investigations for this stage are described below:

Key destinations: Key destinations (either places or buildings) of the target users group should be identified. The identity of these

destination points can be enhanced by using identity signs (see Signage Foundation 2013).

Pedestrian dynamics: Pedestrians' movements can result in a description of pedestrian flow which allows facilitating the pedestrian paths with wayfinding aids.

Transportation hubs: Identify what the arrival modes of pedestrians are and where the transportation nodes are located.

Night-time activities: Identify where the night-time activities are located along the streets and highlight those streets as the attractions and destination points for many pedestrians.

Less legible areas: Surveys, and observation or other suitable approaches can be used to identify the areas that most users have difficulty finding their ways. This can be done separately for each target group.

Decision points: identifying where the nodes or change of path points are. Usually, wayfinding decisions are undertaken at these decision points.

Phase 2 – Wayfinding master plan: This stage covers the following steps:

1) Evaluation of the implemented elements
2) Defining the benchmarks for strategies
3) Recommending strategies
4) Providing detailed design standards
5) Budgeting
6) Pilot implementation and pilot evaluation
7) Feasibility plan

Phase 3 – Implementation: At this stage, the plan can be implemented. Supports for future expansion of wayfinding system can be provided (Toronto City Council 2012) and city can contribute towards the implementation of a consistent wayfinding system.

Phase 4 – Maintenance and asset management: This phase contributes towards the ongoing maintenance and renewal of wayfinding structures and elements. At this stage, a program can be established including the following steps:

1) Auditing and inspecting the wayfinding elements (i.e. the smart and interactive lighting equipment, interactive and smart kiosks, digital signage, digital information panels, etc.) and evaluate their condition and durability.
2) Removal of conflicting or unneeded wayfinding elements.
3) Cleaning and repairing/replacing the broken or damaged elements.

3.4 Conclusions

This study aimed to provide a critical review of current practices and plans that can assist City of Sydney to improve its wayfinding system of at night-time. Three objectives were outlined to reach the purpose of the report. The first objective (outlining the common wayfinding practices) was addressed by reviewing the wayfinding practices. The second objective (highlighting the new and emerging technology in wayfinding) was addressed by reviewing the technologies for smart and sustainable cities which are applicable for the purpose of this report. Accordingly, this report presented a comprehensive review of the common wayfinding exercises nationally and internationally.

A total of twenty-four comparable cases were selected out of fifty-four reviewed case studies. The scope and the applied strategies of these studies were presented and then synthesised according to target users of this report to address the third objective. The third objective was to identify wayfinding strategies and components which can enable different users to navigate through the built environment more effectively at night. Based on this comprehensive review, the most pertinent considerations for City of Sydney are suggested. These considerations are categorised into the contextual urban elements of a city (i.e. streets, intersections, parks and waterfronts, squares, and landmarks.). The considerations cover components such as lighting, digital/non-digital signage, interactive kiosks, smart totems, portable technology hubs, online maps, mobile applications, tactile signage, remote infrared audible signage on digital elements (i.e. kiosks, totems, technology hubs, etc.) and audible pedestrian signals. There are specific considerations for all groups of users including visually and physically impaired, commuters, residents and visitors.

The identified strategies can potentially improve the connectivity of places and could make them more welcoming for all type of users especially at night-time. Applying these strategies can result in promoting legibility, walkability and a successful wayfinding system for the entire City.

The gaps in wayfinding practices were identified in this report. Reviewing the practices demonstrate that there is a general lack of methods reported in the literature for the assessment of the performance of the wayfinding strategies. Accordingly, evaluating common practices, benchmarking wayfinding, and comparing various strategies or different places seems limited.

The authors suggested the following framework to evaluate the wayfinding practices (Figure 3.2) to guide the development of a wayfinding measure, which could be applicable for any built environment. However, benchmarking wayfinding will require further work on devising methods to turn the framework into measurable criteria and identifying required data. Figure 3.2 suggests a framework with four components for benchmarking common wayfinding practices including: consistency, inclusivity, legibility, and sustainability.

Figure 3.2: Suggested criteria for benchmarking wayfinding practices

Consistency could be implemented for wayfinding aids such as signage, and information kiosks. It is suggested wayfinding aids to be consistent in positioning (i.e. strategies for the position of the wayfinding aids), the structure (i.e. consistency in colour and materials of the wayfinding aids), and the walking distance. For example, walking distance should be displayed for pedestrians.

Legibility is defined as the ease of using and understanding the layout of the city. Wayfinding practices should enhance the user's mental image of the city. Simplicity is one example for achieving legibility. Another item could be the contrast in either colour, material, or height which can enhance singularity of a visual cue for pedestrians.

Inclusivity contains accessibility and visibility of information (either tangible or non-tangible) for all users of the built environment. And finally, sustainability covers the energy efficiency of the practices. Solar access, low cost, and durable materials are suggested items for making a wayfinding project sustainable.

Future studies for wayfinding at night can focus on an evaluation system for assessing the ongoing strategies. Another area for future research can be the context of smart cities and big data. Finally with active transport strategies increasingly not only focusing walkability but bikeability of our cities wayfinding considerations for cycling should be given further consideration. These emerging trends create opportunities to produce metrics for wayfinding performance assessment and better planning, as mobility and people's behaviour are now captured in more detail through automated and digital systems, and people seem willing to engage via ubiquitous smart systems and social media providing crowdsourced feedback. With innovative methods and datasets, some modelling techniques of simulation and assessment of wayfinding strategies which are already used for indoors settings, (i.e. 2D and 3D and virtual reality environments), could be extended to large scale areas and assist wayfinding infrastructure planning as well.

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