THÈSE

En vue de l'obtention du

DOCTORAT DE L'UNIVERSITÉ DE TOULOUSE

Délivré par :
Institut National des Sciences Appliquées de Toulouse (INSA de Toulouse)

Présentée et soutenue par :
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le 01 février 2018

Titre :
Towards A Zero-Emission Urban Mobility
Urban design as a mitigation strategy,
harmonizing insights from research and practice

École doctorale et discipline ou spécialité :
ED MEGEP : Génie civil

Unité de recherche :
LMDC (INSA de Toulouse) et LRA (ENSA de Toulouse)

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To the women throughout history whose efforts created the path – nevertheless, they persisted.

ACKNOWLEDGEMENTS

First of all, I would like to thank my supervisors Luc Adolphe and Marion Bonhomme for three exciting years, for their reassurance and support, and for allowing me to find my approach to the wicked problem of daily mobility and urban design. It has been a fun ride, merci! Thank you also to Frédéric Bonneaud and Annie Loiseaux, together with the researchers at the LRA, for all their support. Second, I would like to thank the Toulouse-members of the CapaCity project, Serge Faraut, Anne Péré, and Corinne Sadokh, for our good collaboration, as well as ADEME for funding our project. I am especially grateful towards the project members in Quebec, Catherine Dubois and Geneviève Cloutier, who contributed significantly to my first steps as a researcher in the being. Thank you for your valuable inputs, and for welcoming me to Quebec. The three months at CRAD were a rich and formative experience. At the same time I would like thank Owen Waygood and the other researchers at CRAD who welcomed me among them.

During the doctoral research I have had the pleasure to twice present my work before a thesis committee with experienced researchers. Thank you Anne Aguiléra, Gabriel Dupuy, Aud Tennøy, and Geneviève Cloutier for taking an interest in my work, and for much appreciated advice before, during, and after committee meetings.

The present work would not have been possible without the practitioners who found the time to contribute with their knowledge and insights by participating in the CapaCity workshops, by accepting to be interviewed, or by responding to the survey. Thank you for sharing your experience and observations, the richness of which underlines the importance of exploring experience-based knowledge to better understand the functionings of the city.

Several people have contributed to ensuring that the present work is written at an adequate level of English. A special thanks to Big Jo (with regard) and Alia, your help has been truly invaluable. Remaining gramatical errors and otherwise less than good English is entirely on me.

A doctoral thesis is at once lonely and a shared experience. Luckily we are several in the same situation, which makes the experience worthwhile. I have had the chance to meet several, who have reminded me why we love what we do. To my fellow research students at the LRA thank you for great discussions and sweet thoughts. A special thanks to Guillaume and Ishmael at CRAD for showing me the Quebec-way – day and night, to Hanna for reminding me about the real world (and wine), and to Tiphaine and Laura – for every up and down, for every laughter, for every late night and early morning, for every coffee. This experience would not have been the same without you – I'll be seeing you at the finishing line soon.

To my big and quirky family, thank you. My grit and energy is the heritage of a strong community, of whole and half people, who have taught me important lessons along the way; mafilien has given me the knowledge that one can always take another step. Most important of all is my mother, the amazing Marimette, whose kindness and bravery is my foundation. I promise to grow up – soon. Kjære mamma, tusen takk!

Some three or so years ago I was welcomed in to another family, which has been a wonderful experience from day one. Through these doctoral years they have provided lots of love and lots of coffee, grammatical advice and interesting discussions. Peter, Karin, Johanna, and Chico, thank you for making Basel my Swiss home.

To those back home who have remained in my life despite a constantly prolonged adventure abroad, thank you for being there, and for cheering me along all the way. Ånsebolle for life.

Ten years ago I left Norway to become an engineer in France, which continued into architectural studies, and finally a doctoral thesis. Now, close to the finish line, these last ten years stand as an incredible rollercoaster ride that have taken me far. Along the way I stumbled upon my best friend, my Liebling, my Sunday kinda love. Darling Lukas, you've been there at every step, filled with patience and encouragements, and always with a corky comment. Thank you for being you, and letting me be me. Our adventure has barely begun.

ENGLISH ABSTRACT

The doctoral thesis of Maja Karoline Rynning explores how urban design can be a mobility-mitigation strategy to promote the use of zero-emission modes such as walking, cycling, and public transport. What is the potential contribution of neighbourhood-scale built-environment interventions towards a sustainable modal shift? Knowledge gaps remain within the scientific literature on the relationship between the built environment and mobility behaviours, a significant barrier for mitigation efforts through urban design. Through her thesis, Maja Karoline Rynning has explored the experience-based knowledge of urban design practitioners (urban planners and designers, architects, landscape architects) as a potential source for new insights, complementary to those of research. A mixed-methods approach was employed in France and in Norway, consisting of workshops, interviews, and a survey. The results were crossed with findings research and design literature, analyzed from an interdisciplinary, holistic perspective. In addition to transportation and planning-research, insights from behavioural sciences were explored; incorporating knowledge on decision- and judgment-making contributes to better understanding of how the neighbourhood-scale built environment can help promote zero-emission modal choices. The results show that achieving a permanent modal shift requires the use of zero-emission choices to be both possible and pleasurable. The influence of urban design is likely most significant during trips, when a person moves through a city and its public spaces. Interactions with the neighbourhood-scale built environment influences overall travel satisfaction, and the remembered trip experience matters for future modal choices. Maja Karoline Rynning therefore suggests a shift of perspective: at the neighbourhood scale, daily mobility should be considered as a kind of use of public space. This contributes to making the potential mitigation-influence of urban design more tangible. Modal choices are highly individual; people’s barriers for a zero-emission choice vary. Urban design interventions can help lower these, through bigger or smaller measures. This mitigation potential appears somewhat overlooked in research as well as practice. Daily mobility plays a central role in urban design practices, mitigation of mobility-related

emissions less so. To render the possible contribution of urban design more apparent, Rynning introduces a set of properties that summarizes important characteristics of public spaces that actively promote zero-emission modes. Building upon these and current design practices, she outlines a draft for a framework to support designers in implementing mobility-mitigation in their practices. Linking urban design and modal choice, the framework shows how urban design can be a mitigation strategy towards a zero-emission mobility, promoting a sustainable modal shift in a holistic and interdisciplinary win-win approach.

FRENCH ABSTRACT

La thèse de Maja Karoline Rynning étudie la façon dont le design urbain peut être une stratégie pour promouvoir les mobilités zéro émission, dans le cadre d'une mobilité quotidienne, telles que la marche, le vélo et les transports en commun. Comment est-ce que le design urbain peut-il contribuer à atténuer les émissions de gaz à effet de serre provenant de la mobilité quotidienne? Des incertitudes et des incohérences ont été relevées dans la littérature scientifique. Elles concernent l'influence de l'environnement bâti, à l'échelle du quartier, sur les comportements de mobilité et constituent un véritable obstacle à l'action dans la mesure où la recherche ne peut pas guider et informer la pratique. Dans le cadre de sa thèse, Maja Karoline Rynning explore les connaissances des praticiens du design urbain bâti, à savoir des urbanistes, des aménageurs, des architectes ainsi que des paysagistes. Les connaissances de ces praticiens pourraient-elles être une source complémentaire s'ajoutant à celles issues de la recherche ? Pour répondre à cette question, des enquêtes ont été menées en France et en Norvège : des ateliers, des entretiens ainsi qu'un sondage électronique. Les résultats de ces enquêtes ont été croisés avec la littérature scientifique ainsi qu'avec la littérature issue du design urbain. La thèse de Rynning s'inscrit dans les recherches portant sur le transport et la planification urbaine, mais elle s'appuie également sur des disciplines telles que la sociologie et les sciences du comportement. L'intégration de connaissances, issues par exemple des sciences du comportement et liées au jugement et à la prise de décisions, contribue à une meilleure compréhension des liens existants entre design urbain et promotion de choix modaux zéro émission. Les résultats de la recherche montrent qu'un changement modal permanent requiert que l'utilisation de modes zéro émission soit à la fois une possibilité et un plaisir. L'influence du design urbain sur les choix modaux est particulièrement importante durant le voyage, lorsque l'usager se déplace à travers la ville et ses espaces publics. En particulier, les interactions avec l'environnement bâti, à l'échelle d'un quartier, influencent la manière dont la personne se souviendra de son déplacement. Ce souvenir impactera, dans un second temps, ses futurs choix modaux. Ces interactions sont d'autant plus importantes dans le cas de la marche et du vélo, ce qui impacte directement l'utilisation des transports an

commun. Rynning suggère un changement de perspective : elle invite à considérer la mobilité quotidienne à l'échelle du quartier comme une forme d’utilisation de l'espace public. Ce basculement rend l'influence potentielle du design urbain plus compréhensible et concrète, il facilite la prise en compte des aspects instrumentaux ainsi que des aspects perceptuels qui influent sur l’expérience de l’espace public. Les choix modaux sont éminemment individuels, tout comme les barrières pouvant dissuader les gens de choisir des modes zéro émission. Or, à travers des mesures de petite ou grande envergure, le design urbain peut faire face à ces obstacles. Il porte en effet un potentiel d'atténuation qui semble aujourd’hui négligé par la recherche comme par la pratique. Pour rendre tangible la contribution possible du design urbain, Maja Karoline Rynning énonce un ensemble de principes qui reprennent les propriétés présentées par des espaces publics bien conçus et promouvant activement les modes zéro émission. S'appuyant sur les pratiques de conception contemporaines, elle esquisse les premiers traits d’un *framework* combinant ces propriétés avec des qualités urbaines et des leviers d'action potentiels. Ce *framework* montre dans quelle mesure le design urbain peut être une stratégie d'atténuation vers une mobilité urbaine zéro émission. En reliant design urbain et choix modal, il montre comment favoriser un changement modal durable dans une approche holistique et interdisciplinaire.

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GENERAL INTRODUCTION

Cities are multifaceted, complex systems that millions of people call their home. It is where they spend their everyday lives, going to work, to school, and other weekly activities; it is where they grow up and make friends, meet a partner and start a family, or perhaps a business partner and start a company. The last century saw the beginning of an urbanization that is still taking place; presently, more than half of the Earth's population lives in urban areas, a number that is estimated to surpass 75% by 2070 (United Nations Human Settlements Programme, 2013). The City symbolizes opportunity and progress. Throughout the centuries it has been a place for innovation and development through encounters – planned and unplanned – between urban inhabitants (Ascher, 1995; Gehl, 2010; Glaeser, 2012). The promise of employment, improved living conditions, and access to education, to mention some, continues to draw people from rural to urban areas (Montgomery, 2013; United Nations Human Settlements Programme, 2013). To access these aspects of urban living, people must be able to move around easily, freely, and efficiently. A high level of mobility[1] is fundamental for a city to function and to prosper; moreover, to ensure social and economical sustainability[2] (Glaeser, 2012; UN Habitat, 2011). At the same time, daily travels in cities worldwide contribute significantly to global emissions of greenhouse gases. These emissions stem primarily from the consumption of fossil fuels[3], and in turn lead to global warming and climate change – the consequences of which are severe. A 2°C rise in global temperatures is the so-called 'breaking point', after this the long-term effect will be permanent, and render several places on the Earth uninhabitable (IPCC, 2014). The Intergovernmental Panel on Climate Change (IPCC) concluded that to maintain global warming well under 2°C, compared to pre-industrial times, current

[1] Here understood as the movement of people, not goods. See Glossary for a more elaborate definition.

[2] See Glossary

[3] See Glossary

emissions must be drastically cut, and future greenhouse gas emissions must be strictly limited – i.e. climate change mitigation[4] (IPCC, 2014). In 2015 the large majority of the world's countries signed the Paris Agreement, in which they committed to limit global temperature increase to well-below 1.5°C (United Nations Framework on Climate Change, 2015). Per today, almost every country in the World has joined the agreement.[5] Reaching the 1,5°C target will require a faster and more excessive reduction of global consumptions of fossil energy[6] than has been managed so far. However, in 2016 global temperatures were already at 1,1°C above pre-industrial times (World Meteorological Organization, 2017), and the latest predictions by the United Nations Environmental Program (UNEP) puts the world on a 3°C track (UNEP, 2017). Without enhanced mitigation efforts, exploring new strategies, this seems unavoidable. **The present work addresses greenhouse gas emissions from daily mobility in urban areas, and how to curb these, in this context defined as *mobility-mitigation.***

Urban mobility is a so-called 'catch 22': it is essential for a city to function, but comes with a substantial cost for the environment, and for the planet as a whole (United Nations Human Settlements Programme, 2013). Is the need for mobility for social and economical sustainability compatible with environmentally sustainability? Lack of results at the national level has spiked action at the city level. The large number of people living in a city represents an unprecedented opportunity to reduce the carbon footprint[7] of many people simultaneously; a responsibility more and more cities acknowledge. Paris (France), Oslo (Norway), Copenhagen (Denmark), and Portland (USA) are examples of cities who have pledged significant reduction targets for 2020 or 2025; much of this within the transport[8] and mobility sector. Urban greenhouse gas emissions are a direct result of human activities, for example, daily mobility; consequently, mitigation necessitates a change in these activities (EEA, 2016). There

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[4] In this dissertation the term mitigation will for the most part be used on its own

[5] As of November 2017 the United States of America was the only country in the world not taking part in the agreement. The country initially signed the agreement, but later pulled out under its new administration, although exactly how this will manifest remains somewhat unclear.

[6] See Glossary

[7] See Glossary

[8] See Chapter 1 for a differentiation between transport and mobility.

are two main approaches to mobility-mitigation: travel less or travel differently. The latter is the focus here, i.e. a large-scale, permanent modal shift towards zero-emission mobility modes[9]. Experience has shown that restrictions and limitations, especially upon private car-use, are inevitable to reduce emissions from daily mobility (ibid). But as seen above, mobility is essential for a city and its inhabitants. To avoid an immobile city, restrictions must be combined with adequate alternatives such as public transport services and bicycle possibilities. Urban development[10] can be a strategy to ensure this. There is a strong link between the organisation and design of the built environment and mobility behaviours, which extends from the overall city scale[11] to the street level. However, as the geographical scale decreases the level of detail increases – with regard to the built environment as well as the individual needs and preferences of travellers. This contributes to the complexity of an already challenging issue. Urban development takes place on different geographical scales of the city; each represents a mitigation potential, complementary to other strategies. **The focus here is on neighbourhood-scale built-environment interventions, i.e. urban design, and how this can be a contributing mobility-mitigation strategy to achieve a zero-emission modal shift.**

The thesis is organized in three parts, followed by a General Conclusion. Part 1 establishes the background and the context for the thesis, then presents the status quo of current research knowledge, before introducing the research problematic and the general methodology. The experience-based knowledge of urban designers is suggested as a source for new insights into the relationship between the neighbourhood-scale built environment and people's modal choices. It is hypothesized as complementary to the evidence-based knowledge of research; combining the two is likely to strengthen mitigation efforts through urban design. The professional knowledge was explored through a series of empirical enquiries presented in Part 2. In parallel to these, current research as well as urban design literature was further analysed from a holistic and

[9] Here primarily walking, cycling, and public transport running on renewable energy, see Glossary for more details. The terms 'public transport' and 'transit' are used interchangeably.

[10] Here: built-environment interventions; other aspects, such as the relationship between different actors within a development project and the 'power-play' between these, or the influence of external constraints (beyond the urban context), are for the most part held exogenous.

[11] See Glossary

interdisciplinary perspective. The findings from this are presented in Part 3 in combination with the empirical results. This part concludes on the outlines of a future design framework, directed towards urban practitioners, to help strengthen mobility-mitigation through design projects. Urban design can, in theory, be a mitigation strategy. But as seen by rising emission from urban mobility, several barriers hinder a proper exploitation of this potential. By **harmonizing insights from research and practice** the thesis aims at producing new insights and understandings to enhance mitigation efforts towards a permanent, zero-emission urban modal shift.

Part 1
Background, Context, and Research problematic

INTRODUCTION PART 1

The first part of this thesis situates it in an overall context: the urgent need to curb global greenhouse-gas emissions; in this context, emissions from the everyday travels of urban inhabitants going to work, to school, grocery shopping, etc. Cities produce major greenhouse gas emissions due to the high consumption of fossil energy, but also represent an opportunity to reduce the carbon footprint[12] of a large number of people through mitigation actions. For mobility and daily travels, one approach is to change how people travel by promoting a large-scale zero-emission modal shift. Urban development can contribute to this through built-environment interventions, at the city scale as well as at the neighbourhood scale. The latter is here referred to as urban design. However, several barriers hinder mobility-mitigation[13] through urban design, some of which are discussed in Chapter 1.1. This is followed by a review of the current research knowledge on urban development and mobility behaviours (Chapter 1.2). In addition to transport and mobility research, the review builds upon insights from fields such as sociology and behavioural science.

Chapter 2 establishes the research problematic and the general methodology. Based on the observations in Chapter 1, the thesis asks: "How can urban design be a mitigation strategy to promote zero-emission mobility modes?" Current research literature (evidence-based knowledge) has significant knowledge gaps. Hence, the thesis suggests investigating the experience-based knowledge of urban designers as a possible source for new insights. As experts of urban development, these professionals are likely to provide a particular understanding of how built environments influence urban lives, complementary to that of research. Their knowledge is explored through a series of empirical enquiries (see Part 2). The aim is to provide a better understanding of how

[12] See Glossary

[13] The term applied by this thesis for 'mitigation of greenhouse gas emissions from daily urban mobility'

people interact with their built environments, as a step to strengthen mitigation efforts through urban design. Chapter 2 concludes with a discussion of validity and reliability, essential to ensure the quality of the results from this research work.

CHAPTER 1

ESTABLISHING THE RESEARCH CONTEXT

1.1 URBAN MOBILITY AND MITIGATION OF GREENHOUSE GAS EMISSIONS

1.1.1 Daily mobility produces significant greenhouse gas emissions

1.1.1 a) **An urgent need for mitigation action**

The 21st century is becoming an increasingly urban century: over half of the global population lives in urban areas, from cities of 50.000 inhabitants to megacities with over 10 million inhabitants (UN Habitat, 2013). Urban living leads to opportunities such as access to jobs and education, but also major environmental issues. From a global perspective, the emission of greenhouse gases is the most challenging issue, as these gases lead to global warming and climate change (IPCC, 2014; The World Bank, 2010). According to the World Meteorological Organization, 2016 was the warmest year in human history, with the lowest sea-ice levels ever recorded in the Arctic and Antarctic (World Meteorological Organization, 2017). At the local, national, and global scale, the consequences of climate change are increasingly severe and potentially fatal. Some areas are experiencing more and heavier rains, leading to an increased chance of floods and landslides; other areas are experiencing hotter and drier weather, with extreme heat waves and drought. It is estimated that the 2003 heat wave in Europe lead to the death of nearly 70.000 people (Robine et al., 2008). The long-term effects of climate change include uncertainty in food production and access to potable drinking water. The list of impacts from global warming and climate change is long; the list of actions to limit further warming and change is short: reduce the global consumption of fossil fuels to reduce the emission of greenhouse gases. The present work targets greenhouse-gas emissions from urban mobility.

Mobility vs. transport

Within the literature – research, policy, practice, etc. – there is often an inconsistent use of the terms ‘transport’ and ‘mobility’, which can lead to great confusion. As an example, greenhouse gas emissions from people’s movement in cities at a city, national, or global scale are often described as stemming from ‘transport’, ‘road transport’, ‘urban transport’, or ‘urban mobility’, to mention some. This work employs the term *mobility*, which is to be understood as the movement of a person; in this context, everyday trips in urban areas (daily urban mobility). A trip takes place employing one or several mobility modes, e.g. walking, cycling, or driving, whereby the person travelling chooses the travel mode. Hence, ‘mobility needs’ refers to people’s need to move around in a city, for example to get to work or school. Transport (or transportation) is understood as a broader term comprising the movement of both people and goods, but also as a term for vehicles or transport systems (land, air, water; rail or roads; etc.). It is predominantly employed in the subsequent sections, which explores the amount of greenhouse gas emissions produced from people’s travels. This is done as most of the discussed reports use the term ‘transport’ to combine the movement of goods and people using a broad range of modes.

Emissions from the movement of people and goods

Finding clear and concise numbers on greenhouse gas emissions from urban mobility is challenging, especially numbers that can be compared across cities. This is largely due to methodological differences in data collection (e.g. which trips are included) and the use of definitions (e.g. what constitutes the urban area or the city), which complicates the comparison of mobility-related greenhouse gas emissions[14] among cities (EEA, 2013; Statistics Norway, 2015). In their 2011 report, the UN Habitat concludes that methodological differences in measurement make it impossible to make accurate assertions regarding the scale of urban emissions. There is, for example, currently no

[14] As a reminder: emissions from the movement of people, not goods

comprehensive dataset for proper comparison between European cities (EEA, 2013). As a result, a more qualitative approach to comparing emissions and mitigation strategies between cities is often more interesting (ibid), for example mobility's percentage share of a city's total emissions. Nevertheless, there is an overall consensus that cities and urban living contribute significantly to global greenhouse gas emissions, with urban mobility being one of the major sources thereof (EEA, 2013; UN Habitat, 2013). Due to the lack of comprehensive datasets, the numbers referred to below are intended primarily as an illustration of the magnitude of urban mobility-related greenhouse gas emissions.

The UN Habitat estimates that urban activities account for 40% to 70% of global greenhouse gas emissions (UN Habitat, 2011), while C40 – a global network of over 90 cities worldwide – operates with 70% (C40, 2012). A substantial part of these emissions stem from urban transport (goods and people): currently the largest single source of global transport-related CO_2-emissions, according to the New Climate Economy Report *Accessibility in cities: transport and urban form* (Rode et al., 2014). According to the World Bank (2010), approximately 13% of global greenhouse gas emissions stem from transport (urban and other) (Figure 1) and the consumption of fossil fuels[15] by motorized vehicles[16] (The World Bank, 2010).

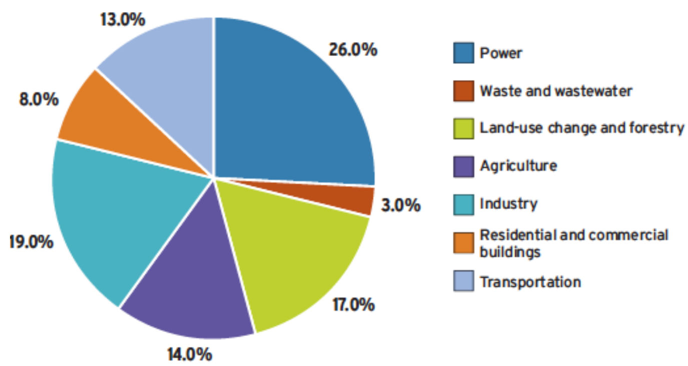


Figure 1 Global CO_2-emissions by sector, figure by the World Bank (2010)

[15] See Glossary

[16] This encompasses all vehicles running by some kind of motor, with the exception of electrical bicycles. Here primarily private cars and buses, as well as rail-based transit with electricity from fossil energy sources.

Figure 2 is an estimation of sources for EU transport-related emissions in 2010, taken from a 2013 report by the European Environment Agency, *A closer look at urban transport.* It shows that urban transport represents about 25% of these emissions, with 9% from the transport of goods (freight), and 16% from the movement of people. The majority of these emissions are attributed to road transport[17] (EEA, 2016). Transport is the only major economic sector where EU-emissions are still rising (ibid).

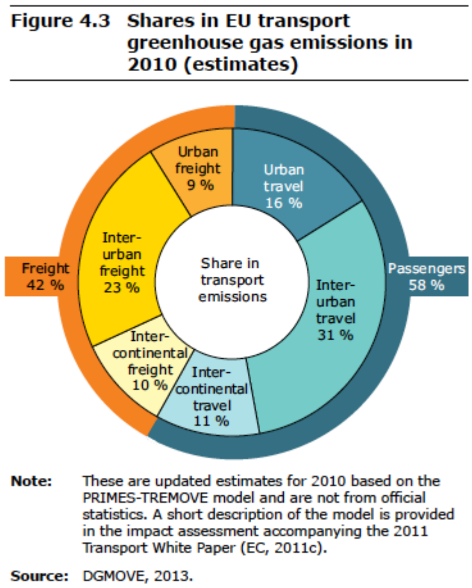


Figure 2 An estimation of sources for EU transport-related emissions in 2010 (EEA, 2013)

Emissions vary significantly across cities, even among cities with similar GDP[18], depending for example on urban form as well as the quality and affordability of alternative modes of transport (OECD (2010) and UN Habitat (2011) in UN Habitat, 2013). With urban populations growing rapidly, cities are experiencing a significant increase in mobility needs and demands (Givoni and Banister, 2013; UN Habitat, 2013). Without the necessary mitigation-action, this will likely lead to a substantial rise in global greenhouse gas emissions, further increasing global warming and climate change. Three primary schemes stand out in order to reduce greenhouse gas emissions

[17] Transport via cars, light and heavy weight vehicles, etc. that drives on roads.

[18] GDP stands for Gross Domestic Product and is a measurement of a country's economy. In short it represent the sum of everything produced by the inhabitants and companies of a country.

from urban mobility: *Technological* and *Planning* (urban development) (Tennøy, 2012), and *Policy*. Several cities have successfully explored the potential impact of policies such as congestion pricing and other urban road-user charging schemes to reduce emissions (EEA, 2013). Reducing greenhouse gas emissions via urban development (*Planning*) implies that a city evolves in a manner that reduces the need for travel, and/or facilitates the use of zero-emission mobility modes. This can occur through the way a city is organized, such as the location of housing, jobs, schools, etc. (i.e. land use[19]). The technological scheme involves an improvement of vehicle technology; , for example, increasing fuel efficiency can reduce greenhouse gas emissions. Despite technological advancements, however, emissions from urban road traffic (primarily passenger transport) are still rising (Tennøy, 2012). In 2015, transport (goods and people) was the highest source of greenhouse gas emissions in Norway before oil production (Statistics Norway, 2015), with private car use as the number one source of emissions. The rapid rise in global mobility demands and needs, particularly in urban areas, is an important reason why technological improvements alone are not enough to curb emissions (Statistics Norway, 2015; Tennøy, 2012). Reducing mobility-related greenhouse gas emissions from urban travels in order to achieve global mitigation objectives necessitates a change in lifestyles and habits (EEA, 2016). Experience has shown that when the modal share of public transport and non-motorized modes[20] goes up, emissions tend to go down (UN Habitat, 2013) – an indication of the potential gains from a sustainable modal shift.

This work explores how urban development at the neighbourhood scale, i.e. urban design[21], can be a complementary strategy to mitigate mobility-related emissions. It centres on daily, utilitarian trips: going to work or to school, grocery shopping, and other regular trips to weekly activities such as sports or culture, i.e. travels that are part of a person's weekly routine. Leisure trips, such as vacation, weekend trips, cycling and walking for recreation, etc., are not included. According to the European Environment Agency, commuting (work) and education related trips represent at least 25% of all trips

[19] See Chapter 1.2

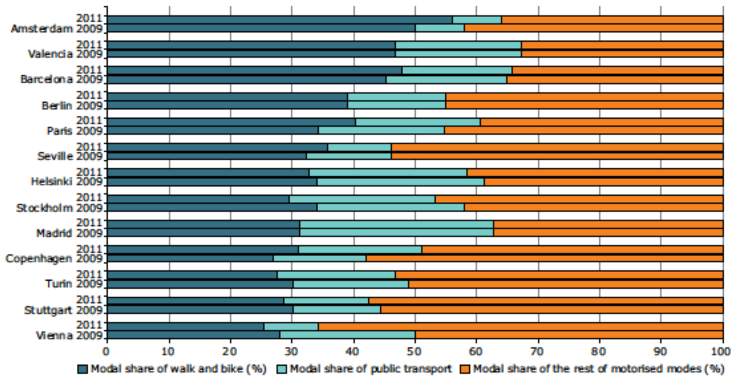
[20] Primarily walking and cycling

[21] See Glossary for an explanation of urban design in comparison to architecture and urban planning.

in metropolitan regions. These utilitarian trips have been identified as easier targets for mitigation measures than leisure trips (EEA, 2013).

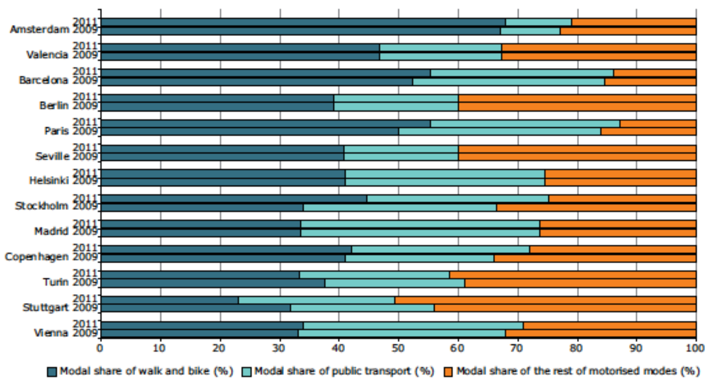
1.1.1 b) **Modal spilt in cities**

Greenhouse gas emissions from urban mobility are primarily related to the consumption of fossil fuels by motorized vehicles (Erickson and Tempest, 2014). Today, viable zero-emission alternatives exists for private cars as well as for bigger vehicles such as buses and trailers, for example electricity, hydrogen, and other renewable sources (EEA, 2016; UN Habitat, 2013). Electric bicycles are an alternative that can increase the range of bicycle trips, and thus its potential use for daily trips. Metropolitan areas tend to have a lower car-share than rural areas (EEA, 2013). A high number of people living in the same area facilitates an adequate transport offer; furthermore, it tends to increase proximity to services and amenities (EEA, 2013; UN Habitat, 2013). Consequently, public transport use is generally higher, and walking and cycling become viable alternatives, particularly within the main city area. Yet car shares typically remain higher for metropolitan areas than in the main city area, as commuting distances increase, and adequate public transport services become more difficult to maintain (EEA, 2013; Næss, 2006). Figure 3 provides an example of the modal split in 13 European cities: Amsterdam, Valencia, Barcelona, Berlin, Seville, Helsinki, Stockholm, Madrid, Copenhagen, Turin, Stuttgart, and Vienna. It stems from the EEA-report *A closer look at urban transport* (2013)*,* and shows the modal split for the metropolitan and main city areas, with numbers from 2009 and 2011 in correspondence to available data for all modes (EEA, 2013). For most of the cities, motorized modes other than public transport (including private cars) are higher in the metropolitan than in the main city area. The further away from the main city centre a person lives, the more difficult it is to achieve a modal change from the private car to public transport or bicycling (walking is generally not an alternative for longer trips). Interestingly, both Amsterdam and Copenhagen, exemplary cities for bicycle facilitation and use, have a relatively high percentage of motorized modes other than public transport in the metropolitan area, further underlining the difficulty to obtain the full-scale modal shift necessary to curb emissions. Another noteworthy observation is Amsterdam's low public-transport share: in 2011 roughly 10% for both the metropolitan area and the city area; in comparison, Paris has a public-transport share of roughly 20% in the metropolitan area, and above 30% in the city area. People in both cities seem to use other motorized modes to a similar degree, but inhabitants in Amsterdam (city and metropolitan area) seem to cycle and walk more. It should be noted that similar to greenhouse gas emissions, it is difficult to accurately compare modal share between cities, in part because of "variations in the precise methodologies used to calculate modal split – for example whether the indicator refers to journey to work trips or all transport trips" (LSE cities, 2014).



Source: EMTA data for 2009 and 2011 (EMTA, 2012 and 2012a).

Modal split for metropolitan city areas for 2009 and 2011



Source: EMTA data for 2009 and 2011 (EMTA, 2012 and 2012a).

Modal split for city areas for 2009 and 2011

Figure 3 Modal split for metropolitan and main city areas for bigger, European cities (EEA, 2013)

Figure 4 shows how the evolution of the modal spilt in Oslo, Norway from 2005 to 2015. Private-car use has decreased with about 11%, while public transport use has increased with approximately 11% (not necessarily a direct transfer from one mode to another). To illustrate, public transport trip increased from 171,5 million trips in 2006 to 262,0 million in 2016. From 2005 to 2015 there was a 2% increase in bicycle use, from 5 to 7%. This is similar to Stockholm's 5,6%, though much less than Copenhagen's 20%, both in 2013 (LSE cities, 2014). In the last years, Oslo has had a particular focus on facilitating bicycling, which has given results. According to Eco Counter, an international company that registers bicycle-rides in cities worldwide, Oslo experienced an increase of 18% from 2015 to 2016 (City of Oslo, 2017).[22] However, despite a gradual shift from driving to public transport, walking, and cycling, private cars remains the primary mobility mode of Oslo's citizens. From a emission-perspective this is arguably less of a problem, as the city has a very high number of electrical cars (City of Oslo, 2016b), and as the Norwegian electrical production is 98% renewable (Norwegian Ministry of Petroleum and Energy, 2014). However, there are several disadvantages to car use in urban areas beyond greenhouse gas emissions such as spatial use: electrical cars use the same amount of the often scarce space in cities as those running on fossil fuel.[23] Air pollution is another major issue experienced by cities worldwide, stemming partly from the abrasion of roads. Several cities have undertaken severe measures on particularly polluted days such as increasing the price to enter the city by car (e.g. expanded congestion charging), or temporary restriction of car use (see for example Oslo and Paris). Air pollution and other negative consequences of urban mobility are further addressed in subchapter 1.1.1c.

The majority of the cities in Figure 3 and Figure 4 have a walking, cycling, and public transport share (combined) that represents at least 50% or more of the metropolitan-area modal split; in the city areas, this number is at least 60% or more. For Paris and Barcelona, the city-area numbers were roughly 85% in 2011; 67% in Oslo in 2015.

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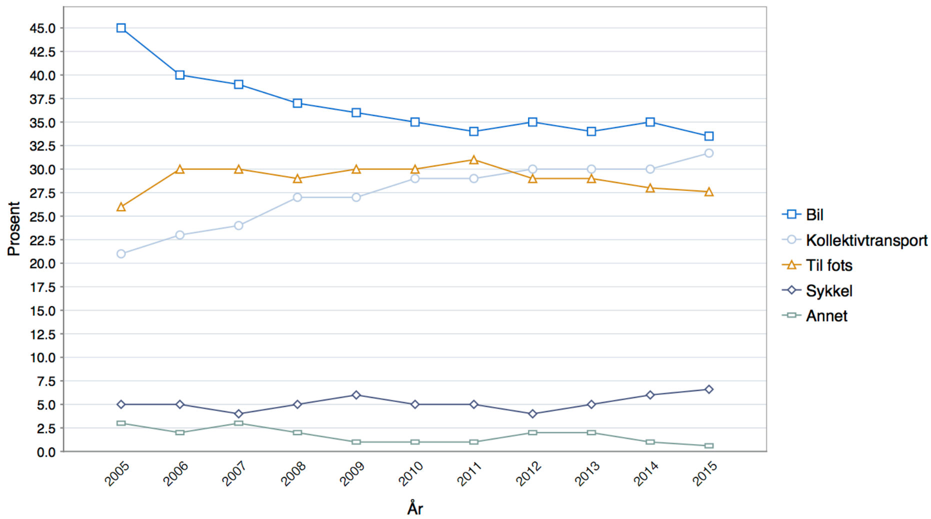
[22] At the moment of writing, the 2016 bicycle share in Oslo could not be found.

[23] There are other environmental consequences related to electrical cars as well, for example the material used for batteries. Moreover, their production will likely produce some levels of greenhouse gas emissions. This is, however, outside the thesis scope and will not be further pursued here.

Overall this is a positive tendency, but a sustainable modal shift has yet to take place at the necessary rate.



From top to bottom: Blue: cars; Light grey: public transport; Orange: walking; Dark grey: bicycle; Green: other

Figure 4 Modal split for daily trips in Oslo, from 2005 to 2015, (City of Oslo, 2016a)

Emissions from mobility are still rising in most European cities including Oslo, despite its high share of electrical cars (EEA, 2016). To obtain a permanent, zero-emission modal shift, cities must seek out additional strategies exploring new measures and solutions that make zero-emission mobility modes the better alternative for daily mobility. This necessitates a combination of 'sticks' (restricting measures) and 'carrots' (enabling measures) (Piatkowski et al., 2017). An interesting aspect of urban design is its win-win approach, where a solution or a measure can address several issues simultaneously. This might contribute to combine restricting and enabling measures in an overall improvement of mobility conditions for zero-emission modes, and the quality of urban living contexts.[24] Which in turn could help creating a positive image of a zero-emission modal shift, despite the necessary restrictions on private car use. Moreover, as the European Environment Agency observes, prioritizing non-motorized modes in urban environments can contribute to improving social equity, a crucial aspect in urban quality of life (EEA, 2013).

[24] See Glossary

1.1.1 c) Other consequences of urban mobility: environment, economy, and health

Urban mobility has additional negative impacts to the emissions of greenhouse gases. Table 1 is a summary of some more significant consequences, organized around three main topics: environment, health, and economy. It is based on Glaeser (2012), IPCC (2014), Norwegian Ministry of Transport and Communications (2014), Speck (2013), The World Bank (2010), UN Environment (2016), and UN Habitat (2013). These consequences are direct and indirect, interdependent, and can be reinforced by climate change and global warming. To ensure a good and healthy urban living context for their inhabitants, city authorities must address these consequences. Interestingly, this can simultaneously contribute to curbing greenhouse-gas emission from mobility. For example, several of the measures and solutions to reduce air pollution mirror those that help reduce emissions. The consequences in Table 1 are often more tangible and comprehensible than greenhouse-gas emissions and global warming, thereby providing decision makers with additional reasons to act upon daily mobility behaviours (which often leads to more ‘winning’). As air pollution and obesity are often more concrete and relevant for people’s everyday life than climate change, this could support acceptance of actions directed towards mobility and modal choices among urban inhabitants (Stoknes, 2015). To some extent, several of the consequences below might be more urgent for cities than climate change, particularly consequences such as air pollution and traffic fatalities (The World Bank, 2010). However, from a global and long-term perspective, climate change and global warming remain the number one problem for nations and cities to tackle.

OTHER CONSEQUENCES OF URBAN MOBILITY	
Environmental	Primarily related to the use of motorized mobility-modes, both rail and road based. Infrastructure can significantly impact biodiversity and ground water; hard surfaces for roads, sidewalks, etc., can create problems with water run-off during bigger rainfalls. Air pollution and noise can similarly be bad for plants and animals.
Health	Generally related to public health issues, e.g. local air pollution is mainly produced by motorized vehicles due to consumption of fossil fuels and the abrasion of roads. According to the WHO air pollution leads to over 7 million premature deaths annually worldwide, as it increases cancer rates, respiratory problems, heart failure, and more (World Health Organization, 2014). Other significant consequences traffic accidents, among the main causes for premature deaths worldwide, and noise, which can be extremely troublesome for those concerned. Finally, obesity is a growing public health problem in many countries (western and non-western), often due (in part) to lack of physical movement.
Economical	The economic consequences from urban mobility can be separated into direct and indirect costs. Direct costs: Primarily related to use, i.e. maintenance and investment. Indirect costs: Largely the result of the environmental and health consequences listed above representing significant costs for society (e.g. treatment of sickness). They are often harder to estimate. There are several discussions on how to properly charge these costs, and to whom. Another indirect cost comes from road congestion, primarily in and out of cities during morning and/or afternoon/evening rush hours. This represents massive economical costs for society and for companies in the form of lost profit.

Table 1 A summary of negative consequences from urban mobility (in addition to greenhouse-gas emissions)

1.1.2 Urban development represents mitigation opportunities

1.1.2 a) **Urban living allows influencing the impact of many people simultaneously**

Urban greenhouse gas emissions are a result of human activities in a city, which means that mitigation unavoidably involves acting upon these activities – in this case daily mobility. Fortunately, although cities and urban areas represent a significant source of emissions, they also provide an unprecedented mitigation opportunity. In essence, cities are the sharing of space, infrastructure, buildings, services, etc. Hence, lowering energy consumptions of the average urban citizen is likely to influence the energy consumption of many inhabitants simultaneously and can have a big impact globally. Moreover, the large populations of cities represent an opportunity to test new solutions and innovations on a big scale.

> "(…) urban areas can become hubs of innovation where alternative options can be designed and tested to promote reductions in GHG-emissions (mitigation) and vulnerability to climate change impacts (adaptation)."
>
> (UN Habitat, 2011)

In a study from 2014 by the Stockholm Environment Institute (SEI), Erickson and Tempest modelled the unexplored potential of urban development. The study developed a reference scenario based on current mitigation plans and policies from cities worldwide, followed by an "urban action scenario" which estimated further mitigation potential by applying other possible actions primarily within transportation and mobility, as well as the building sector (Figure 5). The results show significant mitigation potential from urban development that could be further explored (yellow part in the graphic below).

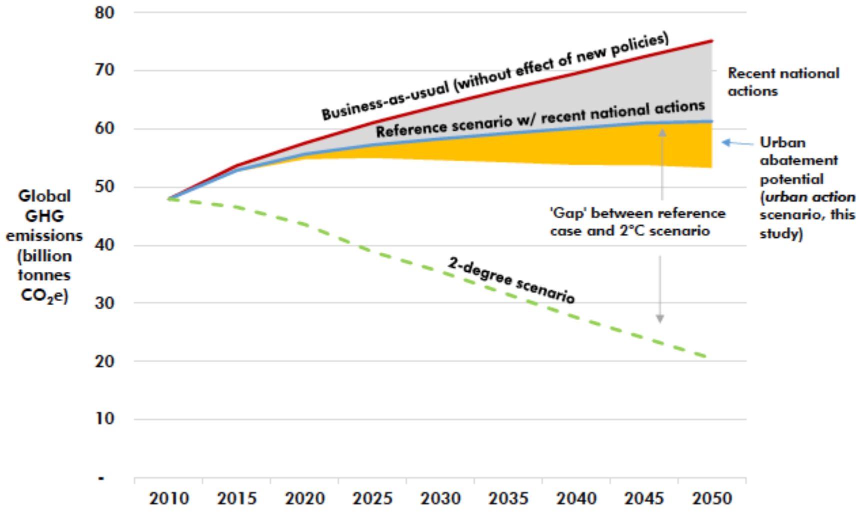


Figure 5 The potential impact of urban actions on global climate mitigation, figure from Erickson and Tempest, 2014[25]

1.1.2 b) **Mobility behaviour: amount of travel and modal choice**

People travel – not cars, buses, or trains; greenhouse gas emissions from urban mobility are directly tied to how, where, and why people travel (Næss, 2012). Consequently, reducing emissions necessitates a change of mobility behaviours. There are variations within the literature regarding terminology: both 'transport behaviour' and 'travel behaviour' are frequently used, often without a clear definition or explanation of choice (see for example Ewing and Cervero, 2001; Næss, 2006; Tennøy, 2012). Here, the term 'mobility behaviour' is primarily employed in line with the use of mobility rather than transport; 'travel behaviour' might also be used occasionally. Mobility behaviour can be defined as amount of travel and modal choice (Ascher, 1995; Ewing and Cervero, 2001, 2010, Næss, 2006, 2012). Amount of travel is understood in accordance with Næss (2006) as the sum of trip frequency (how often a person travels) and trip length (how far a person travels in total). Modal choice is understood as the means by which a person chooses to travel, for instance by foot (walking), by car (driving), or by a combination of modes. Amount of travel and modal choice are interdependent: the longer a trip, the less likely it is undertaken by non-motorized modes. Consequently, a person dependent

[25] See glossary

on walking can be less likely to undertake such a trip. A wide range of elements and factors such as different contexts (social, cultural, physical, etc.) influence a person's mobility behaviour. When modelling mobility behaviours, these factors can be included or kept exogenous depending on the nature and focus of the model, and on the field studying it. Another important aspect is the traveller; how the built environment influences a person's mobility behaviour depends largely on personal preferences, values and beliefs, physical capacities etc., referred to by Næss (2006) as "characteristics of the individual". These characteristics can affect mobility behaviour both directly and indirectly, for example by influencing how a person perceives and experiences a built environment (Alfonzo, 2005; Ewing and Handy, 2009). This is further explored in the literature review in Chapter 1.2.

1.1.2 c) **A reciprocal relationship between mobility behaviours and the built environment**

The underlying rationale for urban development as a potential mobility-mitigation strategy, at the city as well as at the neighbourhood scale, is the reciprocal relationship between the built environment and mobility behaviours, which has been firmly established by research (Ewing and Cervero, 2001; Næss, 2012). The larger-scale built-environment structures and mechanisms (regional-, metropolitan-, city-scale) that influence this relationship are relatively well-known (Næss, 2012; Tennøy, 2012). The reciprocity of the relationship means that changes in the built environment can influence people's mobility behaviours, while likewise changes in people's mobility behaviours can have an impact on the built environment (Ewing and Cervero, 2001; Hickman and Banister, 2014; Laigle and Matthys, 2012; Næss, 2006; Tennøy, 2012). Many interdependencies and influential mechanisms cause this relationship to be complex – in fact, it is a real *casse-tête*.[26] It has been explored in numerous ways: focusing on bigger and smaller aspects, on individual factors separately, or on connections between elements. Næss (2012) notes an interesting difference between North American

[26] *Casse-tête* is a French term that refers to complex problems that require effort and patience to solve, for example so-called 'brain teasers', i.e. enigmas or puzzles (*Larousse des synonymes*, 2007, "Le nouveau petit Robert," 1994). Translation of definitions by author.

research, typically focusing on the neighbourhood-scale built environment, and Nordic research (Europe), which tends to focus on the city as a whole, or on the metropolitan scale[27] (including surrounding suburbs or towns). One contributing reason for this is a difference in urban development policies and regulations on national and regional levels (Næss, 2012). Despite such geographical and disciplinary differences, the overall research objectives are much the same: to understand how the reciprocal relationship works and which elements influence it – individually or in combination (Ewing and Cervero, 2001; Handy et al., 2002; Næss, 2012; Strand et al., 2010). In more recent years, issues such as climate change, environmental consequences, and public health have become increasingly frequent in public, political, and academic discourse (Hickman and Banister, 2014; Neves, 2013). Examples of this reach from curbing mobility-based greenhouse-gas emissions (Schwanen et al., 2011; Tennøy, 2012) to reducing air pollution (EEA, 2014) and confronting public health issues like obesity or respiratory illnesses.

Geographical scales: city versus neighbourhood

The built environment influences mobility behaviour, and vice versa, at all geographical scales from the city to the neighbourhood (Ewing and Cervero, 2001; Næss, 2006). As a reminder, the neighbourhood-scale built environment does not refer to neighbourhoods as an entity. It represents the immediate surroundings of a person travelling through a city on the way to a specific location. These surroundings create the current built-environment context of the traveller at any given moment, and they generally vary over the course of a trip. Research has shown that depending on trip purpose and destination, the importance of the city scale most likely surpasses that of the neighbourhood-scale built environment. (Næss, 2012). However, that does not imply that the neighbourhood scale does not also influence modal choices in some way.

The city-scale built environment is the overall system within which urban inhabitants travel. It establishes initial conditions and premises for a trip, for example which modes are available for getting to work, related in part to the distance to cover. At this

[27] See glossary

geographical scale, the evidence is quite robust regarding built environment mechanisms and structures that influence mobility behaviours (Tennøy, 2012). According to Næss (2006, 2012) the most important of these is the location of the dwelling (residence) relative to a city's main location of activities, normally the city centre or the metropolitan centre. This significantly influences aspects such as the potential effort related to a trip (physical, time, etc.), the range in mobility offer (available modes), and destination choice (Næss, 2012; Salon et al., 2012; Strand et al., 2010; Tennøy, 2012). Other influential characteristics at the city scale are: the location of the residence relative to the closest second-order urban centre (Næss, 2006); the location of the workplace (conditions commuting patterns) (Christiansen and Julsrud, 2014; Næss, 2006; Tennøy, 2012); the distance from the residence to the closest urban railway-station (Næss, 2006); population density (a result of land use) (Næss, 2012; Salon et al., 2012; Steemers, 2003). Population density primarily influences the transport availabilities and the number of services and amenities in an area: the more people, the broader the offer. This has been found to be particularly important with regard to inhabitants' car use (Tennøy, 2012). Research often points to high-density mixed-use development as ideal in order to reduce private car use and achieve sustainable modal shifts; destinations should be within walking or cycling distance, preferably combined with easy access to public transport (Cervero, 2011; Ewing, 2011; Frank and Engelke, 2001; Strand et al., 2010). By default, this would also lead to a reduction in greenhouse gas emissions from urban mobility. However, matters are more complex in terms of individual modal choices. The literature remains inconclusive on pivotal questions such as level of required density, or the maximum distance that people are willing to walk and cycle (Krizek et al., 2009a). This in turn makes it difficult for planners and decision makers to know what to aim for (or to prioritize) in order to promote a sustainable modal shift. Moreover, the potential environmental costs of high urban density could outweigh the benefits (Bonhomme, 2013)[28]. This thesis explores the influence of the neighbourhood-scale built environment upon modal choice. In this work, the city-scale built environment is therefore considered an overall context, establishing initial conditions and premises that influence modal choices. For a more in-

[28] See glossary (and below)

depth discussion regarding particular built-environment mechanisms and effects at the city scale, see for example Boarnet and Crane (2001), Næss (2015), and Tennøy et al. (2014).

1.1.3 Promoting a sustainable modal shift through urban design

1.1.3 a) **Acting upon mobility behaviours to mitigate emissions**

Based on the above, two main approaches for reducing greenhouse gas emissions from daily mobility can be identified: people travelling less, or people travelling differently. The first approach implies travelling less often and/or travelling shorter distances; the second implies travelling with the use of zero-emission mobility modes[29]. Influencing the amount of travel involves reducing travel distances and/or how often people travel. It can, for example, be achieved through densification and mixed land use, increasing people's proximity to daily and weekly activities, thereby making them reachable by foot, bike, or public transport (Banister 2012; Cervero 2000; Cervero 2014; Speck 2013). As a reminder, this work centres on utility travel, the daily and weekly trips in urban everyday life.

> "How cities are built will dramatically determine whether future travel patterns are sprawling and car-based or compact with a significant share of public transport and non-motorized travel."
>
> (Erickson and Tempest, 2014)

[29] In the context of this thesis, 'zero-emission modes' include walking, cycling, and public transport. Zero-emission cars are not included due to other challenges related to car use in urban areas, such as congestion, traffic accidents, consumption of (often scare) space, etc. Reducing emissions could include more energy-efficient cars, or hybrid modes. However, in order to reach the objective of the Paris agreement to keep global warming well below 1,5°C, substantial emission cuts are necessary. Aiming for a completely zero-emission urban mobility is more likely to help achieve this. An additional 'mode' is multimodality: the combination of two or more modes for a trip, usually the case for transit use. Most public transport trips involve walking or cycling to and/or from the transit stop (Hillnhütter, 2016; Mees, 2010).

It is important to consider the amount and kind of travel urban development projects might lead to, as attractive destinations tend to increase travel. This is not necessarily a problem in itself if the trips take place using zero-emission mobility modes (excluding zero-emission cars). However, certain urban development patterns can increase traffic volumes (road traffic, primarily private cars). New residential areas located far from the city centre and/or public transport offers can make its inhabitants car-dependent (Tennøy, 2012). Additionally, densification can have unintended consequences such as increasing the energy need for cooling and lighting buildings, as well as reducing the potential for renewable energy production in the city – i.e. the 'Energy Paradox' (Bonhomme, 2013). There are scenarios and situations for which reducing amount of travel is an important approach. At the same time, it is a strategy to pursue with caution as mobility is essential for a city on several levels. First of all, a well-functioning city is dependent on well-functioning daily mobility to give people access to education, jobs, and other opportunities, as well as economic and social equality (UN Habitat, 2013). For this to happen, a certain level of mobility is always necessary. Second, people's needs and travel motivations are highly individual. Members of the same household can have very different preferences, perceptions of mobility modes and travel routes, etc. Finding measures and solutions that fit an entire household, an apartment building, or a neighbourhood is difficult; even more so for the city as a whole. Additionally, a city is a place of constant change and innovation; as a result, how, where, and why people travel in a city constantly changes too. This can in turn influence the efficiency of urban development measures to reduce amount of travel.

1.1.3 b) **Mitigating emissions through a sustainable modal shift**

The scope of this thesis encompasses the mitigation potential of a sustainable modal shift, and how urban design can contribute to this. Can urban design be a strategy to promote a modal shift towards zero-emission mobility modes? The reciprocal relationship between the built environment and mobility behaviours extends to the neighbourhood scale (Cervero, 2011; Erickson and Tempest, 2015; Krizek et al., 2009a; Lefèvre, 2009; Sallis et al., 2016). Consequently, it should be possible promote walking, cycling, and public transport use through built-environment interventions at this scale.

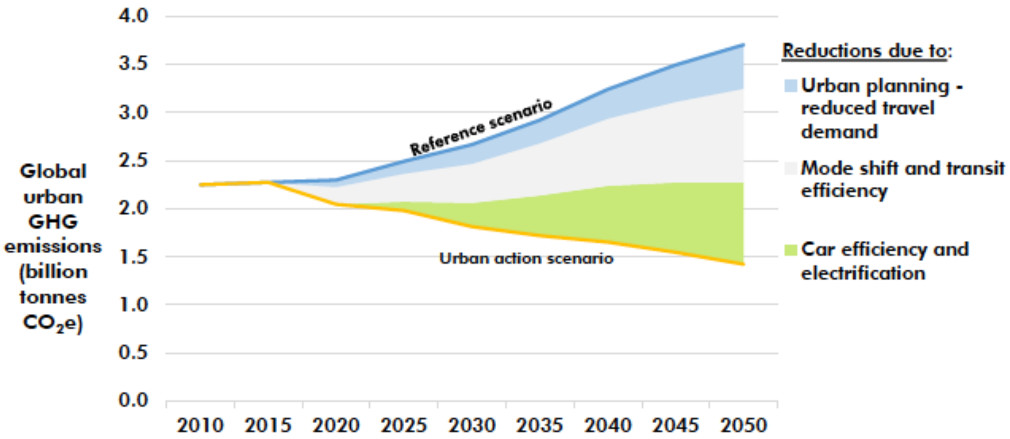


Figure 6 The potential of reducing urban passenger-transport emissions through the urban action scenarios, figure from Erickson and Tempest, 2014

Figure 6 shows estimations by Erickson and Tempest (2014) regarding mitigation of mobility-related emissions through urban development (see above for an explanation of the study). The potential mobility-related gain from the urban action scenario (see Figure 5) is here separated into three categories: reduced travel demand; mode shift and transit efficiency; car efficiency and electrification. The estimations are based on cities opting for compact-, pedestrian- and transport-oriented development, rather than development that necessarily will lead to an increase in private car use (Erickson and Tempest, 2014). Among the three categories, mode shift combined with transit efficiency represents the highest mitigation potential of roughly 1 billion CO_2-equivalents. This is not to say that the two other gain categories are not important; a combination of strategies is necessary to efficiently curb mobility-related emissions (EEA, 2016, 2013; The World Bank, 2010). Moreover, mitigation strategies often overlap and mutually enhance each other. Reduced travel demand and modal shift can, for example, be an outcome of an urban development project. If the urban action scenario is realized, the study projects a decline in private vehicles' share of global transport from 64% in 2014 to 53% in 2050; in contrast, the reference scenario projects a rise from 64% to 72% (ibid). Realizing the potential gains outlined in the study requires cities to heavily invest in public transport, combined with urban construction or renewal to support the use of public transport services; this is often referred to as integrated land-use and transport planning.

Integrated land use and transport development

An integrated land use and transport-planning approach (or coordinated land use and transport-planning approach) is frequently held up by research as key to curbing current and future greenhouse gas emissions from urban travels. The following is a summarized explanation based upon Aguiléra et al. (2004), Bertolini (2012), Cervero (2014), Christiansen and Julsrud (2014), Givoni and Banister (2013), Hickman and Banister (2007), Hjorthol and Gundersen (2015), Lefèvre (2009), Næss (2006, 2012), Strand et al. (2010), Tennøy (2012), UN Habitat (2013).

An integrated approach to urban development of transport systems or land use implies urban development with particular attention to how the one might influence the other: how land use, e.g. a new residential area or the refurbishment of a neighbourhood, will influence transport needs and demands; how the instalment of new transport services, e.g. a new road or a new tram line, will influence land use. Due to the reciprocal relationship between the two, there is always a mutual influence. With regard to mobility-related emissions, it is particularly important to pay attention to the potential increase – but preferably decrease – in traffic volumes from new developments (or refurbishments). The overall objective of most integrated land use and transport-planning is to reduce traffic volume (private cars) and travel demand, and to promote a sustainable modal shift by making it possible (and preferably better) to choose zero-emission modes. For example, avoiding development that creates car dependency by situating a new housing development far away from public transport offers, services and amenities. Some research also points to reducing/avoiding sprawl and/or greenfield development[30] (construction on unused land) as an objective of an integrated approach. Both can be the result of the construction of new transport systems (roads and rails) spiking new constructions, for example around transit stops. Therefore, to ensure a

[30] Greenfield refers to development on previously unconstructed land, for example agricultural lands or a forest, as opposed to brownfield that ‘re-use’ areas that have already been used for constructions. These are often industrial areas.

sustainable development that curbs emissions and avoids new ones, land use and transport development must be planned and organised jointly. As an example, housing developments should be located with regard to public-transport hubs with good connections to the main city centre, as well as in proximity to kindergartens, schools, grocery stores, and other frequent everyday-life destinations. All of these aspects influence daily mobility behaviours. New housing development must take the impact on present and future inhabitants' travel patterns into account; the same applies to the location of bigger hubs, e.g. offices and other workplaces such as hospitals that receive many visitors each day. If a hospital is not easily reachable by transit, the tendency will be to drive there. Density (of housing and jobs, mixed use, etc.) is an important aspect of an integrated approach, as proximity, distance, and number of inhabitants in a neighbourhood (or other) are important for modal services and choices. However, there are also potentially negative effects to take into consideration, such as the Energy Paradox, which can be enhanced by densification (Bonhomme, 2013).

The success and outcome of an integrated planning-approach depends on a number of political and economic factors, as well as the involved actors. Urban development policies can impose an integrated approach and regulation plans (and other documents) can to a large extent determine where and how development may take place. This can contribute to increasing or decreasing the attractiveness of different areas, which is important for developers' willingness to invest in an area (retail, housing, etc.). Collaboration across disciplines such as land use planning and transportation planning is important but not always a given. Despite the large of body of research and concrete cases showing the integrated approach to be an efficient mitigation strategy, few urban development projects are done in an integrative manner, even when public policies take it as an objective. Tennøy (2012) explored this discrepancy, focusing on why planners keep making plans would cause a rise in road traffic, and thereby a rise in emissions. She found a series of elements and aspects that contribute to explaining this. The points below are particularly interesting in this context.

FINDINGS FROM TENNØY (2012)	
Related to the expert knowledge[31] on land use and transport planning	▪ The knowledge is incomplete or inconclusive ▪ It can be ousted by other knowledge, for example economical estimations
Related to the urban planners	▪ Lack of knowledge on the topic (e.g. mechanisms and interdependencies, potential influence of design/planning actions) ▪ Lack of use of the expert knowledge in projects
Related to the planning process	▪ How the collaboration between various actors takes place ▪ How objectives for mitigation of transport and mobility emissions are defined

Table 2 Summary of findings from Tennøy (2012)

1.1.3 c) **Urban design as a mobility-mitigation strategy**

Urban design organizes and constructs the public space between buildings through interventions upon the built environment at the neighbourhood scale, from sidewalk enlargement to the refurbishment of a neighbourhood (Carmona, 2010; Gehl, 2010; Madanipour, 2006). Following the reciprocal relationship between the built environment and mobility behaviours, all actions upon the built environment at the neighbourhood scale are likely to influence people's mobility behaviours, e.g. their modal choice. Today, walking, cycling, and public transport are the most frequent zero-emission mobility modes. By default, the traveller interacts with the immediate surroundings in a more direct and significant way than when travelling by car (Stefansdottir, 2014a). For public transport this applies primarily to the trip to and from the transit stop. It could likewise be expected that the built environment's influence upon zero-emission trips is more significant than on car use (ibid). This applies in particular to the neighbourhood-scale built environment, i.e. the scale of the pedestrians and the cyclists. One reason for this is travel speed, which is usually slower with non-

[31] Tennøy (2012) defines expert-knowledge regarding land-use and transport interdependencies, and effects of various urban development strategies in the following manner:
"The *expert knowledge* in question is general knowledge regarding how and why developments of land use, transport-systems, travel behaviour and traffic volumes are interrelated. It also includes empirical knowledge regarding how, why and to which extent certain changes of land use or transport-systems tend to result in certain changes of travel behaviour and traffic volumes."

motorized modes, making built-environment details at the neighbourhood scale more apparent for the traveller. These interactions are likely to influence the impression of a trip, ideally making zero-emission modes attractive for future trips. The reciprocal relationship dictates that urban design can, in theory, be a complementary strategy to urban planning (city scale) to promote the use of zero-emission modes. However, research and urban design literature show that, so far, this strategy appears to be little explored by research and practice. Initial searches within the scientific literature provided few results. Studies often focus on singular aspects such as the importance of particular urban features (vegetation, sidewalk width, etc.), or the perception of traffic safety and/or feeling of safety in public spaces. How such research results could be applied to promoting sustainable modes through urban design is less studied. Furthermore, the majority of the scientific literature on integrated land use and transport planning tends to address the city scale (see for example Næss (2006, 2012)). This is not surprising, as transport systems (motorized and non-motorized) and larger land use developments are generally planned and organized at this level. The neighbourhood scale seems to be more relevant with regard to the design of particular transit stops, individual buildings, etc.; episodic interventions upon the neighbourhood-scale built environment that are planned one project at the time. Works that address a coordinated neighbourhood-scale strategy to promote zero-emission mobility modes are scarce or inexistent. Urban design and planning literature frequently address mobility as movement through public space or as the circulation of people, but not from a mitigating point of view. Gehl (2010) writes about designing ‘good’ public spaces people will want to use and move through as pedestrians (and to some extent cyclists). Yet he does not specifically relate this to promoting such modes in order to curb emissions from daily mobility; the main focus is on liveability[32], not mitigation.

Although cities worldwide are taking action for mitigation, mobility-related greenhouse gas emissions are still rising, especially from transport and mobility (EEA, 2016). There are several barriers that limit or complicate urban mitigation action, ranging from politics and policy to the physical context of a city (EEA, 2016; Næss, 2006; Tennøy,

[32] See Glossary

2012; UN Habitat, 2013). The following section discusses two possible explanations for the apparent lack of potential mobility-mitigation strategy and exploration in urban design: i) knowledge gaps in the scientific literature; ii) lack of research knowledge implementation in urban design practices. These two aspects have been identified as important barriers to adaptation efforts through urban design (and development) (Dubois, 2014; Dubois et al., 2016; Eliasson, 2000). It seems likely that mitigation through urban design could be facing the same barriers.

1.1.4 Barriers for mobility-mitigation action

1.1.4 a) **Knowledge gaps in the scientific literature**

One potential barrier is linked to scientific knowledge on mitigation through urban development and its influence on urban areas and living. Producing knowledge to guide and inform practitioners (and decision makers) is an important part of the societal role of research. In this context, it is hypothesized that there are significant shortcomings (knowledge gaps) within the scientific literature on how the neighbourhood-scale built environment influences modal choice. This in turn hinders knowledge transfer from research to practice, and thus the application of scientific knowledge for mitigation through urban design. Knowledge gaps refer to shortcomings or 'holes' in the scientific literature, where the evidence is either inconclusive or lacking. For example, there is a knowledge gap regarding which measures are most efficient in promoting walking, or the best way to motivate transit use. Such shortcomings can have an important influence on knowledge use. If the evidence is incomplete or lacking, research cannot fulfil its role in guiding and informing urban design practices (Forsyth and Krizek, 2010; Tennøy, 2012). Moreover, inconclusive evidence can lead to confusion among 'knowledge-users' (here: practitioners), such as uncertainty concerning reliability of studies and articles or limitations in applicability (ibid). This can make it easier to question or disregard (oust) the scientific evidence in favour of other kinds of knowledge (Tennøy, 2012).

1.1.4 b) **Lack of implementation of research knowledge in urban design practices**

Mitigation through urban design is complex. Actions can have unintended consequences due to the high level of interdependency between factors and elements of the urban environment. This can weaken mitigation measures and solutions, or reinforce climate change phenomena such as Urban Heat Islands[33] (Bonhomme, 2013; Dubois, 2014). Implementation of scientific knowledge in urban planning and design is essential for mitigation through urban design (Dubois, 2014; Eliasson, 2000; Susskind, 2010), equally so for mitigation of mobility-related greenhouse gas emissions (Næss et al., 2013; Tennøy et al., 2015). Applying research-based knowledge is necessary to assure practitioners' comprehension of the problem they are addressing, and how to solve it. First of all, practitioners must have a good understanding of global warming and climate change, and how urban living contributes to both. Second, they need to know and comprehend the potential consequences of climate change on urban areas, and on the lives of urban inhabitants. Finally, they must have knowledge of how urban development can be a strategy to mitigate emissions, and how practitioners can contribute to this through their work. Knowledge from research can contribute to all of the above by informing and guiding urban practitioners on the subject. To do so, the scientific knowledge must be valid and reliable, i.e. sound, robust, and trustworthy. Moreover, it must be understandable and useable for urban design practitioners, i.e. easily applicable in a specific project.

Unfortunately, this does not seem to be the case in current design practices. Studies have found that scientific knowledge regarding climate adaptation, mitigation, and other issues such as universal accessibility (Kirkeby, 2015) is little integrated in current urban design practices (Dubois, 2014; Eliasson, 2000; Tennøy, 2012). This is to a large extent related to properties of the scientific knowledge itself. Several studies explain that practitioners often perceive research knowledge as inaccessible and non-applicable for a project. According to them, the scientific knowledge is often too complex, technical, or specific; it can also be too broad, seeking to generalize findings (Dubois, 2014; Eliasson, 2000; Kirkeby, 2015). Additionally, research knowledge is often

[33] See Glossary

communicated in a manner that makes it difficult to understand, for example through complex models and simulations, or as overly technical tools (Dubois, 2014). Significant disparities between research and practice in themselves create further issues that enhance the difficulties of knowledge transfer, for example differences in the importance given to context (Kirkeby, 2015). Research generally aims at producing context-independent knowledge, for example by combining a series of case studies to draw overall conclusions. In practice, however, the knowledge is always context-dependent, as local conditions (physical, cultural, etc.) significantly influence a project and its solutions (ibid). These disparities reinforce the lack of implementing scientific knowledge in urban design practices. Moreover, the communication barriers also hinder practical feedback from practice to research, which could strengthen scientific knowledge production. The hypothesized knowledge gaps within the scientific literature can further increase the difficulties of knowledge transfer from research to practice.

The following subchapter is a literature review of the available scientific knowledge regarding the relationship between the neighbourhood-scale built environment and mobility behaviours, focusing on modal choice. It explores the hypothesis of shortcomings within current research, and if so, how these might be corrected.

1.2 LITERATURE REVIEW: THE BUILT ENVIRONMENT AND MODAL CHOICE

A large body of research exists on the relationship between the built environment and mobility behaviours, which in turn has produced several reviews and even reviews of reviews (see for example Bull and Bauman, 2007; Ewing and Cervero, 2010; Heinen et al., 2010; Krizek et al., 2009). The following literature review is based upon a broad range of research within urban development, transport and mobility. The main works are Alfonzo (2005), Bertaud (2002), Ewing and Cervero (2010), Forsyth and Krizek (2010), Handy et al. (2002, 2014), Heinen et al. (2010), Hickman and Banister (2014), Hillnhütter (2016), Krizek et al. (2009), Laigle (2012), Næss (2006, 2012), Sallis et al. (2016), Stefansdottir (2014), Tennøy (2012). Modal choices are about the choices and decisions of individuals: how to undertake a trip in a manner that best suits personal needs and preferences. To better include this in the theoretical framework of the thesis, research from behavioural sciences and environmental psychology was also explored. This alignes with recent works within transport and mobility research, that call for integrating knowledge from the above fields, in addition to insights from social sciences for a better understanding of mobility behaviour (Al-Chalabi, 2013; Gaker and Walker, 2011; Schwanen et al., 2011; Vos et al., 2015).

The literature review starts by introducing an updated model for modal choices, in line with the above. It combines the traditional utility approach to modal choice with insights into judgement and decision-making, and situates the built environment among the many contexts that influence how a person chooses to travel. Here, the focus is upon the built-environment context, in particular the neighbourhood scale, and how this influences mobility behaviours. The previous Chapter 1.1 defined mobility behaviour as a person's modal choice and amount of travel (distance and frequency). Modal choices are the main focus of this work, and thus equally so for the following the literature review. In those cases when mobility behaviour(s) is applied it will therefore generally point to modal choice. After this, the review explains how the built-environment elements land use, urban structure, and mobility systems influence a traveller's modal choice. This is done at the city as well as the neighbourhood scale; the latter brings forth an additional element: urban features. These are the levers of action that urban design might act upon to influence modal choices. Finally, the review addresses the thesis hypothesis regarding knowledge gaps in the available scientific literature. These shortcomings are in part related to methodological differences among studies, which contributes to the inconsistencies between research findings. As a conclusion and positioning, based on the findings from the literature review, Chapter 1.3 suggests that approaching the thesis topic from a holistic, interdisciplinary perspective might be more efficient and successful. It is likely to provide a better comprehension of how people perceive and interact with the neighbourhood-scale built environment in relations to daily mobility.

1.2.1 Modal choices are a sum of contexts

1.2.1 a) **A model for modal choice**

The model in Figure 7 explains modal choice as a sum of contexts. As a reminder, the built-environment is the focus of this work, in particular the neighbourhood scale – the geographical scale of urban design. It must be noted that this is one way in which modal choices can be explained; in this case, adapted to the context of this thesis, which focuses on the influence of the neighbourhood-scale built environment, and how urban designers can explore this to promote sustainable mobility modes. Other objectives and fields of research are likely produce different models (see following section).

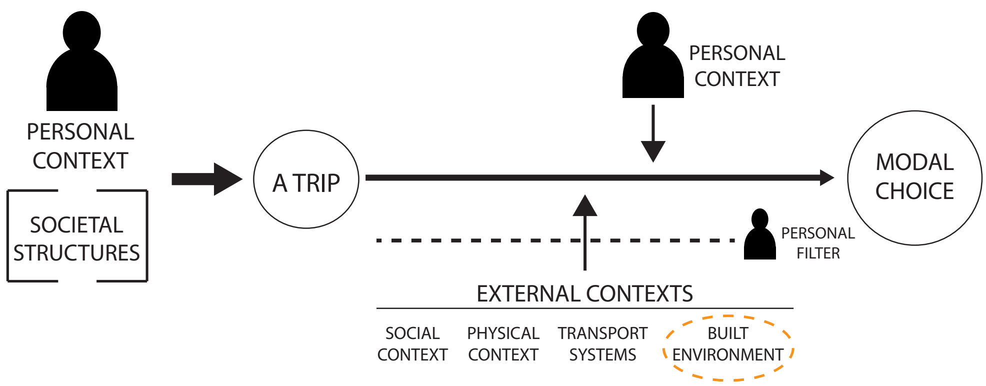


Figure 7 Modal choice as a sum of internal and external contexts, figure by author

The contexts in the model are highly interdependent. The impact of the built environment upon modal choice is generally influenced by the other contexts. A significant topography (physical context) can for example reduce the positive influence of an active and interesting built environment with regard to walking as primary modal choice for a daily commute. The influence of the built environment furthermore depends on the personal context of an individual, for example how a neighbourhood is perceived and experienced. This is further detailed in 1.2.2. The aim of the model is to help identify the limits and possibilities for influencing modal choices through urban design (built environment-context). It is primarily based upon works by Alfonzo, 2005; Ascher, 1995; Cho and Rodriguez, 2004; Gehl, 2010; Hickman and Banister, 2007; Jacobs, 1961; Kahneman et al., 1997; Kahneman and Krueger, 2006; Kahneman, 2012; Mees, 2010; Næss 2006, 2012; Speck 2013; Tennøy, 2012; Thaler and Sunstein, 2009. In the model, the term *context* is used as a collective notion for elements that influence modal choice, summarized as *Personal* (internal), and *External,* for example the presence of a metro system (external context). Personal context are the individual characteristics of a person such as travel needs and preferences, physical capacities, economical situation, etc. Personal and External context represent physiological and institutional needs, personal obligations, and personal preferences (Vilhelmson, 1999 in Næss, 2006), in addition to physical contexts (e.g. topography) and structures (e.g. urban fabric, land use). The contexts can initiate a trip, and/or establish conditions and premises for the corresponding modal choice. Interactions and interdependencies among the contexts can strengthen or weaken their influence on a modal choice (Hickman and Banister, 2007). The actual influence of a context varies depending on one's personal context (Alfonzo, 2005; Næss, 2006). As a reminder, the focus here is on daily urban mobility related to work, education, grocery and similar needs, as well as weekly sports and cultural activities; leisure mobility is not included.

1.2.1 b) **An updated utility approach including remembered travel experience**

Larco (2016) fittingly sums up the complexity of studying modal choice and the built environment in writing that "the relationship between urban design and mode choice seems self-evident on the one hand and utterly complicated on the other". This complexity is largely due to the individuality of experience – in terms of built environments and mobility preferences (Alfonzo, 2005; Ewing and Handy, 2009). Modal choice can be approached from several angles, which has produced a broad range of models and frameworks (here summarized as models). The nature of a model depends on the field studying it (e.g. Geography, Economics, Urban Planning, Civil Engineering), the variables or aspects chosen to explain it (e.g. modal split, evaluation of utility, trip length), or the aim of the model (e.g. predict future traffic volumes) (Al-Chalabi, 2013; Ewing and Cervero, 2010; Næss, 2006); additionally, the level of detail or variables included. These numerous models are neither entirely 'true' nor 'false'. They represent different manners to explore the potential influence of factors and aspects upon modal choices, and are primarily a result of the elements described above.

A utility approach is the most common among the theoretical approaches and frameworks for mobility behaviours employed within transportation research (Al-Chalabi, 2013). This includes utility theories which are among the most frequently used frameworks for studying modal choices (Al-Chalabi, 2013, p.; Vos et al., 2015). Al-Chalabi (2013) writes that the employment of utility theories within transportation research goes back to the 1960s. They are for the most part derived from the economic model of Random Utility Theory (RUT), developed by McFadden, a Nobel Prize laureate within Economics, and his colleagues throughout the 1960s and onwards (Al-Chalabi, 2013; Schwanen et al., 2011). In short, Random Utility Theory assumes that actors making a choice or a decision are instrumentally rational. This means that decisions are based on a rational evaluation of the utility of possible alternatives – measured as the extent to which they minimize effort and maximize satisfaction (Al-Chalabi, 2013; Schwanen et al., 2011; Thaler and Sunstein, 2009). In the context of a mobility modal choice, factors that assumedly could be taken into account from a utility perspective to minimize effort are physical exertion, travel time, waiting time (for transit), and parking availability. Factors which could maximize satisfaction include speed, comfort, and safety (Schwanen et al., 2011).

Despite its extensive application, RUT it is often criticized for being 'incomplete' in terms of over-simplifying; people tend not to be the rational decision makers RUT presumes them to be (Al-Chalabi, 2013; Schwanen et al., 2011; Vos et al., 2015). Rather, people's judgements and decisions are influenced by a number of factors – often referred to as heuristics and biases – in addition to social and cultural values and norms (Kahneman, 2012; Thaler and Sunstein, 2009). A modal choice is not merely a result of a rational evaluation of utility, but also a result of individual perceptions and evaluation of factors such as: how a modal alternative fits a person's values, preferences, and lifestyle (Næss, 2006; Vos et al., 2015); how a modal option is perceived by society (social and cultural norms) (Coogan et al., 2007; Næss, 2012); a person's habits, which can influence their estimation of the costs and benefits of available transport options (Vos et al., 2015). Such evaluations can occur both consciously and unconsciously, and depend on the individual in question; the level of influence of the various factors will vary from one person to another (Alfonzo, 2005). How personal characteristics and macro-scale social factors matters for a person's modal choice has been clearly established within the literature (see for instance Alfonzo, 2005; Næss, 2012: Vos et al., 2016). Al-Chalabi (2013) and Vos et al. (2016) both conclude that insights from social psychology and behavioural sciences can be better predictors of modal choice than the more objective variables applied in most 'discrete choice models'.

Several works conclude on the need to improve or 'update' the random utility approach (Kahneman et al., 1997), including for modal choices (Vos et al., 2015). Moreover, that a mix of approaches, models, and frameworks – from a broad range of disciplines – is required to properly understand modal choices and the influence of built environment factors and elements. Vos et al. (2016) suggest applying findings from behavioural and social psychology regarding the term utility, which distinguishes, for example, between *decision utility* and *experience utility*. Decision utility is associated with the choice of an alternative, and applies to the focus of traditional transportation research on the weight of certain attributes such as modal choice in the mobility decision (Kahneman et al., 1997; Vos et al., 2015). Experience utility is associated with the experience of feelings and emotions, for instance level of satisfaction in relations to a trip; it can be a measure of the quality of an outcome, and is distinct from decision utility (ibid). Kahneman et al.

(1997) explain that experienced utility can be further divided into *instant utility* (immediate responses or reactions to an experience) and *remembered utility* (the retrospective evaluation of the experience). The latter is particularly interesting in the context of this work. In a later study, Kahneman and Krueger (2006) found that when given a choice of activities to repeat, individuals tended to choose the activity that had the highest remembered utility (e.g. remembered satisfaction of a previous choice). The authors concluded that this confirms the influence of remembered utility upon decision utility (Kahneman and Krueger, 2006). In the context of this thesis, such an influence could be equivalent to the remembered satisfaction of a previous modal choice influencing current decisions. This indicates that to achieve a long-term modal shift, zero-emission modal choices must provide positive trip experiences. Vos et al. (2016) explored how decision utility and remembered utility (part of experienced utility) interact with regard to modal choice. The study was conducted in suburban and urban neighbourhoods in Belgium, and focused primarily on the influence of modal choice upon travel satisfaction. The researchers hypothesized that since people tend to seek satisfaction and well-being, the experienced satisfaction – and thereby utility – of a modal choice ought to have a strong influence upon future modal choices. The results from the study indicate a clear link between modal choice and travel satisfaction. This relationship seems to be reciprocal: in the study, modal choice influenced reported travel satisfaction, but there was also evidence that travel satisfaction influenced future modal choices. These results align with the findings of Kahneman et al. (1997) and Kahneman and Krueger (2006) regarding the importance of experienced utility when making choices.

The above, together with findings from judgement and decision-making research (see for instance Kahneman, 2012) and from transportation research regarding individuals' modal choice (see for instance Alfonzo, 2005), serve as a basis for the holistic approach suggested in this thesis: focusing on the overall experience and perception of the built environment as a whole rather than singular elements, and how this influences modal choices. The present review of the state of research knowledge regarding the built environment and mobility behaviours supports this observation, which is further discussed in 1.3.

CONTEXTS THAT INFLUENCE MODAL CHOICE		
	Personal (internal)	**External**
Reasons for a trip *(left in the model)*	**A person's needs and/or preferences** such as weekly leisure activities; a particular grocery store; wishing to meet with a work-collaborator face to face (Ascher, 1995; Glaeser, 2012; Montgomery, 2013; Næss, 2006). This creates a reason to travel, and a destination to go to. Næss (2006) presents choice of destination as a result of the location's attractiveness, and the amount of discomfort the travel involves (friction of distance). An individual's personal context is constantly evolving; it depends on age, family-situation, economy, education, geographical location, and so forth. (Alfonzo, 2005; Krizek et al., 2009a; Næss, 2006; UN Habitat, 2013).	**Societal structures** such as work, education, social events, and weekly activities (Ascher, 1995; Glaeser, 2012; Næss, 2006). They vary between cities and countries, depending on culture and economy (Glaeser, 2012; New Climate Economy, 2014; UN Habitat, 2013). In most developed societies today, daily mobility generally includes at least one trip, for example to get to work or to school (Glaeser, 2012; UN Habitat, 2013). Trips generated by societal structures are largely dictated by the necessity to earn a living, obligatory education, social commitments, etc. They are also subject to some level of personal adaptation and choice (location of residence, workplace, school; where to get groceries, etc.).
Elements that influence modal choice *(right in the model)*	**Individual characteristics:** physical, personal economy, and education, and well as norms, values and beliefs (Alfonzo, 2005; Krizek et al., 2009a; Næss, 2006). Individual characteristics impact modal choice directly (capacity to walk or cycle), and indirectly by influencing the importance of an external context (Alfonzo, 2005; Krizek et al., 2009a). In the model, this is referred to as a 'personal filter'. To illustrate: an able-bodied adult will be less dependent on the presence of cycling infrastructure than a young child, and less troubled by big variations in topography.	**Physical** (e.g. topography, local climate), **Built environment** (e.g. streets, buildings, urban blocks), **Transport systems** (e.g. available means, not infrastructure such as cycle paths), and **Society** (e.g. social, cultural, economical, policy). These contexts can influence modal choice directly and indirectly: significant topography can make cycling a less available mode for a trip (Rodríguez and Joo, 2004); norms and beliefs can influence society's perception of mobility mode (Cervero, 2014). These contexts are interdependent, influencing each other's importance. The extent of this influence, however, depends largely on the personal context of the individual travelling (Alfonzo, 2005; Coogan et al., 2007; Krizek et al., 2009a; Vos et al., 2015). Topography or cultural norms are more important for some travellers than for others.

Table 3 Contexts that influence modal choice

1.2.2 The personal context: individual characteristics of people

Mobility behaviour – and so modal choice – is a result of a person's individual characteristics and traits. They contribute significantly to the variations that can be observed in people's modal choices (Krizek et al., 2009a; Næss, 2006; Stefansdottir, 2014a). Characteristics that can influence modal choices are for example lifestyle, physical capacities, economic situation, personal values, beliefs and attitudes, habits, modal preferences (Al-Chalabi, 2013; Alfonzo, 2005; Coogan et al., 2007; Krizek et al., 2009a; Næss, 2006, 2006; Schwanen et al., 2012; Schwanen and Lucas, 2011; Stefansdottir, 2014a; Waygood et al., 2017); additionally, biases and heuristics that influence a person's judgements and decision-making (Kahneman, 2012). These individualities impact modal choice in different ways and to varying degrees, directly and indirectly. Physical capacities can for example influence whether or not a mode is actually available for a person undertaking a particular trip (Alfonzo, 2005; Cho and Rodriguez, 2015; Krizek et al., 2009a). Similarities in mobility needs and preferences can be found among different segments of the population, sorted by age, mobility experience (e.g. cycling), physical capacities (e.g. able-bodied, hearing impaired), etc. (Cunningham and Michael, 2004; Krizek et al., 2009a; Waygood et al., 2017). People can belong to several groups: a person can be elderly, able-bodied, and an experienced cyclist, or young, physically fit, and blind. Such categorizations can be helpful when communicating scientific evidence to urban design practitioners or to decision makers to strengthen its employment in urban development projects (Forsyth and Krizek, 2010). Especially the needs of the least mobility-able can provide a concrete objective to aim for, as an environment designed to be accessible for those most hindered will (normally) by default be accessible for all others (Krizek et al., 2009a).

Another difference between individuals relates to how people experience and perceive their built environment, which also influences modal choice (Alfonzo, 2005; Johansson et al., 2016a; Stefansdottir, 2014a). Aspects identified as important are for example perceptions of traffic safety (Krizek et al., 2009a; Philip Stoker et al., 2015), feeling of safety in public space (Blöbaum and Hunecke, 2005; Krizek et al., 2009a), perception of distance (Hillnhütter, 2016), and aesthetic or pleasurable experience during a trip

(Johansson et al., 2016a; Saelens and Handy, 2008; Stefansdottir, 2014a). Several studies conclude that people's perception and experience of their built environment is not necessarily in line with their actual environment (Ewing and Handy, 2009; Krizek et al., 2009a). Distances can be perceived as longer or shorter depending on the design of the built environment (Hillnhütter, 2016); despite statistics indicating the contrary, bike infrastructure separate from cars (and pedestrians) are often perceived as safer by cyclists, particularly the more inexperienced (Krizek et al., 2009a). This disjunction between physical and perceived built environment suggests that built-environment interventions may not always have the intended effect, or at lest less than estimated (Krizek et al., 2009a). Krizek et al. (2009) write that measures to improve traffic safety are not necessarily enough to improve people's perception of traffic safety; in particular, parents' perception of their children's route to school.

Individual characteristics can be organized into two categories: objective and subjective. **Factual** are individual characteristics based on actual conditions or realities that form premises and conditions for which mobility modes a person can use. They can impact perceptions; it is probable that a person's physical capacity influences how they experience their surroundings. A person might perceive an environment as less walking-friendly than an able-bodied adult if they have difficulties to walk due to age or physical restrictions. **Perceived** are individual characteristics that influence how people perceive and experience different mobility modes, and different built environments – immediate and bigger scale, built as well as physical. Perceived-characteristics significantly influence how a person makes decisions (e.g. modal choices). They contribute to explain why individuals often make decisions that are irrational and not in their best interest (Kahneman, 2012). Table 5 presents a summary of the primary characteristics, with some examples as to how they might influence modal choices. It is based on Alfonzo (2005), Christiansen and Julsrud (2014), Clark et al. (2016), Ewing et al. (2016), Gehl (2010), Hickman and Banister (2014), Hillnhütter (2016), Næss (2006, 2012), Saelens et al. (2003), Saelens and Handy (2008), Speck (2013), Stefansdottir (2014), Talen and Koschinsky (2014), Tennøy (2012), and van der Waerden et al. (2003). In addition to these, a series of elements influence judgement and deiscionmaking, generally referred to as heuristics and biases. A brief explanation of these are provided in Table 4 based on Kahneman (2012) and Thaler and Sunstein (2009). Although not further explored here, practitioners (as well as researchers and decision makers) ought to be aware of this aspect of judgement and decision-making when aiming at influencing modal choices through urban design. Presently, the extent to which this is done, however, probably depends on the practitioner's experience and/or personal interests towards behavioural sciences. The importance and value of behavioural insights are becoming more and more acknowledged. Yet their implementation in for example urban development and policy-making remains in the early stages (World Bank, 2014).

HEURISTICS AND BIASES THAT INFLUENCES JUDGEMENT AND DECISION-MAKING
Heuristics and biases are mental shortcuts that people rely upon to make complex judgements and decisions under uncertainty, but that can lead to systematic and predictable errors. As an example, people are generally bad at evaluating risk, e.g. traffic safety, and so might make modal choices that are not in line with the actual risk. Other examples: ▪ 'Loss aversion': losses tend to be experienced as more painful than gain, which can play in on how people experience restrictions to car use. ▪ 'Default bias': It is often easier to stick with the status quo, as it involves less mental effort; choosing a different mode can be seen as difficult as it might involve revisiting daily habits and routines. More 'biases' exists that could also contribute to explain how and why people opt for the modal choices that they do. For example, why people keep driving despite being stuck in traffic for several hours every week.

Table 4 Summary of heuristics and biases that can influence modal choices

Summary of how individual characteristics influence modal choice, organized by category		
	Characteristic	**Influence on modal choice**
Factual	*Physical capacity*	Whether or not a person can use the available mobility modes. Age or disabilities can potentially limited usage.
	Economic situation	Whether or not a person can afford available mobility modes, e.g. monthly transit pas, gas for cars. The economic situation can dictate modal choice: necessity to drive in order to get to work.
	Personal situation	Whether or not a person's family situation or similar dictates modal choices, e.g. small children, elderly in their care.
Perceived	*Personal values, beliefs, and attitudes*	How a person perceives mobility modes, e.g. unsafe, unreliable, or pleasurable; the transport of poor people. Environmental beliefs can motivate sustainable choices, while non-belief can push in an opposite direction.
	Habits	How a person's travel habits influence modal choice, in particular acting as barriers for a change in modal choice. Habits are very hard to change, but bigger system changes such as new urban development or less parking can induce different modal choices. Bigger life events can similarly lead to a change in travel habits, for example a new job, change of residence, of children.
	Mobility preferences	How a person's preference, for example for walking rather than bicycling, will influence their modal choice. Some people tend to have very strong mobility preferences, while others are more flexible with regard to mobility mode.

Table 5 Summary of the primary characteristics with examples of they might influence modal choices

1.2.3 The built environment context: Mobility systems, Land use, and Urban structure

The built environment establishes conditions and premises for urban travels: which destinations to go to, how to get there, and so forth. It is composed of a broad range of elements or 'components' – big and small – that all influence modal choice in some way. They can be categorized as *urban structure*, *land use*, and *mobility systems,* the main built-environment elements at the city scale with regard to modal choice and mobility behaviours, here referred to as 'built-environment elements'. The neighbourhood scale introduces a fourth category, *urban features*, which is addressed further below. These elements are considered the design 'levers of action' in a project, i.e. what urban designers can act upon or work with to create a project that responds to the project command and their design principles (see Chapter 3 for more on the design process). The level of influence upon these built-environment elements depends on the geographical scale of a project. In the following, urban structure, land use, and mobility systems, are first described from the city-scale perspective to define how they – at the city scale – establish initial premises and conditions for a trip and its modal choice. A comment is made on density and distance, two important aspects of the built environment, but here seen as a result of the above, not as levers of action in themselves. The review then 'zooms in' on the neighbourhood scale, the geographical scale of urban design and this thesis, and how the built-environment elements influences modal choices at this level.

Urban structure, land use, and mobility systems are highly interrelated and interdependent. Changes in one will necessarily influence the two others, and thus inevitably induce a change in mobility behaviours; the level of which depends on the context and the significance of the change (Næss, 2012; Tennøy, 2012). Built-environment interventions acting upon these elements can facilitate or limit modal choices (Forsyth and Krizek, 2010; Speck, 2013): by creating potential destinations; by influencing how a trip might be undertaken (available and compatible mobility modes and routes) and experienced; or by altering distances through the organization and layout of a city. Through urban development projects, e.g. infrastructure extensions of varying size and scale or refurbishment of an area, there is a constant change happening in a city. The result will always have an effect – directly and/or indirectly – on the mobility behaviours of urban inhabitants (Bertaud, 2002; Tennøy, 2012); numerous interdependencies among the built-environment elements create potential win-win or win-lose associations. Solutions that facilitate cycling can, for example, limit access to cars, but simultaneously limit pedestrian access. Table 6 is a simplified summary of how these built environment elements can influence modal choice.

The built-environment elements and how they influence mobility behaviours			
	Urban structure	**Land use**	**Mobility systems**
Influence upon modal choice	• Can increase or reduce the distance to cover. • Influences the level of route choices for a trip, for example pedestrian alternatives to walking along a highly trafficked road.	• Establish destinations, and influence their attractiveness. • Largely influence the character of an area (residential, sprawled, mixed, etc.), which in turn influence how a traveller experiences it (pedestrian-friendly/car-based, boring/interesting, etc.). • Premise for future development of mobility infrastructure and urban structure.	• Availability and compatibility of different mobility choices with a trip as a whole. • Can increase total distance if, for example, transit stops or parking facilities are far away from start and end points. • Here, transport services, e.g. buses, are not included as the focus is upon built environment-elements

Table 6 A summary of how Land use, Mobility infrastructure, and Urban structure influence mobility behaviours

1.2.3 a) **Urban structure – the fabric of the city**

The layout of a city or a neighbourhood is established by the geometrical organization of bigger and smaller built-environment elements. This includes, for example, road and street networks, the shape and size of building blocks, the location of bigger activities or services (e.g. industry, hospitals, administration buildings). The resulting urban fabric is what is here considered a city's (or a neighbourhood's) *urban structure*. At the city level, the overall structure organizes the urban area, defining clusters of land as districts or boroughs; at a lower scale the urban structure is further divided into neighbourhoods of varying sizes and characters, often with particular traits such as mainly business or residential. The geographical scale indicates which elements and aspects primarily form the urban structure, and thus influence modal choice. The urban structure of most cities today has been established over decades and centuries of development and growth, primarily through historical land use (urban development), and in later decades with the evolution of mobility modes (Ascher, 1995; Lillebye, 1996; Ragon, 2010). Increasing travelling speeds allowed longer distances to be covered in a shorter amount of time; a contributing reason for sprawled development during the last century (Lefèvre, 2009; Ragon, 2010; Speck, 2013). This change occurred first with the development of rail-based transit, then with the automobile becoming accessible to all. The latter significantly influenced the evolution of city streets; demands for onside parking and higher travelling speeds lead, for example, to wider streets (Gehl, 2010; Lillebye, 1996; Ragon, 2010; Speck, 2013). Developments and evolutions, such as those above, have produced an urban structure that today provides conditions and premises for urban travels, and for future development and evolutions. The urban structure is also related to an areas physical context: mountains, rivers, coastlines, etc., provide natural limits and/or constraints for the growth of a city. Figure 9 and Figure 10 shows the cities of Oslo (Norway) and Toulouse (France) from a rather large scale. They are interesting to compare as they have a relatively similar population: in 2013, the city of Toulouse had just below 500.000 inhabitants, and 1.3 million in the metropolitan area; in 2017 Oslo had just below 700.000 in the city area, and 1.7 million in the metropolitan area. Previous urban development (e.g. land use), and the presence natural borders, has made Oslo less sprawled than Toulouse. The latter has no immediate natural borders other than the river that runs through the city.

1.2.3 b) **Land use – the repartition of functions and the characteristics of a neighbourhood**

Land use as a term is often employed without a proper definition or explanation (see for example Ewing and Cervero, 2010; Lefèvre, 2009). This might be related to a general consideration of the term as relatively self-explanatory: the way in which land is used.

For example, in a review of the empirical evidence regarding how local actions can contribute to reduce vehicle miles travelled (VMT)[34], Salon et al. (2012) explored a set of factors in land use planning: residential density; land use mix; regional accessibility; network connectivity; jobs-housing balance. Although the authors do not define the term 'land use' in itself, the chosen factors give a certain understanding of its meaning in the context of the article. The OECD *Glossary of Statistical Terms*[35] defines land use as “the functional dimension of land for different human purposes or economic activities. Typical categories for land use are dwellings, industrial use, transport, recreational use or nature protection areas”. Næss (2012) uses the term 'urban land use', understood as “the geographical distribution and density of the building stock and the urban functions therein”. In addition to the spatial structure of the built environment, Tennøy (2012) includes the location of activities within these structures, and people’s use of activities located at different places. For the purpose of this thesis, *land use* is understood as: i) the geographical distribution of functions within an urban area (e.g. location of residence, of schools); ii) the character assigned to a neighbourhood (e.g. residential, mixed use, business).

Tennøy (2012) writes that land use “defines the framework for travel behaviour in a city and for the transportation system”. Taking place as urban sprawl or as densification, urban developments (land use) “have direct effects in travel behaviour (modal choice, frequency, travel length/destination)” (ibid). A city’s previous land use, together with its existing urban structure and mobility systems, establishes premises for future land use: which areas are available for new development; which areas need rehabilitation or renewal; which functions, services, and amenities are lacking in a city; where should major functions such as sports facilities, higher education, or public offices be located. Previous land uses have categorized some areas as primarily residential, implemented significant structures such as universities and business districts, or may have restricted

[34] VMT stands for Vehicle *Miles* Travelled and is similar to VKT – Vehicle *Kilometres* Travelled. The use is often related to the country of research, depending on its use of imperial or US units (miles, foot, etc.) for length, or the metric system (meters, kilometres).

[35] The Organisation for Economic Co-operation and Development (OECD) *Glossary of Statistical Terms* https://stats.oecd.org/glossary/index.htm visited 07.05.2017

development in some areas while promoting it in others (Glaeser, 2012; Ragon, 2010; Speck, 2013). Land use can impact modal choice by creating new destinations, or by rendering existent ones more attractive (Strand et al., 2010; Tennøy, 2012). The location of frequent destinations such as educational facilities, hospitals, work hubs, and so forth, largely determine the overall flow of a city's daily mobility (Bertaud, 2002; Hickman and Banister, 2007; Næss, 2006). Planned land use can have an influence on plans for improving or developing transit systems: densification of areas can increase the potential number of users (Næss, 2012); implementation of large businesses can spur the instalment of new transit lines to avoid increased traffic volumes.

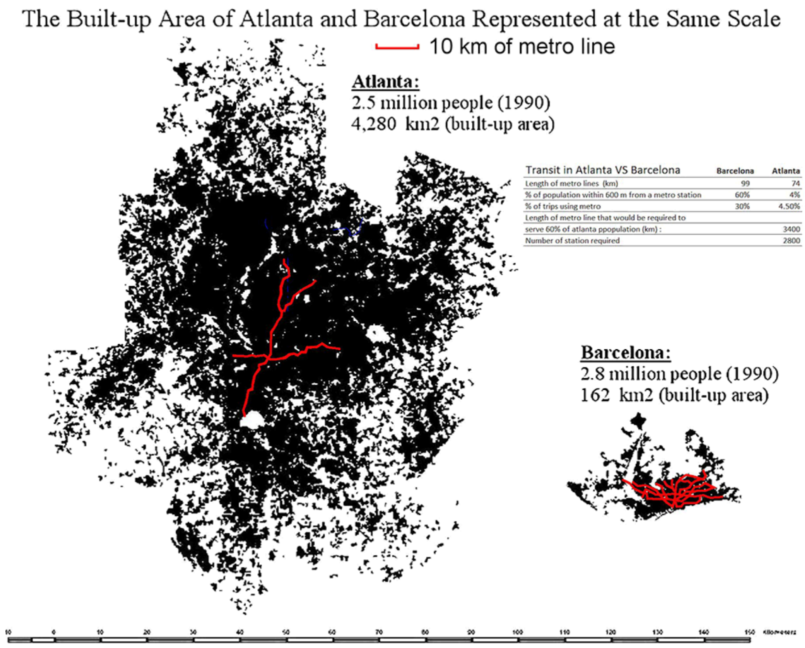
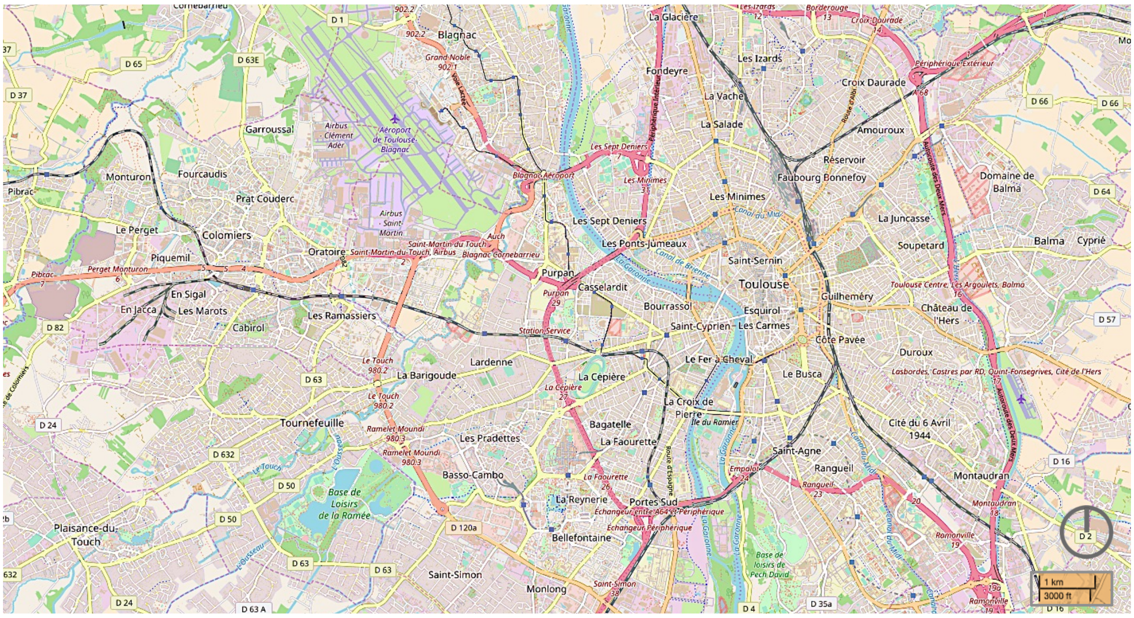


Figure 8 A comparison of the urban structure and the land use of Atlanta and Barcelona, the space each city consumes, and parts of their public transport system. Figure by Bertaud (2002, 2003)

The sum of the existing urban structure and previous land uses establish a significant premise for future urban developments, for example a city's potential for an efficient, well-functioning transit system. In a study from 2002, Bertaud explored the spatial organisation of cities. One part of the study explored the link between density and transport efficiency. To determine density, Bertaud defined the built-up area of a city as including all uses with the exception of continuous open space larger than four hectares, agricultural land, forests, bodies of water, and any unused land. He also excluded airports, as well as roads and highways not adjacent to urban used land. Bertaud found that for relatively connected built-up areas (not large isolated areas like satellite towns) trips lengths are shorter in cities with high densities than in cities with low density. To illustrate this, Bertaud compared Atlanta and Barcelona, two cities with fairly similar populations (per 1990) but very different built-up areas (Atlanta roughly 26 times larger than Barcelona per 1990). He found that the longest trip in Barcelona was merely 37 kilometres, compared to 137 kilometres in Atlanta. In a later study, Bertaud (2003) further compared the cities' public transport systems (see Figure 9, Figure 10). Due to its density, the transit system of Barcelona covers a large majority of the city. The urban structure of Atlanta, sprawled over a very large area, makes it virtually unimaginable to achieve a similar metro system.



The city of Toulouse and its metropolitan area

With no natural borders the city of Toulouse is relatively spread. On the map the larger traffic arteries are easily seen: the interstate/major roads (red/orange), the big city roads (yellow), the streets (white), the rails way tracks. Toulouse has a medieval centre, situate within the organ 'circle' (see map below), and the city has spread around it, divided by the river La Garonne. As Toulouse has grown, surrounding villages have become a part of the urban structure. The airport North-West constitutes an important barrier for urban development in that direction. The horseracing track La Cepière (see below, South-West) is an example of a larger land use that has a bigger influence upon the urban development; likewise the hospital Purpan just North of the racing track.

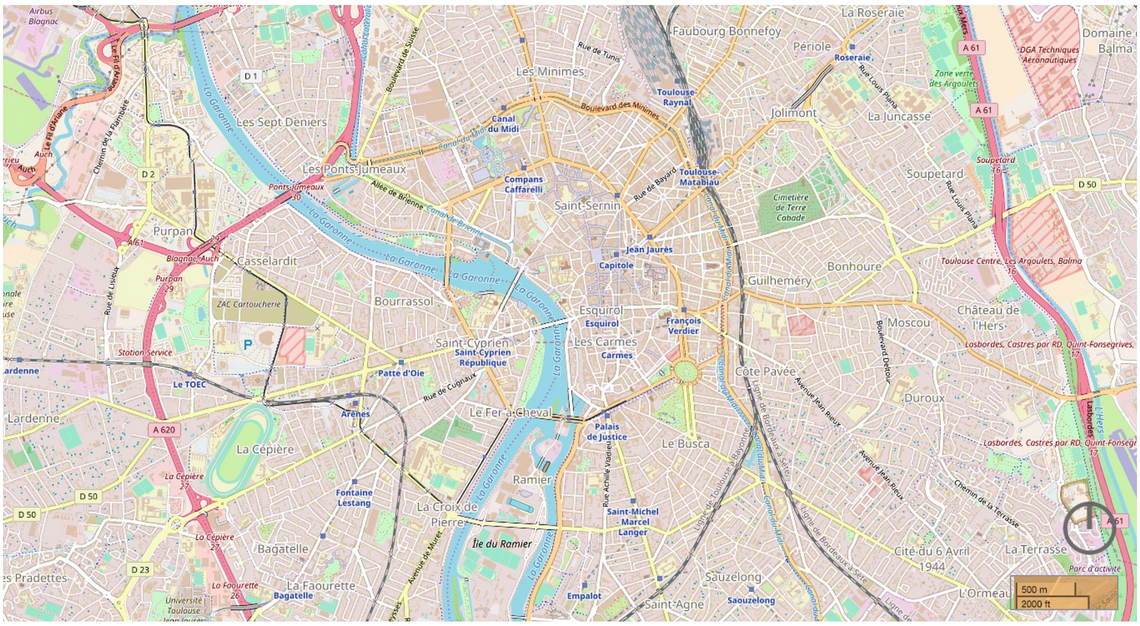


Figure 9 Toulouse (France) and the surrounding metropolitan areas (Openstreetmap.org)

The city of Oslo and its metropolitan area

Bordering a fjord and protected forests, the city of Oslo has a distinct form, and spreads south on both sides of the water. On the map the larger traffic arteries are easily seen: the interstate/major roads (red/orange), the big city roads (yellow), the streets (white), the rails way tracks. Oslo has several parks that can be seen as green spots within the urban structure. As a port-city, the oldest parts of Oslo are located by the water around Akershus Festning (fortress from late 1200s). The red line marking an interstate (for Oslo highway) running along the water on the map below was put in a tunnel some years ago, which opened up the sea-front for urban development.

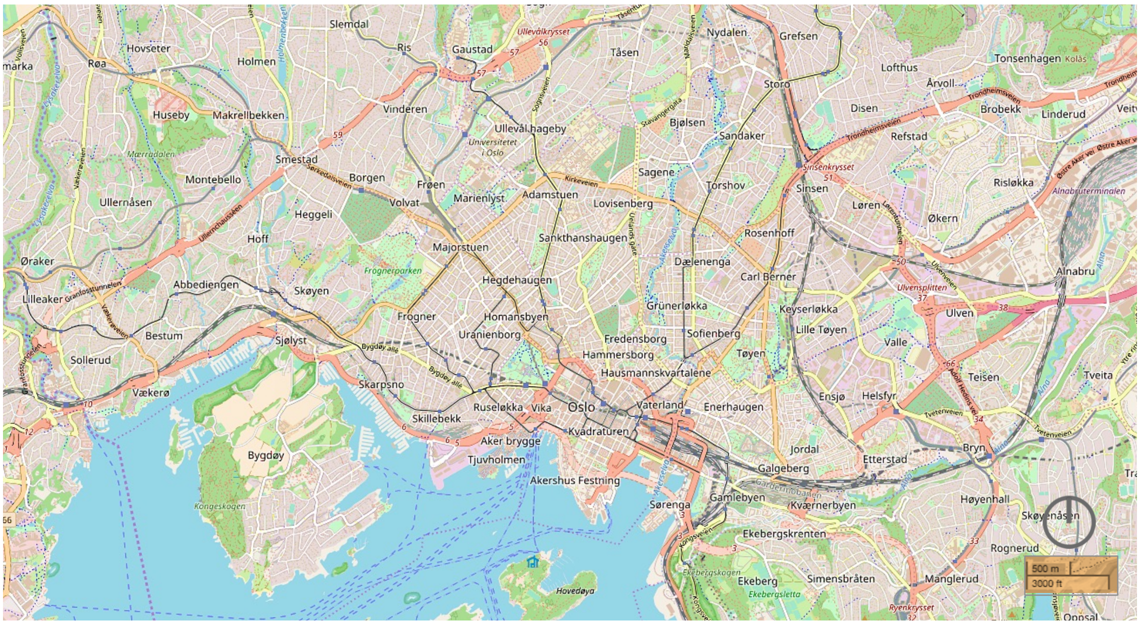


Figure 10 Oslo (Norway) and the surrounding metropolitan areas (Openstreetmap.org)

1.2.3 c) **Mobility systems – the infrastructure for urban travels**

In the context of this thesis, the term *mobility systems* refers to the built environment infrastructure for urban travels: roads and streets; parking facilities; bicycle infrastructure (lanes, paths, parking, etc.); pedestrian infrastructure (sidewalks, crossings, etc.); transit stops; rails for trams; separate lanes for buses; etc. Figure 11 shows some examples of mobility systems in Barcelona (Spain) and Basel (Switzerland). Transport services such as buses and metro is not included as the focus here is on built-environment elements. A city's mobility infrastructure can be studied as layers, gradually structuring and defining a city, its networks, and its urban structure (Panerai et al., 1997). This categorisation is somewhat different from what is often seen in the scientific literature. Roads and streets are often included in urban structure, while elements such as cycle lanes, and transit stops, are often referred to as infrastructure. The choice to separate roads and streets from urban structure is to underline their capacity of transformation (see Figure 12). While their trace is less transformable (ref. description of urban structures remaining the same for centuries), their nature is more temporary. Recent years have seen several city-roads where the car is dominant be transformed to streets with wide sidewalks, bicycle lanes or paths, street furniture, etc. The trace in the urban fabric remains the same, but their nature changes, and with it the perception of urban travellers. With regard to distinguishing transit stops, parking facilities, pedestrian infrastructure, etc., this is primarily to make more evident the range of aspects urban designers can act upon in order to make environments more inviting for zero-emission mobility modes.

Main roads and rail systems are the principal arteries. Additionally, they establish the basic urban structure of a city. Streets, both for cars and for pedestrians and bicycles only, form a secondary layer, like the veins of the city. They contribute to a finer division of the urban fabric. Finally, neighbourhood paths, such as 'hidden' passages through city blocks (see Figure 13), are the fine capillaries that add to the richness and complexity of a city's fabric. Together these mobility infrastructures provide the urban traveller with a choice of possible routes depending on the starting point, end point, and the chosen mode for a trip (Gehl, 2010; Speck, 2013). Diversity in the mobility structures, with a fine-grained urban structure, allows the traveller to adapt a trip according to his or her needs and preferences. For instance, choosing a route that has less traffic, or that offers a certain view. If the mobility structure of an area is very homogenous, for example mainly major roads, this can act as a barrier for modal choices such as walking and cycling (Pucher and Buehler, 2010; Stefansdottir, 2014a). It contributes to the pedestrian or the cyclist feeling less 'welcome', as the area is perceived as primarily car-friendly (Stefansdottir, 2014a). In relation to this, Krizek and Forsyth (2009) concluded that enhancing pedestrian infrastructure such as sidewalks was likely to have most overall effect on improving bigger roads with heavy traffic. Infrastructure for walking and cycling is more important for some travellers than for others, generally depending on level of walking/cycling experience, a person's age, and/or their physical capacity (Krizek et al., 2009a; Waygood et al., 2017). The non-presence of infrastructure can hinder – partially or completely – the use of such mobility modes. Lack of infrastructure for public transport, for example a transit stop within a certain distance of the beginning and end of a trip, can influence both modal choice and destination choice. Improvements in the mobility structure can thus change modal choices to a bigger or smaller extent (Tennøy, 2012). For cycling, smaller interventions are most efficient according to Krizek and Forsyth (2009), e.g. filling in 'holes' in the cycling infrastructure to assure continuity. Larger interventions, such as instalment of rail-based public transport, will change mobility behaviours more fundamentally and have significant influence upon a city's general development, for example by rendering certain areas more attractive and/or easier to access (Tennøy, 2012).

Barcelona (Spain)
A city street with car lanes, bicycle lanes separated by red markings and/or a physical border, pedestrian crossings (white markings), and sidewalks.

Basel (Switerland)
A city street with sidewalks, car lanes, bicycle parking, and a tram stop (where people in the picture are waiting).

Figure 11 Examples of mobility systems in Barcelona (Spain) and Basel (Switzerland), pictures by author

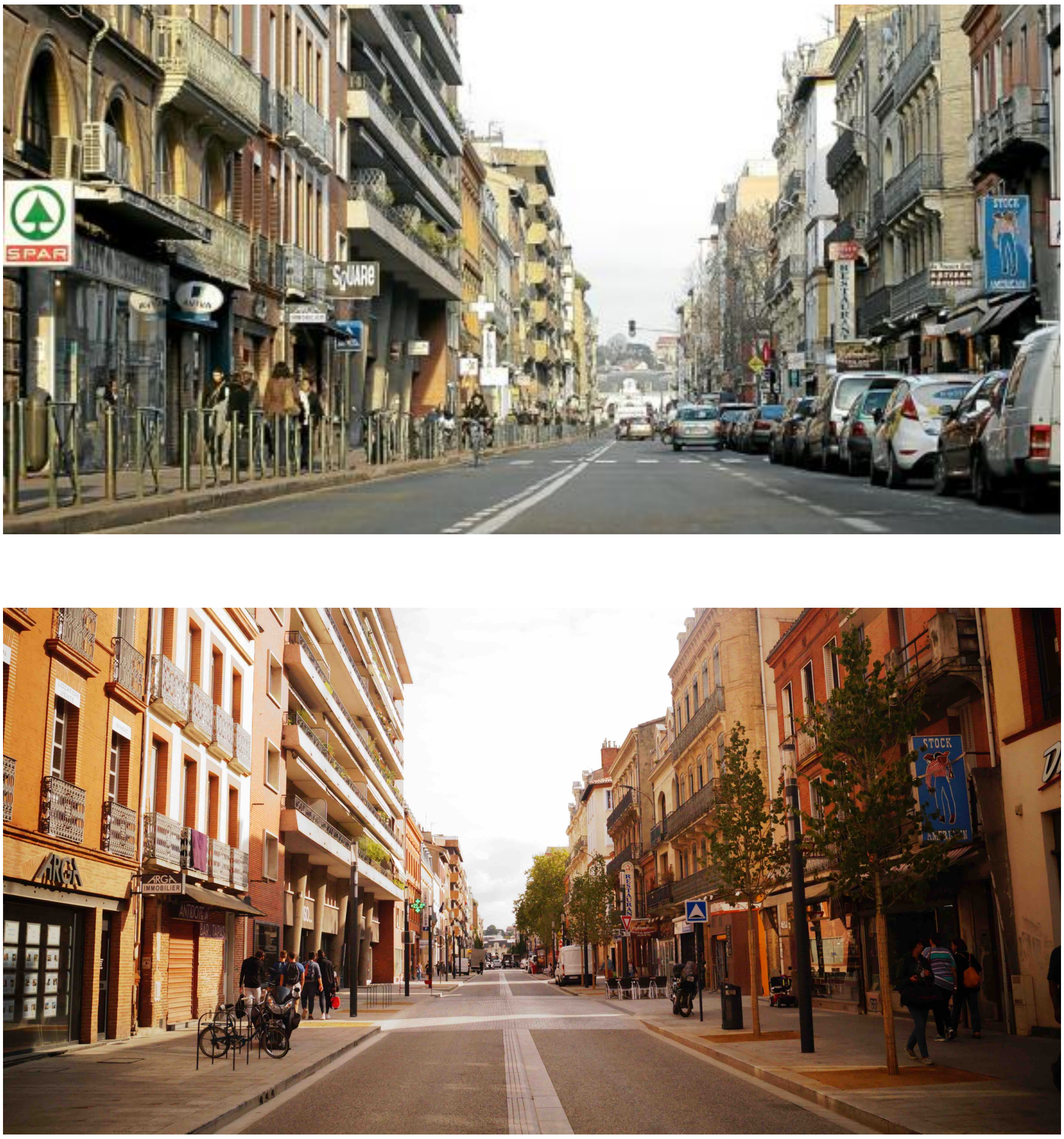


Figure 12 Transformation of the Rue Bayard in Toulouse, France. Rue Bayard had typical city- street profile, but was largely dominated by cars. In the recent refurbishment, sidewalks were enlarged, parking spaces removed, street lights changed, and trees planted (www.archives.toulouse.fr, www.toulouse-m2ct.com)

Figure 13 Examples of less formal paths for pedestrians (and cyclists) in Edinburg (Scotland, left) and Toulouse (France, right), photo by author

1.2.3 d) **Variables resulting from the built-environment elements: density, distance, proximity and connectivity**

The research literature explores other variables related to the built environment, in addition to land use, mobility systems, and urban structure. Of these, distance and density, stand out in particular, as well as proximity and connectivity (though to a somewhat smaller extent) (Ewing and Cervero, 2010; Forsyth and Krizek, 2010; Næss, 2012; Saelens and Handy, 2008; Salon et al., 2012). Distance can influence modal choice directly and indirectly, while density impacts other factors such as offer of mobility services, or the local land use. Connectivity and proximity can be seen as measures of the closeness of things, impacting for example travel distance, which in turn impacts modal choice (Krizek et al., 2009). These variables are a result of a city's urban structure, land use, and mobility systems, and so are in this context not pursued individually as 'levers of action'. Yet, as frequently encountered variables in transport and mobility research they are addressed in more detail below to properly establish their relation to modal choices.

Distance

The length of a trip, from beginning to end, is highly influential upon modal choices (Gunn et al., 2016). It can impact both choice of destination and choice of mobility mode, often simultaneously as the two are interdependent. A particular modal choice can, for example, increase or decrease the distance to cover, as it might dictate possible travel routes. For walking and cycling, distance is most likely related to its direct impact on the physical effort required for a trip (Næss, 2012). It can be decisive for which modes are compatible with a trip, and it can render a destination more attractive than another, by increasing or decreasing the price of travel. The latter refers to the level of annoyance, bother, or friction related to time, monetary costs, physical effort, etc. (Boarnet and Crane, 2001 in Næss, 2012). Its impact upon mobility behaviour depends on the person travelling (Alfonzo, 2005; Næss, 2012). Physical capacity in an example of an individual characteristic that can influence how far a person can walk or bike; how a person perceives his or her environment can influence perception and experience of distance (Alfonzo, 2005; Ewing and Handy, 2009; Pucher and Buehler, 2010). One important question that research so far has not conclusively answered is how far is too far? In other words, how far are people willing to go? (Here: primarily walk and bicycle.) The answers are mixed, although many researchers and planners operate with thresholds such as 400-500m for grocery shopping, 800m for walking to transit stops, 2km for shorter bicycle trips (Gunn et al., 2016; Krizek et al., 2009). Krizek and Forsyth (2009) conclude that there is apparently a strong market for cycling trips under 2,5 km. This represents an area of 6,25km^2 if calculated as a circle, a relatively large area that can cover many people and potential destinations. It could perhaps offer an alternative or a supplementary measure to the frequent planning objective of a '10-minute neighbourhood' where daily or weekly destinations are reachable by foot within 10 minutes (see for example Speck, 2013). Recent studies – from Europe, North America, as well as East-Asia – imply that people are willing to walk further than previously assumed, depending on the reason for walking (Krizek et al., 2009). Hillnhütter (2016) found that the design of the immediate surroundings during a walk to or from a transit stop, are likely to increase or decrease people's accepted walking distance, as surroundings can make distances seem shorter or longer. As an example, a crowded sidewalk along trafficked street, with boring facades, and little or no vegetation can make a distance appear 10% longer; a narrow, busy pedestrian street with many shops (but also little or no vegetation) can make distances seem 10% shorter. This, Hillnhütter concludes, shows the importance of the design of built environments in close proximity to transit stops, as a strategy to promote public transport use.

Density

Density is measured as 'variable of interest' (population, residence, employment, etc.) per 'unit of area', for example number of inhabitants per km^2 (Ewing and Cervero, 2010). It is one of the most researched built environment factors for mobility, in part because it is expected to influence other factors such as destination, distance, and transportation services (Salon et al., 2012). A high population density is often associated with an extensive, local offer of services and activities (destinations) that are reachable by foot or bicycle (short distances, reduced price of travel). Moreover, urban areas with a high population density tend to have more frequent transit departures (transportation services), and shorter distances to transit stops (Krizek et al., 2009; Næss, 2012; Saelens and Handy, 2008). However, it is not evident if the observed impacts of density are due to density in itself, or to covariates (Ewing and Cervero, 2001; Salon et al., 2012). Several studies conclude that density is more likely a proxy for other factors such as those cited above (Salon et al., 2012). It can enable or cause factors that directly influence modal choice, for example an increased offer in mobility services, but density does not in itself influence modal choice directly. This does not reduce density's importance for mobility behaviours and modal choices, but has implications when exploring which measures and solutions might contribute to a more sustainable urban mobility. Additionally, densification can produce negative effects that must be taken into account. Densification is often promoted as a strategy to reduce the environmental impact from transport and mobility, by enabling walkable neighbourhoods where daily destinations (groceries, primary schools, etc.) can be reached by foot instead of by greenhouse gas-emitting modes (primarily private cars) (Talen and Koschinsky, 2014). On the flip side, densification of urban areas can enhance phenomena such as Urban Heat Islands[36], which in turn increases the cooling need for buildings and public spaces (Bonhomme, 2013; Steemers, 2003). High densities can also reduce the possibility of producing renewable energy in urban areas. These potential trade-offs from densification are known as the *Urban Energy Paradox*[37] (Bonhomme, 2013). Another implicit complication from urban densification is increased congestion within the road network and the public transport services, unless mobility services (in particular transit) and infrastructure are developed simultaneously in an adequate manner (Melia et al., 2011; Steemers, 2003).

Connectivity and proximity

In a review of reviews from 2002 to 2006, combined with a review of 29 studies from 2005 and 2006, Saelens and Handy (2008) found proximity to potential destinations to be a recurring element correlated with levels of walking. It impacts walking directly and indirectly, as it influences elements such as accessibility to and range in potential destinations, and resulting travel distance. According to Næss (2012), living close to relevant trip destinations increases the potential of a person using non-motorized modes,

[36] See Glossary

[37] See Glossary

as distances are shorter. Levels of proximity are defined by land use, in particular density and levels of mixed use, as seen above. It is also related to an area's level of connectivity, in itself an important variable. Connectivity describes to what extent streets, paths, and so forth split up a particular urban area, creating connections between building blocks or towards other areas. This can heighten or reduce distances, and thereby levels of proximity, which in turn can increase or decrease the number of accessible destinations (Ewing and Cervero, 2001; Krizek et al., 2009, 2009). Connectivity can also expand the choice of travelling routes, allowing people to adapt a trip to preferences and needs (Saelens and Handy, 2008). In addition, it impacts the potential directness of routes, again relating to total travel distance. Proximity is not further explored in the context of this work. Connectivity, on the other hand, is often referred to as an urban quality[38], together with for example Human scale or Complexity (Ewing and Handy, 2009). As is discussed in Chapter 1.3, these kinds of qualities appear more relevant with regard to people's perception and experience of their built-environment surroundings. Their potential impact upon modal choice is further explored in and Part 2.

1.2.4 The neighbourhood-scale built environment and modal choice

1.2.4 a) **Premises and perceptions at the neighbourhood scale**

Urban structure, land use, and mobility systems establish premises and conditions for a trip: where to go, how to get there, the required effort, etc. The geographical scale at which a trip is studied determines the level of detail (of the built environment and of the traveller), and by consequence which aspect of the built environment can/must be included. The city scale tends to study the movement patterns of a large number of people, with the aim of understanding the mechanisms that influence these movements (Næss, 2006; Tennøy, 2012). At this scale, individual differences between travellers and built-environment contexts tend to become somewhat 'blurred out'. The present work centres on the neighbourhood scale, which implies an increased level of detail, for

[38] See Glossary

example with regard to personal individualities and variations between different travel groups. An able-bodied adult and a child probably do not have the same needs in regard to pedestrian infrastructure; moreover, how do these needs vary? Many studies have focused on the impact of built environment elements often referred to as ‘gross qualities’ (Ewing and Handy, 2009), such as distance to potential destination, density of neighbourhoods, local urban structure, and presence of infrastructure (for different modes) (Alfonzo, 2005; Ewing and Cervero, 2001; Forsyth et al., 2007; Saelens and Handy, 2008). They add further premises for a trip in addition to those created by the overall city-scale built environment, for example possible route choices.

The neighbourhood scale seemingly matter the most for walking and cycling, when the interaction with the built environment is more direct, as opposed to driving or taking public transport (Stefansdottir, 2014a). Yet, as Mees (2010) emphasizes, public transport and walking are inherently linked: every transit user is also a pedestrian as most travellers walk for a part of each transit trip. This is supported by Hillnhütter (2016) who refers to an extensive travel survey of public transport riders in four German cities (Halle, Fürth, Augsbrug, and Nuremberg) by Brög (2014). The survey found that walking to and from transit stops represented about 47% of the travel time for public transport riders, but that it largely dominated the remembered travel experience (Brög, 2014 in Hillnhütter, 2016). This is important to take into account with regard to the significance of remembered trip experience for future modal choices. Studies have shown that how people perceive areas – for example as pedestrian-friendly or cycling-unfriendly – can significantly influence both travel experience and route choice (Pucher and Buehler, 2010; Stefansdottir, 2014a). Disparities between the perceived and the objective built environment is a particular challenge for neighbourhood-scale interventions meant to promote certain mobilities (see for example Alfonzo, 2005; Ewing and Handy, 2009). As explained previously, these disparities represent potential limits to the impact of neighbourhood-scale built environment-interventions for promoting walking and cycling. This highlights the importance of personal context (age, gender, physical capacity, etc.), which can significantly influence the impact of the built environment-context for a person’s modal choice. Studies on the perception of built-environment surroundings are, however, relatively recently within most of transport and mobility research. In the following, the differences in perception and experience of the built environment between segments of the population, in addition to the influence of individual characteristics will not always be pointed out; this is considered as well established by the previous explanations.

1.2.4 a) **The influence of urban structure, land use, and mobility systems at the neighbourhood scale**

The built-environment elements detailed in the previous sections remain important at the neighbourhood scale, which furthermore introduces a fourth element: *urban features*. How these elements manifest, however, as well as their influence upon a person's modal choice, vary from the city to the neighbourhood scale. It will also vary from one urban context to another (physical, economical, social, and cultural context). Here the elements are explored primarily with regard to mobility behaviours and modal choices.

Urban structure

At the neighbourhood scale, the urban structure (fabric) is further detailed by the shape and size of building blocks, smaller streets and paths, and so forth; creating a more intricate network than can be perceived at the city scale. The layout of a network can be categorized according to typology. Common layouts at the neighbourhood scale are cul-de-sac, gridlike, and star-shaped (*étoile*) (see Figure 15). Cul-de-sac is often found in suburban areas, particularly in the USA. A star-shaped network can be found in many older European cities, created by a public place with several roads leading up to it, for example the *Arch de Triumph* in Paris, France. A gridlike network, as indicated by its name, is a network of streets in an orthogonal layout, of which the more famous example is Manhattan, New York. Local street network has been identified by a number of studies as central for modal choice (Ewing and Cervero, 2001; Krizek et al., 2009a; Næss, 2012). It influences total travel distance and possible route choices, which in turn impact travel time, especially for walking and cycling (ibid). Depending on the layout it can allow travellers to adapt their route to needs and preferences (Krizek et al., 2009a; Stefansdottir, 2014a). An urban structure with large building blocks tends to offer little choice in travel routes. Similarly, cul-de-sacs tend to discourage walking and cycling as the layout makes trips excessively long (Pucher and Buehler, 2010). If the available routes are primarily roads, with little or no cycle infrastructure, this can be a significant barrier to cycling as a modal choice (Stefansdottir, 2014a). Næss (2012) writes that street pattern (network layout), in addition to other urban design elements, can impact the attractiveness of non-motorized mobility modes, and by correlation affect trip destinations. Ewing and Cervero (2001, 2010) found that gridlike networks improve walking and transit access, offering relatively direct routes and alternatives to high-trafficked streets. At the same time, this layout also heightens automobile access, unless coupled with restricting measures. The authors conclude that it is difficult to determine which modes gain (the biggest) advantage and potential impact upon travel decisions from gridlike networks. In their extensive review from 2009, Krizek and Forsyth similarly observed that street pattern is found to be significant in some studies, while insignificant in others. These disparities might be related to difficulties regarding measurement and methods, but it "may also reflect the complexity of this topic". Exploring the connection between access to public transport and street network, Hillnhütter (2016) refer to several studies that show how network layout influences the actual access to a transit stop (transit catchment area). Gridlike networks, for example, might force the traveller to take a longer route, as they in theory do not offer the possibility of taking diagonal shortcuts. This increases the walking distance to or from a public transport stop, which in turn can discourage transit use (Hillnhütter, 2016; Næss, 2006). Figure 14 illustrates the influence of urban structure upon actual accessible area, for example in a 700m radius from a transit stop (catchment area). Different urban structures, in addition to physical context (e.g. water), determine which parts of the catchment area is actually reachable by foot. Level of connectivity equally influences accessibility. This is important to consider with regard to potential user of a public transport service within a certain range from the station. Hillnhütter (2016) write how hypothetical coverage is not enough; to know the actual available population it is necessary to study for example the urban structure.

Figure 10: Theoretical area within a 700-metre radius around stops and actual accessible area though the footpath network around train and ferryboat stations in the Lisbon Metropolitan Area (Vale 2015, p. 76)

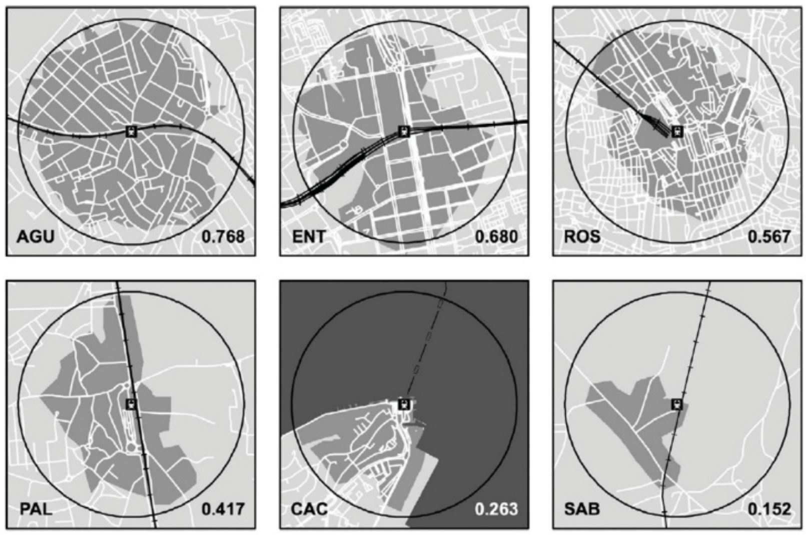


Figure 14 Comparison between theoretical (circle) and actual accessible area (highlighted dark grey) within a 700m radius from a transit stop, depending on the urban structure. 1 corresponds to 100% overlap theoretical/actual, 0 corresponds to 0% overlap. (Vale (2015) in Hillnhütter, 2016)

Barcelona, Spain

Guadalajara, Mexico

Grammichele, Italy

Paris, France

Four examples of urban structures. Barcelona has several so-called ‘superblocks’ with cut of corners, which, for example, contributes to a more open street crossing. Paris and Grammichele are examples of ‘étoile’ – star shaped – structures, which usually originated from a public square. The picture from Guadalajara also shows a star-shaped structure, and how this further evolves throughout the city. On the right of the picture it becomes a ‘gridlike’ structure, with seemingly large block. Different structures have a significant impact upon daily mobility, for example the efficiency of walking and cycling through its importance for connectivity.

Figure 15 Examples of different urban structures, Image Courtesy of Daily Overview. © Satellite images 2016, DigitalGlobe, Inc

Land use

The neighbourhood scale land use represents the location of activities, amenities and services, but also if an area is primarily residential, industrial, business, or otherwise. As explained above, the character of an area influences the perception of it, particularly for walking and cycling (Hillnhütter, 2016; Stefansdottir, 2014a). A monotone area tends to be less interesting to walk through, making distances seem longer; an industrial or big-box area is generally car-dominated, which tends to be perceived as uninviting by cyclists (ibid). Furthermore, Pucher and Buehler (2010) conclude that land use is critical for walking because it largely determines distance, which has been established as a highly significant factor for walking as well as for cycling. The local land use is often related to an area's density, measured for example as number of people per square metre or kilometre, or number of facilities per square meter or kilometre. Næss (2012) writes that in dense cities (and by association dense neighbourhoods), activities tend to be closer, making a higher proportion of relevant destinations within walking or cycling distance from the home. Dense areas also tend to have better public transport offers in terms of frequency and distance to transit stops (Næss, 2012; Tennøy, 2012). The latter can be a substantial barrier for transit use as explained previously. In their review of reviews from 2008, Saelens and Handy found support for mixed land use as being associated with more walking. This is in part related to the density of activities, amenities and services in an area. Mixed-use neighbourhoods have a certain mix of dwellings and facilities (and other things), which in turn reduces travel distance from home to a potential location. Several studies (and official recommendations) point to mixed land use as an important instrument to promote the use of non-motorized modes (Talen and Koschinsky, 2014). Destinations that are too far away for walking might be within cycling reach, as people are generally willing to cycle longer than they'll walk (Krizek et al., 2009a; Pucher and Buehler, 2010). Although a relatively rough estimation, Pucher and Buehler (2010) write that most walking trips are 1km or shorter, while cycling trips 3km or shorter.

Mobility systems

At the neighbourhood scale, mobility systems primarily represent the infrastructure for different mobility modes, the presence and design of transit stops, and parking facilities. The majority of findings relate to presence or non-presence of infrastructure, the kind of infrastructure, and the quality of it. The impact of mobility systems upon walking is further explored below. For public transport, one could look at the mere presence as well as the kind of service. As this generally depends on other factors than urban design, and is therefore not included here. Urban design can, however, influence the quality of transit stops, for example protection from weather, and possibility to sit while waiting. Of the studies explored here, only one puts some emphasis. Pucher and Buehler (2010) relate transit use to walking (primarily) and to cycling. They therefore conclude that it is important for public transport stations to have safe, convenient, and comfortable pedestrian and cycling facilities. For automobiles, the relevant infrastructure is generally parking and streets (shape and size), as well as access – one-way streets, pedestrian streets, etc. In a report from 2010, Strand et al. explains why parking is an important lever for urban planning, for example to reduce car use and traffic volumes. Car use is dependent on access to parking; it is the start and the end point for most car trips (Institute of Transport Economics, 2011). Reducing parking availability has been shown an efficient measure to limit driving to city centres (ibid). Similarly, reducing parking facilities at work can promote zero-emission modal choice for daily work-trips (Strand et al., 2010). Parking often takes up large quantities of land, which could often be used differently, for example as playgrounds or other services and amenities. Strand et al. (2010) writes that changing land use from parking to other uses can provide the foundation for establishing a better public transport offer.

Several studies emphasize the importance of exploring walking and cycling separately (Pucher and Buehler, 2010; Stefansdottir, 2014a). They have different built environment requirements; they can cover different distances; they imply different speeds and thus different safety concerns – to mention only a few differences. Pedestrian infrastructure (primarily sidewalk) is for example of high importance among segments of the population such as elderly and children, and people with some level of disabilities (Krizek et al., 2009a; Krogstad et al., 2015; Pucher and Buehler, 2010).

Cycling infrastructure separated from the sidewalk and the car/tram lane by physical barriers, Amsterdam (Netherlands)

Combined cycling and pedestrian infrastructure, protection from traffic by being on the inside of parked cars, Toulouse (France)

Figure 16 Examples of cycling infrastructure, photos by author

Able-bodied people on the other hand, adults in particular, are much less dependent upon sidewalks to walk (Krizek et al., 2009a). Elderly travellers tend to prefer separated infrastructure that protects them from motor vehicle traffic (Krizek et al., 2009a; Krogstad et al., 2015; Pucher and Buehler, 2010). Parents' perception of infrastructure adequacy in terms of traffic safety highly influences children's level of walking (Bull and Bauman, 2007; Krizek et al., 2009a). Saelens and Handy (2008) found a correlation between walking and presence of infrastructure (sidewalks) among the studies they reviewed, but less for utilitarian walking than for leisure; leading them to conclude on the evidence regarding such infrastructure to be equivocal. The different needs for segments of the population, in addition to the influence of context, make it difficult to provide good recommendations on how to design pedestrian infrastructure. Sidewalks are likely to matter more in the context of major roads than residential streets. However, "merely building a sidewalk will not make an environment walkable" (Krizek et al., 2009a). Other aspects matter too, in addition to the individuality of how a built environment is perceived. Traffic-calming measures can contribute to increased walking among children and elderly, as making the environment more welcoming to pedestrians potentially heightens levels of walking. Figure 16 and Figure 17 illustrates variations of cycling and pedestrian infrastructure; other examples include painted cycling lanes in the car lane, or completely pedestrianized streets. Depending, for example, on the street layout (e.g. placement of vegetation, of parking, etc.) pedestrians and cyclists tend to experience different levels of protection from traffic.

Krizek et al. (2009) categorizes cyclists in to three main typologies: i) experienced; ii) occasional, less confident in traffic; iii) less experienced, including children and elderly. The importance of the presence, the kind, and the quality of cycling infrastructure vary among these groups (Krizek et al., 2009a). Experienced cyclists are likely to cycle despite the infrastructure being lacking or incomplete, while other groups can see this as significant barrier for cycling (Pucher and Buehler, 2010; Stefansdottir, 2014a). Krizek et al. (2009) also differentiate between Separated Bicycle Facilities (SBF, e.g. off-road paths) and On-street facilities (e.g. on-street bicycle lanes, wide sidewalks, and other non-intersection solutions). Although perceived by many as such, SBF is not necessarily safer than on-street solutions. The separation from the rest of the traffic picture tend to create dangerous situations at intersections where cyclists meet other vehicular traffic (Krizek et al., 2009a). However, because they are perceived as safer, installing SBF's can encourage less competent cyclists to cycle. This, the authors write, can influence actual traffic safety by increasing the number of cyclists, thereby making them more visible in traffic. Finally, Krizek et al. (2009) interestingly conclude that a "redundancy of facilities" (several bicycle infrastructures in proximity but not necessarily linked) can be a good thing; it can provide different offers to different cycling profiles, such as bicycle-highways for rapid cyclists, and slower lanes for less experienced ones. A concrete example of this can be found in London, which has so-called 'cycle superhighways' – cycle routes from outer to central London (Transport for London, 2017). They are often particularly interesting for commuters as they offer a more direct and high-speed route. Here, bicycle highways have not replaced existing infrastructure, but provide an additional service, completing the total offer.

Pedestrian infrastructure with additional separation from cars by range of trees, Toronto (Canada)

'Classical' sidewalk, Oslo (Norway)

Figure 17 Examples of pedestrian infrastructure, photos by author

1.2.4 b) **Urban features**

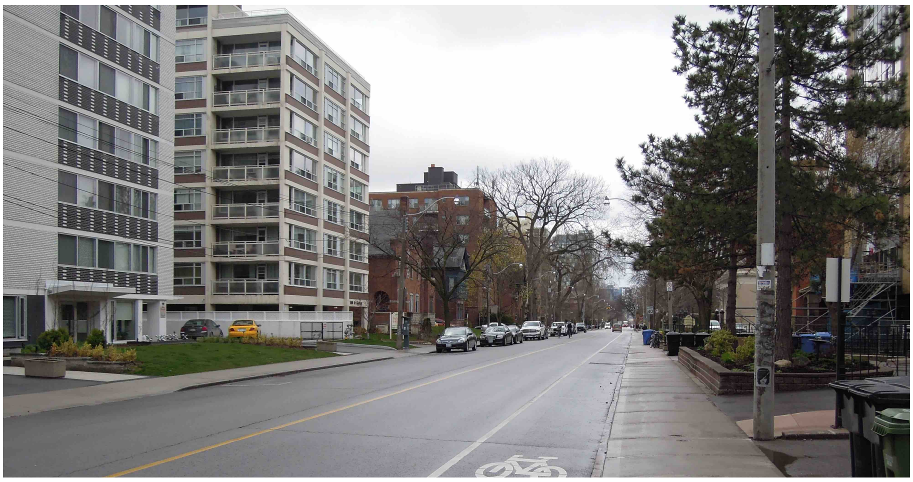
In addition to the previous categories, the neighbourhood scale introduces built environment elements such as sidewalk and street width, building height, facade design, view or sight lines, and so forth; here defined as *urban features*. These built environment elements are interrelated with the other main components, as they influence and are influenced by them. A residential area generally has different facades than a more industrial or business area; likewise, the design of the streets and other infrastructure might vary. On a similar note, the urban structure of an area establishes the basis for possible view lines. Several urban features are interdependent: building height can also influence view lines; street width and presence of vegetation are strongly related to sidewalk width. Urban features can have a functional[39] role as part of infrastructures (sidewalk width), or a more conceptual role, for example the aesthetics of an area (facade design on ground floor). Some research has focused on instrumental[40] features (concrete, physical) such as building height, sidewalk width, and block size (Ewing et al., 2016; Giles-Corti et al., 2005); others on perceptual features such as aesthetics (which is a result of features, but can also be defined as a feature in itself) (Stefansdottir, 2014a; Timms and Tight, 2010). Urban features have been studied in general, and in relation to specific modes such as walking (Ameli et al., 2015; Doescher et al., 2014) or cycling (Pooley et al., 2010; Pucher and Buehler, 2010). Moreover, they have been put in relation to the distance people are willing to walk (Gunn et al., 2016), or to the mobility behaviour of particular segments of the population (Giles-Corti et al., 2009; Walford et al., 2011). A common factor for much of this research is the dominant focus on singular elements or aspects, e.g. the importance of aesthetics for cycling, the importance of sidewalks or of street network connectivity for walking. Studies exploring elements as a whole – i.e. the environment they create – appear less frequent within mobility and transport research. Most of the research concludes that urban features influence modal choice to some extent, depending for example on the traveller or the urban context.

[39] See Glossary

[40] See Glossary

Oslo, Norway

Amsterdam, Netherlands



Toronto, Canada

Figure 18 Examples of urban features: sidewalk and street width, facade design, vegetation, street lights, etc. Photos by author

The pictures in Figure 18 show different built-environment contexts with similar features; the experience of the street depends on the context and the execution of the various features For example, each street has buildings, but how their facades contribute to making the street interesting (or not) varies. The street and sidewalk width equally varies. Although research has identified a number of influential elements and aspects, the evidence remains inconclusive as to which are most important (Gunn et al., 2016; Larco, 2016). These uncertainties are likely due to the increased level of detail at the neighbourhood scale (see previous sections), and by consequence the number of potentially influential variables involved at this scale. It is also likely to vary due to the individual differences among people (Alfonzo, 2005; Krizek et al., 2009a; Sallis et al., 2016). However, as urban features are important for the perception and experience of a built environment, their influence will be further explored in the thesis enquiries.

1.2.5 Knowledge gaps in the scientific literature

1.2.5 a) **Increased complexity with a reduced geographical scale**

Despite the large amount of literature within transport and mobility research, there are still significant levels of uncertainty and incoherence. This is particularly apparent at the neighbourhood scale, where things tend to become more “muddied” (Krizek et al., 2009a). This leads to significant knowledge gaps within the scientific literature, which in turn hinders its application in urban design projects and by extension climate change mitigation (and adaptation). Studies at the neighbourhood scale generally explore smaller geographical areas, thereby allowing for a higher level of detail regarding the built environment as well as people’s individual characteristics. This can increase the number of variables and uncertainties, particularly due to individual differences between travellers and built environments, which can make it difficult to draw more general conclusions about mobility behaviours. Some neighbourhood-scale studies are extensive cross-sectional studies employing large data sets (see for example Cao, 2015 and Sallis et al., 2016). However, they often aim at or end up generalizing broader tendencies and effects, rather than providing in-depth knowledge about specific relationships. Conversely, studies at the city scale generally look at a larger group of people, observing overall patterns of movement and behaviour over a longer period of time, for example the Copenhagen Metropolitan Study by Næss and colleagues (Næss, 2006). The size of a sidewalk or the ground floor facade design for a particular street is less important when looking at the city as whole, or studying larger parts of it. City scale studies tend to look at land use patterns, urban structure, or densities (population, dwellings, activities, etc.), to mention some (Cervero, 2000; Næss, 2012; Strand et al., 2010). Similarly, variations between individuals tend to 'disappear in the crowd' for larger scale studies with a high number of participants. To counter this, studies can control for factors related to socio-economic variables (income, education, etc., see for example Næss, 2006; Sallis et al., 2016). However, this does not provide the level of detail necessary for understanding the built environment's impact at the neighbourhood scale. Exploring particular questions such as the importance of aesthetics upon cycling (Stefansdottir, 2014a), or the maximum distance people are willing to walk (Gunn et al., 2016), requires a closer focus on individual characteristics, for example how people experience and perceive their environment (Johansson et al., 2016b; Stefansdottir, 2014a; Vos et al., 2015).

1.2.5 b) **Methodological differences**

Another explanation for the inconclusive evidence lies within methodological challenges and measuring differences between studies. As this literature review has sought to illustrate, the relationship between the built environment and mobility behaviours is not a straightforward one; studying it is not a simple task. The large variations in how studies are designed and executed, what and how they measure, can make it difficult to compare or combine findings, in order to achieve more overall, general conclusions.

A SUMMARY OF VARIATIONS IN METHODOLOGY WITH ADVANTAGES AND/OR LIMITATIONS	
Study design	• Simulations, cross-sectional, meta-study (of existing literature), empirical
Data sources	• National, regional, city-wide, or local area
Measuring methods (3 main approaches)	• *Self-reporting* – travel diaries, surveys, etc. ▪ Cheaper but less accurate than other methods ▪ Travel surveys tend to undercount walking and cycling ▪ Unclear definitions, for example what constitutes a walking trip, can disturb measurements • *Observation of behaviour* – manually, sensing equipment (counters, video, etc.) ▪ Provides basic information but little detail about travellers (beyond approximate age and gender) • *Measuring equipment* – instrument (accelerometers, pedometers, etc.) ▪ Often high costs ▪ Faulty use by researcher/reporter is a significant source of error
Analysis	• Cross-tabulations, descriptive case-study, bi-variate analysis, multi-variate analysis
Definition of units and variables	• *Generally measured outcome* ▪ Amount travel for specific journeys (work, grocery) ▪ Total number of trips (per day, week, month, etc.) ▪ Mode choice ▪ Trip length • *Other, frequent variables*: ▪ Density (dwellings, employment, population) ▪ Geographical area (neighbourhood, urban area) ▪ Types of travel (leisure, utilitarian)
Other potentially influential aspects	Time frame for the study (day, year); geographical location; sample sizes; controlling for factors such as socio-economic variables

Table 7 A summarized overview over methodological differences within mobility and transport research, based on Bonhomme (2013), Handy et al. (2014), Hickman and Banister (2007), Krizek et al. (2009b).

Table 7 is a summary of some of the variations and difficulties, based primarily on Bonhomme (2013), Handy et al. (2014), Hickman and Banister (2007), Loukaitou-Seideris (2006), Krizek et al. (2009b). These methodological differences also contribute to on-going debates within mobility and transport research. Many of these are about empirical limitations reflected in the research design, or misspecification of the examined relationships (Cho and Rodriguez, 2015). One example is the question of self-selection and its influence or non-influence on mobility behaviours. For details on other frequently debated topics within transport and land use research see for example Hickman and Banister (2007) or Næss (2012).

1.2.5 a) **The debate on self-selection**

Self-selection refers to the idea that people choose where to live based on mobility (more specifically modal) preferences (Cao et al., 2009; Strand et al., 2010). I.e. that someone who prefers to drive will settle somewhere that facilitates or even favours driving, while someone who prefers to walk will settle accordingly. The debate largely centres on whether or not self-selection undermines the influence of the built environment upon mobility and transport behaviour (Strand et al., 2010). Many North-American studies seem to support the view of self-selection as being more important (Cao et al., 2009, Eluru 2009 in Strand et al., 2010). In their 2010 review, however, Strand et al. concluded that in most of the studies supporting self-selection, there were no findings that contradicted the importance of the built environment. They refer to Næss (2009), who firstly finds little support for self-selection compared to the built environment, and secondly writes that if the built environment did not matter at all then people would settle down 'wherever' (which they generally don't) (Strand et al., 2010). It is possible that self-selection is an important factor for some, who consciously choose to live somewhere that favours their preferred modal choices (and mobility behaviour). Similarly, it may very well not matter at all for others, whose mobility behaviour is primarily a consequence of necessity, or other preferences such as having a house rather an apartment (and by consequence, generally, living less urban).

1.3 TOWARDS A HOLISTIC-FOCUSED MOBILITY RESEARCH

Despite efforts, most cities worldwide see car shares and greenhouse gas emissions rising. A modal shift towards zero-emission alternatives – walking, cycling, and public transport – can significantly contribute to curb and reduce emissions, particularly from daily mobility, but modal habits have proven difficult to influence. A permanent change requires a combination of carrots and sticks (Piatkowski et al., 2017). The previous subchapters discussed how the built environment might contribute to this. The organization and design of urban structures, mobility systems, or land use can facilitate zero-emission modal choices, for example by making distances shorter, or through the presence of adequate infrastructure. Through the reciprocal relationship between the built environment and mobility behaviours, urban development can be a mobility-mitigation strategy to promote zero-emission modes – at the city scale as well as the neighbourhood scale. A frequent conclusion within research literature is that achieving this necessitates a mix of measures and solutions (Alfonzo, 2005; Krizek et al., 2009a; Pucher and Buehler, 2010; Saelens and Handy, 2008; Stefansdottir, 2014a); "individual urban design features seldom prove significant" (Ewing and Cervero, 2001). Pucher and Buehler (2010) conclude that no single strategy is sufficient to promote walking and cycling; communities must implement a fully integrated package of measures for sound results. The impact of any particular measure can be further enhanced by the synergies with complementary measures in the same package (Pucher and Buehler, 2010). Krizek and Forsyth (2009) similarly conclude that community design, i.e. organizing and structuring an area or a neighbourhood as a whole, is very important, especially for walking. They support the findings by for example Saelens and Handy (2008) regarding the need for connected street patterns and accessible destinations, which is best achieved through a holistic development approach (Krizek et al., 2009a). This is little reflected in much of transport and mobility research, although a gradual shift seems to be taking place (Stefansdottir, 2014a).

Mobility needs and preferences are individual; so are perceptions of built environment surroundings. What is perceived as safe for cycling by some can be seen as high risk for others; the same applies to feeling of safety from crime. Perception of distance is another aspect that is significant for mode choice, and likewise highly individual. How a trip is experienced influences travel satisfaction, which in turn influences future modal choices. The interaction between the traveller and the built environment is more direct for walking and cycling, when travel speed is lower and there is less distance between the traveller and the surroundings than if in a car or a bus. It can therefore be expected that the design of the immediate surroundings during a trip influence travel satisfaction more for these mobility modes, as well as for public transport use. Consequently, exploiting urban design as a mobility-mitigation strategy require an in-depth understanding of how people perceive and interact with their built surroundings, and how this affects modal choice for daily trips. Research should provide such knowledge to decision makers and practitioners as a support for adaptation and mitigation efforts, but per today has significant shortcomings. The literature review in Chapter 1.2 highlighted some of the uncertainties and inconsistencies in the scientific literature, particularly regarding the neighbourhood scale, which creates barriers for its implementation in design projects. Many studies aim at determining which aspects of the neighbourhood-scale built environment might matter the most for modal choice. However, with the high number of aspects and variables to consider, as well as the importance of urban context and individual differences among travellers, it seems reasonable to ask whether this is actually possible. Moreover, is it the best approach to knowledge production for mobility-mitigation through urban design?

Based on observations and findings discussed in subchapters 1.1 and 1.2, it seems that a holistic, interdisciplinary approach to the topic might be more interesting and effective. For example studying how qualities and characteristics of a public space as a whole influence trip experience. This is supported by several works that similarly call for a change of perspective towards a more wholesome approach, focusing on the sum of built environment elements (Bertolini, 2012; Ewing et al., 2016; Krizek et al., 2009a, 2009b; Saelens and Handy, 2008; Stefansdottir, 2014a). One of the main reasons for this is that people tend to experience their surroundings as whole environments rather than a series of singular elements (Ewing and Handy, 2009; Stefansdottir, 2014a). Hence, a holistic perspective seems likely to produce a better understanding of how the neighbourhood-scale built environment influences trip experiences and modal choices.

Some example of this can be found within current research literature. In an explorative study from 2009, Ewing and Handy (2009) attempted to quantitatively measure the influence of urban qualities upon walking, based on findings from urban design literature and practice[41]. They identified six as particularly interesting: imageability, enclosure, human scale, transparency, and complexity. This was an initial attempt at quantifying characteristics frequently pointed to by practice as important for a pleasurable walking experience (and so assumedly important for promoting walking). The authors recommended that the qualities to be explored more, for example in different contexts to further their applicability. Stefansdottir (2014) studied the influence of urban spaces and aesthetic experiences on the commute to work by bicycle. She found that aesthetics and the pleasure of cycling a particular route matters for trip experience and travel satisfaction. In part because it can reduce perception of travel time and distance, as well as linking the commute to a positive travelling experience (Stefansdottir, 2014a). Which in turn can help motivate such mobility behaviour. Another study by Johansson et al. (2016) explored the influence of perceptual urban design qualities such as complexity and aesthetic quality, upkeep and order, well-maintained greenery, and coherence upon the experience of walking. They found that these elements could enhance travelling experience, suggesting that they contribute to "strengthening the intention to choose to walk a certain route" (Johansson et al., 2016b). This is in line with Vos et al. (2016) who concluded that travel satisfaction matters for future mobility behaviour.

The above are examples of recent works that have approached the issue of mobility and the neighbourhood-scale built environment in a more wholesome manner, often with interesting results. A common aspect is the consideration of how people perceive and experience their surroundings, and how this can be measured and evaluated in a scientifically sound manner. Urban design organizes and structures public spaces, the

[41] To establish a framework of qualities to test, Ewing and Handy asked ten well-reputed practitioners to assess different streets and describe their qualities and characteristics with regard to walkability. They additionally explored urban design literature such as *Life between buildings* (Gehl, 1987), *Life and Death…* (Jacobs, 1961), *The Image of the City* (Lynch, 1960), *City Planning According to Artistic Principles* (Sitte, 1889)

space between buildings. In order for research to produce solid and useable knowledge on how urban design can be a complementary mitigation strategy, holistic efforts must be strengthened. Stefansdottir (2014) and Hillnhütter (2016) describe environments as being pedestrian and/or cycling-friendly. These are public spaces that actively invite and facilitate for cyclists and pedestrians, determined by the sum of the built environment elements such as sidewalk and street width, vegetation, façade design, etc. As an example, Hillnhütter (2016) refers to research that shows how people walk up to 70 per cent longer in pedestrian-friendly environments compared to car-oriented ones. A public space being pedestrian and/or cycling-friendly is an interesting notion. Although arguably a relatively vast concept, it might provide an overall objective for urban design with regard to mobility-mitigation.

In addition to a holistic shift, there is a need for a more interdisciplinary approach. For a long time, transport and mobility research seems to have underestimated and/or overlooked the influence of social and cultural aspects upon daily travel habits. In recent years this has been changing; Schwanen et al. (2011) writes about an "expanding and diversifying" research literature with transport and mobility that is gradually becoming more interdisciplinary, but that has yet to fully exploit the benefits of an interdisciplinary approach. The authors highlight potentially added value in drawing on social science traditions such as a wider repertoire of research methods, or a different set of research questions (Schwanen et al., 2011). As an example, Hillnhütter (2016) used insights from psychology in his observation of how different surroundings might impact people's behaviour when walking to and from transit stops. The aim was to explore how the neighbourhood-scale built environment influences pedestrian trips to public transport. Stefansdottir (2014) employed insights from philosophy as well an environmental psychology to determine the influence of aesthetics upon the experience of commuting by bicycle. This work similarly looks to other fields and disciplines. Implementing insights from behavioural sciences on decision- and judgment-making, which contributes to explain how urban design can influence modal choice.

> "Whilst communication across research traditions poses significant challenges, it is our firm belief that pluralism will ultimately produce richer, more textured understandings of effective climate change mitigation in transport than at present."
>
> (Schwanen et al., 2011)

Hillnhütter (2016), and Stefansdottir (2014), are additionally interesting examples with regard methodology. Both employ an observational approach, as opposed to modelling or measuring physical elements. Stefansdottir (2014) used a method she refers to as 'bike throughs', where cyclists undertook predefined routes and afterwards responded to a survey about their experiences. This was combined with a survey of commuters in Iceland and Norway. Hillnhütter (2016) used amongst others video to study how people moved through different spaces, observing step frequency and head movement. The results from both studies have provided new insights into how people interact with their environments during a trip. Interestingly, these approaches reflect to some extent the approach of two significant works within urban design and development literature that remain important in the present day: *The Image of the City* by Kevin Lynch (1960) and *Life and Death of Great American Cities Life and Death of Great American Cities* by Jane Jacobs (1961). Both books are largely based upon observing how people use their city and the neighbourhoods they live in, and discussing with inhabitants to gain insight into their perceptions and experiences of the city. Concepts and notions introduced by these authors, for example 'eyes on the street' (Jacobs, 1961) or 'imageability' and 'legibility' (Lynch, 1960), are often found in research literature. Other frequently cited works, by research as well as by practice, are *Life between buildings* (1987) and *Cities for People* (2010), both by Jan Gehl. They are similarly based primarily upon observation of people's use of public space. These examples underline the value and importance of observation in order to understand why people use public space in a certain way, or how they perceive and experience different kinds of spaces. That is not to say that modelling and other forms of measurement are unproductive or inefficient. GIS-based models[42] can, for example, provide valuable data on people's movement

[42] GIS stands for Geographic Information System, see Glossary for further explanation.

patterns in a city, linked to mobility modes, or location of workplaces. These data can give researchers an indication of aspects such as where people prefer to walk, or how long bicycle-commutes tend to be. For a more complete picture of how the environments people pass through influence these movements, this data must be combined with other methods, such as on-site observations. It also requires an in-depth understanding of how neighbourhood-scale built environments influences trip experiences and modal choice. Such holistic, interdisciplinary approaches, employing a broad mix of methods, can help address the observed shortcomings in the research literature. Exploring new sources for insights equally so. Changing people’s mobility habits, particularly for daily trips, necessitates a broad range of approaches. With an enhanced understanding of how the neighbourhood-scale built environment influences a trip and travel satisfaction, urban design can be further exploited as part of these strategies.

CHAPTER 2

RESEARCH PROBLEMATIC AND GENERAL METHODOLOGY

2.1 RESEARCH PROBLEMATIC

2.1.1 Cities are systems of organized complexity producing wicked design problems

2.1.1 a) **Systems of organized complexity**

Sound mitigation action through urban design requires an in-depth understanding of cities: their nature and particularities, the urban development processes, and the kind of problems city development represent. Jacobs (1961) describes cities as systems of organised complexity, composed of quantities that vary simultaneously in an interconnected manner. There is nothing accidental or irrational about the ways in which they affect each other, and every action upon a part of a city will necessarily affect others. As a result, a city cannot be reduced to a singular problem of organised complexity that can be fully understood. Rather it must be addressed as a series of such problems that are related to one another in an organised way as a "whole" – as a system (Jacobs, 1961). This aligns with how a city and its functionings are understood in the context of this thesis: a system where everything is connected and interdependent. All built environment interventions – at all scales – will influence other aspects of a city directly and indirectly, to a larger or smaller extent. The complexity of the city, combined with the constant changes and developments taking place in a city, makes it difficult to predict exactly how an intervention will impact the city in a short- and long-term perspective, "(…) new development is a challenge to the current situation, as it can transform the status quo in unprecedented ways” (Madanipour, 2006). This represents a level of uncertainty that is always present in an urban development project, with regard to the end result and its influence upon the city and its inhabitants. Every aspect and variable of a project can never fully be controlled. Understanding and accepting this is an essential part of urban design and development. The uncertainty of urban development, together with the nature of cities as systems of organised complexity, is why the problems cities produce are so-called wicked design problems. As Madanipour (2006) writes, cities are constantly changing and evolving, “new development is a challenge to the current situation, as it can transform the status quo in unprecedented ways”.

2.1.1 b) **Wicked design problems**

During the beginning of the last century the main tasks of urban planners, architects and engineers, were to provide city inhabitants with clean water and sanitary housing, and to manage waste handling (Ragon, 2010; Rittel and Webber, 1973). As these fundamental challenges were (for the most part) managed, new problems arose, or rather, became more apparent. They were of a more social or economic nature, often related to poverty or crime-rates. As a result, the urban planning problem became more complex, having to address social issues with a multitude of underlying explanations (Rittel and Webber, 1973; Schön, 1983).

> “The professional’s job was once seen as solving an assortment of problems that appeared to be definable, understandable and consensual. (…) Now that these relatively easy problems have been dealt with, we have been turning our attention to others that are much more stubborn.”
>
> (Rittel and Webber, 1973)

These “stubborn” problems are often characterized as *wicked problems,* problems that are ill-defined, complex, uncertain, and unstable (Dubois, 2014; Lawson, 1993; Rittel and Webber, 1973; Schön, 1983).

> "The kinds of problems planners deal with – societal problems – are inherently different from the problems that scientists and perhaps some of the classes of engineering deal with. Planning problems are inherently wicked."
>
> (Rittel and Webber, 1973)

The opposite of a wicked problem is often considered a *tame* problem (Rittel and Webber, 1973). Such problems can be clearly defined, and have a proper beginning and end, for instance a mathematical problem. That is not to say that tame problems are easier to solve or to comprehend, merely that they are more structured and concise, and different knowledge and skills – savoir-faire – are required to solve them. A mathematician would probably have difficulties solving an urban planning problem, and an urban practitioner would most likely not fare well faced with a problem of theoretical mathematics. In general, wicked problems have no beginning, no definitive end, and are never fully solved; they have no right or wrong answer, nor an optimal solution (Dubois, 2014; Lawson, 1993; Rittel and Webber, 1973; Schön, 1983). As a result, they can (probably) never be completely understood. Rittel and Webber further write that "every wicked problem can be considered to be a symptom of another problem", there is always another level of detail or point of view to be explored or considered. One example is traffic-related accidents for children walking to school. They can be explained by inadequate pedestrian infrastructure, lack of public transport services that force children to walk to school, the school being located near heavily frequented roads, stressed people in a hurry in the morning being inattentive drivers, and so forth. These factors can be considered symptoms of failed urban development policies, failed land use and transportation planning, or other, more fundamental issues of society. The level on which the problem is defined, and the limits established for doing so, tend to indicate how and by whom the problem is to be solved. In the case of urban development, the limits of a project (where its implications end) are often defined by allocated time or funding, meaning that 'good enough' tends to be the attainable level of quality. This is not necessarily a bad thing; compromises are needed when taking into account the numerous actors and factors influencing a project.

Wicked problems are unique, in part because of variations in context or other external premises. Knowledge of the problem's context is therefore essential when trying to grasp and/or 'deal with' a wicked problem. This implies that a solution used for one wicked problem cannot directly be used on a different problem. Rather, it provides the practitioner with knowledge about that particular kind of wicked problem, or a particular aspect of a wicked problem, that serves him or her the next time a similar problem is encountered (Lloyd and Scott, 1994). For urban development, understanding the context and the potential implications of a problem is important because, as Rittel and Webber writes, every solution (and on a broader level every project) leaves traces upon the city and its inhabitants that cannot be "undone". Using the example of a freeway, they illustrate how "every trial counts": one cannot construct a freeway to test its effects upon the city and then simply tear it down if the results weren't good. The physical and social effects of its construction are relatively permanent for the city; it cannot simply go back to the initial status quo. This mirrors the above regarding the inherent inertia of urban development. It also relates to the impact of urban development problems, and the permanent changes it incites. A city is a complex network built up of many interdependent elements and variables. Changing one part of the network will inevitably influence other parts – directly and indirectly.

2.1.1 c) **Implications for urban design as a potential mitigation strategy**

Solving problems of a wicked nature – here, mobility-mitigation through urban design – necessitates a profound understanding of the kind of systems one is working on, as well as the kind of problem at hand. Over-simplification can hinder results, and in the worst case lead to unintended, negative consequences. An example of this is the Energy Paradox (Bonhomme, 2013). According to Tennøy (2012), "if we are fundamentally misinterpreting the phenomenon we are dealing with, it should be no surprise we are not succeeding". In this context, "succeeding" refers to reducing emissions from urban mobility, at which we are not succeeding as mobility-related emissions are still rising. Jacobs (1961) writes that solving the kind of problems a city represents, requires observing and understanding the numerous processes going on in a city – at all scales – and the circumstances and the contexts in which they exist.

> "City processes in real life are too complex to be routine…They are always made up of interactions among unique combinations of particulars, and there is no substitute for knowing the particulars."
>
> (Jacobs, 1961, p. 441)

The relationship between the built environment and mobility behaviours is reciprocal, changes in one leads to changes in the other and vice versa. Combined with cities being systems of organized complexity, urban design interventions upon the built environment at the neighbourhood-scale will necessarily influence modal choices somehow. The literature review in Chapter 1.2 showed that the experience of a trip as a whole matters for travel satisfaction (Vos et al., 2015), and so by correlation for future modal choices; this equally applies to the influence of the built environment. A person travelling through a city interacts with their surroundings all along the trip. The sum of these interactions establishes the total influence of the neighbourhood-scale built environment upon modal choice, from beginning to end. How a person perceives and experiences their immediate surroundings is individual; what matters to some, might be considered irrelevant by others. This mirrors the individuality in mobility behaviours, and modal needs and preferences, although there are similarities between different travel groups. Through Chapter 1 it was firmly established that the neighbourhood-scale built environment can influence mobility behaviours, and more specifically modal choice. Based on this, in combination with the observations from the sections above, the following postulate on urban design and mobility is put forward:

Acting upon the neighbourhood-scale built environment simultaneously means acting upon the daily mobility of urban inhabitants and vice versa. Every intervention upon the built environment can be considered an intervention upon the city as a mobility system, and will therefore influence people's daily mobility in some kind of way.

Consequently it seems relatively clear that urban design can be a mobility-mitigation strategy to promote zero-emission mobility modes. Urban design is about the organization and structuring of the public spaces between buildings, approaching the built environment as a whole. A holistic approach to mobility-mitigation is necessary in order to properly understand and exploit the influence of the neighbourhood-scale built environment upon modal choice, for example public spaces and scapes. The wicked nature of urban development problems, with the many interdependencies, further supports this. How can urban design be better exploited so as to ensure that its influence pushes the traveller in a sustainable direction, towards a zero-emission daily mobility behaviour?

2.1.2 Aspects that reinforce barriers for mobility-mitigation

The preceding chapter explored two central topics as potential barriers for mitigation of mobility-related greenhouse gas emissions through urban design: i) knowledge gaps in the scientific literature; ii) lack of implementation of research knowledge in urban design practices. The lack of use of research in design practices has been established by previous studies as a significant challenge to enhancing mitigation as well as adaptation efforts through urban development. The hypothesis of knowledge gaps in the scientific literature was explored and largely confirmed through the literature review; especially for the neighbourhood-scale built environment and modal choice. The two are related: uncertainties and inconsistencies in the scientific literature can complicate its implementation in design practices; lack of implementation in design practices can in turn hinder further knowledge production by not providing research with feedback on the relevance of findings and theories in concrete cases. According to Bertolini (2012), such exchanges between practice and research are essential in order to produce knowledge for sound integrated land use and transport-planning (Bertolini, 2012). Based on the literature review, together with the insights on wicked design problems, additional barriers for mitigation can be identified. It is difficult to point to one aspect as being more significant or hindering, largely because of interconnections: one aspect is dependent on several others, which in turn are co-dependent, and so forth. In the following, the most relevant for this thesis work are explored.

The individuality of people's mobility behaviours

From the city scale to the neighbourhood scale there is a significant increase in detail. Where the city scale allows the 'smudging out' of the individual differences as it involves a large number of people, the neighbourhood scale reduces the scale and the number of people, while heightening the level of detail. Consequently, the individual differences between people's mobility needs and preferences become more apparent, rendering the topic even more complex. The individual differences in mobility behaviours – and choices – become more significant for the research results, but remain difficult to include and/or control for.

The interdependencies between elements of the built environment

As systems of organized complexity, cities are composed by a variety of quantities or elements that are interdependent, which largely contribute to the wickedness of urban development. Actions upon one part of a neighbourhood, or a city, can have multiple secondary effects on other parts. This complicates attempts by research to identify singular elements or aspects of the built environment, which might influence mobility behaviours: how can one measure the influences of one element, without interference by others?

Context matters

The local, urban context matters for the influence of the neighbourhood-scale built environment upon mobility behaviours, (Hillnhütter, 2016; Krizek et al., 2009a; Stefansdottir, 2014a). Hence, it seems questionable whether or not it is possible to produce generalized knowledge on the topic as research mostly aims to do. Focusing on different kinds of environments, and how they influence modal choices, might provide a more interesting approach. The question of context moreover represents an important difference between research and practice, as discussed in Chapter 1. While research often aims at detaching knowledge from context for transferability, practice puts high emphasis upon context; i.e. context-independence versus context-dependence (Kirkeby, 2015). This contributes to practitioners often finding it difficult to implement research knowledge in projects.

People experience and perceive environments and scapes, not singular features

Transport and mobility research tends to focus on singular built environment elements or factors, rather than the sum of them; people, however, tend to perceive and experience their surroundings as environments. This indicates that current research approaches have limitation with regard to promoting sustainable mobility modes, as it is how the elements are combined rather than the elements in themselves that seems to have the most impact upon modal choice. Combined with the individuality of people's mobility needs and preferences, and the subjectivity of how an environment is perceived and experienced, this again points to a need for a more holistic approach.

Lack of interdisciplinarity including knowledge from other research fields

Several authors call for including insight from social and behavioural sciences in transport and mobility research, in order to better comprehend and take into account the 'human factor' of what is here defined as the 'personal context' (Al-Chalabi, 2013; Gaker and Walker, 2011; Schwanen et al., 2011; Vos et al., 2015). Lack of properly taking into account the personal context, is one of the major critiques towards the utility approach that has dominated much of transport and mobility research for decades (Al-Chalabi, 2013). People travel, not vehicles; understanding the behaviour of individuals, and the mechanisms for choice-making (which are often irrational, Thaler and Sunstein, 2009), as well as other aspects of the personal context, is thereby essential to "unpacking travel behaviour" as Al-Chalabi calls it (Al-Chalabi, 2013). However, this still appears to be the exception rather than the norm.

2.1.3 Urban design practices as a source for new insights

Urban development represents an important potential for mitigating greenhouse gas emissions from urban living. This includes emissions from daily mobility, through the reciprocal relationship between the built environment and mobility behaviours

(Erickson and Tempest, 2014; Tennøy, 2012). Robust and efficient mitigation action necessitates the use of sound and dependable scientific knowledge (Bonhomme, 2013; Schwanen et al., 2011). The significant shortcomings of the current literature within transport and mobility research (Forsyth and Krizek, 2010; Tennøy et al., 2015), indicates that new sources for insight should be explored, combined with different approaches to knowledge production. The present work suggests that the experience-based knowledge of urban design practitioners might represent such a source of insight. Architects, planners, landscape architects, and urban designers – professionals of the built environment – are experts on urban development, and assumedly knows how to create areas and public spaces that provide good living contexts for urban dwellers (Skogheim, 2008; Tennøy, 2012). Through their work they observe the city and its functionings, how its inhabitants use it, and how different elements of the city interact (Carmona, 2010; Skogheim, 2008). When in need of designing a building or planning a neighbourhood, city authorities (and others) call upon these professionals; indicating that there is a particular urban development-knowledge other disciplines do not encompass[43]. Moreover, the possibility of studying for these professions within higher education contributes to establish the existence of a particular 'expertise of the built environment' that urban design practitioners (should) encompass. Urban practitioners imagine the city as it could or should be, and work towards achieving this (Kirkeby, 2012, 2015). Their materials or resources are the built environment structures of the city; the buildings, the streets, and the public spaces are the physical embodiment of the project.

> "Architecture is about the life that plays out, and that the building itself does not create but can make possible."
>
> (Kirkeby, 2012)

[43] There are arguably many other actors involved in an urban development project, and consequently many connections and power relations to be taken into consideration. This can significantly influence a project, its processes, and its final outcome; including a project's mobility-mitigation potential. However, to properly explore how urban design, as a kind of urban development, can be a mobility-mitigation strategy, these aspects are held exogenous. The objective of this work is to explore what the possibilities of urban design are, and perhaps how to better exploit this potential.

If an experience-based 'built environment-expertise' exists, it can be assumed that it might hold insights on how people interact with their built environment-surroundings. Findings from research on urban planning and design practices and professionals (here: design research) support this: urban designers have a distinct 'built environment'-expertise that makes them particularly equipped to address and solve the wicked problems of urban development (Cross, 1982; Kirkeby, 2012; Lawson and Dorst, 2009; Schön, 1983; Skogheim, 2008; Tennøy, 2012). Skogheim (2008) writes that through their practice, urban design professionals develop a so-called 'professional eye' that enables them to perceive, observe, and understand the built environment in a different manner than non-practitioners.[44] For example how built environment structures 'works', or how people interact with their built-environment surroundings. This professional eye enables practitioners to 'just know' which measures and solutions might work for a particular situation or context when designing.[45] These properties of urban designers make them an interesting and potentially rich source of insight into cities and their functionings. Their experience-based knowledge comes from a different perspective and rationale than that of research. The two are complementary; combining them might strengthen the knowledge on how to mitigate mobility-emissions through urban design.

Several studies have concluded that combining experience-based and evidence-based insights is essential for producing sound knowledge for urban development, in particular with regard to mobility-mitigation (Næss et al., 2013; Tennøy, 2012). Hence, it is hypothesized that the experience-based knowledge of urban design practitioners can be a source for new insights into the relationship between the built environment and mobility behaviours, complementary to that of research (typically evidence-based). Moreover, that the experience-based knowledge can contribute to explain aspects where

[44] Skogheim originally used the term 'architectural eye' when studying architects and the architectural profession. Works on other urban design professions by Darke (1979), Lawson (2006), Kirkeby (2012; 2015), and Tennøy (2012), to mention some, also point to such practitioners having a distinct manner of observing and comprehending the built environment. Based on this Skogheim's term is extend to urban design practitioners, and used as 'professional eye'.

[45] The notion of 'just knowing' is further developed in Chapter 3.

research currently remains inconclusive. Exploring this professional expertise might also contribute to new approaches for an improved knowledge production.

2.1.4 Research problematic: mitigation through urban design

The thesis seeks to answer the following: “How can urban design be a mitigation strategy to promote zero-emission mobility modes?” That it can be a strategy has been established through the previous subchapters; however, it was also established that this potential appears to be somewhat overlooked by research as well as practice. This is in part due to the significant shortcomings of the scientific literature regarding the relationship between the neighbourhood-scale built environment and mobility behaviours. To better understand and explore the potential of urban design, a holistic shift is needed within mobility and transport research, exploring environments and public spaces, and how these can promote the use of zero-emission mobility modes. Urban design practitioners have a particular expertise on how to design and organize the built environment, hypothesized as a potential source for new insights, complementary to that of research. Exploring this experience-based knowledge in parallel to a holistic, interdisciplinary investigation of evidence-knowledge on urban design and daily mobility can hopefully to produce new understanding of how interventions upon the neighbourhood-scale built environment can influence modal choices. Moreover, enhanced comprehension of how urban design as a kind of urban development can be a mobility-mitigation strategy

2.1.5 Questions for the thesis enquiries

The main research question of the thesis is: **How can urban design be a mitigation strategy to promote zero-emission mobility modes**? The overall research methodology combines knowledge from research and practice in a holistic, interdisciplinary manner, for more complete and in-depth insights. Based on the literature review, and explorative enquiries with urban design professionals, two sub-questions were developed for centring the thesis explorations:

QUESTIONS FOR ENQUIRIES
Question 1: What is the influence of urban qualities and urban features upon a. People's modal choices b. People's perceptions and experience of a neighbourhood scale built environment? **Question 2:** What is the role of mobility in urban design practices, particularly in the design process?

Table 8 Questions for research enquiries

Question 1: What is the influence of urban qualities and urban features upon modal choice, and on people's perceptions of a built environment?

Strengthening urban design as a mobility-mitigation strategy necessitates knowledge on how the neighbourhood-scale built environment influences modal choice. As an example: which measures and solutions are most efficient to promote zero-emission mobility modes through urban design? Such knowledge should to a large extent be provided by research, but shortcomings within the scientific literature act as a barrier for knowledge production and -transfer. Furthermore, the literature review explains how there is often a disparity between the general focus of research, and the manner in which people tend to perceive and experience their immediate surroundings. The topic should therefore be pursued from a more holistic point of view; focusing less on the hierarchy of elements and factors, but rather on the interactions between them and the perceptions, environments, and scapes they create.

Question 2: What is the role of mobility in urban design practices, particularly in the design process?

The main activity of these designers is their professional activity – the project – designing the neighbourhood built environment. Enquiring their approaches and practices (the kind of solutions and measures included, the kinds of decisions, etc.) is therefore likely to provide insight into their savoir-faire on particular topics. Urban design is about creating good living contexts for urban dwellers (Carmona, 2010; Gehl, 2010; Madanipour, 2006); mobility is just one of a broad range of issue to be dealt with in an urban design project. Given the importance of mobility for a city's well-functioning, however, it seems likely that it would be considered an important issue in order to create good living contexts at the neighbourhood scale. Exploring the role of mobility in design practices is therefore hypothesized as an efficient approach to assess the experienced-based knowledge regarding 1) the relationship between daily mobility and the built environment, 2) the interactions between the built environment and inhabitants, and 3) the influence of daily mobility upon the everyday lives of people. How practitioners address and solve mobility in a project, and how they relate it to other issues, is likely a result of their professional knowledge, e.g. measures and solutions they by experience know that works.

On a more general level, exploring the role of mobility in a project is thought to contribute to the thesis objective in two principle ways. On one hand, new insight into the relationship between urban design and modal choice, on the other, new insight into urban design practices. The latter is important in order to strengthen a reciprocal knowledge transfer between research and practice, establishing foundations for a dialogue. Research should inform practice, but practice can likely inform research, especially on the topic of urban development and the less tangible aspects of city functionings.

2.2 General methodology

2.2.1 A research approach adapted to the nature of the problem

Tennøy (2012) writes that a problem cannot be properly solved unless it is properly understood. The problem this thesis addresses – mobility-mitigation through urban design – is a wicked one, created by larger problems that are also wicked (urban design problems and climate change mitigation). Wicked problems can never fully understood; they can, however, be better understood. Processes and mechanisms can be studied to get a better grasp of the complexity; their inherent interdependencies can be further uncovered; potential manners in which to addressed them can be tested. The societal role of research is to a large extent to be a provider of knowledge. In the case of urban development, knowledge to guide and inform decision makers and urban practitioners in order to address and to tackle the wicked problems a city produces. For mobility-mitigation through urban design the more 'traditional' research methods appear to be somewhat limited; existing literature has so far failed to properly account for the high level of interdependencies that exists among the elements and aspects of a city. The literature review showed how knowledge gaps regarding the relationship between the neighbourhood-scale built environment and modal choice hinder the use of research knowledge in urban design practices. Chapter 1.3 concluded that a different, more holistic approach to scientific knowledge production is necessary in order to address these shortcomings. One way to achieve this is to shift the focus from singular built-environment features to environments. The totality of the neighbourhood-scale built environment of an area, e.g. public spaces, appear more important for the perception and experience of said area than its singular built environment features (Hillnhütter, 2016; Johansson et al., 2016b; Pucher and Buehler, 2010). Moreover, the zero-emission modes primarily considered in this context, walking, cycling, and transit, engage the traveller in closer interaction with his or her surroundings than when travelling by car. Additionally, recent research has shown that the experiences these interactions create can influence future modal choices (Stefansdottir, 2014a; Vos et al., 2015).

The purpose of this work is to strengthen urban design as a strategy to promote zero-emission mobility modes, thereby reasserting its role as a tactic for climate change mitigation. A necessary step towards this is to further knowledge regarding the link between urban design and modal choice, i.e. provide better knowledge of how different environments influence and create experiences and perceptions for the traveller, and how these might influence trip experience. According to Jacobs (1961), observing and understanding the processes that go on in a city are essential to produce sound knowledge for urban development. Urban designers are experts of the built environment. Through their practice they observe city inhabitants and their interactions with, and use of, various built environments in their everyday lives. These observations, together with the rest of the professional savoir-faire, are explored as a new source of insight to better understand the wicked problem at hand (mitigation of mobility-related emissions), and the suggested means to address and, to some extent, solve it (urban design as a mitigation strategy).

2.2.2 Research design: Combining evidence-based and experience-based knowledge

The general research design of this work consists of combing the experience-based knowledge of urban design practitioners with the evidence-based knowledge of research, seeking new insights into how urban design can be a mobility-mitigation strategy (see Figure 19). The two are hypothesized as complementary; harmonizing them should provide a better understanding of how people interact with, and are influenced by, built environment surroundings during a daily trip. This in turn can help understand how urban design can be a strategy to promote a sustainable modal shift. Findings from the literature review were further pursued, this time from a more holistic perspective, in combination with works from other research fields as well as urban design literature. The experience-based knowledge of urban designers was explored through a series of empirical investigations, which constitutes the majority of Part 2. Through an iterative process the two inform each other: emerging topics from the theoretical analyses helped orient the enquiries, while initial findings from the enquiries indicated additional topics to explore within scientific and urban design literature. The enquiry results are presented in a descriptive manner in Part 2 (Chapter 5), then combined with findings from the theoretical investigations in Part 3 (Chapter 6 and 7).

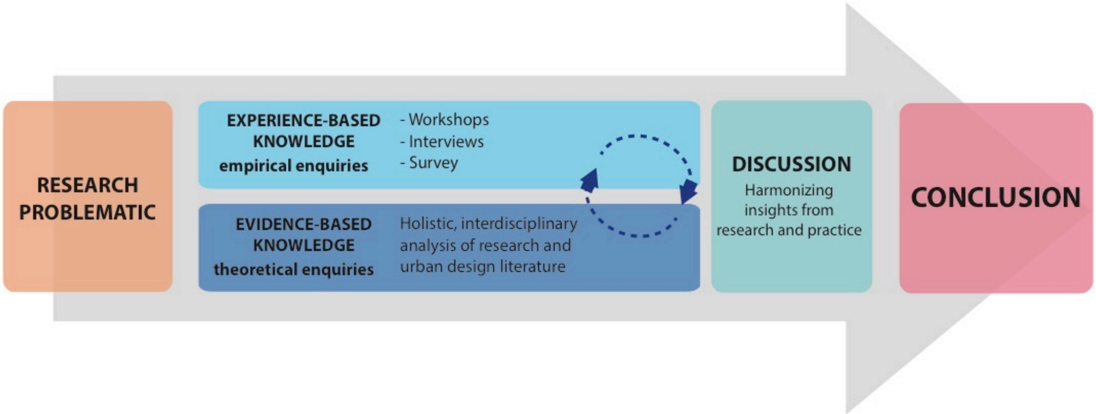


Figure 19 A simplified figure of the research design with an iterative exchange between the empirical and the theoretical enquiries

The thesis was written in the context of an international research project, CapaCity. The objective of CapaCity was to develop a prototype design-aid tool, directed at urban design professionals, to strengthen climate change adaptation through urban development. A more detailed presentation of CapaCity can be found in Chapter 4. While centred on adaptation, the project dresses similar issues to the thesis. The most important of which are a general lack of knowledge transfer from research to practice, and lack of implementing of scientific knowledge in urban development projects. To develop a tool that is accessible as well as applicable by practitioners, the initial phases of CapaCity consisted of exploring design practices, and the knowledge status on adaptation among practitioners. This was done through empirical (workshops and survey) and theoretical investigations, which simultaneously informed the thesis explorations. A review of current literature within design research was undertaken in the context of CapaCity, and further pursued in the context of the thesis (Chapter 3). This allowed ‘profiling’ practitioners in order to adapt enquiry methods to properties and particularities of their experience-based knowledge and practices. A mixed methods approach was developed for the empirical enquiries, here: workshops, interviews, and a survey. Experience from design research has found this to be an optimal approach for a broad and detailed image of design practices and the professional savoir-faire (Chapter 4 and 5). The CapaCity workshops contributed to these enquiries.

2.2.3 Validity and reliability

The outcome of a research project – the produced knowledge – must be credible, i.e. trustworthy and reliable. This requires the researcher to ensure that how the research topic is approached, as well as choice of overall methodology and particular methods, is valid; meaning the scientific protocol of the project must 'fit' the problem it addresses and/or the cases it studies. How this is ensured vary between qualitative and quantitative research (Ryen, 2002), but there is seldom an absolute right or wrong (Hellevik, 2011; Skogheim, 2008). Qualitative research has often been critiqued by quantitative research regarding the question of validity and reliability. Qualitative enquiries, e.g. interviews, cannot be as easily copied as a quantitative laboratory experiment, e.g. different formulae for concrete; it is, for example, difficult to replicate an interview and obtain the exact same results every time. The object of study (person) can be in a different mood or want to emphasize different aspects; the researcher might (unintended) steer the interview in a different direction; other external contexts might equally vary (Ryen, 2002; Skogheim, 2008). These debates are not further explored in the context of this work; see for example Ryen (2002) for a thorough exploration of the topic.

Ryen (2002) and Skogheim (2008) both discuss how to ensure validity and reliability for qualitative research, and conclude that the question of can easily become unclear, and even controversial. These works stem from a primarily sociological research tradition. Ryen (2002) explores several opinions and ideas about validity and reliability for research within sociology (and ethnography), though none of which seem directly applicable to this work. In part because of its interdisciplinarity, building on a range of fields and research traditions, quantitative as well as qualitative. As is further discussed in Chapter 3, this is not uncommon for architecture or urban design research. There is no 'General Theory' as within medicine, or different 'schools of theory' as within sociology. Consequently, for the present work, measures to ensure validity and reliability are adapted to the concrete ‘experiment’ to the extent possible. One example is employing experience from previous design research for the empirical enquiries, which lead to a mixed-methods approach to ensure validity. Another example is undertaking several rounds of testing the set-up for the empirical enquiries with practitioners. Experience-based knowledge can be difficult to access and assess, in part because it is deeply engrained in the person’s habits and every day work routine (Eikseth, 2009). Combining workshops, interviews, and a survey, allow approaching it from different perspectives, as well as in different contexts for a broader result. Furthermore, it reduces the influence of methodological challenges of each method separately, for example the limited number of interviewees and survey respondents, especially in the context of a doctoral thesis where resources are often limited. Few participants can reduce the representativeness of findings and observations. However, for qualitative work such as this thesis, representativeness has to be considered differently than for example a medical study with a cohort of several thousand people, over many years. The objective of this work is in itself not to generalize findings, or establish causal relationships. Here the practices and the experienced-based knowledge of a selection of practitioners in Norway and in France are explored through a qualitative approach. The findings will not represent the experience or opinions of all urban designers in Norway and France, nor will they provide an absolute truth about the reciprocal relationship between the neighbourhood-scale built environment and modal choices. Combined with previous findings and observations from previous research they can, however, enhance and further explain the existing knowledge. It should also help further knowledge with design research. Design research builds upon decades of individual explorations such as this thesis that collectively have established the current knowledge, for example how design thinking tends to differ from how engineers think (Lawson, 2006a). A more in-depth discussion of these methodological limitations and challenges can be found in Chapter 5.

CONCLUSION PART 1

The important role of cities to curb greenhouse gas emissions worldwide has been widely recognized. One reason for this is the opportunity to reduce the carbon footprint of a large number of people simultaneously, for example from daily travels – a major source for urban emissions. People travel, not vehicles. Consequently, reducing emissions necessarily involves a change in mobility behaviours. Two primary strategies exist to mitigate mobility emissions: travel less or travel differently. Both are needed to achieve the necessary emission cuts to limit global warming to below 2°C. This work focuses on travelling differently; a large-scale sustainable modal shift towards zero-emission mobility modes. More specifically, how urban design – built environment-interventions at the neighbourhood scale – can contribute to promote walking, cycling, and public transport use. In this context the neighbourhood scale refers to the built environment surroundings that travellers experience as they move through the city, the three dimensional space between buildings and other structures (by some referred to as pedestrian scale). There is a reciprocal relationship between the built environment and mobility behaviours; how a city is structured and designed – from the metropolitan scale to the sidewalk – influences how people move around in it, and vice versa. This indicates an opportunity for mitigating mobility related greenhouse gas emissions through urban development. Indeed, there is a broad consensus among researchers, urban development practitioners, and decision makers that city development can be a strategy to promote a zero-emission modal shift. However, the potential contribution of interventions at the neighbourhood scale appears less explored. Two barriers that explain this are addressed: i) knowledge gaps in the research literature, and ii) lack of implementation of research knowledge in urban design projects. The two enhance each other. As an example, the shortcomings of the scientific literature make it difficult for practitioners to employ it in projects, which in turn hinder feedback from practice to research on the validity and applicability of results from studies.

The literature review showed that a large body of research exists on urban development and modal choice. At the city scale this relationship is relatively well explored; at the neighbourhood scale the evidence tends to become 'muddied'. "The relationship between urban design and mode choice seems self-evident on the one hand and utterly complicated on the other" (Larco, 2016). One reason for this is the often monocriteria approach of research, aiming to identify which elements or factors are most important for promoting for example walking or cycling. However, people tend to perceive their surroundings as environments and spaces, not singular elements. Additionally, mobility behaviours are highly individual, much due to the importance of the personal context of the traveller (physical capacity, preferences, perceptions of one's surroundings, etc.). What matters for some is likely to matter much less for others. Another reason is a lack of including insights from other research fields, for example social sciences, to better understand how and why people choose to travel the way they do in everyday life. In light of the above it seems reasonable to question the interest – and even possibility – of identifying what matters the most for promoting a sustainable modal choice through urban design. Instead, a holistic, interdisciplinary approach might be more adequate; considering the built environment at the neighbourhood scale as a whole, and how these environments and spaces influence modal choice.

PART 2
THE DESIGN PRACTICES AND THE SAVOIR–FAIRE OF URBAN DESIGNERS

INTRODUCTION PART 2

The previous part introduced the main research problematic, namely how urban design can be a mobility-mitigation strategy. Barriers and challenges for achieving this were identified. There are significant knowledge gaps in the scientific literature that hinder its use in urban design practices, but also future knowledge production for mobility-mitigation through urban development. A more holistic approach to the neighbourhood-scale built environment and its influence upon modal choice is likely to be more beneficial. Additionally, new insights are needed; the savoir-faire of urban design professionals appears as a potential source of knowledge, complementary to that of research. In the following, this professional knowledge is investigated with regard to

a) The role of mobility in urban design practices, and more particularly in design processes
b) How urban qualities and features influence modal choice, perceptions and experiences of the built environment, according to the practitioners.

In addition to providing new insights for addressing the research problematic, the results from these enquiries should contribute to a better understanding of urban design practices in general. This, in turn, can help strengthen a reciprocal knowledge transfer between research and practice.

This second part presents the empirical enquiries: the theoretical framework; the design, execution, and analysis; the obtained results. The latter are presented in a descriptive manner; they are further discussed in Part 3 together with the findings from the theoretical enquires. Chapter 3 presents the theoretical framework developed based on a review of the literature regarding urban design practices and savoir-faire.

Designers' knowledge tend to be tacit or 'silent' - i.e. difficult to explain or describe verbally, and thus challenging to assess and comprehend (Eikseth, 2009; Skogheim, 2008). Accessing such knowledge requires a particular attention to choice and development of research methods. Here three different methods were employed: workshops, interviews, and a survey. The literature review also showed how the practitioner's own experience or that of colleagues is the primary source of information and knowledge for urban designers. This indicates that the urban design project might be an interesting point of entry for exploring their savoir-faire, particularly for the interviews.

The first round of enquires, the workshop, were organized in the context of CapaCtiy, an international research-collaboration between France and Canada. The project and the workshops are presented in Chapter 4. The workshops were held in Toulouse, France, May and June 2015, with a total of 18 practitioners. As the doctoral thesis was written in the context of CapaCity, the workshops were analyzed both for CapaCity and for the doctoral thesis. This provided initial insight into the role of mobility in a design process, as well as the practitioners' apparent knowledge on daily mobility. Working hypotheses were developed based on observations; establishing a basis for the second round of enquiries - interviews and a survey. They are presented together in Chapter 5, as they were designed and executed in parallel as complementary follow-ups of initial observations from the workshops. Consequently, the findings from each are directly combined in Chapter 5.4 and 5.5, compared to observations from the workshops.

Part 2 furthermore discusses the enquiries' methodological limitations, before concluding on a summary of the enquiry results combined. One of the main findings relates to how the designers tend to see daily mobility as a kind of use of public space. This influences how they address it in a project, and how they act upon it – i.e. the solutions and measures they see as important for creating public space people want to move through.

CHAPTER 3

URBAN DESIGNERS – A THEORETICAL FRAMEWORK

3.1 URBAN DESIGN HOLDS NO GENERAL THEORY

When working on the structure for a bridge, the civil engineer has rules and scientifically based theories to follow, almost like a recipe. They provide clear instructions on how to proceed, and dictate the necessary results of calculations for the structure to hold. In contrast, design does not have a similar set of scientifically based laws and theories; there is no “General Theory of Design”. This lack of common theory and rules is a characteristic trait of most design disciplines. For urban designers, their knowledge tends to build upon other fields such as Engineering, Medicine, Art, and Humanistic and Social Sciences (Skogheim, 2008). It is the sum of these, combined with experience and the specific design education – as detailed below – that gradually forms each designer’s personal design theory.

> “There is no theory of relativity or quantum theory in design and not even the equivalents of the laws of gravity, friction, force, mass and so on that enable engineers to calculate the sizes of structural components. Designers do not then have a set of systematic rules that enable them to move from a problem to a solution.”
>
> (Lawson and Dorst, 2009, p. 124)

In a project, the designer often faces issues that can only be solved through a combination of knowledge and theories from a broad range of fields. When designing a hospital, the architect must create a building that is at once i) a good workplace for the doctors, nurses, and other hospital staff; ii) a good place for the patients to get treatment, and potentially to stay for a longer period; iii) a good place for relatives and the likes to accompany or visit patients. There are rules to follow with regard to areas for medical treatment, hygiene, etc., deriving from medical research. There are findings from other research with regard to the need of daylight for good working conditions, or required air quality for the well-being of a building's occupants. Then there are opinions, notions, and ideas regarding the optimal design of an operation room or a patient room, the best layout of a hospital for efficient logistics, and so forth. The architect is expected to know how to combine all of this in a proposal for a hospital building, while also crafting pleasing aesthetics in the design. An urban designer faces similar challenges for interventions upon the neighbourhood-scale built environment.

One could argue that there are general theories within branches of design, such as Architecture or Urban Design, with regard to the design of public places, or particular kinds of buildings (e.g. schools). This is true to some extent; a general consensus can be found within those disciplines on such design topics. However, there is an important difference between consensus and scientifically proven evidence that form the basis of rules. Rules must be followed, whereas design consensus can be challenged and/or disregarded.

Skogheim writes that an architect is expected to have knowledge and competences from the technical and juridical, to the creative and aesthetical; these design professionals are expected to know about everything from "rubber packaging around a window to a highway crossing" (Skogheim, 2008). Skogheim focused her research on architects, but her findings are in accordance with the works of researchers such as Lawson, Cross, and Kirkeby, regarding other 'built environment practitioners' (here: urban designers). The diversity of the projects a designer works on, the broad variety of actors within an urban design project, and the number of issues the project (and thus the designer) deals with, are among the main reasons for this. Kreiner[46], in an interview with Kirkeby (2010), explained that because of the loosely structured nature of the problems architects (and

[46] Professor Kristian Kreiner was at the time of the interview (Kirkeby, 2010) head of the Center for Management Studies of the Building Process, and specialized in knowledge managment at Copenhagen Business School.

designers) work with, the knowledge used in a design process is for the most part only identifiable in retrospect of a project. The knowledge actually needed to solve the problem at hand therefore cannot be predicted, only summed up after the project has been concluded (Kirkeby, 2010).

> "…the special solution for a particular project often derives from knowledge you learn or developed through the process."
> David Zahle, Architect, B.I.G. Copenhagen, in an interview with Kirkeby (Kirkeby, 2015)

The lack of general design theory does not mean there is no particular urban design savoir-faire. Based on design research literature, a framework for the general structure of an urban designer's savoir-faire can be developed (see Figure 20). This forms the basis for the designer's practice. However, the lack of general theory does indicate that large variations can be found within the professional savoir-faire, which the empirical enquiries of this thesis must take into account. Much of this is a result of experience being among the most important sources for new knowledge, i.e. learning by doing; both an advantage and a disadvantage for the furthering of urban designers' knowledge throughout a professional career (further discussed in the following sections).

3.2 DESIGNERLY WAYS OF KNOWING AND OBSERVING

An important rationale for exploring the savoir-faire of urban designers as a source of insight is society's definition of these professionals as experts of the built environment (see Chapter 2). Their assumed expertise goes beyond knowing how to create a building or how to organize a neighbourhood – practically and physically. A Building Engineer is for example capable of conceiving a house that is structurally sound and well insulated. An Architect, however, is expected to ensure that the house is a good place to live in, that it has a high aesthetic quality, and that it works well with its context. An urban designer is expected to know for to ensure that a street 'works' with regard to logistics (flow of traffic, delivery of good to stores, etc.), but also with regard to the social life of a city. In other words, these practitioners are expected to know how to create and/or address the less tangible, yet highly important, aspects of the built environment. They are assumed to have a particular understanding of the 'functioning' of built environments, but also how people interact with their built-environment surroundings – on all geographical scales. Society generally expects these professionals to have the necessary expertise to deal with the inherently complex task of designing good living contexts for the heterogeneous population of a city. Politicians and other decision makers might have 'the final say' in many development projects, but they turn to design practitioners for project proposals, and guidance on how to accomplish their ambitions for a neighbourhood or a city. It seems that designers – here urban designers – have a particular skill set, and a particular way of observing and understanding the built environment and urban life; summarized in the following as designerly ways of knowing and observing.

3.2.1 A designerly way of knowing

The notion of a particular, *designerly way of knowing* was (presumably) introduced by Cross in an article from 1982. In it, Cross sought to define typical skills and methods of designers, and establish why these are distinct for design He identified several aspects related to designerly ways of knowing, which often refer to how designers approach and attempt to solve problems, which is explored more in-depth in 0. Here, Cross' findings are summed up in three points that are particularly interesting in the context of this work. Evidently, they do not apply equally to all designers; as most professionals, these practitioners are a highly heterogeneous group, with different levels of experience and areas of interest.

1. *Designers tackle ill-defined problems.*

Urban design projects represent so-called *wicked problems* (see Chapter 1), which tend to be highly complex, with no clear beginning or end, and with a high level of interdependence. These are the ill-defined problems of urban designers. Knowing how to tackle and (to the extent possible) solve them is a distinct skill of these design professionals.

2. *A constructive, solution-based approach (see chapter 3.3)*

Designers tend to have a constructive, solution-focused approach to solve wicked problems, as established by Lawson (1979). The designers test potential solutions through an iterative method, solutions are kept or discarded depending on their fit to the problem and other measures and solutions. Through this, the designer gradually gains a deeper understanding of the many facets of the problem at hand.

3. *Knowledge from objects*

Designers have the capacity of extracts knowledge about an object, e.g. how it works and how it is conceived, and then translating that in to conceiving new objects (identical or somewhat different). Putting acquired knowledge into conceiving new objects, is part of what Cross calls a constructive mode of thinking. It is an example of a kind of knowledge defined by Kirkeby (2012) as *objet trouvé*, further detailed in 0.

These characteristics support the idea that urban designers have particular characteristic, making them ‘experts of the built environment’. The basis for these characteristics or skills lies in the designer’s savoir-faire, their ‘know how’, which enables them to develop and apply their designerly way of knowing in urban development projects.

3.2.2 A designerly way of observing

A designerly way of observing is related to Skogheim’s ‘architectural eye’ as discussed in Chapter 2; here referred to as a ‘professional eye’. It is the urban designers’ particular way observing and understanding the built environment and its interaction with its context and its inhabitants. This notion of a ‘professional eye’ is an interesting aspect of what distinguishes the way urban designers see and comprehend a city from that of an economist, a high school teacher, or a lawyer.

> ”The Architectural education contributes to students developing an ’eye’ proper to the discipline, an ’observational meeting’ that enables them to consider/determine which architectural solutions that are appropriate for different situations. (…) What appears to particularly unite the discipline of Architecture across different ways of exercising the profession, are particular ways of seeing, interpreting, and understanding surroundings. The Architectural ’eye’, which can also be interpreted as judgement and delicacy, is established through the education, and refined through the experience as an Architect. This comprises an innate ‘understanding’ when it comes to appraising architecture, it be single buildings or city plans.”[47]
> (Skogheim, 2014)

Urban practitioners tend to develop knowledge about, and an understanding of, the city and its functioning, specific to their profession. This gives them a unique insight into how to develop the city in a way that improves the living conditions of its inhabitants.

[47] Translated by the author

As with most kinds of skills and knowledge, it is not identical for all urban designers. Some might have more insight on a particular topic; some might be strongly influenced by a particular mind-set or ideology; some might just simply be better designers than others. It should not be assumed that all urban practitioners have the same level of expertise or skill, which is why it is important to enquire a range of designers with different background and experience.

3.3 THE SAVOIR-FAIRE OF URBAN DESIGNERS

3.3.1 A theoretical framework for the urban designer's savoir-faire

In the context of this work, *savoir-faire* describes the sum of the knowledge (theoretical and practical), the skills, and the experience the urban practitioner; what enables the urban practitioner to work on wicked urban design problems. This savoir-faire, together with the designer's *governing principles* (see 3.4.1), form the basis for their designerly ways of knowing and observing[48], as described in the above. Based on works by Bonhomme (2013), Dubois (2014), Eliasson (2000), Kirkeby (2012, 2015), Lawson (2006), Lawson and Dorst (2009), Schön (1983), Skogheim (2008), and Tennøy (2012) a theoretical framework has been developed in order to describe this savoir-faire, and how it is constructed and continually 'fed' by different kinds of knowledge (Figure 20). The main activity of an urban practitioner is the design project, the nature of which (i.e. the kind of project) is distinctive to the designer's field (craft-design, architecture, urban planning, etc.). Consequently, the theoretical framework is organized around a design project to help identify the particular savoir-faire employed at different moments or for different design actions. As the designers studied in this context are urban designers, the framework is described using notions from their practices.

Figure 20 shows the urban designer's savoir-faire as comprised of four categories: **Process, Methodological, Technical,** and **Design Savoir-Faire**. There are overlaps between the categories; a savoir-faire might be classified as both Technical and Design. The classification contributes, however, to an improved comprehension of the different skills and knowledges a designer tends to need in their work. It represents a potential tool for research to communicate findings and results in more specific and applicable manners, linking it to particular aspects of the urban design savoir-faire. This is a contributing step to overcoming the current barriers of knowledge transfer between research and practice.

[48] See Glossary

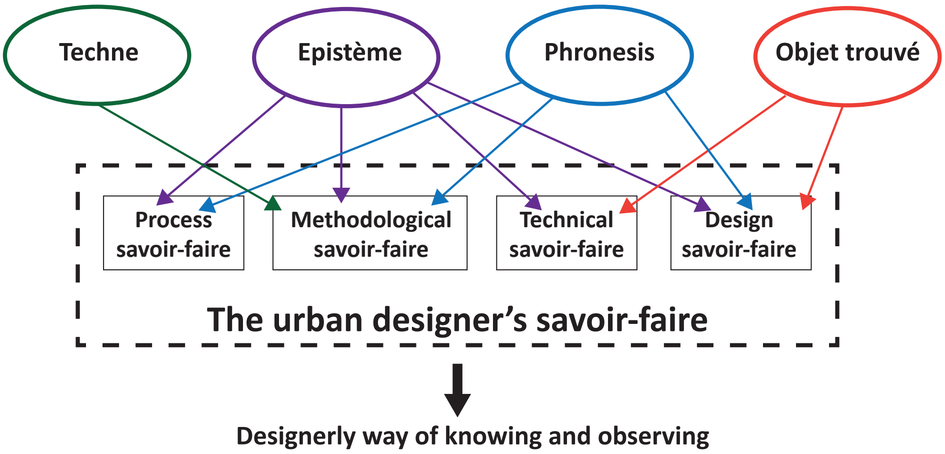


Figure 20 The urban designer's savoir-faire is constituted of different kinds of knowledge, it forms the basis for the particular designerly way of knowing and observing of design practitioners

Each category of savoir-faire is fed or informed by different kinds of knowledge, summarized as **Techne, Epistème, Phronesis, and Objet Trouvé**. The first three are based Skogheim's use of Aristotle's division of knowledge[49] (Skogheim, 2008), while the latter, objet trouvé, is a kind of knowledge distinctive for design practices as introduced in 0 (Cross, 1982; Kirkeby, 2015). The categories and the different kinds of knowledge are further developed below, followed by a summary of common sources of knowledge for the urban designer's savoir-faire and for their projects.

3.3.1 a) **Categories of savoir-faire**

Technical savoir-faire

Technical savoir-faire primarily represents evidence-based knowledge produced by research, for example about building structures, or knowledge about the energy consumption of building. It can also be knowledge about particular kinds of solutions and materials, knowledge about climate adaptation and mitigation, etc. Technical savoir-faire is primarily related to Epistème and Objet trouvé.

[49] For more discussion about the ideas and theories of Aristotle see *Phronetic Planning Research: Theoretical and Methodological Reflections* (Flyvbjerg, 2004)

Process savoir-faire

Process savoir-faire is primarily management: managing a project; managing a design process; managing an architectural firm (not the focus here). Process knowledge is important in order to ensure the fulfilment of a project – from time management, budgeting, and knowing when to involve different actors, to knowing when to file required legal documents for building permits. Process savoir-faire is primarily related to Epistème and Phronesis.

Design savoir-faire

Design savoir-faire represents the inherent knowledge of the designer regarding which solutions and measures fit the particular project at hand – the 'just knowing' what works (Schön, 1983). This experience-based knowledge, acquired through projects, encompasses the practitioner's understanding of potential tacit and qualitative effects of solutions and measures upon a project: how they might relate to various aspects of a site and its context; how they might interact with other solutions and measures; how a solution can contribute to the overall objective of an improved living context[50] for the inhabitants. In short, the designer's knowledge of which solutions and measures to apply in order to achieve established goals, and respond to identified problems and challenges. Design savoir-faire is primarily related to Epistème, Phronesis, and Objet trouvé.

Methodological savoir-faire

Methodological savoir-faire here means methodology, which differs from method. The latter refers to a specific way of doing something, for instance a method for site analysis. Methodology refers to the overall approach to a problem, for example from a particular perspective, or with particular objectives. Choice of methodology generally influences or dictates choice of methods. For designers, methodology is often something they develop over time, their manner of approaching and addressing a

[50] See Glossary

development problem. In this context, methodological knowledge also encompasses the practitioner's knowledge of how to proceed from a problem to a project. That is, which actions to take or tasks to engage in in order to conceive a constructible project that responds to the client's command. Methodological savoir-faire is primarily related to Epistème, Phronesis, and Techne.

3.3.1 b) **The kinds of knowledge that constitutes the savoir-faire**

Skogheim groups an architect's kinds of knowledge using Aristotle's division of knowledge as *techne, epistème* and *phronesis* (Skogheim, 2008). This allows her to relate the knowledge of an architect to actions in a typical design project, from representing an architectural idea on paper to cooperating with an entrepreneur for the construction of a building (Skogheim, 2008). Some knowledge can be categorized as both epistème and phronesis, or as phronesis and techne, depending on which aspects of the knowledge are emphasized and studied, or the manner in which it is acquired. As explained previously, although she focuses on architects, her results and conclusions generally applies to urban designers as well. Kirkeby, on the other hand, classifies a designer's kinds of knowledge as *factual, experience,* and *objet trouvé* (Kirkeby, 2012). Factual knowledge corresponds to Skogheim's notion of epistème, while experience is here considered a source for knowledge, not a kind of knowledge in itself. Objet trouvé, however, represents a different kind of knowledge than the three categories of Skogheim.

Techne – practical knowledge, or skills

Techne is the technical, craftsman-related knowledge, for example how to create sketches, physical models and other visual representations. Skogheim (2008) emphasizes the difference between mental capacity of transforming an idea to a concrete design (phronesis-related knowledge), and the actual techne-skill of producing drawings and models. Techne also comprises knowledge of the execution of projects, from formal aspects related to legislation or construction processes (e.g. how to build in a manner so that the building stands), to handling potential conflicts with internal and external actors.

Epistème – theoretical knowledge

Epistème typically represents scientific or other, abstract knowledge acquired through written material and/or through lessons with a teacher. Epistème knowledge includes scientific laws and theories, which are necessary in order to conceive buildings that can be built. Aesthetics, form, and design, are other examples of epistème-knowledge as they can be acquired through reading and through lessons (in addition to experience, not the focus here). These are vaguer knowledges; they can be understood at once as "personal, indescribable, and subjective assessment (phronesis), and as practical-natured knowledge (techne)" (Skogheim, 2008, p. 63)[51], but also as theoretical knowledge (epistème) in the form of common principles for architectural representations (on building plans).

Phronesis – judgment and subjective assessment

Within architecture (and much design in general) *phronesis* refers to practical wisdom, such as being able to distinguish between good and bad solutions to a problem (Skogheim, 2008). Such judgment is to some extent based on epistème-knowledge, as seen above, but also much upon a subjectiveness that tends to reflect the practitioner's own principles and preferences. Phronesis are skills the practitioner acquires through education, experience, and through their developed principles. An interesting aspect of phronesis-knowledge is its 'silent nature' (Eikseth, 2009; Skogheim, 2008), how design professionals often 'just know' how to do something or to solve a task without knowing how to explain why (Schön, 1983). For example, 'just knowing' which solution or measure will be optimal for a particular design problem. Drawing a parallel to manual professions, Skogheim writes that this kind of knowing is learnt through practical experience, and becomes part of what she calls the 'architectural eye' (here: professional eye).

[51] Translation by author

Objet trouvé – knowledge from things and surroundings

Objet trouvé refers to the understanding and/or inspiration a practitioner can gain from things that surround him or her, concrete objects, a radio show talking about new research, literature and art, and so on (Kirkeby, 2012). Skogheim (2008) found similar references of gaining knowledge from things in interviews with Norwegian architects. Cross (1982) compares a ‘object-approach’ to how craft-design evolves, where a craftsperson takes an existing product and evolves its design somehow. He further explains that objects are in themselves knowledge. That is, they represent knowledge about a particular thing or issue, for instance on how to satisfy certain requirements, or how to perform in certain way.

> “If you want to know how an object should be designed – i.e. what shapes and sizes it should have, what material it should be made from – go and look at existing examples of that kind of object, and simply copy (i.e. learn!) from the past.”
>
> (Cross, 1982)

According to Cross, this knowledge is – in theory – available to anyone, but knowing *how* to extract and use it is a particular skill of designers. Similar examples can be found within the practices of architects and other urban professionals. When designing a hospital, the architect usually draws on existing sources, i.e. existing hospitals to understand how they work, how they respond to requirements of different users, which characteristics and properties are necessary to make the building function. On a more general level, a site-analysis is an essential aspect of every urban design (and development) project. The designer explores the project site and its urban context to understand how it relates to and interacts with its surroundings, how it is used by inhabitants, etc. The object-knowledge aspect of the savoir-faire enables the urban designer to incorporate the gathered information in a project.

3.3.2 Sources of knowledge for the savoir-faire

A designer is expected to have, and to be able to handle (address, comprehend, use, etc.) a broad variety of knowledge, stemming from a range of sources, as illustrated by Table 9.

DIFFERENT SOURCES FOR AN URBAN DESIGNER'S SAVOIR-FAIRE				
	Techne	**Episteme**	**Phronesis**	**'Objet trouvé'**
Education	x	x	x	x
Experience (own, colleagues)	x	x	x	x
Experience (experts)	x	x	x	x
Scientific knowledge	x (some)	x (some)	x	x (some)
Non-scientific knowledge	x	x	x	x
Objects, context			x	x

Table 9 The different sources for an urban designer's savoir-faire, and how they contribute to the different kinds of knowledge

Education

A designer's education, i.e. how and where he or she studied, establish the basis for the designer's development of savoir-faire and governing principles (Lawson and Dorst, 2009; Skogheim, 2008). Where the designer studied can have a significant impact, as schools (e.g. architectures schools) – both internationally and nationally – often have varying principles and philosophy about design. This variation is more within design studies than for example medicine or engineering, and is perhaps related to the absence of a General Theory for design (as discussed initially). Throughout a career, the urban designer might undertake various forms for continued education; supplementary studies of varying length (a day, a week, several years), within any topic depending on professional and personal interests. Lawson (1979) explored particularities of engineers' and architects' approach to problems, studying first-year and fifth-year students through a series of experiments. Among first-year students of Architecture and Engineering there was little or no difference in methods for problem solving. First year students appeared to have a somewhat similar approach to the presented problem (a series of boxes to assemble). Towards to end of their studies, however, a clear difference could be observed: analysis-focused (engineering) versus solution-based[52] (architects). Lawson found that the architects tended to advance by generating a sequence of high scoring solutions that allowed them to better understand the problem and eventually determine a solution. The engineers on the other hand, approached it through a analysis-focused strategy where the problem was thoroughly analyzed for a full understanding before advancing towards a solution (Lawson, 1979). These findings have been confirmed through other experiments (Lloyd and Scott, 1994) and interviews with designers (Kirkeby, 2012, 2015; Lawson, 1993). The difference among first-year and fifth-year students indicates that a solution-based or analysis-focused approach is primarily acquired through the respective studies. Which in turn underlines the important role of education in establishing the basics of a designer's savoir-faire. In several countries urban design professionals, for example architects, are required (by the government or their professional organisation) to take courses throughout their career to maintain their qualification (right to exercise or just the right to use a certain title). These can be courses on materials and energy use, regulations, etc. Even if not required many professionals still take courses if possible in order to stay informed on recent development, changes in building codes, etc.

Experience – own, colleagues

Experience knowledge refers to the practitioner's own experience or that of others. The experience of a practitioner, primarily acquired from projects, spans from knowing how a design process usually goes and the different challenges that might occur, to knowing that placing benches this or that way can influence how a public space is used. It is an important source of knowledge (Kirkeby, 2012), indicating that 'learning by doing' is particularly influential for how designers acquire new knowledge. If an issue, a solution, a specific technique, etc., has been explored in a project, the practitioner will have some kind of knowledge about it that can be applied in later projects, for example water management, or bicycle infrastructure. Lloyd and Scott (1994) conducted an experiment with designers of varying years of professional experience. They found that

[52] This approach is further detailed below

if a designer had previously encountered the same or a similar design problem, the person appeared to recognize the *type* or *kind* of solution that might ‘be a fit’, based on what had worked before. As the authors put it, specific experience of a design problem allows “designers to perceive new problems through old solutions” (Lloyd and Scott, 1994). Several observations have been found that support the importance of previous experience, for instance Lawson, who calls it “knowing what might work” (Lawson, 2009). Consequently, if the designer has not worked on a topic in a project, there is less chance that he or she has knowledge about it. Although education provides an initial basis, the professional experience appears to account for the majority of the practitioner’s design knowledge. The practitioner’s experience comprises a wide range of topics; it can be considered the ‘archives’ of the designer, but is often difficult to quantify (what do they or don’t they know) or to describe outside a design situation. Schön (1983) draws a parallel to baseball and a pitcher who ‘just knows’ how to throw the pitches and how to adjust if necessary; knowledge that has been acquired through numerous practices and games. It is a distinct knowledge to the practitioner of a discipline, but difficult to define outside the project-situation (Schön, 1983).

Experience – experts

For this work, an expert is defined as someone with profound and approved knowledge within a specific field (by peers or by society), acquired through studies or long-time experience. Kirkeby found that design companies were positive to invite researchers to their offices to talk about their work, and potentially collaborate on topics (Kirkeby, 2012, 2015). In a series of interviews conducted by the Nordic Journal of Architectural Research with Norwegian architects, the interviewees similarly referred to enriching experiences from talking to researchers in person, for instance PhD-candidates giving a presentation of their thesis (Stoltz, 2010). It is interesting to note designers’ frequently observed preference for human ‘sources’ versus written sources when seeking information. Designers have been found to appreciate the possibility to ask questions directly, and to discuss the meaning of particular aspects of a study or a fact (Dubois et al., 2016; Kirkeby, 2012). This might facilitate relating the expert knowledge, for example research works, to their ongoing project and its context. Which in turn can help overcome the barrier of context-independent versus context-dependent knowledge (see below). Several works discuss the challenge of an adequate dissemination of scientific knowledge, for example towards practice (Tennøy, 2012). The findings from Dubois (2014) and Kirkeby (2015), indicate an opportunity to strengthen this by facilitating more direct interaction between research and practice. This is further discussed in Chapter 6 and 7.

Another important aspect of seeking out and employing expert knowledge is time. For designers, talking to an expert in person (e.g. a researcher) is seen as more efficient than first gathering the knowledge and then trying to understand it on their own. Having the researcher (or another expert) explain his or her work in person makes the knowledge more accessible and thus more attractive to the designers (Kirkeby, 2015).

> "We're trying to basically talk to people and find out. (…) I guess a lot of people have already done a lot of the research that you're about to do on a topic, so you're basically finding out the researchers – the ones that are knowledgeable in the topic – and jump some steps ahead."
>
> Quote from interviewee, Kirkeby (2012)

Scientific knowledge

In this context, scientific knowledge primarily refers to evidence-based literature produced by scientific research. Studies show that scientific knowledge, at least in the traditional forms of articles, reports, and books, is seemingly little used by practitioners (Dubois, 2014; Dubois et al., 2016; Eliasson, 2000; Kirkeby, 2015; Lawson, 2013; Skogheim, 2008; Tennøy, 2012); however, this is not necessarily due to ignorance or lack of interest. Several studies imply that practitioners are generally interested by knowledge from research, aware that it can strengthen their design in various ways (Dubois, 2014; Eliasson, 2000; Kirkeby, 2015). When designing a neighbourhood, applying research on how to cool down the area on particular warm days using vegetation and water sources is a way to assure climate adaptation. The barriers for seeking out and using research-based knowledge therefore seem to be more related to the means and manner of communicating such knowledge, rather than a lack of interest and investment from the practitioners (Eliasson 2000; Kirkeby 2015; Lawson 2013; Skogheim 2007; Tennøy 2012). The gap between research and practice has been problematized for several decades as it hinders exchange of knowledge and information (Dubois et al., 2016). One explanation can be found in context-dependent versus context-independent knowledge. While research aims at producing context-independent knowledge that can be generalized, practitioners generally seek out context-dependent knowledge; design projects are heavily related to and influenced by their urban context (Kirkeby, 2015). Another explanation can be found in the level of technical detail that often characterizes research-based knowledge. This can make it difficult for practitioners to identify elements that are relevant for their immediate needs (Dubois, 2014).

Non-scientific literature

These are written, non-scientific sources such as architectural and design magazines, various guidelines, legislative and regulatory documents, and so forth. Some are consulted for inspiration, for finding references and precedents. Others are consulted for legal reasons, or for technical information, such as geological reports.

Objects, contexts

This refers to what Cross (1982) and Kirkeby (2012) wrote about objet trouvé – the knowledge and understandings a designer can obtain from objects. For an urban designer, the site and its context represent such information; not written down, but contained in the physical and built environment context, and among the inhabitants and/or users of a site.

3.4 SOLVING WICKED URBAN DESIGN PROBLEMS

"Architecture is about the life that plays out, and that the building itself does not create but can make possible" (Kirkeby, 2012). The result of an urban development project influences not just the physical structures of a city or its technical functionings. It also impacts social relations and interactions between inhabitants, the social and economical functionings of a city, and more. According to Rittel and Webber there is no real beginning or end to urban planning problems, they are never solved, "only re-solved" (Rittel and Webber, 1973).

Jane Jacobs described a city as "an immense laboratory of trial and error, failure and success, in city building and city design" (Jacobs, 1961, p. 6). There is no blueprint on how to develop it. Every element, big or small, is connected and related to another in some manner, and interact constantly. Changing one facet of the city will inadvertently have an influence upon several others (Rittel and Webber, 1973). As a result, urban development has an inherent inertia[53], a certain 'slowness' that makes changes take time to properly manifest their influence upon a city: how a project changes from initial plans to the built result, its effects and consequences upon the city and its inhabitants (intended and unintended, felt and perceived), how a project influences and interacts with other parts and elements of the city's built environment, and so forth. This inertia is a result of several factors, such as the numerous actors that are involved, the size of the project, political decisions and processes that can be constructive or limiting, or the public's opinion. Conditions and premises for the project may also change along the way. All of this are elements that make it is difficult to predict the actual outcome of a design proposal and the constructed project, short-term and long-term. Additionally, the long-term effects are often only properly perceived after five, ten, or even fifteen years – another example of the inertia of urban development. Urban development is an ever-ongoing process (Rittel and Webber, 1973). According to Jacobs (1961), experimenting and learning through mistakes is the only viable and realistic approach to urban

[53] "The property that a body has that resists motion if at rest, or resists speeding or slowing up, if in motion, is called inertia. Inertia is proportional to a body's mass, or the amount of matter that a body has. The more mass a body has, the more inertia it has." www.grc.nasa.gov on The First and Second Laws of Motion, visited 31/01/2017

development. The savoir-faire of urban designers, as described by the previous subchapters, makes them particularly equipped to take on wicked problems.

3.4.1 Governing principles

Over time, a designer develops a set of personal design principles and paradigms, values, and beliefs – their governing principles. They complement the savoir-faire, but more personal. Lawson (1993) refers to them as the designer's "intellectual luggage". They include how a designer might consider a particular issue, or how he or she believes architectural and urban design should be done (execution, approach, relation to the user, etc.). Through a series of interviews with internationally renowned architects such as Santiago Calatrava, Lawson (1993) explored overall design approach and methods. He discovered that the designers all had embedded thoughts and beliefs about design, which conveyed how they considered the act of designing, or what are they believed to be the objective of design. Governing principles also express how certain aspects of a design project might be treated or worked in a project, illustrated by the use of walls in Mies Van der Rohe's Barcelona Pavilion, Barcelona, Spain. Lawson found that governing principles significantly direct a designer's work. At the same time, the governing principles are themselves nurtured by a designer's projects, developing them further. They "represent not only the ideals and values of the designer but a growing and authorative body of knowledge about how to realize those principles through design" (Lawson 2009 p.112-113).

3.4.2 A solution-based approach

3.4.2 a) **Framing the design problem, discovering what it really is**

The practitioner's strategy to solve urban development problems reflects their wicked nature. To gain a better understanding of the problem, its context, and possible implications for inhabitants, the practitioner explores the problem from different angles and scales. According to Rittel and Webber, *defining* the problem (identifying the difference between an observed and a desired condition) and *locating* the problem (where in the complex causal networks of the city the issues really lies) represents “one of the most intricate” tasks within urban planning and designing (Rittel and Webber, 1973). Schön (1983) uses the term *framing*, how to ‘see’ the problem. This determines, for example, which elements to consider, which aids he practitioner in going from a problem to a project.

Design problems “are often not apparent but must be found” (Lawson, 2006a), which can to a large extent be said to apply to urban development. An urban development initiative can spring from a city’s intention to develop parts of its land, for instance refurbishing of a neighborhood[54], or improving the design of a street or a public space. From an intention of development, a program (a brief) is established: the client’s command to which the urban practitioner must provide an answer in the form of a design proposal. The client’s design brief “presents a problem and a set of issues to be considered in resolving that problem” (Buchanan, 1992). However, it does not necessarily provide the practitioner with the ‘big picture’: how the intended development fits in with and will affect the physical and social context; potential social, cultural, and economic issues and needs, and so forth. To uncover and understand these aspects, the practitioner seeks to *define, locate,* and *frame* the problem. Wicked problems are a “knowledge rich activity”, meaning that more knowledge is needed to solve them than what is offered by the problem description, for example the client’s command (Lawson, 2013). Figure 19 is a summarized representation of an iterative urban design process, from a little defined design problem to a concrete design proposal. Primary generators and governing principles influence the generation of potential measures and solutions that are tested and evaluated with regard to the project as a whole. To do so the designer uses references, precedents, and rules of thumb. The assessment of potential design actions contributes to a better comprehension of the problem, and thus of possible solutions. External and internal constraints equally influence the design process.

[54] This work does not go in on the discussion surrounding gentrification. Here, ‘refurbishing of a neighbourhood’ refers to the city undertaking projects to ameliorate the area, for example by intervening upon the public spaces.

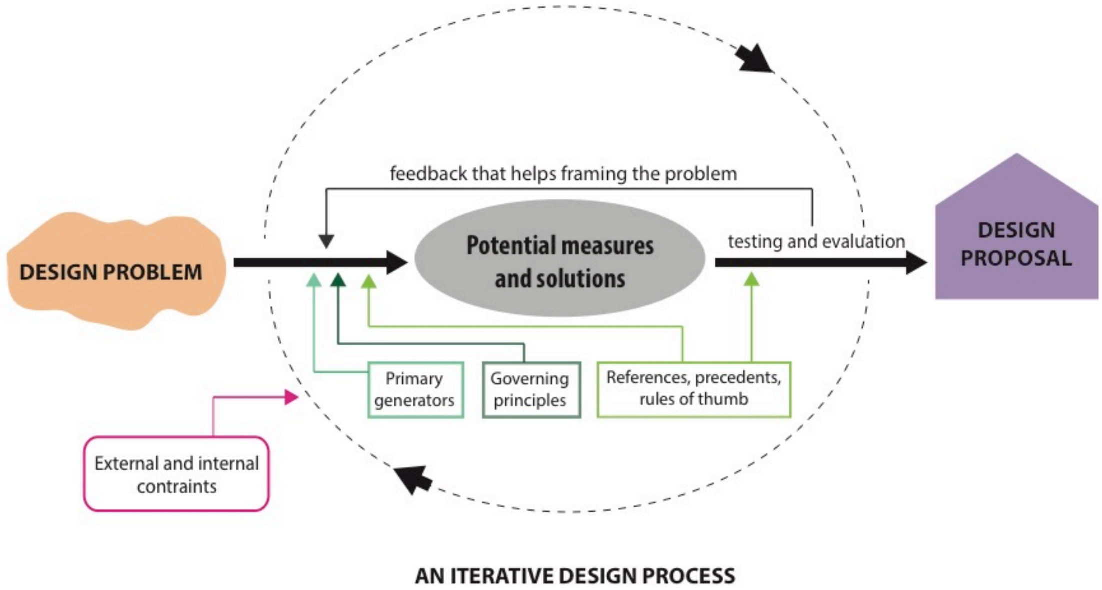


Figure 21 The iterative design process where a solution-based approach allows the designer to gradually frame the problem and develop a design proposal

The main manner in which the urban designer frames the design problem is through a solution-based approach (Lawson, 2006a). Urban development addresses a series of issues simultaneously. These wicked problems offer no straightforward method for solving them, and there are an almost unlimited number of possibilities and solutions. A common approach is therefore to advance by suggesting and testing potential solutions.

> "Wicked problems are the sort of problems where the information you need to solve them rather depends upon your ideas for solving them."
>
> (Lawson, 1993)

In order to get a complete grasp of the problem, practitioners "develop an exhaustive *inventory* of all conceivable *solutions* ahead of time" (Rittel and Webber, 1973). This approach is characterized as a 'solution-focused strategy (Lawson, 1979) as previously explained. The use of solutions to explore the depths and details of a problem is a distinctive trait of the design field. Through generating and testing potential solutions, the practitioners gain a better understanding of the problem and of interdependencies between elements and variables (Darke, 1979; Kirkeby, 2012; Lawson, 2006a). This allows them to go beyond the client's brief, identifying issues and aspects that can be important for the overall result and its impact upon a neighbourhood or a city. In a solution-based approach every solution that does not 'fit' further enhances the designer's understanding of the problem and gives further indications of what might work (Buchanan, 1992; Cross, 1982; Darke, 1979; Kirkeby, 2012; Lawson, 1979, 2006a).

Discovering the design problem through solutions suggest that the designer has an inkling of the direction in which to proceed early on (i.e. a designerly way of knowing). Several authors point towards an element of *recognition* as a kind of source for solutions (Cross, 1982; Darke, 1979; Lawson, 2009; Lloyd and Scott, 1994). Initially, the number of potential solutions is high. Throughout the process the designer leans on different elements to guide and structure the process. Having treated similar problems before makes it easier for a designer to choose potential solutions that are likely to fit (i.e. realistic conjecture), which demonstrates the influence of previous experiences. It suggests that recognizing the *type* of design problem at hand due to previous experiences provides a starting point for the process.

3.4.2 b) **References, precedents, and rules of thumb**

These are tools the designer relies upon in a design process to test and evaluate potential solutions, towards a final design proposal. The practitioners' knowledge of possible solutions builds over time, through various academic, professional and personal experiences. *Precedents*, *references* and *types* form an important part of this knowledge (Cross, 2006; Schön, 1988); previous projects – own or of others – that provide the designer with a basis for establishing potential solution to the problem at hand. The practitioner draws upon them for inspiration, using different pieces and elements either directly or in a transformed way (Kirkeby, 2012; Skogheim, 2008). This is an example of the savoir-faire Objet trouvé.

Rules of thumb are another example of the experience-based nature of the designer's savoir-faire. These are simple principles that allow the practitioner to rapidly evaluate the performance of a potential solution, estimate the dimensions for parking spaces or sidewalk, and so forth (Lawson, 2006b).

3.4.2 c) **Primary generators**

Another 'design tool' are *primary generators*, an interesting framework for describing the initial 'moves' in a design process that allows the designer (here: urban practitioner) to set out a potential course (Darke, 1979). Through a series of interviews with British architects, Darke (1979) identified a similar set of methods and approaches among the interviewees. In the beginning of a design process, they would establish a set of hypotheses that reduced "the variety of potential solutions to the yet imperfectly-understood problem". Darke calls this a set of *primary generators,* a tool which enables the designer to arrive at conjectures and estimates of solutions that might work for the design problem (Darke, 1979). The primary generators can be a group of concepts that gives the designer a way in to the design problem so that a potential solution can be explored. It is described as an "act of faith", or a self-imposed constraint by the designer, "a particular objective or a small group of objectives" the designer uses as an entry point to the design problem (Darke, 1979). However, they do not offer a complete solution or a clear view of the totality of the problem. The primary generator is based on the designers' subjective judgment. Darke underlines that the use of 'primary generators' do not apply to all architects. However, she writes that many architects use them (maybe even the majority), but without necessarily being aware of doing it. Lawson later concluded that primary generators are often based upon i) the governing principles of the designer, and ii) the different constraints of the design process (Lawson, 1993).

3.4.3 External and Internal constraints

In addition to the designer's savoir-faire and governing principles, a broad range of variables influences a design project – and the design process. Lawson (2006) classifies these as external and internal constraints. While these constraints may become limitations, the designer can also see/use them as a pathway to finding new possibilities for the project and the resulting proposal. For example, a project's energy consumption requirements can push the architect to explore different materials or may provide grounds to develop innovative design solutions. Lawson writes that "external constraints are not under the designer's control, they already exist and the designer must work with them," while "internal constraints traditionally forms the basis of the problem as most clients initially tend to express it (and) frequently comprise the majority of the brief" (Lawson, 2006b).

External constraints correspond to the many contexts of a project: institutional, physical, climatic, social, budgetary, cultural, historical, etc. Furthermore, the designer must take into consideration the needs of future inhabitants as well as current. Another constraint is the surrounding context, the neighbourhoods bordering the project-area. The practitioner does not control what the external constraints might be. However, he or she are generally in the position to decide *which* constraints to take into consideration, *how* to address and include them, and so forth. Thus the external constraints can be structuring or used as an inspiration in the design process, not just a restriction (Kirkeby, 2012; Lawson, 2006b).

Internal constraints consist primarily of the project's program (the client's design brief), in addition to the client's overall goals and objectives (Lawson, 2006b). Unlike external constraints, the designer has a limited choice as to which internal constraints to consider or not. Though they may be somewhat different or even contrary to the designer's own principles and values, the designer must often abide by them – at least to some extent. Significant differences between internal constraints and the designer's governing principles, or the design philosophy of an urban design firm, can be a reason not to engage in a project or respond to a design competition (Lawson and Dorst, 2009). In some cases, differences may only emerge during a project, and can be a source to conflict between client and designer(s).

3.5 Implications for empirical enquiries: A mixed-methods approach

3.5.1 Exploring tacit knowledge through the design project

Every professional discipline has its characteristics and particularities, for example typical traits of the practitioners, distinct professional skills, and so forth (Skogheim, 2008). Identifying and understanding these particularities is important when exploring a profession. For all experiments or investigations, it is essential to apply the adequate methods to obtain the best possible result. The previous sections provided insight into the professional savoir-faire and design practices from a theoretical perspective. Particularities and characteristics to take into consideration have been identified; the most important being the tacit or silent nature of the designers' savoir-faire (Eikseth, 2009; Schön, 1983). This signifies knowledge that can be difficult to describe or explain verbally to others. The person holding the knowledge – here the urban designer – "just knows it" (Schön, 1983). Generally learnt by practice and experience, tacit knowledge is often difficult to quantify. As a result, accessing and assessing tacit knowledge can be challenging. It requires the researcher to remain particularly open and attentive subtleties in what is said or done by the object of study (the practitioner); going beyond immediate observations to identify the savoir-faire behind a designer's actions or expressions. It also requires a thorough choice of enquiry methods, reflecting the tacit characteristic and other particularities.

> "If we want to understand the design process there are several research paradigms we can employ. We can analyze the task and propose logical structures and processes that we imagine must or should take place. We can observe designers at work. We can conduct laboratory experiments on designers. Or we can ask designers to tell us what they do."
>
> (Lawson, 1993)

Experience from design research has shown that the design project is a particularly interesting entry point for enquiries and investigations. 'Project' refers to the various operations a designer works on, ranging from minor street interventions to the refurbishment of an entire neighbourhood.[55] Project-work constitutes the main activity of most design practices. The section above furthermore showed how design projects are significant for the development of a professional, experience-based savoir-faire (Darke, 1979; Dubois, 2014; Kirkeby, 2015; Lawson, 1979, 1993; Skogheim, 2008). Focusing enquiries on the design project, as well as the designer's methods and approaches, allows the professional to simply describe what he or she does, rather than explaining it from a more analytical point of view. It is then up to the researcher to extract insight and understanding about the professional knowledge from the gathered material.

3.5.2 Choice of methods

A mixed-methods approach was employed for the empirical enquiries of the professional savoir-faire. Combining methods contributes to ensure the reliability and the validity of the results, reducing the overall influence of the researcher in the data gathering (Hellevik, 2011; Ryen, 2002; Van Campenhoudt and Quivy, 2011). Design research builds upon research traditions from several fields, for example Social Sciences. In the *Manuel de recherche en sciences sociales*[56], Van Campenhoudt and Quivy (2011) write that disciplines within Social Sciences can be considered empirical disciplines. They generally imply gathering and analysing "concrete data such as responses to questions asked in a survey, statistical data, information collected through interviews, documents produced by some kind of organisation (an business, an administration, or a newspaper), audio-visual or electronic documents, or direct observations undertaken within the living context of the studied people" (Van Campenhoudt and Quivy, 2011, p. 141).[57] This parallels the empirical methodology of this doctoral research.

[55] An urban designer might work on bigger city interventions too, but that is outside the scope of this thesis.

[56] *Manuel for research in social sciences* – translation by thesis author from French

[57] Translation by author from the original French version

Three main methods were employed: workshops, interviews, and a survey. A total of 149 practitioners were enquired (some possible overlap between survey and interviews). The methods are complementary, assessing the professional knowledge from different viewpoints (Hellevik, 2011). Additionally, combining methods gives access to a larger group of practitioners for a broader range of 'designer types'. The different methods can be summed up as follows:

SUMMARY OF METHODS EMPLOYED FOR EMPIRICAL ENQUIRIES	
Workshops	Observing what the designers do in a project, how they relate to particular topics, how they employ knowledge from different sources
Surveys	Exploring views and perception on particular topics
Interviews	Asking the designers what they do with the opportunity to follow up in situ

Table 10 Summary of methods employed for empirical enquiries

Each method has advantages and limitations, but in combining methods some of these can be evened out. Interviews offer the possibility to follow up questions in situ, to go in depth on particular topics, and adapt questions to the interview object and the interview situation (Van Campenhoudt and Quivy, 2011). At the same time there is a risk of the researcher influencing the interviewee's responses, for example through the manner in which questions are asked (Hellevik, 2011; Ryen, 2002). This is also a risk when conducting surveys, through how questions are phrased, possible answering options, the question order, to mention some (Hellevik, 2011). Moreover, as the researcher is usually not present during survey participation, the above elements must be developed carefully to avoid confusion, which can falsify the results (see 5.1). An advantage of surveys is the opportunity to enquire a larger number of people on the same topic. It is easier to obtain a good-sized cohort through surveys than with interviews, as it demands less interaction between the researcher and the respondent for each person enquired. The third approach, workshops, is rather flexible, and so particularly interesting in this context. Workshops can be organised in a series of ways, depending on the research objective(s), the targeted participants, the context, and so forth. One example is as a direct observation of people, with little or no participation from the researcher, thereby limiting the latters' influence upon the gathered data (Hellevik, 2011; Van Campenhoudt and Quivy, 2011). This is interesting for design research, as insights can be gained as much from what the design professionals *do* as from what they *say.* It is arguably difficult to obtain completely non-influenced data (by the researcher) when studying individuals and groups. A research situation (e.g. workshops, interviews) will always affect behaviour to some degree, but the researcher must strive to keep this to a minimum (Ryen, 2002). A different approach could be to observe practitioners without their knowledge, or under a different pretext. It was not considered an option in this context, in part because it raises a series of ethical questions not discussed further here (see Ryen (2002) for a more detailed discussion on this topic). The three methods inform each other during conceptualization (design of) and during analysis, through a constant iteration.

An interesting aspect of empirical explorations is the uncertainty of what might be found and observed. As with most research, the end-result is never entirely predictable; more so when studying people (here: designers). The researcher generally has a clear objective(s), but explorations tend to uncover supplementary aspects or elements of interest. According to Van Campenhoudt and Quivy (2011) this unpredictability is a fundamental aspect of empirical enquiries. The researcher must therefore "systematically and deliberately" engage in a notion of being open to surprising and unexpected results. This 'state of surprise' is particularly important when enquiring tacit knowledge. Examples of this can be found within the design research literature. Darke (1979) interviewed a series of British architects regarding a particular housing scheme in Great Britain. Through the interviews she detected a particularity of the design process that she later named *primary generators*: a way of generating ideas early on before the design problem is entirely comprehended (Darke, 1979). Another example is Lawson (1993), who undertook a series of interviews with well-known architects, asking them to describe their design processes and methods. The results uncovered what Lawson called the designer's *governing principles*, a set of personal design principles, based on personal values, experience, perceptions, etc. – the designer's 'intellectual luggage' (Lawson, 1993). They can heavily influence the practitioner's design approach and design decisions.

> "(…) construction and formalism of the [research] method must not be a means of isolation within a conviction, but rather a means to explore aspects of the studied phenomenon which *might* deviate from the initial intuition. Properly conceived, methodological constraints are not a 'straitjacket'; on the contrary, they compel the researcher to see what he did not think he saw. In order to be in a position of constant surprise, a systematic approach must be adopted that requires 'rummaging' in places and in ways that make the surprise not just probable, but likely." [58]
>
> (Van Campenhoudt and Quivy, 2011, p. 142)

About workshops

One way of exploring the Design and Method knowledge of urban designers could be to follow an actual project and its design process. This would require entering a project at the right time, and ideally be present at all times to observe all smaller and bigger developments. For research purposes, a much-used approach is instead to simulate design activities, creating situations where designers can be observed in action. Lawson (1979) is an interesting example of this. Students from Architecture and Engineering studies where gathered during a series of laboratory sessions, and asked to solve various problems. Lawson observed how the students approached and discussed the problem, how they intended to solve it, etc. This provided interesting insights into differences between architects and engineers with regard problem solving (Lawson, 1979). Another approach is design workshops, particularly well suited for working with design professionals due to their methodological flexibility (Dubois, 2014). As illustrated by the CapaCity workshops, this research method can be adapted to a format familiar to designers. Organized for instance as a design situation, they can be an efficient way to observe practitioners' methods and approaches 'in action'. This can help reduce

[58] Translation by thesis author from French

contamination of data; every research situation can influence participants' behaviour as discussed previously. A simulation will never be exactly like real life, but workshops offer a good alternative to an actual design project. People tend to be less aware of the on-going research situation during an activity like a workshop, than when sitting with a researcher face to face (Van Campenhoudt and Quivy, 2011). This can bring out different aspects of the object of study and their properties, here often tacit knowledge, which may not be as well accessed otherwise (Hellevik, 2011). Furthermore, it allows enquiring a group of professionals simultaneously, observing not only their design methods, but also their interactions with other each other.

The somewhat 'standard' format of workshops is to gather a group of people, often a particular segment of the population (e.g. urban design professionals), to discuss a particular topic (e.g. climate adaptation) or work together on something (e.g. a design situation). The activities are generally intended to make participants interact and discuss, a source to insights for the researchers. In a study aimed at better understanding the preferences and needs of the elderly with regard to walking, Krogstad et al. (2015) used workshops as part of the research methodology. In combination with a survey and participatory observations, the workshops were a means to explore the topic in depth together with the studied population (elderly people).

About interviews and surveys

Engaging designers to talk about their work, their methods, their experience, etc. through interviews, is an approach that has been used by several researchers with good results (see for example Eikseth, 2009; Kirkeby, 2012, 2015; Lawson, 1993). As Skogheim (2008) and Tennøy (2012 showed, a survey or questionnaire form another research method that can provide interesting insights into design practices. The added value of interviews lies in the possibility to follow up statements and answers in situ, while surveys enable the researcher to question a larger group of professionals on targeted topics or issues (at once) (Hellevik, 2011; Ryen, 2002; Van Campenhoudt and Quivy, 2011).

Hellevik (2011) writes that for surveys, the absence of the researcher during participation is an advantage; it can make respondents more at ease in answering, particularly on topics that might be somewhat controversial or socially unacceptable. This limits errors in the data gathering due to influence by the researcher or due to the researcher misinterpreting replies (a source for error during interviews or workshops). On the other hand, during an interview the researcher can explain a question, or stimulate a reply to a somewhat complex question. In a survey, these aspects can lead to respondents skipping questions or answering inaccurately (Hellevik, 2011). In interviews, contrary to surveys, there is less chance for the respondent being influenced by an external party (other than the researcher him- or herself) (Hellevik, 2011). In the context of this research, the latter was considered a less probable factor, as the survey topic was not controversial (to the extent of the author's knowledge). There would be less interest of, for example, company leaders attempting to influence survey participation.

CHAPTER 4

THE CAPACITY WORKSHOPS

4.1 PRESENTING CAPACITY

The doctoral thesis was written in the context of *CapaCity – from Concepts to Action*

The doctoral thesis was written in the context of *CapaCity – from Concepts to Action for a Proactive Adaptation of Cities*. The project ran from July 2014 to July 2017, and was an international research collaboration between the Laboratoire de Recherches en Architecture (LRA) at the Ecole Nationale Supérieure d'Architecture de Toulouse (ENSA Toulouse), France, and the Centre de Recherche en Aménagement et Développément (CRAD) at the Université de Laval, Québec, Canada, in addition to the Institut de la Ville, and the professional organization of urban planners in the Midi-Pyrénées region, Association des Professionnels de l'Urbanisme de Midi-Pyrnénées (APUMP). The project was funded by the French environment and energy management agency, ADEME.

The overall objective of CapaCity was to strengthen climate change adaptation of cities through urban development. Increased use of scientific knowledge by urban practitioners in projects is essential to for sound adaptation efforts; which in turn necessitates an enhanced knowledge transfer from research to practice. As a contribution to this, CapaCity developed a prototype design-aid tool directed towards urban practitioners, i.e. architects and landscape architects, urban planners and designers. The focus was on knowledge dissemination, making the large body of research on urban adaptation more available to practitioners. Findings and observation from the thesis results were implemented in the final tool. An essential criterion was to create a tool that responds to the actual needs and requirements of practitioners. Despite the many tools and guides that exist, there is a lack of implementing evidence-based knowledge in design projects (Bonhomme, 2013; Dubois, 2014). As explained in chapter 3, own experience (or that of colleagues) remains the primary source of insight. Knowledge transfer from research to practice is a long-term challenge; several studies relate this to how scientific knowledge is presented and communicated to practitioners (Dubois, 2014; Eliasson, 2000; Kirkeby, 2012). Tools and guides for urban climate adaptation (and mitigation) are often criticized for producing data that are too general or too technical, being too complex to use, etc. In addition, they are often expensive to acquire. All of the above are significant barriers that weaken the implementation of scientific knowledge in urban planning and design practices. Consequently, the first phase of CapaCity explored the practices and methods of urban designers. The objective was to assess i) the current knowledge status among practitioners with regard to climate change adaptation through urban development, and ii) how they consider, seek, and apply knowledge from different sources in a design process. This was done through a two-fold study: an online survey, held from February to April 2015 among practitioners in the Midi-Pyrenees area, and workshops in Toulouse, France, in May and June 2015. These empirical enquiries were combined with a literature review of design research, which was further detailed for this thesis work as presented in the previous chapter. Based on findings from the enquiries, CapaCity was created as an online tool. The following is a brief presentation of the tool, a more detailed explanation can be found in Chapter 7. The CapaCity tool is based on a typical design process, which tends to be iterative with some distinct phases: diagnostic (site analysis), programming, and design. It is intended to be integrated into existing design practices; a guide to identify the adaptive potential of a site, and to assure the implementation of adaptive solutions and measures. The enquiries showed that current design practices has an adaptive potential, there are several win-win opportunities with frequently applied solutions and measures. However, this potential appears somewhat overlooked by practitioners; for example, adaptation did not seem to be a concrete design objective, in part due to a lack of awareness of adaptive possibilities. CapaCity aims for adaptation to become an implemented part of the holistic, solution-based approach of urban practitioners, rather than an additional burden – which it can often be perceived as. Emphasizing interdependencies and win-win potential between current practices and adaptation topics is one means to achieve this. Furthermore, CapaCity has a clear, educational aspect, targeting the 'learning by doing'-approach of practice. Further description of the CapaCity project and the prototype tool can be found in Dubois et al. (2016), and Bonhomme et al. (2017).

Figure 22 Screen shot of the CapaCity tool (front page) with the logos of the collaborating institutions as well as ADEME

4.2 DESIGN AND EXECUTION OF THE WORKSHOPS

The workshops were organized in the context of the CapaCity research project. Research members from the University of Laval (Canada) designed the overall set-up, later further developed and locally adapted in collaboration with the team in Toulouse (France). While the whole team contributed to their execution, the researchers at the University of Laval and doctoral researcher undertook the main analyses of the observations and recordings from the design game. For the doctoral thesis, the CapaCity workshops provided initial insights into design practices and knowledge with regard to daily mobility, and its role in a design process. As such, they served as exploratory enquiries that contributed to establishing working hypotheses for the following investigations (survey and interviews). At the same time, the workshops were used as a source for insight in their own right, not merely as a foundation for the next phases.

Organization

The workshops took place in May and June 2015, with a total of 18 participants (6+12). Their design took into account the project's research objectives, as well as particularities of urban design and urban design professionals, as previously explained. The CapaCity research team counted five architects and planners with up to 15 years of experience, which provided a relatively broad perspective. The workshops had three phases: i) a one-hour plenary course on how to achieve climate adaptation of cities through urban development; ii) a two-hour design game where the workshop participants undertook a concrete design project; iii) plenary restitution of results, followed by a discussion on the use of scientific knowledge and design-aid tools in urban design projects. A two-hour design game was the main activity, a simulation of a design process at the neighbourhood scale where participants had to establish a design proposal for the refurbishment of a neighbourhood close to the centre of Toulouse. The CapaCity team aimed at observing the designers in action, in order to access the tacit aspects of the professional expertise. The design game is the workshop-part further explained and developed here.

Participants

The workshop participants came primarily from the urban design fields Architecture, Landscape Architecture, Urban Design, and Urban Planning. Three of the participants teach at the Toulouse School of Architecture (ENSA T) or at the University of Toulouse (section Jean Jaures) in addition to their professional practice. Their ages range from 25 to 60+. They work on various geographical scales, from buildings to regional, with a relatively even split between private and public clients.

Educational background	Workshop 1	Workshop 2
Architect	1	7
Architect and urban designer/planner	1	1
Urban designer/planner	2	
Engineer	1	1
Geobiologist specialized in urban development	1	
Architect, teaching at ENSA T		1
Sociologist and Professor at the University of Toulouse		1
Landscape architect, teaching at ENSA T		1
Total	**6** (2M, 4F)	**12** (8M, 4F)

Table 11 Workshops participants sorted by profession, M = male, F = female

The design game

The chosen neighbourhood, la Cité Blanche, is part of Toulouse's densification strategy Figure 25. Today, Toulouse is a sprawling city. The project site measures 500m x 500m, and the number of dwellings are to increase from 100 to 400, with parking limited to 0,5 per dwelling (200 places). The refurbished neighbourhood is to be exemplary with regard to energy and water consumption. As activities and services are being developed around a nearby metro station less than 1km away, the client (Toulouse Métropole) does not aim for a mixed use-development. Over a longer period, la Cité Blanche has experienced so-called social challenges of varying nature, such as a high level of unemployment and different kinds of crime. Together with the rather unsanitary state of current dwellings, this contributed to the city's decision of urban renewal. For the purpose of the CapaCity workshops, requirements with regard to climate adaptation were strengthened, in particular tackling and preventing Urban Heat Island-effects.

Moreover, the design proposal had to include at least one public place of high design quality, as well as infrastructure for pedestrians and cyclists.

For the design game, the CapaCity team organised the participants into predefined groups of 3-4: two groups for the first workshop, three groups for the second workshop. Each team had a facilitator (a CapaCity member) to guide the activity if necessary, and to answer general questions about the task. As initial information the groups were given a plan of the site, aerial photos, and other photos of the site, in addition to basic information about the site and its surroundings (existing activities, services, demographic of current inhabitants, etc.). A SketchUp-model[59] of the site had been prepared and was available to all groups if they wished to use it. The game-maker was also a CapaCity member. She managed the game, kept track of time, made sure the groups all advanced as necessary, etc. The game-maker had a set of joker-cards that could be introduced to a group at any time, altering the design situation in an unpredictable way, as often is the case in projects. These included (non-exhaustive): a requirement to produce 50% of the energy locally; inhabitants protesting the instalment of solar panels on buildings; 100% of all rain-water to be collected on the site. The joker-cards were also a manner in which to assure a continuous activity, in case one of the groups got blocked somehow in their design activity.

The groups also had a set of playing cards that gave access to a variety of tools (in a broad sense), in accordance with the objective of observing the use of tools and knowledge in a design process, as well as the kind of information the designers might seek. The card represented often used, or assumed often used, in design processes. With the design cards the group facilitator could keep track of employed tools. He or she was also responsible for observing its use, e.g. which kind of information the players/designer sought from experts, which kinds of Internet-sites they consulted. The following sums up the playing cards:

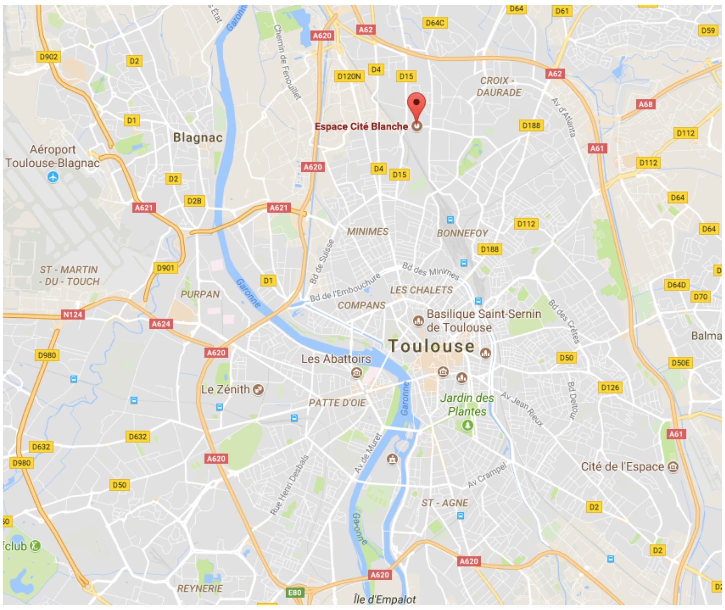
[59] A simplified 3D-model

SUMMARY OF DESIGN GAME CARDS	
Technical or technological resources (3 cards)	Computer tools such as ArcGIS, ArchiWizard and other simulation tools; Internet; Design guides and technical regulations; etc.
Human resources (2 cards)	The groups could consult a number of experts from fields such as Energy, Mobility, etc. These were CapaCity members with expertise in the field, and each cards provided a 10-minute consultation.
Information from the client (1 card)	A representative from the city was present, and the cards provided 10 minutes to ask her questions about the site and the project

Table 12 Summary of the design game cards

Figure 23 Workshop participants during the design game, photo by author

Figure 24 Design proposal with explanatory post-its, unused cards in the lower left of the picture, photo by author



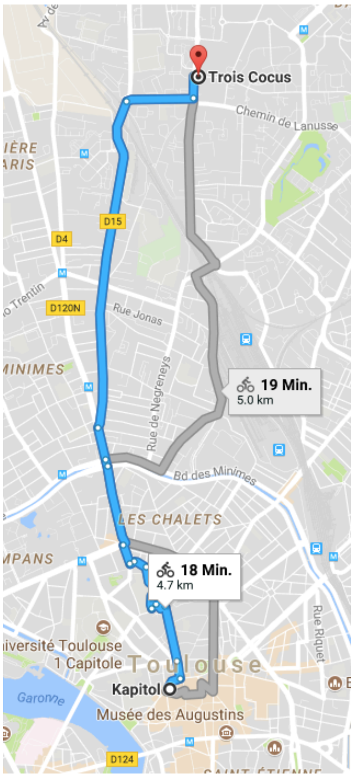
The Cité Blanche (red pin) is located North of the centre of Toulouse

The Cité Blanche in its present stage,
awaiting new development

The Cité Blanche before refurbishment (1)

The Cité Blanche before refurbishment (2)

The Cité Blanche before refurbishment (3)



The Cité Blanche is a 20 minute bicycle ride (approx. 5km) from the centre of Toulouse.
Trois Cocus is the nearest metro station, less than 1km away.

Figure 25 Location of the neighbourhood Cité Blanche, the project site for the design game; pictures of the neighbourhood before refurbishment (source: Google Maps and Street view

4.3 A CONTENTS ANALYSIS

The main activity of the workshops was the design game. Each group was filmed and recorded, which the thesis author and the researchers from the University of Laval later transcribed. These transcriptions, in addition to notes and observations during the design game, form the basis for the following analysis. The researchers undertook two series of analysis. In the context of the CapaCity project, three topics were explored: climate adaptation; sources for knowledge; use of knowledge. The doctoral-analyzes focused on mobility and its role in a design process. The design game transcriptions read as elaborate discussions on designing neighbourhoods (how to, what to do, etc.). Consequently, methods for analysing of interviews were applied for the CapaCity analyses. An iterative contents analysis was chosen, as described by Van Campenhoudt and Quivy (2011) and Ryen (2002).

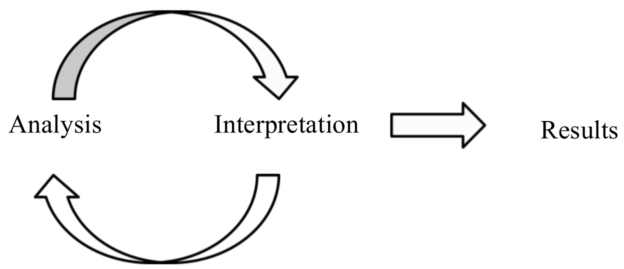


Figure 26 Iterative loop between analysis and interpretation

In an iterative process, actions (for example analyses) are repeated a number of times, depending on the data and the findings. This allows exploring the data further in depth, discovering aspects that are less apparent upon first or second lecture. As this approach proved efficient and productive for the workshops, a similar method was applied for the interviews (see 5.2). An analysis-framework was developed combining pre-defined categories and hypotheses (from research literature) with a grounded theory-based approach. The latter is a methodology from within social sciences, developed by Glaser and Strauss in the 1960s, often referred to as an experience-based theory (Ryen, 2002; Van Campenhoudt and Quivy, 2011). It is an inductive method where the analysis framework – what to explore, hypotheses, etc. – is derived from the gathered data. The researcher approaches the material without established categories and questions; rather, they are developed progressively as the lectures advance. Initial lectures of the gathered data establish preliminary categories – codes. Through new rounds of analysis, these codes are synthesised and further developed, finally producing concepts and/or ideas upon which conclusions are drawn (Ryen, 2002). In comparison, a more deductive approach involves the researcher starting of with a series of predefined hypotheses that he or she aims at confirming or refuting (Ryen, 2002). In the first round of analysis the gathered data (here transcriptions) is coded into predefined categories based on the analysis framework. These tend to be hypotheses or questions to explore. Additional categories are added if necessary throughout the analyses. For CapaCity, the coding consisted of identifying ideas, concepts, and other elements that corresponded or related somehow to the predefined categories. New rounds of analysis are undertaken, revisiting the original material, while simultaneously synthesizing and reducing the coded categories; combining some and adding new ones. The aim is to gradually identify key concepts and ideas that provide insight or answers to hypotheses and questions from the pre-established framework. The number of iterations depends on the material, the researcher, and the time frame.

CapaCity analyses

The analysis framework for the workshops was developed through initial lectures of the transcriptions, as well as elements from design research literature, in particular Cross (1980), Darke (1978), Kirkeby (2012, 2015), Lawson (1993, 2006), Schön (1983), and Skogheim (2008) (see Chapter 3). CapaCity's overall research objective formed the basis for the analyses. At the same time, it was important to remain open to the 'element of surprise' as explained by Van Campenhoudt and Quivy (see 3.5), as the object of study was the tacit knowledge and the practices of urban design professionals. The iterative aspect contributed to this; the different analysis questions and hypotheses were explored in several rounds to capture the more 'silent' elements of the professional savoir-faire. The analyses used Microsoft Office software such as Word and Excel. They focused on: i) kinds of, and sources for, the knowledge used in the design process, ii) elements that influenced the process and/or shaped the design proposal, and iii) the nature of applied design solutions and measures.

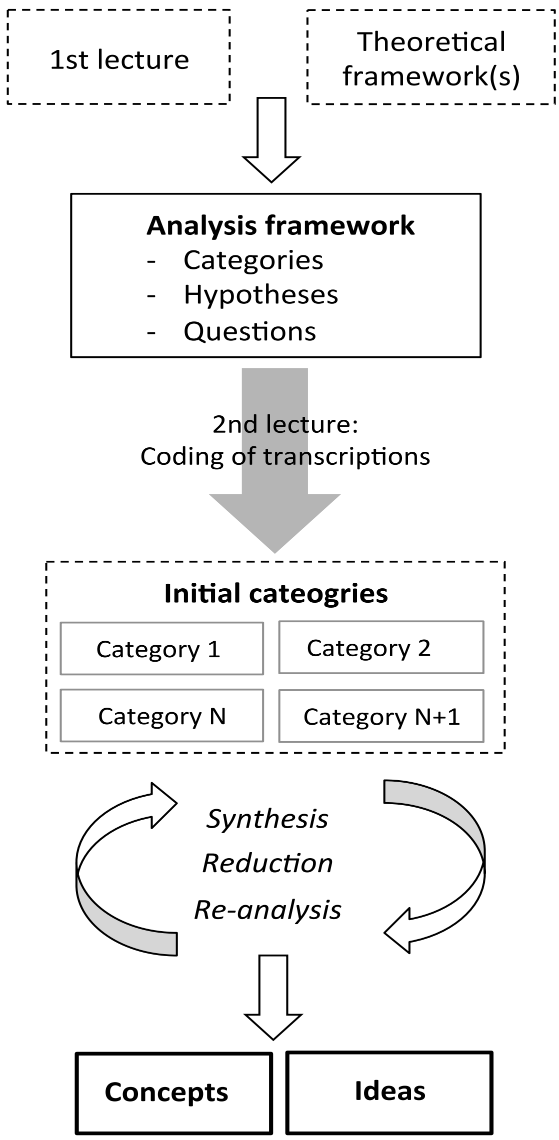


Figure 27 An iterative analysis method

Thesis-analyses

The thesis-analysis explored the role of mobility in a design process. A similar context analysis was undertaken, establishing a framework in the form of open questions (see below). The aim was to explore how mobility is solved within an urban design project, and how the designers consider and regard mobility, especially in relation to other issues within a design problem. These questions helped identifying overall tendencies, and provided an initial comprehension of how urban designers work with and solve the issue of mobility.

FRAMEWORK FOR THESIS-ANALYSIS	
1.	How is mobility solved in the design process? a. Is it given a high priority, or is it rather a consequence of other choices? b. How is it considered in relation to other issues and objectives in the project? c. How are design choices situated within the context of the city's mobility network? d. Do practitioners consider how their design might affect mobility behaviours (modal choice, etc.)?
2.	Which design solutions are employed?

Table 13 The framework for the thesis-analyses

The thesis analysis identified tendencies and topics that formed the basis for a series of working hypotheses regarding the role of mobility in a design process, and how daily mobility is influenced by and influences urban living contexts. These hypotheses were then used for the development of the survey and the interview guide.

4.4 OBSERVATIONS FROM THE DESIGN GAME

4.4.1 The design process in general

The following is a synthesized description of findings from the CapaCity workshops. It is organized around four main observations focusing on design methods and the design process. (see below). A more in-depth description and analysis on these topics can be found in Dubois et al. (2016).

Although a simulated design situation, the designers engaged fully in the task. In discussions following the design game, several of the participants said the design session had been a relatively realistic experience. They reported that their approach and the applied design methods largely corresponded to an actual urban design project despite the limited time and simplifications. Moreover, they were pleasantly surprised at the amount of detail they had achieved despite the limited time. Throughout the activity all four kinds of savoir-faire were observed, with Design savoir-faire particularly in use. The designers knew how to manipulate the built environments of the site, how to successfully introduce new structures, how to exploit the qualities of the site, etc., in order to produce a design proposal that corresponded to the project command as well as own design objectives. Interestingly, all five groups ended up with quite different project proposals despite working on the same site and with the same project command. This is similar to experiences from, for example, architectural studies, where design studios are a typical educational method. Students working on the same site often produce highly different project proposals, illustrating one aspect of the wicked nature of urban design problems: there is no 'one right solution' (Rittel and Webber, 1973). It depends in part on which objectives and priorities are emphasized, how the site and its needs are interpreted, how the problem is framed, etc. Which in turn shows the level of interdependence and interreliance between elements and aspects of a city – at all geographical scales (Jacobs, 1961; Rittel and Webber, 1973; Tennøy, 2012).

4.4.1 a) **A holistic, solution-based approach**

All of the groups appeared to follow a similar method for tackling a project: a solution-based approach based primarily on own experience, as described in Chapter 3. It started with a combination of a site-analysis and a discussion of conceptual solutions, through which the designers explore the problem in a bigger context, and identify potential opportunities and challenges for their future design proposal (Darke 1979; Kirkeby 2012; Lawson 2006). Here the practitioners explored various aspects of the site, its urban context (physical, social, economical, etc.), its history, its uses (e.g. movement of people, various activities or lack there of), and so forth. The aim was to gain knowledge and understanding of the site, its inhabitants, and its relation to the surroundings – part of what design literature refers to as *framing the problem*: going beyond the project command to discover what the problem really is (Lawson and Dorst, 2009; Schön, 1983). Analyzing the site was an important step towards this, allowing the professionals to form an impression and an understanding of the site. In the CapaCity workshops, the site-analysis exposed the site's physical and social isolation. The former was primarily due to major traffic arteries bordering its limits, the latter in part to unemployment and crime. This became part of the 'actual problem' for several of the design groups: how to re-integrate the neighbourhood and its inhabitants in its urban context while contributing to enhanced social capital.

Identifying the 'core' problem(s) of a project is important in order to achieve the common, 'global objective' for urban design: creating a good living context for urban inhabitants (Gehl, 2010; Madanipour, 2006). This aligns with the 'holistic approach' of urban designers to a design problem: an overall, wholesome approach that constantly considers – and takes into account – the totality of a problem with its many facets and interconnections. The notion of 'holistic' remains important within urban design, as it illustrates a typical view and understanding of the city as a system of interdependent elements and variables (Carmona, 2010; Gehl, 2010). During the workshops potential solutions and design decisions were constantly evaluated in this regard. The designers explored how a solution would work in itself, how it would influence other solutions, and, most importantly, how it would influence the project as a whole – i.e. its influence upon the neighbourhood as an urban living context. Which demonstrates Design savoir-faire as well as Technical savoir-faire. The designers furthermore displayed knowledge and understanding of interdependencies between the different elements in an urban development project. How the elements' interactions could affect the overall outcome was always taken into account.

The site analysis was followed by the exploration of potential solutions, and how they might influence the project (see above), providing the designers with a gradually deeper understanding of the design problem and its interdependencies. All groups, during both workshops, discussed potential solutions within the first 15 minutes (then in parallel to the site analysis). It was often done as a sort of thought-experiment, following a series of hypothetical questions *"if this then that…which can lead to…meaning we would have to…it could allow to…but then that must be in place too…"*. An approach somewhat similar to what Tennøy (2012) calls *professional reasoning.* At times new solutions made the designers re-evaluate previous decisions, adjusting them or even discarding them depending on the recent design developments. Exploring possibilities contributes to discovering and framing the design problem, and to understanding the project site and its uses; little by little establishing a design proposal that fulfils the global objective of creating good living contexts for current and future inhabitants.

4.4.1 b) **Establishing a design framework to guide the process**

The design process gradually evolved to more concrete design actions where the designers explored potential solutions. The level of detail also evolved, from structural and conditioning elements (e.g. primary orientation of buildings, organization of movement within the site, connections to surroundings) to issues of a more specific nature (e.g. the width of a street, building materials). This took place as the kind iterative process described before, where the practitioners tested and explored potential solutions as a means to comprehend the site; establishing its possibilities and its limitations, in line with Lawson's descriptions of external and internal constraints. Determining these included several round of discussions, the designers often landing on compromises. The common objective of an improved living context (governing principle), together with the client's command (internal constraint), seemed to be a unifying element. In the workshops, these constraints, together with the designers' governing principles, appeared to form a sort of design framework: a set of 'rules' upon which the practitioners agreed, and which guided their work throughout the design game. It also helped the designers keep track of previous decisions and choices as the project evolved. All five groups had this in common. Establishing a design framework was not done in an outwardly expressed manner, i.e. "we need to establish a design framework". Rather, it seems to be a part of the Methodological savoir-faire of urban designers, and an example of their tacit knowledge. They 'just know' that this is something that will facilitate and further a design process.

Governing principles are a personal characteristic of each practitioner; differences in these could also lead to discussions. Again, the somewhat global objective proved a unifying element. The extent and importance of a designer's governing principles appeared to be related to his or her age and/or level of experience. The governing principles of the younger practitioners seemed less set, and so less of a design foundation than those of the more experienced practitioners. The latter formed many of their design choices and judgments upon their governing principles; a relatively dictating element together with the established design constraints.

4.4.1 c) **Win-win solutions that are potentially adaptive and mitigating**

Potential solutions, and how they would affect the design proposal as a whole, were a significant part of the design process, as detailed above. A common factor was their *win-win nature*: solutions that address and potentially solve several issues at once. This can be seen in connection to the overall holistic approach of the urban designers, i.e. a constant focus on the project as a whole, and how potential solutions influence it. In the workshops, the designers tended to privilege solutions with the capacity to address multiple issues and aspects simultaneously. One group decided that the buildings on the western edge of the site should be arranged as a 'comb', i.e. several thin bars oriented East-West. This would open the façade to the road bordering the site at this edge, thereby allowing for visual and physical connections to surrounding neighbourhoods (creating urban design qualities such as permeability, transparency, connectivity). Furthermore, this ensured that the façade most exposed to the sun (West) would be one on the smaller facades, and allowed for all-through apartments[60] oriented North-South – optimal for a passive-energy strategy and natural ventilation. Similar win-win objectives were observed for smaller solutions as well.

The observed win-win solutions often had an adaptive or mitigating potential, though this was seldom identified by the designers. Whether this was due to lack of knowledge or lack of focus among the designers is difficult to establish; either way it was not an aspect the designers dwelled upon. It is, however, an aspect to further explore and build upon, as it would be easier to enhance adaptation through urban development if designers perceive it as complementary to current practices.

4.4.1 d) **Sources for knowledge and insight**

Finally, with regard to sources for knowledge and insight, the practitioners prioritized human resources: first and foremost, experience-based knowledge, their own or that of their group colleagues; secondly, the experts and the representative from Toulouse Metropole (client). This corresponds with Kirkeby (2012), Dubois (2014), and others, found that own experience is the primary source of knowledge for design practitioners. Furthermore, when consulting evidence-based knowledge there was a clear preference for discussing with experts and researchers in person. Occasionally, the design practitioners also used the Internet, for example, to explore historical maps of the site. Two groups explored more technical design aids (modeling and simulation, GIS), but both were somewhat negative about this due to the apparent complexity and their lack of the necessary skills to rapidly learn the programs and interpret the results.

[60] ‘All-through’ means apartments that go all the way through a building, and have windows on each side, for example in the direction Nord-South, or East-West.

4.4.2 The role of mobility in the observed design processes

The workshops analyses for the doctoral thesis focused on the role of mobility in a design process, here illustrated by the design game. The analyses explored how the designers approached mobility, how they solved it, and how they related it to other issues or objectives.

- Mobility was evoked early in the design process
- Mobility was central in the holistic, solution-based design approach
- Mobility had a structuring role
- Mobility seemingly considered primarily within the context of the site

4.4.2 a) **Mobility was evoked early in the design process**

Mobility within the site – internal circulation – was an important issue during the initial design phases. In the site analysis the designers located main axes for circulation, studied how the circulation flowed within the existing structures, identified existing and potential connections to surrounding sites, nearby transit stops, and so on. Discoveries from these analyses helped identifying and/or understanding other issues. In line with the holistic approach described above, challenges regarding mobility were often related to other issues such as lack of social cohesion (e.g. an isolated site with few internal meeting points) and the inhabitants' sense of lacking security (e.g. little frequented streets, lack of sidewalks).

Addressing mobility at an early point furthermore appeared to establish premises for potential design choices later in the process. Collective parking solutions at the entrance of the site liberated public space within the site, which in turn created a design potential that could be used in numerous ways. For example, the area could provide larger sidewalks with planted trees or community gardens along a street, depending on which issue(s) or objective(s) the designers chose to address. In general, the gained space was in this case used to heighten the quality of the public space, as a means to invite and encourage more people to be 'out in the street'.

4.4.2 b) **Mobility in a holistic, solution-based design approach**

A holistic design approach with win-win solutions was equally observed in relation to mobility. Though often addressed individually, mobility was generally seen as closely related to, and influential upon, other issues; moreover, as important for achieving the global objective of an improved living context. Urban qualities expressed as important in relation to daily mobility – *porosity, transparency, visibility,* and *openness* – are the same as those highlighted for generating "a neighbourhood feeling" (Participant 11). Which in turn is essential for creating a good living context according to the designers.

In line with the objectives of the client, most groups prioritized pedestrians and cyclists over cars. Several therefore aimed for a "permeable urban fabric" (Participant 2). This enabled them to create a range of formal and informal paths and connections through the site and towards surrounding neighbourhoods. Additionally, this was said to help "reduce walking and cycling distances" (Participant 1). Conversely, the designers avoided creating big building blocks with continuous facades that would present physical barriers. This demonstrates an example of how mobility choices might influence the urban structure. Traffic-calming measures such as narrow streets were introduced, and groups often opted for collective parking solutions at the limits of the site. The latter was also done to "save public space" (Participant 4) by not having onside parking (see above). One group used the placement of community gardens (demand from inhabitants through a joker-card) as a traffic calming measure, and situated them along one of the major streets bordering the site.

Increasing the number of people in the street was highlighted by the practitioners as enhancing the feeling of safety in public realm. Encouraging pedestrian activity was furthermore seen as a means to achieve this, as well as social cohesion or capital. The latter was linked to the possibility for random encounters and exchanges, created by 'forcing' people to move through public realm on their way to and from the dwelling. Prioritizing pedestrians and cyclist seemed to be motivated by the designers' governing principles as much as by the client's wishes. However, while the client (Toulouse Metropole) had environmental ambitions, the designers were more focused on living context aspects as described above. An apparent, although unspoken, objective was to design an environment that was experienced as pedestrian-friendly and car-unfriendly. Trees and other vegetation provided a measure to protect buildings from the sun (reduce energy consumption). Additionally, this could protect pedestrians and cyclist from the weather (sun and rain), as well as contributing to the aesthetic experience of the neighbourhood – i.e. a win-win solution that joined various objectives.

Interestingly the teams frequently employed similar measures and solutions regarding mobility. This is somewhat contradictory to previous observations of 'no one solution to a problem'. Indicating perhaps, that for movement through public space – the organization of circulation in an urban area – there is to some extent a general design savoir-faire on how this is best done.

4.4.2 c) **Mobility had a structuring role**

Mobility was used as a constructive element in the design process, presenting both internal and external constraints to take into account. As explained previously, constraints were used to establish a sort of design framework; internal constraints being largely imposed, external constraints more optional. Moreover, certain needs and functions must be respected, such as access for emergency vehicles, or the number of parking places demanded by the client (although to some extent subject for negotiated in projects). The frequent choice of prioritizing pedestrians and cyclists, while parking cars at the entrance of the site, established important premises for the subsequent phases as it both eliminated and created certain mobility requirements. It provided more public space, but simultaneously obliged some dwellings to exist a short distance from the parking structure for future inhabitants with potentially reduced mobility capacity.

Design-decisions regarding primary axes for internal circulation established the initial structure of the site. A secondary layer of smaller streets and paths further developed the site's urban fabric. The latter was often done in parallel to exploring possible orientation of buildings, and it is difficult to say which element actually defined the other. Rather, the results seemed to be based on an evaluation of a series of options that each presented different advantages and disadvantages; an example of the solution-based design approach.

4.4.2 d) **Mobility primarily considered within the context of the site**

In the CapaCity workshops, the designers seemingly related the question of mobility to organization of the internal circulation, rather than to the daily mobility of inhabitants (e.g. getting to and from work). They focused on movement within the project site, and on existing and potential connections to surrounding neighbourhoods (mostly related to social isolation). Influencing inhabitants' mobility behaviour for daily travels outside the neighbourhood, however, was not really discussed; nor did the participants seek to situate and/or connect the neighbourhood to the mobility network of Toulouse. Only one group discussed creating an easy and inviting access to the nearby metro station and bus stops in order to encourage the use of transit.

This was a somewhat surprising observation, especially as the urban context of the site remained a very important notion in the design process. Several groups underlined the importance of integrating the neighbourhood in the city of Toulouse by re-establishing physically and psychologically links. Yet, how their design would (and could) influence the daily mobility of current and future inhabitants was not discussed in this context, at least not in an expressed manner. It is difficult to determine the reason for this, but two possible explanations stand out: i) the design game being a simulation; ii) daily mobility not seen as part of urban designer's domain. The design game was a hypothetical and restricted design situation. The lack of time and the simplifications can have contributed to the participants having an exaggerated focus on the site in itself, excluding aspects they might normally accord more importance. Perhaps the influence upon daily mobility would be evoked at a later stage, when the design proposal is more concrete? Another explanation could be that the designers do not see inhabitants' daily mobility behaviour as being within their 'action field', nor their responsibility. The traditional separation between transport and land use planning largely remains within urban development, despite efforts of implementing an integrated approach (Aguilera et al., 2013; Tennøy, 2012). This can lead to design practitioners perceiving daily mobility as something they have limited possibility to influence. Issues perceived in such a manner can easily become less prioritized in a design process (Dubois, 2014; Eliasson, 2000; Tennøy, 2012). The explanation(s) is likely a mix of the above, in addition to other, individual reasons. However, it opens some interesting questions with regard to urban design as a mobility-mitigation strategy, to be pursued in the following enquiries.

4.5 WORKING HYPOTHESES BASED ON OBSERVATIONS

The CapaCity workshops lead to a series of working hypotheses, which were explored through the subsequent interviews and survey. These hypotheses centred on: 1) the role of mobility in a design; 2) practitioners' savoir-faire regarding urban mobility; 3) urban design as a mobility-mitigation strategy.

WORKING HYPOTHESES BASED ON OBSERVATIONS	
The role of mobility in a design process	▪ Mobility is a central and structuring elements that strongly influences how the project evolves. ▪ Mobility – how people travel within and out of a site – enables designers to better understand the site, its urban context, and the overall design problem at hand. ▪ Mobility is seen as directly related to the quality of urban living contexts: it both influences and is influenced by the built environment and its urban qualities. ▪ Mobility can be both a function and a means. As a function, people's possibility to move around freely must be highly operative; as a means, how and where people travel can help address and potential solve other issues.
Practitioners' savoir-faire regarding urban mobility	▪ Urban designers know how to analyze and comprehend people's travel habits and needs by interpreting circulation patterns, the occupation of public space, uses of a site, and so forth. ▪ Urban designers know how to address and act upon mobility through built environment measures and solutions. ▪ Urban designers know how to design environments that favor and provide pleasant experiences for pedestrians and cyclists.
Urban design as a mobility-mitigation strategy	▪ Mobility actions, measures and solutions observed in design processes have a mitigating potential. They can facilitate or limit certain mobility behaviours, which in turn can promote sustainable mobility choices. ▪ This potential appears either ignored or not recognized by the designers. They are aware of the influence of design decisions upon mobility behaviours, but do not seem to actively promote zero-emission mobility modes for mitigation purposes.

Table 14 Working hypotheses for further enquiries

CHAPTER 5

INTERVIEWS AND SURVEY

5.1 DESIGN AND EXECUTION

A series of interviews and a survey followed the CapaCity workshops and took place in France and Norway. This was not done for comparative purposes, but rather to obtain a broader picture of the professional savoir-faire as previously discussed. Consequently, for the interviews and for the surveys, the studied designers were considered as one cohort.

Design research literature similarly draws upon decades of empirical enquires such as those employed for this thesis, for example Darke (1978), Dubois (2014), Kirkeby (2015), Lawson (1979), and Skogheim (2008). The international character of the thesis provided access to design research from Anglo-Saxon, Norwegian, and French design cultures, to mention some (see bibliography). Based on the level of coherence between the findings of these works, it was hypothesised that a common 'design culture' exists across countries, for example within urban design. This supported the decision to regard French and Norwegian designers as one cohort. Differences naturally exist between the two, for example how planning regulations are decided, or planning authorities are organized. For the purpose of this work, however, these differences are as less important.

5.1.1 Constructing question-based inquiries

The survey and the interview guide were primarily constructed during a research stay in Québec, Canada, at the Centre de Recherches en Aménagement et Dévéloppement

(CRAD) at the University of Laval from March to May in 2016, in collaboration with researchers there. The enquiries were based on observations from the workshops, the working hypotheses, findings from design research literature, as well as a series of exploratory interviews. The survey and the interview guide were developed in parallel, as they explored similar aspects, but from different points of view and to a varying degree of detail. Developing a survey and an interview guide is comparable on a series of points, which are explained in the following sections. Each method is then further detailed separately.

Hellevik (2011) outlines certain particular aspects for developing survey questions, which resonate with Ryen (2002) and Van Campenhoudt and Quivy (2011) regarding interview guides (and questions). First of all, questions must not be leading or guiding. For interviews, this applies to both the question in itself, and for the manner in which the researcher asks it. Questions must be balanced, providing either no answering alternatives or all possible alternatives. The latter is particularly important for surveys; while during interviews the researcher should avoid providing alternatives so as not to influence the responses. Furthermore, questions should be organized in an order that influences the participation as little as possible. Previous questions can have an impact on how the respondent answers a question. Hellevik (2011) uses a series of survey questions about politics as an example, followed by the question “are you interested in politics”. Such a composition can increase the change of the person answering yes even if not actually the case, as they have been tuned to the topic of politics ahead of the question. Hellevik refers to this as *context-effect*[61]. Finally, questions must be comprehensible, and perceived as relevant by the targeted recipients (here: urban designers) lest these become demotivated and/or frustrated; another source for potentially incomplete survey responses.

The interviews were *semi-directive*. This indicates a balance between letting the interviewee talk freely with no direction from the researcher (open interviews), and an exchange where the researcher clearly steers the interview and asks concise questions

[61] Translated from Norwegian by author (MKR)

(directed interviews) (Ryen, 2002; Van Campenhoudt and Quivy, 2011). The choice of form depends on the objective(s) for the interview, and on the overall research problematic (ibid). For the purpose of this thesis it was decided that a semi-directive permitted to assure the interview covered the intended topics, while allowing the interviewed practitioner to talk freely, using their proper terms and/or professional language. The latter was considered particularly important in order to access the 'silent' aspect of the professional savoir-faire. Furthermore, a semi-directed form allows the interview to transpire in a manner falls 'naturally' to the interviewee and to the interview situation (Van Campenhoudt and Quivy, 2011). The researcher generally has an interview guide with a number of topics or themes to cover, sometimes phrased as concrete questions, but adapted to each interview situation. Whether or not all topics are covered for each interview depends on the research project and its objectives.

For surveys, variation lies more within the kinds of questions, and how they are answered. Questions can be either open-ended where the respondent writes in their answer, or close-ended with answering alternatives (Hellevik, 2011). Open-ended questions can provide a more nuanced response than close-ended. However, they can simultaneously render the participation more complex and laborious, a frequent source for incomplete survey responses. Moreover, rendering the analysis more complex and time-consuming. In this context, the choice fell upon close-ended questions with ranking and rating scales, in part because the survey aimed at covering a broad range of aspects.

The survey and the interview guide were developed in French and Norwegian; English translations are provided in Annex 0 and 0. They were tested several times with researchers and professionals, first during the research stay Quebec, then in France and Norway, since the empirical explorations took place in both countries. Thorough testing remains an important element to ensure the validity of the gathered data (Hellevik, 2011; Ryen, 2002). One objective lies in assuring the relevance and the comprehensibility of questions asked or issues approached. This can be achieved by adapting an approach somewhat familiar to the targeted group. All disciplines tend to have their proper 'language'; when exploring a discipline or a profession through empirical enquiries – in particular with surveys where the researcher cannot follow up with explanations – this should be taken into consideration (Ryen, 2002).

5.1.2 Semi-directive interviews: conversations about urban design and mobility

The semi-directive interviews used an interview guide (see Annex 0) composed of properly phrased questions, a measure to assuring the reliability of the gathered data, and to reduce the influence of the researcher (to the extent possible). While the interviews leaned on pre-phrased questions as a support, the chosen interview form required flexibility in its execution and could become more dynamic in application. Registering the interviews provide another way to assure reliability. Contrary to the survey, the interview guide started with an open question regarding the professional background and experience of the interviewed practitioner; a conscious choice in order to get the person in a 'recounting and explanatory mode'. In addition to concrete questions regarding their practice and methods, the interview guide contained a case (densification of suburbs) where the interviewee was asked "How would you solve this", "How can one achieve such and such qualities", and "How can such and such effect be avoided".

THE INTERVIEW GUIDE – FOUR PRINCIPAL TOPICS
1. The design process a. Design methods and practices in general b. The role of mobility in a typical design process 2. The design project a. Decision-making in a project b. How various contexts and constraints influence design choices c. The designer's role in this 3. A design case on densification of suburbs and potential mobility consequences, 4. Questions of a more general nature, regarding the daily mobility of urban inhabitants and its relationship to and influence upon urban living and living contexts.

Table 15 The main topics of the interview guide for the empirical enquiries

The interviews took place in September and October 2016 in Norway (mostly the Oslo-region, one in Trondheim via Skype), and in November and December 2016 in France (mostly the Toulouse-region, one in Paris via Skype). Twelve practitioners were interviewed in Norway (four women, eight men), seven in France (two women, five men). One of the interviewed practitioners in Norway was French, but his entire professional career has taken place in Norway. Practitioners were recruited via personal invitation based on a series of criteria. Online 'amenities' such as LinkedIn, Google, and the websites of design companies, provided information for this. The main criteria were: more than five years of experience; working on projects at the neighbourhood scale and preferably in relation to urban development. Furthermore, the interviews aimed at including at least one person, in France and in Norway, from the main design fields included in this work (urban design, urban planning, landscape architecture, and architecture). Urban design appears to be a less used professional title, although the interviewed design practitioners clearly work as such or contributed to such projects (though to varying degrees). Table 22 contains information about the interviewees. Most of the contacted professionals immediately agreed to participate, but recruitment was somewhat easier in Norway than in France.

The interviews lasted 1 to 1,5 hours. The interview guide provided structure to the interview, while allowing the exchange to maintain a conversational flow as the form could dynamically respond to the interviewees' train of thought, reasoning, etc. Some of the questions from the interview guide were asked in each interview, but at a suitable moment depending on the individual session. The meetings took place at the individual's offices or, if possible, in a more neutral setting. Research literature recommends the latter to assure more straightforward or open responses (i.e. avoid influence of colleagues or leaders) (Van Campenhoudt and Quivy, 2011). As the interviewees did not consider the research topic as controversial, however, this precaution appeared to be a somewhat unnecessary. Generally, the location of the interview seemed to have less importance for the people interviewed. Each interview was recorded so as to assure an easy 'flow' of the interview. The recording ensured the correct registering of answers and opinions in preparation for the word-by-word transcription; this was a specific choice to allow for an in-depth contents analysis of the interviews.

5.1.3 Online-based survey on design practices and urban living contexts

The survey had two mains topics, much in line with the research questions developed in Chapter 1. The survey questions can be found in Annex 0. This led to the survey being more elaborate and lengthy. This was a conscious choice in order to obtain the necessary depth of information, despite the risk of a high number of incomplete responses. The survey targeted a specific group, urban design practitioners, and the topics related directly to their professional practice. Moreover, throughout the survey the respondent could follow the level of completion at all times. These aspects were assumed to motivate the professionals to complete the survey despite its length, which turned out to be comparatively successful: of the 120 professionals who started the survey, 71 (63,4%) completed it – a relatively good rate in light of the complexity and length of the survey. To simplify the participation, and the later analysis, the survey was composed of close-ended questions, without providing a neutral answer option. Respondents were for the most part asked to assess levels of importance or influence of an element, or to what extent they agreed to statements (e.g. *Strongly agree, Agree, Agree to some extent, Disagree*). Each question had the possibility to add a comment, but this was rarely used. Personal information was asked at the end of the survey, in order to avoid putting the respondents in a so-called automated response mode (Hellevik, 2011). This is an interesting difference to interviews, where starting a conversation with questions about education and professional experience can be a way to put the interviewee in a 'narrative mood'.

The survey was held from November 2016 to January 2017, using the online tool SurveyMonkey©. The response rate and the profiles of the respondents could be followed during the survey-period. Respondents were recruited via online forums for professionals and personal invitation. The targeted respondents were urban designers, as was explicitly stated in the beginning of the survey. However, it was not an absolute participation criterion, as urban design professionals tend to have a mixed background.

The first part of the survey asked about mobility in a design process. Based on workshop-observations, a series of working hypotheses had been established on the role of mobility in a design process. Here the survey aimed at testing whether these observations might apply to a large number of professionals and their practice, or if they are distinctive for practitioners in the Toulouse-region. The survey inquired whether or not the daily mobility of inhabitants was taken into account in projects, and if so, to what extent: included in the site analysis only; included in the site analysis, and solutions and measures implemented in order to act upon people's daily mobility. It then asked what including daily mobility in the site analysis might contribute to, and what implementing solutions and measures might contribute to. Finally, the respondents were asked which elements influence choice of mobility solution and measures the most.

The second part of the survey explored how features and qualities of the built environment at the neighbourhood scale influences i) modal choice, and ii) people's perception and experience of the neighbourhood scale built environment. Respondents were given four tables linking urban features or urban qualities (Table 16) to modal choice and to perceptions, respectively. Figure 28 and Figure 29 show excerpts of these questions. The survey did not include pictures to illustrate the qualities, to avoid influencing the respondent by displacing their own examples or perceptions of the questioned features and qualities.[62] Because the targeted respondents were urban design professionals it was estimated they would recognize and have knowledge of the qualities simply through a textual explanation. In view of the answering rate, and the answers, this appears to have been a correct assumption. Each answering box had a drop-down menu with three options: *Very important/influential; Important/Influential*; *Somewhat important/influential*. The respondents had the possibility of not choosing a box, in which case their response would be considered as *Unimportant* or *No influence.*

[62] For the reader of this thesis a series of pictures illustrating the qualities can be found in the annex.

The features (sidewalk width, vegetation), the qualities (Legibility, Complexity, Human scale), as well as the perceptions and experiences (e.g. traffic safety, distance), were selected based on findings from research literature and design literature, following the holistic approached discussed in Chapter 1.3. Overall observations from the workshops supported this; moreover, several of the qualities such as Connectivity and Transparency were explored during the design game. The perceptions reflects common topics from research literature (see for example Foster et al., 2014; Giles-Corti et al., 2005; Høye et al., 2015; Loukaitou-Sideris, 2006), as well as the public debate, that are found and/or assumed to matter for people's day mobility and modal choices: i) traffic safety, ii) feeling of safety, and iii) perception of distance. The physical distance to cover is significant for modal choice, particularly non-motorized modes such as walking and cycling (Ewing and Cervero, 2010; Næss, 2012; Saelens and Handy, 2008). At the same time, people's perception of distance can vary significantly, much due to individual characteristics – subjectivity versus objectivity. Ewing and Handy (2009) write that people's perception of their surroundings is often not 'in line' with the actual built environment. Which poses a challenge for built environment interventions meant to promote, for example, walking (Krizek et al., 2009a). A better understanding of how the built environment tends to influence perceptions like the above is needed. Here explored through the professional savoir-faire of urban designers, i.e. the professional eye: observing people's use of and interactions with their built environment.

URBAN FEATURES	
• Sidewalk width • Building height • Distance (real) to transit stop • Street width	• Façade design at street level • Vegetation • View lines/sight lines • Physical context

URBAN QUALITIES	
Legibility, Imageability	How easily one can recognize and understand an area, a neighbourhood. A legible area/neighbourhood has easily identifiable elements that aid orienting one-self.
Human scale	The dimension of built environments in relation to people and the perceptions, experiences this creates. (street width, building height, block size, etc.) For example: (1) relationship street width/building height: balanced, towering, or wide; (2) large blocks that create long distances.
Enclosure	To what extent buildings, vegetation, and other vertical elements define and shapes streets and other public spaces. [63]
Connectivity	Connections between streets, cycle and pedestrian networks, etc., in order to connect parts of an area/neighbourhood or different neighbourhoods.
Transparence	To what extent one can see or perceive what goes on at the end of a street and past it, for example human activity or particular buildings.
Coherence	Whether the built environment creates an overall impression, e.g. through shapes or facades.
Complexity	How a rich variety of buildings and other elements create a diverse visual impression.

Table 16 Urban features and qualities explored in the survey

[63] Hillnhütter (2016) defines enclosure as building height divided by street width, with buildings and walls representing the edges of the public space in which people walk. This ratio influences how pedestrians observe and interact with edges: « only when edges are close, as in narrow pedestrian streets below 15 metres in width, all details become visible and increase the amount of visible sensory stimuli". The level of interaction gradually decreases as the street widens. In broad streets over 40 metres wide, or in very large squares, the visual stimuli and thus level of interaction is very low as the edges are too far away for pedestrians to perceive details.

10. **To what extent are the same urban qualities important for creating the perceptions and/or experiences below?**
Classify according to level of influence: *"Very important"; "Important"; "Somewhat important"* . If you consider an urban quality as not influential upon a modal choice you can leave that box blank. This will be considered as *"Unimportant"*.

	Perceived traffic safety "I do not risk being hit by a vehicle when walking down this street"	**Feeling of safety in public space** "I do not risk being mugged in this neighbourhood"	**Reduce the perceived distance when going from one place to another**	**Comfort (physical) in public space** (protection from wind, weather, noise, etc.)
Sidewalk width				
Building height				
Distance (real) to transit stop				
Street width				
Facade design at street level				

Figure 28 Clipping from the survey, the influence of urban features upon perceptions of the built environment

11. **To what extent are the following urban qualities influential for the use of the mobility modes below?**
Classify according to level of influence: *"Very influential"; "Influential"; "Somewhat influential".* If you consider an urban quality as not influential upon a modal choice you can leave that box blank. This will be considered as *"No influence".*

	Walking	Cycling	Public transport
Legibility, Imageability How easily one can recognise and understand a neighbourhood. A legible neighbourhood has easily identifiable elements that aid one for orienting one-self.			
Human scale The dimension of built environment elements in relation to people, and the perceptions/experiences this creates, e.g. the relationship street width/building height, or large urban blocks that increase walking distances.			
Enclosure To what extent buildings, vegetation, and other vertical elements defines and shapes streets and other public spaces.			

Figure 29 Clipping from the survey, the influence of urban qualities upon perceptions of the built environment

5.2 Analysis

The interviews and the survey were analysed in parallel but separately, with corresponding analysis frameworks based on the theoretical framework from Chapter 3 as well as workshop observations. For the interviews a contents analysis similar to that of the workshops was applied, further developed with insights from Ryen (2002), Van Campenhoudt and Quivy (2011), and Skogheim (2008); the survey was primarily analysed through descriptive statistics. Findings from each were gradually combined in an iterative manner, following the principles of grounded theory, allowing each method to inform the other.

It was hypothesized that there is a common design culture among urban designers, across countries, justifying the combination of results from Norway and France (see previous sections). To verify this, initial analyses of survey responses and interview transcriptions from each country were done separately. A somewhat common urban design culture was indeed observed. Similar examples or illustrations were often evoked by French and Norwegian practitioners during interviews, for instance to explain the importance of "forcing people out in public space on their way to or from work". Differences exist, naturally, but none so important so as to require separating the cohort. The differences between Norwegian and French urban design practitioners seem to be related to cultural and social differences – aspects of the intellectual baggage or governing principles of a practitioner – rather than the professional savoir-faire in itself. Insight from design research as a basis, and personal experience, helped distinguishing between such governing principles and the savoir-faire during analysis of the interviews and the workshop. For the surveys, the questions were phrased in a manner so as to take into account the potential influence of the respondents governing principles.

5.2.1 Interviews

Each interview was recorded and later transcribed, to assure a correct record of answers, opinions, explanations, etc. The thesis author transcribed some of the contents, but the majority was completed by an external entity.[64] The interviews were explored according to interview questions and theme, rather than as separate cases (interview by interview). Skogheim (2008, referring to Patton, 1990) calls this a *cross-case comparison*. She writes that a cross-case comparison can be understood as a kind of synthesis of understandings and points of view. Variations among interview objects must be taken into account. The approach is particularly interesting in cases where the aim is not to compare the practitioners among themselves, but to gather insight and understanding of their professional savoir-faire.

Although the interview analyses were done after all data collection was complete, the analyses are somewhat similar to the principles of grounded theory: A preliminary analysis was done with a random selection of 6 of the 19 interviews to establish an initial analysis structure, combined with the interview guide; a tentative framework to guide the further analyses. The analyses were done using Nvivo© for coding according to emerging themes or tendencies, based on the initial analyses, but evolving as the coding progressed.

5.2.2 Survey

The purpose of the survey was to explore the workshop hypotheses and findings from design literature. Moreover, the survey was not intended to be representative for urban design practitioners as a whole – contrary to election polls, for example. For this a much higher response rate would be needed than was possible to obtain in the context of this work – in part because of the use of several enquiry methods. Survey analysis was therefore primarily done as qualitative statistics, focusing on tendencies and trends.

[64] This was possible thanks to the *Eva og Erik Ankers legat*, a Norwegian grant for Norwegian students pursuing a degree in France. The thesis author received the grant in 2014 and in 2016.

The survey questions, primarily close-ended, asked respondents to assess the importance or influence of an element, or to what extent they agreed to statements. A rating average was calculated with coefficients from -2 to 2: 2 = strongly agree, 1 = agree, -1 = agree to some extent, -2 = disagree. The highest rating average was 2 (100% strongly agree) and the lowest -2 (100% disagree). This provided an indication of the response tendencies, such as the importance of mobility in a design process, or the importance of urban features versus urban qualities for modal choice. For a more detailed picture, and an easier lecture of results, the initial rating scale was further divided in to six categories (Table 17).

A SIX-POINT SCALE FOR DEGREES OF IMPORTANCE, INFLUENCE, AGREEMENT					
2 to 1,35	1,34 to 0,68	0,67 to 0	-0,01 to -0,67	-0,68 to -1,34	-1,34 to -2
Extremely	Very	Important/influential	Moderately	Slightly	Not at all
Particularly	Strongly	Agree	Somewhat	Vaguely	Do not

Table 17 Scales for rating averages, six-point scale

Interesting aspects and apparent trends were pursued further, focusing in part on potential relations between responses to different questions. For example, how responses to "what implementing mobility solutions and measures contribute to" might relate to "elements that influence the choice of mobility solutions and measures". After initial analysis, findings from Part 1 (the role of mobility in a design process) were combined with Part 2 (how urban qualities and features influence modal choices and perceptions of the neighbourhood scale built environment). Not all parts of the survey were explored for the purpose of this work. As for the interviews, some of the questions turned out less relevant for the thesis. They may be explored further at a later point. The survey was one of three approaches to explore the savoir-faire and the practices of urban designers. The main focus of the survey analyses (and interview analyses) was therefore elements and aspects where the three methods could provide complementary insights. Particular findings from the individual methods were included if judged relevant.

5.3 The enquired practitioners

5.3.1 Survey participants

112 practitioners commenced the survey, 67 in Norway and 45 in France. 71 (63,4%) of these completed it, of which 67 (59,8%) provided information about their practice. There was a good repartition among male and female respondents (54% women, 46% men). The tables and figures below present main characteristics of the survey respondents, France and Norway combined.

SURVEY RESPONDENTS					
	Began survey	Completed survey	Provided Information	Female	Male
France	45	37 (82,2%)	36 (80,0%)	21 of 36	15 of 36
Norway	67	34 (50,8)	31 (46,3%)	15 of 31	16 of 31
TOTAL	**112**	**71 (63,4%)**	**67 (59,8%)**	**36 of 67**	**31 of 67**

Table 18 Information about survey response rate and the survey respondents

Age and professional experience

The majority of the respondents were between 25 and 45 years old, their professional experience span from 5 to 35 years. This big gap is in part due to many of the French respondents who provided information (15 of 36) had less than 5 years of experience.

Educational background

Several choices were possible regarding educational background, as this often varies for urban practitioners. Architecture (39 of 67) was most common, followed by Urbanism or Urban Design (26 of 67), Urban Planning (17 of 67), and finally Landscape Architecture (10 of 67). Urbanism/Urban Design and Planning are somewhat juxtaposing categories. There are differences between France and Norway with regard to the educational system, and there are differences in how practitioners themselves define their studies. A few respondents had other backgrounds, such as Sociology (2 of 67), Geography (2 of 67), or Engineering (2 of 67). The most common combination was Architecture and Urbanism (17 of 67).

When asked about additional education or courses, 27 of 67 replied positively. These tend to be specialization within a particular topic (e.g. legislative, regulatory, technical), or directed towards project management.

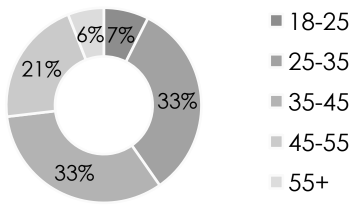


Figure 30 The survey respondents' age, 67 responses

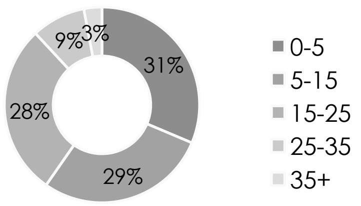


Figure 31 Years of professional experience, 67 responses

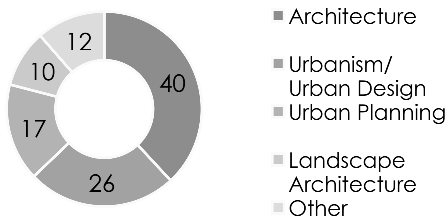


Figure 32 The educational background of survey respondents (n°), 67 responses

Geographical scale, typical client, and kinds of projects

The survey respondents work primarily at the neighbourhood scale (58 of 63), followed by city scale (44 of 63) and building scale (35 of 63); a few work frequently at the regional scale (17of 63). See Table 19 and Table 20.

GEOGRAPHICAL SCALE (very often or often)	
1. Neighbourhood scale	92,1 %
2. City scale	69,8 %
3. Building scale	55,6 %
4. Regional scale	27,0 %

Table 19 The geographical scale at which the respondents work very often or often, 63 responses

TYPICAL CLIENT		
	Private	Public
France	12 of 24	20 of 24
Norway	14 of 23	21 of 23

Table 20 The typical client, 47 responses

Public clients in France are typically State (4), Regional (10), Commune/City (13). 12 respondents report working for Public clients only. Private clients are typically real estate developers or individuals. 3 respondents work for Private clients only. Public clients in Norway are typically State (8), Commune/City (15), Norwegian National Rail Administration or Norwegian Public Roads Administration (7), 2 non-specified. 7 respondents report working for Public clients only. Private clients are, as in France, typically real estate developers and individuals. 2 respondents work for private clients only. The respondents were asked to specify frequent kinds of projects. These answers were then categorized in Table 21 below.

FREQUENT KINDS OF PROJECTS	
NORWAY (26 of 31 respondents)	
Urban planning	16
Transport and infrastructure planning	10
Buildings (e.g. Kindergarten, Residential, Hospitals)	6
France (26 of 36 respondents)	
Urban planning	17
Transport and infrastructure planning	6
Buildings (Kindergarten, Residential, Hospitals, etc.)	11

Table 21 The kinds of project respondents frequently work on, 52 responses

5.3.2 The interviewed designers

A total of nineteen professionals were interviewed, twelve in Norway and seven in France, Table 22 provides an overview of their profiles, stating initial education. They represent all the targeted design-professions, including urban design although not apparent in the table. A common element among the interviewees was the range of projects they work on, and the passion they have for cities and urban development. Being an urban practitioner is more than a profession; it is a integral part of who or what they identify as. The interviewed practitioners were primarily from 35 to 45 years old, with three above 50, and one under 30.

EDUCATIONAL BACKGROUND	FRANCE	NORWAY
Architect	2	3
Architect and urban designer/planner or Engineer	3	2
Urban designer/planner, Urbanist	-	5
Landscape architect	2	2
Total	**7** (5M, 2F)	**12** (8M, 4F)

Table 22 Summary of interview participants

The interviewees work on most geographical scales, from buildings (only a few) or parts of a street, to a whole street, an area, a city center (smaller cities). Only very few might touch on regional planning. The kind of projects varied from feasibility studies and assessment of impact/consequences of potential projects to concrete design proposals and construction phases. Many of the projects are a public command, while some often work for bigger investors or developers where the size of the projects entail some elements of public space (e.g. large building complexes) or an important interaction with public space (e.g. an apartment building in a city center).

Few had specific training in mobility and transport planning, except the urban planners might have had some training during their studies. Despite this, the interviewees all ‘touch upon’ daily mobility in their projects. They address it and act upon it, and have many reflections about what, why, and how. This might be related to the fact that the designers appeared to perceive or ‘think about’ mobility as movement in an urban space, rather than an activity fulfilling a daily need. Circulation in a building is a part of how a building is used. Similarly, circulation in an area is part of how an area is used. Which in turn might be related to another observation: addressing and acting upon mobility appeared to be primarily about promoting particular uses of an area, for example by inducing particular movement patterns. Actively promoting particular modes was less of focus. These aspects, movement and promoting uses, are addressed more in detail in the following sections, as well as in Part 3.

The practitioners tended to talk in 'images', illustrating or explaining their responses with examples of own work (or sometimes others'), or more common references such as Le Corbusier and Modernism, Central Park in New York, etc. A similar tendency was observed in the workshops, when the designers discussed during the design game. Well-known references particularly seemed to help establish a common 'design ground' for the practitioners who initially did not know each other. During the interviews, the use of concrete projects (own) helped the designers express and explain design principles and ideas, design actions during the process, reasons for choosing particular solutions, and so forth. This was as expected, and much in line with findings from similar studies. The tacit savoir-faire – just knowing how – is often best conveyed through examples and images.

An interesting element is the personal investment of practitioners. Through their responses, their explanations, and their way of talking about urban development, it is apparent that for most of the interviewees, urban design is not 'just a job'. They had several governing principles about city building and urban living, which often seemed closely related to who they saw themselves as. Several said that a project always depends on and is influenced by the person designing it; "you always bring something of yourself in to it" (interviewee 18). This might be a challenge with regard to mobility, when aiming at satisfying the needs of as many segments of the population as possible. One interviewee wondered if it makes a difference if the designer has kids, and thus has experienced the city that way? Or whether or not the designer cycles on a regular basis? As there are few seniors who (still) work as urban designers, are their needs and preferences properly taken into consideration?

> "I think it matters a lot how one [the designer] moves around in the city. (…) But I think that if you walk or cycle a route every day then there is a higher probability for knowing how to achieve the kind of mobility that you do yourself. (…) I think it is kind of naïve to think that one does not influence one's projects."
>
> – Interviewee 18

Looking at the responses, it is clear that the designers see their work as having an influence upon urban life, and how people live in and use city. It is a 'natural' part of their profession; every intervention upon the built environment will influence it somehow. And, by consequence, influence the living context of urban inhabitants. Assessing this influence, its impact, and how it 'fits' with the existing context, appears to be a fundamental part of the professional savoir-faire.

5.4 MOBILITY IN A DESIGN PROCESS

The vast majority of the survey respondents (101 of 109) reported that they consider the daily mobility of inhabitants in a project. Some only in the site analysis (25 of 97), but most also implement mobility measures and solutions (72 of 97). In the interviews the practitioners frequently associated mobility-related design actions to other issues in a win-win approach. According to one, considering mobility "mobilizes the reflection" (interviewee 4); more so, "reflecting on the mobility can help advance the project quite a lot" (interviewee 3). This generally parallels conclusions from the workshop-analyses: mobility is an urban necessity to solve – it must 'function' – while simultaneously an opening to address other topics.

Looking at the interviews and survey, it appears that organizing the mobility within and through a site often comes down to how and where people move, and how the designer(s) wishes them to move (for a broad range of reasons). This was also seen in the workshops. The designers can influence movement patterns/behaviour by manipulating the built environment. At the same time they seem to view their design as influenced by people's movements. Mobility is related to dynamic built-environment elements such as streets, paths, and sidewalks, but also to static built-environment elements such as transit stops and public places. Dynamic elements can be static elements, and vice versa. A public place is both a space where people spend some time and a space to pass through on their way to a destination. This multi-functionality of the neighbourhood-scale built environment touches upon some of the complexity of urban design and mobility. Different mobility uses, modes, and speeds have different requirements, but they all take place within the same built environment. Knowing how to conceive contexts that satisfy the needs of as many as possible is part of the Design savoir-faire. This is further developed in chapter 6 and 7.

The workshop-observations showed how exploring the role of mobility in a design process can provide insight into how urban designers perceive the relationship between urban inhabitants and the built environment; moreover, between the built environment and daily mobility. The interviews and the survey therefore pursued this research question. During the workshop design processes, mobility appeared to be a sort of ‘design tool’. It was part of the design framework established by all groups that helped advancing the design process. Mobility influenced design actions, directly or indirectly, through the objectives and ambitions of the designers, as well as the program. Initial decisions established significant premises for later design decisions, and for the end product. This indicates a somewhat multifaceted role for mobility in a design process. The survey and the interviews further explored this apparent ‘tool’-role. When and how is it considered? What does it contribute to? How does it relate to other aspects or issues?

5.4.1 A multifaceted ‘design tool’

5.4.1 a) **An integral and structuring element**

The survey and the interviews confirmed that daily mobility has an important and central role in an urban design process, as seen in the CapaCity workshops. According to the interviewees, mobility is always present in (to some extent) in a design process, “…mobility exists on all [geographical] scales. (…) It can introduce a considerable change in a neighbourhood” (interviewee 7). Another said that it is not possible to conceive an urban development project without thinking about mobility.

> “It is an important part of planning cities. In my opinion, [cities are] primarily composed of transport, of housing, and of staying[65]…those three elements.”
>
> – Interviewee 16

> “For us it [mobility] is very, very important. And it is much about how to facilitate for people to have a simpler everyday life.”
>
> – Interviewee 15

[65] By ‘staying’ the interviewee meant a temporal stay, for example staying/resting some time in a public space

Mobility as a structuring element for a project and a design process was recurrent in the interviews. This corresponds to observations during the CapaCity workshops; it was one of the first elements the interviewee evoked, using it to comprehend and to explore the site and its surroundings. The survey results show a similar tendency (Table 23, Table 24). This aspect of mobility can be understood in part through the interviews. Several of the practitioners described the urban structure, e.g. the roads and streets of a city, as the founding structures of a city. How transport and mobility is organized is highly significant for how a city develops.

> "Take London. The street network of London is there, in about a hundred years the same street network will be there. Lots of houses which are there today will still be there right, you'll probably find your way if you're there in a hundred years, though it is clear that there will been some new. But the street network remains there, so… the street network is kind of the play rules of the urban development game. You can say tat the role of infrastructure is to provide opportunities for urban development, and frameworks for the city to grow and change, etc.; that is very important. Because that is where you steer – the rest are singular events that happen in the background."
>
> – Interviewee 14

The role of mobility in a specific project depends in part on the urban context, on the site's previous history and land use, and to some extent the program. The latter can for example indicate or impose prioritization of pedestrians. These are examples of internal and external constraints that establish initial conditions and premises for a project, limitations as well as possibilities. Together with the designer's governing principles, they form a design framework for the process and the development of a project proposal (Lawson, 2006a). Initial design decisions found the basis for the framework; as the process advances, the framework generally becomes more solidified and detailed. In the workshops mobility often had a central role in this framework. One group used pedestrian priority as a fundamental premise, designing the neighbourhood with regard to achieving optimal walking distances and conditions.

In some contexts, mobility might be a significant determinant, for example, if the site is near a major road, or if a tramline runs through the concerned street. In other contexts, mobility might be a less influential element. Nevertheless, it is always present, and always taken into account to some extent. According to the interviewees, what defines an area's qualities as a living context is closely related to its location, which in turn defines its urban context[66]. This context also influences available mobility alternatives; there is a strong link between daily mobility and an area's qualities as a living context. Indeed, many of the practitioners saw mobility as movement (how, where, etc.), and in direct relation to the qualities of an area as a living context. Acting upon mobility – i.e. movement within and through a site – was therefore part of the so-called 'common goal' of improving living contexts.

5.4.1 b) **A means and a function to address instrumental and perceptual aspects**

Overall, the findings assert the notion of mobility as being both a means and a function: a design objective on its own, and a 'tool' to achieve other project goals. During the interviews, the practitioners were asked if the 'concept' of means and function was something they could agree to and perhaps even identify with, to which all answered positively. They reported that it allows addressing instrumental[67] aspects, as well as perceptual, less tangible aspects of urban design and development (e.g. social, cultural, experiences, etc.). Mobility components such as streets, paths, sidewalks, etc., together with buildings, contribute to structure and physically compose a block, a street, or a neighbourhood. This is done to solve mobility needs, but also to establish structures and spaces for other needs and functions of urban living. Acting upon inhabitants' mobility, i.e. movement within or through a site – a street, a block, or a neighbourhood – can also

[66] As a reminder: physical, economical, social, and cultural context

[67] See Glossary

be done to provide a better basis for social cohesion; for example, by initiating movement patterns that enable encounters between people in public space. Which also requires the public space to be interesting, pleasant, and well-designed; something mobility measures and solutions can contribute to. This is an example of the reciprocity between mobility and the built environment: acting upon one necessarily implicates acting upon the other. A notion the interviewed practitioners seemed both familiar and comfortable with. More so, a common opinion was that acting upon mobility so should somehow improve the urban living context; on a physical and/or conceptual level.

> "…the question of movement or mobility, it has to bring something extra. (...) It can for example be quality of public space. (...) Often that's what it means, crossing use and quality of space."
>
> – Interviewee 1

5.4.1 c) **Understanding a site and its challenges**

Identifying what the problem really is

A site analysis forms an important step in a typical urban design process. The global objective is to gain a better comprehension of a site: how its natural and built environment is like; how it relates to its urban context; how its inhabitants use it (depending on size and project), etc. In the workshops, exploring mobility in the site analysis seemed to contribute to this, and observation confirmed by the interviews and the survey (Table 23). The interviewees explained that mobility has a central role in this analysis. How people move within and through a site contributes to comprehend uses, challenges, and potentials, as mobility systems are a result of the urban structure and prior land uses. They can recount a site's history, its relationship to the urban context, former intentions and strategies, etc.

The site analysis furthermore aims at identifying a site's potential as well as its challenges. This contributes to finding what the problem "really is" (Schön, 1983), and, moreover, to frame it as described in Chapter 3. The survey respondents confirmed that considering mobility in a site analysis contributes to achieving this (Table 23). A similar tendency emerged in the interviews. Many of the interviewees emphasized the importance of exploring a site in person, in order to observe and to talk to inhabitants and neighbours. Current inhabitants of a site are both a part of the existing context, and the future users of the finished 'design product' (the designed or redesigned neighbourhood). By correlation, understanding the inhabitants' uses of the neighbourhood can be a means to comprehend the existing context, as well as the needs and requirements of its future users. This is essential to get a "proper understanding" of a site, which in turn helps conceiving a design (e.g. a public space, a path) that actually gets used by the inhabitant – a measure of a project's success according to some.

CONSIDERING MOBILITY IN THE SITE ANALYSIS CONTRIBUTES TO (87 responses, "Strongly agree" and "Agree")		
	Analysis (19 resp.)	Analysis+Sol./Meas. (66 resp.)
1. Link the project to the urban context	100 %	91 %
2. Understand the inhabitants' use of the neighbourhood	95 %	96 %
3. Identify challenges and issues beyond project description	89 %	88 %
4. Establish an idea, a concept	79 %	78 %

Table 23 What mobility in the site analysis contributes to, percentage who "Strongly agree" or "Agree", 87 responses

Generating ideas and solutions to better understand the problem

Rittel and Webber describe urban development problems as societal problems that are inherently related to, and interdependent with, other facets of a city (Rittel and Webber, 1973). They are wicked problems where the necessary information to tackle them is largely generated by the designer's ideas for solving them (Lawson, 1993). The survey showed that considering mobility in a site analysis, and implementing mobility measures and solutions, generates ideas, and helps establishing a concept (Table 23, Table 24). The interviewees similarly described that mobility can offer an entry point for initial design actions, producing potential solutions and measures. Testing and evaluating these provides the designer with a gradual comprehension of the complexity of a site – an example of the iterative solution-based approach presented in Chapter 3.

According to Darke (1979) and later Lawson (2006), practitioners apply and develop primary generators for such design actions in the early stages of a design process. Based on observations and findings from the enquires, it seems that mobility can provide one or several primary generator(s) – or perhaps be one itself.

IMPLEMENTING MOBILITY SOLUTIONS/MEASURES IN A PROJECT CONTRIBUTES TO (65 responses, “Strongly agree” and “Agree”)	
1. Facilitate walking and cycling	95 %
2. Facilitate the use of public transport	91 %
3. Link the project to the urban context	91 %
4. Introduce measures to reduce the inhabitants' use of cars	91 %
5. Structure/shape the neighbourhood	91 %
6. Create an identity to reinforce the inhabitants' sense of belonging to the neighbourhood	75 %
7. Establish an idea, a concept	74 %

Table 24 What implementing solutions/measures contributes to, percentage who “Strongly agree” or “Agree”, 65 responses

Linking a site to its urban context

The CapaCity workshops indicated that context – particularly urban context – is highly significant for a project and its outcome. This is in line with previously observed design practices: a project’s urban context establishes premises and conditions for the design; at once possibilities to explore, and limitations to take into consideration (with some variation) (Eliasson, 2000; Kirkeby, 2015). In the workshops, analysing and acting upon mobility was done to counter the site’s physical and social isolation, for example by creating new connections, or by establishing new public places. One objective was to invite neighbouring inhabitants to use the site. Based on this it was hypothesized that mobility can be a means to link a site to its urban context, i.e. its physical, social, cultural, and economical context, which the survey responses largely confirmed. A majority of the respondents reported that considering mobility in the site analysis and/or implementing mobility measures and solutions contribute to linking a project to its urban context (Table 23, Table 24). Similar descriptions emerged from the interviews. .

5.4.2 Complexity, flexibility, and an improved living context

5.4.2 a) **Addressing complexity through a holistic approach**

Cities are systems of organized complexity that produce wicked urban development problems (Jacobs, 1961; Rittel and Webber, 1973). Addressing and acting upon them can impact the city in unpredicted ways, due to the many interdependencies among city elements. This influences their long-term effect upon a city, which can take years to properly manifest due to the inertia of city development. These elements represent a complexity that urban designers seem perceive as a sort of default premise that is always present in projects. Understanding it and knowing how to work with it, is part of their Methodological and the Design savoir-faire. Their holistic, solution-based approach can be seen as a sort of common design strategy to deal with this complexity. A project's end result and its long-term outcome depend on the sum of design action, solutions, and measures, which in turn creates an urban living context. A holistic approach is necessary in order to properly consider and address the totality of a project. It was observed through the interviews and the workshops, and parallels findings from previous design research. Lawson (1993) describes it as the designers working with parallel lines of thought, focusing on one then on another in an iterative manner, but always having the wholeness of the project in view. For the interviewees, this totality is often related to how a project impacts and is impacted by the city as a whole is, how "the edges of a piece fits with the other pieces" (interviewee 8). Which on a more general level is related to the overall design objective of improving urban living contexts.

> "(…) complexity is to say "no we do not have the solution"; instead, we can try to understand the situation in which we find ourselves in order to attempt to unravel this complexity and find ways to act upon it by...accepting that it is complex, that proposals, even if they are relevant, will only be punctual, limited. One does not seek completeness, but rather relevance and adaptability. "
>
> – Interviewee 1

Daily mobility is a significant aspect of the complexity of urban development. In part because of the individuality of mobility behaviours, which is more visible at the neighbourhood level than at the city scale. Mobility is related to some of the conflicts that can occur for urban development projects, for example is the needs of the big city versus those of the small city, e.g. a street or a neighbourhood versus the city as a whole. Ensuring efficient mobility at the city scale might require buses to travel through an area at relatively high speeds. As a living context, however, the area might benefit more from prioritizing crossing traffic (e.g. pedestrians) and lowering traffic speeds. Both represent uses of public space that impacts the neighbourhood or the street in different ways. It then becomes a question of priority: whose needs are satisfied at the detriment of others'? There are no clear answers to this. According to the interviewees some groups will always be more negatively affected than others. The aim is to make these effects as little intrusive as possible, preferably giving extra attention to so-called 'weaker mobility groups' such as elderly and children. Several interviewees called for a clearer priority from city authorities, especially for public transport or cycling. According to them this would make it easier for all travellers to navigate through the city for everyday travels. From the enquiries it seems that the urban designers tend to favour the needs of the neighbourhood scale; if possible they will prioritize solutions and measures that ensures a good, local living context, over an efficient mobility at the city scale. However, it seems to often come down to compromises and finding equilibrium. Mobility as a means and a function plays an important role for this; particularly to balance a good living context with a high level of mobility.

Improving people's living contexts is an overall goal for urban design; "all architects believe that architecture is about making environments more purposeful and better in most ways" (interviewee 17). The quality of an area as a living context was frequently linked to its social cohesion and capital, in turn often related to the presence of people in public spaces (streets, public spaces, etc.). Inviting people to use public places was for example said to enable the possibility of random interactions; moreover, it was related to people feeling safe in public spaces. According to the interviewees, urban design can contribute to this, for example by situating typical common spaces such as playgrounds in public areas rather than in the common areas of apartment buildings. It can also be achieve through the movement patterns the urban design invites to or even forces.

> "(...) that you have a human perspective on what you create, and on there being people who will use it and live there. You create the frames for people's lives, and that must function for all groups, especially the weaker groups; that you bring in the elderly and the children (…) the city must embrace everyone."
>
> – Interviewee 16

However, public spaces must be well designed for people to want to be present in public space. These elements are further explored in 5.5. The above shows the strong reciprocity between mobility behaviours and the built environment, here between quality of daily mobility and quality of public space. Which in turn implies that acting upon one also means acting upon the other, regardless of the magnitude of the intervention (the project); that every change to public space – increasing/decreasing a sidewalk, installing a bench, changing the façade of a building, etc. – will influence people's daily mobility to some extent. Sometimes just a little, but perhaps just enough to provoke a modal shift – hopefully in a sustainable direction. This is an aspect of urban development that appears often neglected or omitted. Studying the impact of the neighbourhood-scale built environment upon modal choices, considering mobility more closely in relation to use of public space might contribute to counter this.

The workshops also illustrated how bigger mobility decisions such as prioritizing pedestrians can have a considerable impact upon the design process and the final proposal. It opened for allocating space differently as parking was situated at the entrance of the site; at the same time it established requirements for the location and orientation of buildings to avoid long walks from parking to home (the possibility of inhabitants not having a car at all was little discussed). This illustrates how mobility must function in order for a neighbourhood to function, another indication of the close relationship between daily mobility and the quality of a living context. The common denominator is how public space is to be used. This furthermore illustrates show how the designers can achieve objectives through the way they structure, shape, and organize public space; illustrating the reciprocity between mobility and urban design at the neighbourhood scale.

> "Often, you get a customer who says, "we want 200 homes". Fine, what more should we plan for? What more could this part of the block, or this area be suitable for? Sometimes it's only suitable for housing so then you take that seriously and design dwellings that have some inherent, garden-like qualities. But the moment you're in a street where there's a lot of traffic, or a bus and so forth, you can use that larger degree of public contact to design something that gives something more urban back to the surroundings, for instance."
>
> – Interviewee 11

5.4.2 b) **Flexibility to ensure capacity of future development**

Several practitioners emphasized the importance to design for *current* inhabitants as well as for *future* inhabitants. One interviewee saw herself and her colleagues as "protecting the interests of future inhabitants who are not yet present" (Participant 8). Who they are is unknown; as a result, so are their particular needs, which might be quite different from those of the present inhabitants. A demographic shift in a neighbourhood from primarily retirees to younger couples with children is likely to result in new demands to public services and equipment. According to the practitioners, good design must incorporate an element of flexibility, allowing for future changes and development without necessarily requiring a 'tabula rasa'. Designing for flexibility is also a way to ensure a robust and sustainable development. For mobility this seems particularly important, as rapidly increasing urban populations forces cities to rethink their transportation schemes. Mobility behaviours are changing, for example car-sharing, declining car-ownership city bicycles, or electrical bicycles. However, as one interviewee explained, these changes are more likely to be embraced by younger generations. With regard to mobility, ensuring flexibility means conceiving neighbourhoods that take into account future mobility needs and preferences, which are often unknown, for example the shape of urban structure. All while ensuring the objective of good living contexts in a win-win approach.

> "The big majority most likely will not suddenly change [mobility] behaviour towards the end of their lives, but we are planning for tomorrow's users, those who are young today, so that we have enough flexibility to make these places function, function for the future that is."
>
> – Interviewee 16

This call for flexibility can be related back to inertia of urban development, and to the constant evolution of a city. While responding to the problems and needs of today, interventions must simultaneously have the capacity to adapt to an unknown future. Over decades and centuries, roads transform to streets with sidewalks and trees, an industrial area might become a mixed-used neighbourhood as industry moves out of the growing city. Yet the trace of the road (street) might remain the same for hundreds of years. Several cities in Europe have examples of this. One practitioner said that in order to achieve flexibility, he always aimed for incorporating a certain level of *generality* in the structures he designs.

> "I, at least, always try to think longer then the next four years when making regulation plans and so forth…building generality and flexibility. (…) My focus is on finding the good measures and actions for cities and urban development to achieve a [street]system that enables development over time."
>
> – Interviewee 14

Generality for him represent structures that have a high capacity of harbouring different uses and activities, over decades or more, without needing major changes. It does not indicate standardization of solutions and design proposals. Rather, leaning on urban forms and structures that have shown robustness to changes in society and culture over time. Some of the interviewees referred to grid-like networks and the Renaissance building blocks that "can incorporate almost any structure and shape" (interviewee 11); "good generality one takes into account the unknown future" (interviewee 14).

Flexibility was also seen at the buildings scale: one architect explained that if dwellings were planned for the ground floor he would design with an increased height below the ceiling (4-5m if possible) to incorporate a possibility for more mixed uses later on. This shows the long-term perspective of practitioners. Their built-environment intervention is only one of many interventions upon public space, all of which alter the urban context to a larger or smaller degree. Incorporating flexibility, and having an understanding of the unpredicted uses and consequences, was considered important. On a more general level, this flexibility is an example of the capacity of urban design to be a mitigation strategy, ensuring good living contexts today while at the same time ensuring a public space that can accommodate a zero-emission mobility future. The urban designers have the skills and the knowledge to achieve this.

5.4.3 Measures and solutions

5.4.3 a) **Win-win solutions**

When addressing mobility, the workshop participants often aimed for the kind of win-win solutions described previously. This approach similarly became apparent through the survey and the interviews; an example of the designers' knowledge of how to 'manipulate' built environment elements in order to achieve specific goals and ambitions. Implementing measures and solutions contributes to act upon mobility, while simultaneously structuring a site or contribute to establish ideas (Table 24). Mobility measures and solutions described by the interviewees would frequently address other issues as well, for example contributing to high quality public spaces. Another example of the win-win approach from the interviews is the location of parking to establish particular movement patterns in public space in order to strengthen social capital. The nature of solutions was often a result of the role given to mobility in a specific project; related to aspects considered important for the quality of the particular living context; or related to what the designers might see as optimal use of the public space of an area.

Combining measures for improved walkability with the addition or extension of public places was a frequently mentioned example. Depending on the governing principles of the practitioner and/or the objectives of the design team (company), the designers might for example choose to implement measures or solutions to initiate or even force particular movement patterns they perceive as more beneficial for a neighbourhood and its inhabitants. The win-win tactic can be seen in relation to the holistic design approach as observed in the workshops. Knowing the win-win potential of a solution necessitates knowing how to evaluate and assess the potential outcomes, effects, and implication of a solution, upon specific issues and upon the project as a whole – knowledge urban designers encompass through their Design and their Methodological savoir-faire.

5.4.3 b) **Urban structure, land use, mobility systems, and urban features**

The kind of solutions and measures described by the designers are generally a result of acting upon the urban structure, the mobility systems, the land use, or urban features. The extent to which the designers considered land use to be an efficient mobility solution or measure was somewhat surprising, as this element was assumed more relevant for city-scale interventions. But depending on the geographical scale, from the activity and façade design of a building's ground floor to the location of bigger activities such as schools and sports facilities, the designers clearly saw this as a tool to influence mobility movements. The win-win nature of many of the measures and solutions creates interdependencies: a land use-action might also influence the urban structure and vice versa. Moreover, a solution might fall under several categories, for example land use and urban features. In this context they are described within one category in order to simplify the analysis and the lecture.

Measures and solutions often have the objective of creating qualities or characteristics seen as particularly favourable for a good organization of neighbourhood-scale mobility or for specific mobility modes (often walking). These were primarily Legibility, Flexibility, Hierarchy, and Connectivity. Land use and urban features were said to contribute to Legibility and Hierarchy, while urban structure and mobility systems were often connected to Hierarchy, Flexibility and Connectivity. The link between Flexibility and urban structure (and mobility systems) was much rooted in the view of the latter as the founding structure of the city. In a project it is often described as highly significant for the configuration of a site.

LAND USE

SUMMARY OF FREQUENTLY MENTIONED LAND-USE SOLUTIONS FROM INTERVIEWS
• Public places can be part of a neighbourhood's (a city's) pedestrian and/or cycling network • Act upon, for example soften, the relationship and the transition private/public space • Use of the ground floor of buildings to activate a street, day and night • Locate of daily destinations (e.g. playgrounds, grocery stores) in the city centre, not just cultural activities (theatres, etc.) • Similarly situate for example playgrounds in public space, not in semi-private (in building complex) • Acting upon parking provision and solutions one of, if not the, the most efficient measure to influence car use • Privilege win-win solutions, mutualizing land uses can enable multiple uses • Differentiate uses throughout out day, for example pedestrian street day/open-access night • Generally aim for a more equitable use of public space (available to a majority of people)

Table 25 Summary of land use-solutions and measures

Land use-measures could be bigger and smaller, depending on the project and the designer's role. In some projects, the designers are merely in the position to suggest and counsel land use for a street or a bigger area. For such cases, prioritizing daily destinations, from education and sports to grocery stores were a common objective, coupled with networks and infrastructure that simultaneously discourage increased car use. In other projects, the designers described having a more 'hands on' influence. Here, locating playgrounds in public space rather than inside an apartment-complex could be a means to invite for more use of public space, and enable random encounters between people.

The use of a building's ground floor offers another example, prioritizing stores or other services over dwellings, as this leads to more open and visually available facades. These examples demonstrate measures aimed at activating public space in order to make walking and/or cycling more attractive, while simultaneously making temporal stays in an area more pleasant. It also illustrates how the designers see solutions not directly related to mobility as a possibility to act upon it.

> "We cannot go in and design all of the architecture for example, we can not ensure that everything that is built is of high quality. But we can for example ensure that there is a good public place somewhere, or ensuring street qualities, or more green surroundings, etc. That one redirects a road, which means that you get a bigger car-free area centrally located where children can walk to school themselves. "
>
> – Interviewee 8

With regard to land use parking must be particularly highlighted. It was the most frequently mentioned measure among the interviewees, particularly to reduce or limit car use – both in Norway and in France: "if you have parking you'll drive, if not you will choose differently" (interviewee 9). The designers often aimed at reducing parking space to discourage residents from having their own private car, or to make it more complicated to go to a destination by car. However, several of the interviewees underlined that such measures must be coupled with public transport alternatives. To the interviewees, parking provision and solutions appear to first and foremost be a question of space and how to use it; often how to use it more equitably. Reduced parking requirements in a project opens for allocating it differently, for example to obtain more common spaces or public spaces (as previously discussed).

> "I think people forget that it changes the premises for how you use and experience a space if you remove the cars."
>
> – Interviewee 15

Parking requirements and parking solutions can become a part of the program, or stem from the designers as a result of their site analysis. Here again the holistic and long-term perspective can be detected. One interviewee described a project where he and his colleagues had suggested removing 30-40 parking spaces around the town square. They estimated that there was enough parking in adjacent streets, with only a slight increase in walking distances. The liberated space could be given a flexible use for the ‘benefit of all’. Interestingly, several of the interviewees reported that city authorities seem more convinced of the positive effects of this than before; “it is no longer necessary to prove that a pedestrian city centre is better than a city centre full of cars” (interviewee 4). Another reason to act upon mobility was to have people present in public space. With underground parking (or similar) at one’s residence and at work, a person can spend the whole day without being in the public realm; “you won’t get a lively city like that” (interviewee 11). Instead, several practitioners favoured locating parking (e.g. parking cellars) some couple of hundred meters away to force people to walk some distance in public space. This was said to enable potential interactions between people, impulse buys, etc.; even just the presence of these people in public space without any interaction was seen as positive. Another example of how local land use (here parking) can influence mobility behaviours, while simultaneously improve an area as a living context.

It must be specified that few, if any, of the practitioners were completely against cars in a city and its central areas. Cars are part of the urban picture, and necessary for certain segments of the population, however, they ought not to have the priority and amount of space as today. Which is perhaps why parking restrictions were held up as efficient and interesting measures to reduce or limit car use. It does not ban cars entirely, but makes it more complicated to use them; moreover, it shifts the priority. Drivers must adapt, not vice versa, and the public space is given a fairer and more public use – an important element in improving living contexts. Some interviewees talked about the possibility of allowing drivers to access a city, but not to drive through, “they must have a purpose to be there” (interviewee 19). This would involve a reorganising of driving patterns so that people could enter with their private cars, but drive through; seemingly a measure to reduce both the number of cars and driving speeds. Another alternative is to differentiate use of streets throughout the day. During daytime a street might be pedestrian, while open for cars during the evening or the night.

URBAN STRUCTURE AND MOBILITY SYSTEMS

SUMMARY OF FREQUENTLY MENTIONED URBAN STRUCTURE- AND MOBILITY SYSTEM-SOLUTIONS FROM INTERVIEWS
• A finely meshed urban fabric with a high number of connections between street networks and building blocks, and with a clear allocation of space to different modes • A grid-like network can enable connectivity, and encompass different mobility modes simultaneously • Informal paths between buildings or through building blocks to offer short-cuts, primarily to pedestrians • Design at human scale, for example breaking up continuous building blocks • Extension of sidewalks, paths, etc. to link pedestrian and cycling networks • Clearly marked usages (and priorities) at intersections • Width of sidewalks and streets a way to structure an area and its uses • Wide sidewalks to allow for dynamic and static uses simultaneously • Transition from road to streets (barrier to seam) can increase 'transformation capable' area

Table 26 Summary of urban structure- and mobility system-solutions and measures

How people travel in a city is highly influenced by its urban structures and mobility systems, as seen in the literature review in Chapter 1. Consequently, many of the measures and solutions the practitioners implement in a design process are related to these. Again, the extent and nature of the solutions depend on the project and its context. A common tendency was aiming for a finely meshed urban fabric with many potential routes, allowing travellers to adapt a trip according to their needs and preferences. This is often referred to as Connectivity in the research and urban design literature, a quality previously visited. The more meshed the structure, the higher flexibility, according to the interviewees, making it possible for different mobility modes to 'co-habit' an area. Several reported preferring a grid-like network, in part because it has a high capacity to transform for new needs and uses. With regard to urban living and quality of living contexts, many talked about transformations from road to street. This reduces speeds, and invite to other uses; a street is a city element, while a road is primarily for efficient transport. In this context, intersections and for the limit between sidewalk and street were also important aspects to properly solve.

URBAN FEATURES

SUMMARY OF FREQUENTLY MENTIONED URBAN FEATURE- SOLUTIONS FROM INTERVIEWS
• Openings in buildings and building blocks to create visual connectivity towards other areas, other streets • Design and use of facades on ground floor, favour businesses, cafés, etc. that have open facades (not closed of or screened of) • Signage and other traffic communication to create hierarchy and legibility • Allowed travel speeds, lowering speeds is favourable for pedestrians and cyclists • Place buildings at edge of sidewalk to avoid 'residue' private space between sidewalk and building

Table 27 Summary of urban features-solutions and measures

The neighbourhood scale introduces an additional built-environment element: urban features, e.g. sidewalk width, façade design, view lines, and vegetation. These are singular elements and aspects that together with urban structure, land use, and mobility systems make up the neighbourhood-scale built environment. Some can also be categorized as urban structure or mobility systems (sidewalk or street width). Here they are placed with urban features, as they represent a level of detail distinct for this geographical scale. The interviewees described acting upon urban features directly, or using them as a means to achieve particular objectives. Sometimes for instrumental purposes, other times for more perceptual (aesthetic) purposes, often both as part of their win-win approach: creating spaces that are well-functioning transport axes as well as pleasant places for temporal stays. Interestingly, several of the features described by the interviewees corresponded to the features explored in the survey (see Table 32 and Table 34).

5.4.3 c) **Choice of mobility measures and solutions**

The survey asked practitioners which elements might influence choice of mobility measures and solutions. The respondents were given a list of elements of which to choose the three most influential (Table 28). The responses correlate with other survey findings, as well as observations from workshops. Context, in a broad sense, is most influential, particularly the immediate and surrounding physical context (1, 2, 4 in the table). This corresponds to previous research results that have found the influence of neighbourhood-scale built environment elements upon modal choice to be strongly related to the particular urban context (Forsyth and Krizek, 2010; Stefansdottir, 2014b).

These responses also underline the apparent importance given to existing context by practitioners, especially for mobility actions. Few urban design projects take place within a completely untouched setting. They are generally situated within an urban context that has a long history, and a number of factors (internal/external) that will influence and be influenced by the project. Understanding this, and how address and tackle it, is part of the urban designer's Technical savoir-faire and Design savoir-faire.

ELEMENTS THAT INFLUENCE CHOICE OF MOBILITY SOLUTIONS/MEASURES (63 responses)	
1. Existing and potential access to area (street network, access to public transport, active mobility infrastructure, etc.)	81 %
2. Existing structure, urban fabric and form	56 %
3. The program (mixed use, dwelling density, parking solutions, public space, etc.)	51 %
4. The physical context (local climate, vegetation, topography, etc.)	40 %
5. The client's objectives for daily mobility (facilitate public transport, reduce n° parking spaces, space for various modes, etc.)	33 %
6. Society's targets of reducing traffic volume growth	29 %
7. The economical, social, and cultural context	14 %

Table 28 Which elements that influence choice of mobility solution/measure the most, choosing from a list of three alternatives

The program and the client's objectives are also reported to have some influence upon choice of solutions and measures (3, 5 in the table). For the most part, the designer has to take these internal constraints into consideration in a project. It is therefore interesting to observe that existing urban context – an external constraint – is said to be more important. This might be related to the governing principles of the practitioners, as well as their savoir-faire. Based on the interviews, it seems the urban structure represents a more dictating constraint for what can actually be achieved than a client's objectives and wishes. Nevertheless, the internal constraints of the program and the client objectives remain influential for design choices of solutions and measures. In the workshops, the reduced parking requirements (0,5 per dwelling) indicated the client's sustainability focus. This appeared to reinforce and/or support the groups' initial inclination towards of a pedestrian-oriented neighbourhood.

The option “society's targets of reducing traffic volume growth” was one of the few aspects where a clear difference was observed between Norwegian and French respondents. In Norway, this is a national objective, well-know by most practitioners; several of the designers referred to it during the interviews. Whether urban development is actually planned accordingly, i.e. in a manner that will contribute to its achievement, is disputable (Tennøy, 2012). However, it is always the overall planning goal, together with the objective that all traffic-growth is to be done via public transport, walking, and cycling. Such objectives appear less clearly expressed in France, though some of the interviewees referred to a general planning objective of reducing car use. It is therefore not surprising to find that 37% of Norwegian responding practitioners, versus 18% in France, judge this to be an influential element.

5.4.4 Particular requirements for the different mobility modes

Through the enquiries some particularities or requirements stand out for the different mobility modes. The following is a summary of the main elements. Parallels exist between walking and cycling, which is not surprising as they are both non-motorized transportation means. It is important to keep in mind the relation between walking and transit use. As the two are inherently related, important aspects for walking equally applies to transit use – and by consequence to element to ensure when promoting an increased use.

PARTICULAR OBJECTIVES AND PRINCIPLES FOR THE MOBILITY MODES	
Cycling	❖ A person must *want to* cycle, it must be pleasant, satisfying, and perceived as safe in order for people to choose it over for example driving ❖ Travellers' needs are more varied for cycling than for walking ❖ Differentiating infrastructure for categories of cyclists is an interesting solution, for example cycling highways – can reduce conflicts pedestrians/cyclist; cyclists/cyclists ❖ The cycle network must be complete in order to get people to choose to cycle ❖ The e-bike opens new and interesting possibilities, it can reduce importance of distance and physical context ❖ Cycling is traveling with a vehicle although non-motorized like walking; they must be treated differently ❖ Must accept that streets with much cycling may not be as pleasant for pedestrians, necessary to prioritize ❖ Signage and other markings to mark cycling rights, how and where to behave in traffic *Significant urban qualities:* Connectivity (extremely influential); Legibility (very influential) *Significant urban features:* Street width (very infl.)
Walking	❖ Pedestrian mobility must be very pleasant (instrumental and perceptual), people must want to walk • Must feel safe (traffic safety, safe in public realm) • Many route choices, possible short cuts through building and urban blocks • Interesting surroundings, pleasant views, active ground floors, etc. • Favour aesthetics, vegetation, activities, and variation • Avoid noise, much traffic, and high speeds ❖ Hierarchy: what is the pedestrians place in the traffic? ❖ Distance is particularly challenging: the longer the walk, that much 'better' the built environment must be (i.e. more active, varied, pedestrian-friendly) ❖ Location and provision of parking, parking solutions can force certain movements patterns to get people out in the street *Significant urban qualities:* All either extremely or very influential *Significant urban features:* All except building height extremely or very influential
Public transport	❖ Quality and ambiance of the trip is important ❖ Getting to and from transit stop can be a barrier: "if you have to walk 50 minutes to get to the bus you won't" (interviewee 9) ❖ In dense and highly urban areas, distance between transit stops can be higher than in less dense and urban ❖ Perhaps public transport should be considered as public space, like sidewalks? A place where random people meet everyday, with less possibility to choose whom. Could change the responsibilities and priorities ❖ Must be actually prioritized over cars, for example parking and lanes. ❖ Move parking (for example commute parking for trains) further away to that walking to transit (e.g. train station) is a better alternative than driving for those who live nearby *Significant urban qualities:* Connectivity (influential) *Significant urban features:* Distance to transit stop (very influential)

Table 29 Summary of particular requirements for the different mobility modes

5.5 Mobility and the neighbourhood-scale built environment

5.5.1 Overall observations

The survey and the interviews explored how urban qualities and features influence people's interaction with the neighbourhood-scale built environment, and how this influences modal choice and daily travels – according to the practitioners. The survey asked the respondents to assess the importance or the influence of urban qualities and urban features upon i) perceptions or experiences of the built environment (Table 31 and Table 32) and ii) modal choice (Table 33 and Table 34) Examples of qualities are Complexity or Transparence, while features counted for example sidewalk width, building height, or façade design on the ground floor. The interviews enquired the topics directly and indirectly through questions such as how to conceive an environment where people feel safe in public space, as well as the transformation case study. They were also asked about the relationship between mobility and quality of living contexts.

5.5.1 a) **Qualities generally more significant than features**

Overall, the survey respondents rated urban qualities as more important or influential than urban features. In the interviews, the designers similarly focused principally on qualities, in addition to perceptions and experiences, but less on singular elements and features. The latter were described more as 'tools' or measures to create a particular perception or quality. This aligns with the holistic approach observed in the workshops and confirmed through the interviews. It should be noted that the enquired qualities can in themselves be perceptions and experiences, for example Legibility or Enclosure. This can create some ambiguity. However, while the qualities can establish/create the enquired perceptions and experienced, the contrary is not possible: feeling of safety in public space cannot create Legibility. Another aspect to consider is the interdependencies between qualities, for example between Connectivity, Human scale, and Transparency. Which can make it somewhat difficult to exploit the results: is Legibility really more important for walking than Complexity, when the latter is necessary for a legible environment? This remains a question of interpretation, but somewhat less important in the context of this thesis. Rather the enquiries focus on exploring how qualities (and features) influence perceptions and modal choice, in order to determine how urban design can be used to promote zero-emission mobility modes.

5.5.1 b) **Mobility seen as movement within built environments**

Similar to design processes, the interviewees see mobility as more than 'just' a trip from A to B, from a starting point to an end point; it is also a kind of use of public space. Daily mobility has a purpose: "people are always going somewhere in order to do something" (interviewee 9). During a trip, however, the traveller passes through various urban environment and scapes. With regard to urban design and the neighbourhood-scale built environment, it is the movement within or through an area that seems to be of interest to the designers: how people move, where they move, the experiences this produces, etc. The built environment in which he or she is at any given time of a trip establishes a traveller's immediate surroundings. It creates perceptions and experiences that influence the overall travel experience. The impact of immediate built-environment surroundings are a result of their qualities, as well as their properties and characteristics. The latter refers to particular capacities of a public space, which are further explored in 5.5.2. This way of considering mobility can to a large extent explain its importance in a design process, applied mobility measures and solutions, and how mobility can contribute identifying what the problem 'really is'.

> "It is actually more a question of movement. Creating movements that bring [with them] a lot of things. Create movement that bring something else to the area."
>
> – Interviewee 1

According to the practitioners, the interaction between the person travelling and the immediate built environment depends on travel speed. In the survey, for example, urban qualities and features had less influence upon transit use than cycling. This is supported by research literature: the higher the speed of travel, the lower the level of interaction with immediate surroundings (Pucher and Buehler, 2010; Stefansdottir, 2014b; Timms and Tight, 2010).

> "But then the interesting with regard to the city as an experience is perhaps not the people who cycle, or take the subway or the bus, or drives, but rather those that walk, because it is those who walk that really influences how the public space is perceived. And that's very big difference."
>
> – Interviewee 17

The interviewees were relatively equivocal regarding the requirements for movement in public space: people must be able to move around freely and easily get to where they are going. This indicates that the practitioner must ensure access and choice – two elements that are recurring in the following sections. Mobility represents space, or rather spatial needs, for example the built environment-elements needed to move around: streets, roads, and paths; public places; infrastructure for pedestrians, cyclists, cars, and transit. Several interviewees introduced the idea of considering public transport as public space, "the biggest in the entire city" (interviewee 9). It provides an arena for possible social encounters, as one temporarily encounters people one perhaps does not meet every day.

5.5.1 c) **Physical context – an initial and significant premise for modal choice**

Physical context refers to topography, climate, presence of water (river, stream, pond), and so forth. It is an aspect of a site that is generally almost or completely unchangeable; an initial premise for a project's development. According to the enquiries it is an essential condition for modal choice. In the survey, its importance was explored together with the urban features to be assessed. In contrast to sidewalk width or facade design, the physical context is not an element the designer can act upon directly. The physical context of a site is an external constraint, but generally not an optional one. As can be seen from Table 28, 40% of the survey respondents reported that in a project, physical context influence their choice of solutions and measures (63 responses).

During the workshops, physical context was mainly considered in terms of climate (which is quite hot), as the site had an insignificant topography. Table 30 shows the survey respondents' assessment of the influence of physical context upon modal choice: extremely influential for walking and cycling, moderately influential for public transport. One explanation for this can be found in Næss (2012). He writes that physical effort is an important rationale for modal choice, especially for non-motorized modes. The physical context can significantly impact this, the extent of which depending for example on the physical capacities of the traveller. Following the reasoning by Næss, physical context (natural environment) can have a significant influence upon modal choice – as indicated by the survey respondents. The interviewees seemed to agree to this reasoning, often emphasizing physical effort as an important factor for walking and cycling. However, it was not a frequent topic during the interviews.

PHYSICAL CONTEXT AND MODAL CHOICE (68 responses)				
	Walking	**Cycling**	**Public transport**	**SUM**
Physical context (e.g. climate, topography)	Extremely influential	Extremely influential	Moderately influential	**Very influential**

Table 30 The influence of physical context upon modal choice, 68 responses. Ranged order based on rating averages

The moderate influence upon public transport use is likely related to the level of interaction between the built environment and the traveller during a trip; the use of a motorized means of mobility basically eliminates potential barriers such as topography or harsh climate (very hot, very cold). The result for public transport indicates that the practitioners focused primarily on the actual transit ride and less upon the travel to or from the transit stop. This primarily is done by foot or by bike, and so physical context could be expected to have a higher influence for transit use.

5.5.2 Perception and experience of urban spaces

5.5.2 a) **Designing 'good' spaces that people want to use**

The interviewees often focused upon public space and how people use this. Public space generally included urban space that is not private and so theoretically available to all, the space between buildings such as public places, streets and their sidewalks, smaller paths between buildings across an urban block, crossings under bigger streets and rails, etc. The urban scapes and environment of the city that people move through or stay in for some time. To the interviewees, people being present in public space, using it some way or merely passing through is seen as a sign of successful design. Consequently, making places people want to use or want to be, stand out as another common design objective, "a good space is a space that is used" (interviewee 9). A space has multiple functions, depending for example on the geographical scale; a factor that represents different kinds of interaction between people, and between people and a particular space. At hyper-local scale, a sidewalk can be the extension of a building's ground floor, for example for cafés. It can also be the playing area for children living on the particular street. At the neighbourhood scale, the sidewalk is part of the walking routes through an area. People use it daily, for example, on the way to a transit stop. At the city scale, the sidewalk can be the pedestrian part of a transport axis where a tram or a bus passes through. This can create conflicts between the needs of the linear (city scale) and the crossing (neighbourhood scale) traffic; between the mobility needs of the city, and the needs of a street as a living context. Ensuring a balance between these was important to the interviewed designers. However, they seemed to somewhat favour the local needs, in line with their overall concern for the quality of urban life and its living contexts.

According to the interviewees, there is no general theory for what constitutes a 'good' public space, or what quantifies the quality of public space; on this topic there exist many different schools. A common opinion is that frequently used spaces have particular qualities, characteristics, and properties that make people want to use them. These tend to include people feeling comfortable and safe in public space; people feeling invited in public space – i.e. that they are supposed to be present and use the space. Through the interviews certain requirements or objectives for achieving such places emerged (see below). They translate as properties or characteristics of a public space, which in turn influences, for example, how it accommodates different mobility modes.

- ❖ Capacity to accommodate various kinds of uses, dynamic and static, as well as different speeds of movement
- ❖ Allowing for functional needs such as daily mobility, i.e. people wishing to move through when travelling
- ❖ Contributing to pleasant everyday experiences, i.e. people wishing to stay there over a short or longer period

The latter is important for creating a good living context, e.g. to build social capital. Being a ‘good’ space also means that people have a reason to go there, other than merely pass through. Having something that draws people, e.g. a playground, can be a way to activate the space and make people come. According to the interviewees, people attract people. Creating a space where people want to spend time can encourage others to use it as well, which in turn can attract more people, and so forth. This also indicates to what extent the practitioners see people as both users of the urban space and as a part of it – for example part of the immediate surroundings of a person walking down a street.

The qualities or measures held up as important by the interviewees for creating places with the above described characteristics and properties, resonate with several of the urban qualities explored in the survey, namely Complexity, Enclosure, Legibility, and Human scale. These also came up often regarding mobility in a design process. Complexity was said to be important in order to activate public space, for example through mixed uses, varied design, and so forth; i.e. avoiding monotony, so that the space does not become “boring”. This is largely related to aesthetics, but measures and solutions that create Complexity can also have a other functions. One way to ensure Complexity is through the design and use of a building’s ground floor. The interviewees favoured businesses and stores (mixed uses) with window facades, rather than apartments or service entrances. These are often more closed off, creating a long and uniform wall. Window facades can create a relationship between inside and outside, opening up the building and bringing the life of the ground floor to the street. With regard to the relationship between a building and a street, some of the interviewees also emphasized the need to properly align the building with the street (sidewalk), in order to avoid 'residue' space in front of it. Such space is often difficult to give a concrete use. Moreover, it creates a 'dent' in the street-façade that can produce a feeling of insecurity. This is related to Enclosure. Smaller design measures such as benches and vegetation are a way to invite people to stay in an area for some time.

Being recognizable and/or readable is another important property of a space. People must be able to understand where they are (geographically, culturally, etc.), how to behave in the area, and how to move around in it or through it. These are aspects of Legibility, a place's capacity to be understood so that people can orient themselves in it. These qualities or properties were said to be important in order to balance different needs, accommodating both static and dynamic use. Human scale was also brought up, particularly for public places. If designing a very large public place its borders should be well organized, for example buildings, which should have defined uses to activate the space. This can also contribute to Legibility, making it easier to orient oneself in bigger, public space.

5.5.2 b) **Exploring particular perceptions**

The survey respondents were asked to assess the importance of particular urban qualities and urban features for i) perceived traffic safety, ii) the feeling of safety in public space, and iii) reducing the perceived distance going from one place to another. Table 31 and Table 32 summarize the results. The responses range from extremely important (one feature for traffic safety) to slightly important, none were rated as unimportant; qualities are overall more significant than features. The features are mostly moderately important or important, while the qualities are mostly important or very important. The qualities and features are rated as most important for 'feeling of safety' and 'reducing perceived distance', less so for 'perceived traffic safety'. According to survey respondents, features and qualities influence the latter, but it is perhaps seen as more reliant upon measures such as the presence of sidewalk and other infrastructure, traffic lights at intersections, etc.; illustrated by sidewalk width being the only feature or quality rated above important (rated extremely important) with regard to ‘perceived traffic safety’.

URBAN QUALITIES AND PERCEPTIONS/EXPERIENCES (survey, 68 responses)				
	Perceived traffic safety	**Feeling of safety in public space**	**Reducing the perceived distance going from one place to another**	**SUM PERCEPTIONS/ EXPERIENCES**
1. Legibility - How easily one can recognize and understand a neighbourhood, for instance to orient one-self	Important	Very important	Very important	**Very important**
2. Human scale - Dimension of built environments relative to human dimensions (e.g. street width, block size)	Important	Very important	Very important	**Very important**
3. Connectivity - Connections between streets, pedestrian networks, etc. for connections within a neighbourhood and/or between several neighbourhoods	Important	Very important	Very important	**Very important**
4. Enclosure - To what extent buildings and other elements define and shape spaces	Important	Very important	Important	**Important**
5. Transparence – The possibility to see what goes on at the end of a street and past it, for example human activity or particular buildings	Important	Very important	Important	**Important**
6. Complexity - How a rich variety of buildings and other elements create a diverse visual impression	Slightly important	Moderately important	Important	**Moderately important**
7. Coherence – To what extent the built environment creates an overall impression, e.g. through shapes or facades	Slightly important	Moderately important	Moderately important	**Moderately important**
SUM QUALITIES	**Important**	**Important**	**Important**	

Table 31 The importance of urban qualities upon perceptions and experiences of the neighbourhood-built environment, 68 responses. Ranged order based on rating averages

URBAN FEATURES AND PERCEPTIONS/EXPERIENCES (survey, 68 responses)				
	Perceived traffic safety	**Feeling of safety in public space**	**Reducing the perceived distance going from one place to another**	**SUM PERCEPTIONS/ EXPERIENCES**
1. Sidewalk width	Extremely important	Important	Moderately important	**Important**
2. Facade design at street level	Moderately important	Very important	Important	**Important**
3. View lines/sight lines	Moderately important	Important	Important	**Important**
4. Vegetation	Moderately important	Important	Important	**Important**
5. Street width	Important	Moderately important	Moderately important	**Important**
6. Size urban block	Moderately important	Important	Important	**Important**
7. Distance (real) to transit stop	Moderately important	Moderately important	Important	**Moderately important**
8. Building height	Slightly important	Moderately important	Slightly important	**Slightly important**
SUM FEATURES	**Important**	**Important**	**Important**	

Table 32 The importance of urban features upon perceptions and experiences of the neighbourhood-built environment, 68 responses.

Perceived traffic safety

Traffic safety was an important built-environment aspect for the interviewees, even if less frequently mentioned; the practitioners appeared to view it as a somewhat 'default' property of the kind of public spaces people want to use. It must be safe from traffic. Achieving it was often related to mobility speeds and to a clear hierarchy between mobility modes. The latter was said to be important for pedestrians or cyclists to comprehend their place in the street, how to move so as not to get run over by cars (or by cyclists for pedestrians). Looking at the survey results a similar tendency stands out, for example, the importance of sidewalk width (Table 32). Street width is similarly important, but could be expected rated as more important. Several interviewees explained that narrow streets are a measure to reduce driving speeds, a similar approach was seen in the workshops; indicating perhaps that the survey respondents first and foremost had pedestrians in mind when filling out the table? The other features are much less important. Qualities are rated as somewhat more important (Table 31). Here the survey respondents match their colleagues to some extent, as perception of traffic safety seem to be related to the possibility of reading a space and its uses (Legibility, Enclosure, Human scale), and to have an overview of the traffic and other activities (Transparence, Connectivity, Human scale). As can be seen from the table, these qualities are rated as very important for the feeling of safety in public space – likely for similar reasons.

Feeling of safety

When asked how the built environment could contribute to people's feeling of safety in public space the interviewees were markedly similar in their responses, which in turn are supported by the survey responses. According to the interviewees, people's feeling of safety in public space is first and foremost related to the presence of other people. This mirrors the CapaCity workshops, where lack of people in public space was deemed a significant contribution to feeling of insecurity. Others people's presence feels preventive, e.g. "nobody will do me harm", or "if something happens people can intervene". Although, as one interviewee pointed out, it depends on who these 'people' are. Several called people's presence a form of social control, some using the term 'eyes on the street' as defined by Jacobs (1961): how people on sidewalks, and more specifically in bordering apartments, looking out on the street can be preventive for crime. Interestingly, this provides another reason for designers to aim for people to be present in public space. In addition to indicating the kind of places people like, and to contributing to social capital, it can contribute to making people feel safe in the public realm. In light of this, it is not surprising that 'façade design at street level' is rated as very important for this in the survey. It was similarly brought up by several of the interviewees; it can help activate a street or a place, thereby attracting people. The interviewees talked about the importance of facades that are light up or have windows with lights on in the evening, creating a connection between the inside and outside can contribute to the feeling of safety. For the presence of other people to matter, they must be seen; the public space has to provide oversight (Connectivity and Transparency rated very important), and be properly lit when it is dark. The interviews also underlined some potential design-outcomes to avoid: shadowy corners, obscure passageways, narrow alleys with bad lighting, etc. Several interviewees emphasized the importance of context, as different contexts will give different meaning to the same urban feature or quality.

The survey respondents rated Legibility and Enclosure as very important for the feeling of safety, to which the interviews can provide some detail. The designers explained that being able to orient oneself, and to predict what to expect from that place, is important for the feeling of safety; i.e. what kind of people live or frequent this place; what kind of activities normally goes on here; where is the way to this or that destination; etc.

Reducing perceived distance

Distance – objective and subjective – was not addressed directly in the interviewees. Research has found it to be highly significant for modal choice, and so the objective was to see if the designers equally accorded it importance, which they did. Distance was brought up frequently, and particularly influential for walking and cycling. As an example, the space – scapes and environment – a traveller passes through must not be "boring" or "monotone" as this can increase the perception of distance. By correlation, this indicates that the designers see varied and active public spaces, as described in 5.5.2, as influential upon perceived distance. Furthermore, there seems to be a link between the kinds of spaces people want to use – interesting, active, and ‘good’, and the kind of environments that can make travelling distances seem shorter (or at least not longer). The survey responses support this interpretation. The type of qualities or properties described by the interviewees for ‘good’ and interesting public spaces resonates with the qualities rated as very important or important: Connectivity, Legibility, and Human scale.

‘Façade design at street level’ was expected viewed as highly important, based on the above, as well as the interviewees’ description of this feature. However, none of the features are rated as more than important, and one as merely slightly important; another indication that the practitioners tend to view qualities – wholesome experiences of a built environment – as more important than singular features.

5.5.3 Urban qualities, urban features, and modal choice

The survey asked respondents to assess the influence of urban qualities and features upon modal choice (see Table 30, Table 33). The interviews mostly explored urban features and qualities, and their link to modal choice, indirectly through questions about mobility’s influence upon a design process, and upon the quality of living contexts. During the conversations the interviewees described a series of characteristics, properties, and qualities they believe a neighbourhood-scale built environment should encompass with regard to mobility. Some were directed at particular mobility modes, but for the most part they concerned how to ensure a functional daily mobility in combination with what they considered as important for good loving contexts. This was much related to the interaction between the traveller and his or her immediate built environment during a trip. Connectivity and Legibility stand out as particularly influential, and are therefore explored more in detail than the other qualities.

The previous sections showed that according to the enquired urban designers (survey and interviews), the neighbourhood-scale built environment influence people’s perceptions and experiences of an urban space. It does so through its qualities, properties, and characteristics. The interviews, as well as the workshops, showed that practitioners see daily mobility as a kind of use of public space, as movement within or through an area. The built environment-influence depends on travel mode, as this determines (possible) travel speed, and the extent to which the movement requires interaction with immediate surroundings. With transit the traveller is transported in a vehicle, and so the immediate surroundings influence the movement less than if the he or she was walking.

The notion of spaces people want to use applies in this context as well. For mobility, interviewees emphasized that public spaces must be of the kind people want to move through, i.e. to be a part of their travel route. The opposite, spaces people do not want to use, can make a trip longer as the person has to take a detour to avoid the particular area. With regard to this, the interviewees often brought up similar perceptions and experiences as those enquired through the survey (see above): feeling of safety; traffic safety (objective/subjective); distance (objective/subjective). This supports their significance as important not just for the quality of an area as a living context, but also for mobility and people's modal choices.

The enquired qualities and features matter less for transit than for cycling and walking. However, transit use and walking are inherently related (Hillnhütter, 2016; Mees, 2010). Hillnhütter (2016) found that most transit users spend over 40% of their trip walking to or from the public transport stop, and that the built environment during these walks heavily influenced the travel experience (over 60% of the remembered trip). Hillnhütter also found that the design of this environment can significantly heighten or lower the accepted walking distance. As one of the interviewees explained, the longer the walking distance, the 'better' the built environment must be (i.e. activated, varied, aesthetically pleasing, etc.). Since remembered travel experience influence future modal choices, the influence of neighbourhood-scale built environment upon transit use should not be ignored.

URBAN QUALITIES AND MODAL CHOICE (survey, 68 responses)				
	Walking	**Cycling**	**Public transport**	**SUM MODES**
1. Connectivity - Connections between streets, pedestrian networks, etc. for connections within a neighbourhood and/or between several neighbourhoods	Extremely influential	Extremely influential	Influential	**Very influential**
2. Legibility - How easily one can recognize and understand a neighbourhood, for instance to orient one-self	Extremely influential	Very influential	Moderately influential	**Very influential**
3. Human scale - Dimension of built environments relative to human dimensions (e.g. street width, block size)	Extremely influential	Influential	Moderately influential	**Influential**
4. Enclosure - To what extent buildings and other elements define and shape spaces	Extremely influential	Influential	Moderately influential	**Influential**
5. Transparence – The possibility to see what goes on at the end of a street and past it, for example human activity or particular buildings	Very influential	Influential	Slightly influential	**Influential**
6. Complexity - How a rich variety of buildings and other elements create a diverse visual impression	Very influential	Influential	Slightly influential	**Influential**
7. Coherence – To what extent the built environment creates an overall impression, e.g. through shapes or facades	Very influential	Influential	Slightly influential	**Moderately influential**
SUM QUALITIES	**Extremely influential**	**Influential**	**Moderately influential**	

Table 33 The influence of urban qualities upon modal choice, 68 responses. Ranged order based on rating averages

URBAN FEATURES AND MODAL CHOICE (survey, 68 responses)				
	Walking	**Cycling**	**Public transport**	**SUM MODES**
1. Distance (real) to transit stop	Extremely influential	Moderately influential	Very influential	**Very influential**
2. Street width	Influential	Very influential	Moderately influential	**Influential**
2. Sidewalk width	Extremely influential	Influential	Moderately influential	**Influential**
3. Vegetation	Extremely influential	Influential	Slightly influential	**Influential**
4. View lines/sight lines	Very influential	Influential	Moderately influential	**Influential**
5. Size urban block	Very influential	Influential	Moderately influential	**Influential**
6. Facade design at street level	Very influential	Influential	Slightly influential	**Influential**
7. Building height	Moderately influential	Slightly influential	Slightly influential	**Slightly influential**
SUM FEATURES	**Very influential**	**Influential**	**Moderately influential**	

Table 34 The influence of urban features upon modal choice, 68 responses. Ranged order based on rating averages

5.5.3 a) **Perceptual and instrumental**

Similarly to perceptions and experiences, qualities are overall rated as more important or influential than features. A similar interpretation is probable, that this relates to the observed holistic approach of urban design professionals and their view on how people experience the built environment as environments and scapes – for example with regard to travel speed. As the speed increases, the influence or importance of the built environment decreases. The difference is particularly striking when comparing walking and public transport. The qualities that influence walking the most are related to physical distance (Connectivity, Human scale) and perceived distance (Legibility, Connectivity, Human scale, Complexity), to orientation in an area (Legibility, Enclosure, Transparency), but also to aesthetically pleasant travel experiences (Complexity, Coherence). A similar tendency can be seen for cycling, but much less for transit. Connectivity and Legibility will be further commented upon below, as they arose frequently in the interviews as well. Another recurring observation is the relationship between perceptual and instrumental, particularly for the qualities. Those with a more instrumental tendency, such as Connectivity and Human scale, are rated as more influential than Complexity and Coherence, which are more perceptual. Similarly, distance, and sidewalk and street width are rated as more important than, for example, façade design. This separation is not absolute; Legibility has a relatively strong perceptual and instrumental aspect. Indeed, several qualities and features contribute both instrumentally and perceptually. This combination of instrumental and perceptual (experience) is an interesting aspect. The built environment must support the use of a particular mode, especially for walking and cycling (transit depends first and foremost upon whether the offer is there); the instrumental aspect must be ensured. Is it easy, difficult, or even possible at all? Does a person have the possibility to choose, both mode and travel route, according to individual preferences and needs? At the same time, the interviewees underlined that a trip must be “pleasant” and not “boring” which can make it seem longer, which refers too perceptual aspects. To what extent a mobility mode is “welcome” in an area also influences travel experience (e.g. presence or not of infrastructure for pedestrians). Stefansdottir (2014) found that for cycling, instrumentality and aesthetics both matter, but that the former tends to matter more. In other words, if instrumentality is not satisfied (e.g. infrastructure), the aesthetic qualities of a space are likely to have less importance. This does, however, also depend on the level of experience of the cyclist. It should be noted that there is not always a clear line between what is instrumental or perceptual. Additionally, both are subject to a person's individual characteristics and evaluation.

All the proposed urban qualities were rated as influential to some degree, depending on travel mode. This was as expected, based on the existing literature, as well as exploratory enquiries. The qualities represent aspects, properties, and characteristics of an urban environment that are frequently emphasized by urban design literature (Carmona, 2010; Gehl, 2010). A certain relationship can be observed between the qualities and features and how they matter for the different modes: Connectivity and distance to transit stop matter the most for public transport use; Connectivity and Legibility, combined with street width matter the most for cycling. Street width can determine the possibility to separate mobility modes, for example cars and cycles, using different kinds of asphalt (or paint), or more extensive measures. Which in turn can help the cyclist comprehend their 'place' in traffic, and how to behave in a particular street (e.g. where to cycle).

For transit, the qualities and the features tend, in sum, towards *moderately influential/important.* This is likely related to the respondents focusing primarily on a traveller using or not using transit, and to a lesser degree including going to and from a transit stop, which generally made by foot or cycle. If this had been equally integrated, the responses would probably have been closer to those for walking and cycling. The lesser influence and importance of the neighbourhood-scale built environment upon transit use – according to the survey respondents – probably mirrors the interaction with the built environment, which will be more distant when travelling by bus, metro, etc. (see above). It might also be that the designers tend to link public transport use to longer trips, estimating that travel time and modal offer outweigh the influence of surroundings during a trip. However, this brings up new questions about the neighbourhood-scale built environment at the starting and ending point for walking (or cycling) to and from transit stops: Is it generally seen as less important? Or merely not considered in this context as the survey simultaneously asked about walking and cycling? This is difficult to conclude upon, as surveys do not offer the possibility to follow up questions and responses.

5.5.3 b) **Connectivity**

A high level of connectivity – connections between urban mobility networks – can shorten distances to destinations, for example by offering more direct routes to potential destinations. By consequence, it can increase accessibility and proximity to daily destinations (Næss, 2012; Saelens and Handy, 2008). Connectivity can also increase potential route choices, allowing travellers to adapt the trip to individual needs and preferences (Krizek et al., 2009; Næss, 2012). Few of the interviewees referred to Connectivity directly, but frequently brought up the importance of distance and proximity, rendering destinations more accessible, as well as increasing route choice – all strongly related to Connectivity. Route choice was seen by some as a way to reduce the importance of individual characteristics. With regard to interdependencies between qualities, a high level of Connectivity is necessary to obtain Transparency, which in turn can produce view/sight lines.

Survey respondents rated Connectivity as the most influential quality. Additionally, it is the only quality rated as extremely important for cycling. The importance of Connectivity is probably strongly related to distance; for cycling, route choice might also be an important factor. The latter primarily remains an interpretation, while distance can be concluded upon relative certainty as Connectivity was rated as very important to reduce perceived distance (Table 31). Moreover, the survey respondents report that distance to transit stop is highly influential for walking and transit use.

Human scale is related to Connectivity as the size of urban blocks, which can increase or reduce it. Human scale was similarly reported as very important for reducing perceived distances, probably much for the same reason. For modal choice, human scale is reported as extremely important for walking, though somewhat less for cycling. This is likely a result of the person using a means that can increase travel speed, making for example the size of urban blocks less influential for travel efforts. The influence of the latter upon walking supports this interpretation.

5.5.3 c) **Legibility**

Legibility, in itself or in terms of readability or comprehension of an area, came up frequently in the interviews with regard to general use of public space, and to daily mobility (see 5.5.2). In short, Legibility is said to help a person orient him- or herself in public space with regard to the nature of it, how to behave and use a space, etc. For mobility, this particularly applies to the hierarchy between different mobility modes and travelling speeds. The interviewees explained how this is important for traffic safety, and for reducing the level of conflict between modes. Legibility is also important for the traveller to find their way, which in turn can strengthen the feeling of safety and reduce perception of distance, as well as enhance the overall travel experience (e.g. reduce frustration). It should be noted that the characteristics and properties upheld as important for daily mobility in urban environments, especially for walking, are also said to be important for general use of public space and good living contexts.

According to survey respondents, Legibility is most influential for walking, followed closely by cycling, but much less so for transit. This probably reflects earlier observations about how the respondents considered transit when answering, for example for the level of interaction with the built environment. With public transport the traveller is being transported, the need to orient oneself comes before the trip: finding the correct bus or tram to get to the destination. There is less need to find one’s way once on-board (except to and from transit stop). In terms of interdependence, Legibility is an interesting quality; it can be considered an instrumental as well as a perceptual quality. Where Connectivity can be objectively measured, Legibility largely depends on the individual’s perception of the built environment. At the same time, based on the interviewees, it seems that there are some ‘principles’ that can be followed to create or establish Legibility. Hierarchy between mobility modes is one example, which can be enhanced by sidewalk and street width; distinctive features is another, using façade design, vegetation, or creating view/sight lines towards memorable built environment elements; thus showing the link to other qualities.

METHODOLOGICAL LIMITATIONS

Important elements for the particular methods were addressed in the individual chapters. The following is a more general discussion, where particular elements for each method are highlighted when relevant. The overall methodological limitations in the context of this thesis can be summarized as representativeness, time consumption, influence of the researcher, and the subjects. They influenced the explorations during the design-, the execution-, and the analysis-phase. Table 35 presents the main aspects of each, and some of the measures that were taken to address them, followed by further detail on representativeness and time-consumption.

A frequent challenge to a thesis project is how the knowledge and understanding of the research topic advance in parallel to the design and execution of enquiries (here primarily the empirical enquiries). This makes it difficult to ensure that they explore or test the most important and/or interesting aspects, as it hard to predict what these are; part of the general uncertainty to be dealt with. In this context, little work was found on the topic of design practices and mobility (with the exception of Tennøy (2012), and to some extent Stefansdottir (2014)), which could have indicated some areas to particularly focus on. The doctoral thesis of Hillnhütter (2016) was published after the empirical enquiries were executed and analysed, but his results have been incorporated to the extent possible in the discussions in Part 3. Consequently, the workshops provided a valuable basis for the interviews and the survey. Ideally, the survey might have been undertaken before the interviews or vice versa, allowing one to further detail the other. Due to time constraints this was not possible. They were still designed as complementary, but probably not to the extent they could have been in a different context. There are aspects that could have been omitted or should have been included in both the survey and the interviews. Follow-up interviews could have been an option, but the availability of the practitioners as well as the time frame complicated this approach. Another example of challenges related to enquiring people, and of the general uncertainty that comes with a research methodology as that of the thesis. At the same time, designing and executing the two lead to exploring similar aspects and questions through different methods, which can be seen as strengthening the validity of the results.

SUMMARY OF METHODOLOGICAL LIMITATIONS THESIS ENQUIRIES		
	Why, how, and implications	*How addressed*
Representativeness	• With a small cohort the results will not be representative for an entire discipline. • Choice of methods limits the possible number of enquired practitioners, particularly for workshops and interviews because of the time and effort required. • A survey can compensate somewhat for this. Though here too, time can hinder a high response rate, as personal invitation remains most efficient.	• Test/compare results against existing research; here decades of design research, which is based upon a broad range of empirical enquiries of designers. The sum provides a solid base in how designers work, think, design, etc.; against which enquiry results can be compared.
Time consumption	• Design, execution, and analysis are phases that require much time and effort; often limited elements in a research project. Can ‘force’ shortening some aspects, for example testing of the workshops design. • Recruitment is an often-underestimated time-consumer, particularly since personal invitation proved most efficient for all methods. • Enquiries cannot be undertaken too late in a project because of the time needed for analyses, potentially imposing a somewhat premature execution. • The time-aspect further complicates follow-up interviews, additional workshops, etc. Must therefore get it as ‘right’ as possible the first time.	• Build upon experience from project colleagues and others, particularly for design-phase interviews and survey. • Privilege additional testing of interview guide and survey to ensure validity and reliability, and that the necessary aspects are (to the extent possible) covered. • CapaCity workshops based upon previous experiences so required less testing. • Outsource transcription of interviews. • Establish initial analysis-framework to guide and somewhat quicken analyses survey/interviews.

Influence of researcher	• During enquiries there are risks of influence through the way questions are asked, the discussion(s) steered, etc. See Chapter 5 for a longer discussion on this. • During analysis there are – as in most research – a risk of bias, for example confirmation bias, where opposing evidence is consciously or unconsciously ignored.	• For interviews and survey see Chapter 5. • For workshops this was a bit more challenging as researchers played game maker and table guides. Fellow researchers helped ‘tempering’ the influence of the guides for each table, and the game maker had previous experience from workshops so knew what to avoid. • Construction of a solid analysis framework, together with frequent discussion of results with colleagues, can act as ‘filters’ for biases during analysis.
Subjects	• Enquiring people requires adapting to their availability, which can complicate recruitment, execution, limit follow-up sessions, etc. • It involves an uncertainty of what – if anything – will be found or observed during workshops and interviews. Surveys perhaps a bit more ‘sure’ in this regard. • Semi-directed interviews also means the interviewees to some extent steers the conversation. • Every situation is unique: an interview with the same person and researcher, in the same location but on a different day can give highly varying results (Ryen, 2002).	• Assign as much time as possible to recruitment and to execution (survey held for 3 months, interviews over a course of 4+ months). • Expect uncertainty; be open for new ideas and elements that can advance the research topic. • Privilege preliminary interviews to prepare and test, and to gain good knowledge of interview guide so the conversation can flow freely while still covering main enquiry points.

Table 35 Overview of main methodological limitations of thesis enquiries

Representativeness

Throughout the enquiries, the methodological limitations were addressed to the extent possible so as to reduce their influence. The results seem to indicate that this was adequately done; particularly when testing against existing research. The findings on design practices correspond to previous results from design research. That is not to say that differing results would directly indicate non-representativeness, or be incorrect. Research aims at advancing knowledge within various fields, which often imply confronting existing consensus or ‘truths’. For design practices this less so. Current evidence builds upon years of empirical enquiries observing designers, in various contexts and from different cultures. This has produced a sound knowledge-basis on general tendencies and design practices. The enquiry results corresponded well to these, which is positive with regard to validity and reliability. Moreover, it supports the hypothesis of a common design culture; the premise for addressing survey respondents and interviewees from France and Norway as one cohort. Such comparisons are no absolute manner in which to test representativeness, but provide a good indication. Another ‘test’ were the discussions after the workshops, where the participants were asked about the design game. The general consensus was that it corresponded well to frequent design situations, despite the limited time and the simplifications.

Time

Certain compromises had to be made during all phases of the empirical enquiries due to time-restrictions. The workshops set-up was, for example, not tested, but having two rounds allowed making certain adjustments in between without changing the general set-up of the design game. Previous experiences of other project members provided additional insurance of validity of the method. For the thesis, this experience proved valuable for preparing the interviews and the survey, particularly for their analysis. The decision of a smaller cohort – for the workshops and the interviews – was primarily related to the limited time, and a wish of pursuing the designers’ savoir-faire in depth. A broad representativeness was therefore not the objective, as it likely would have ousted the latter. The workshops could probably have had up to 20 participants (the largest had 12 participants), but would have complicated a sound observation of all groups. It would also have added to the analysis-time, or, on the contrary, have pushed towards a lower level of analysis-detail. Adding interviewees would likely have had a similar effect. Limiting the number to an approximate 10 per country allowed for longer interviews, and thus (generally) more detail. These are examples of assessments and potential compromises that had to be made during the construction of an empirical-based research methodology.

CONCLUSION PART 2

This part of the thesis presented the enquiries undertaken to explore the savoir-faire and the practices of urban designers. The aim was to gain better insight and understanding of people's daily mobility, and their interaction with the neighbourhood-sale built environment during a trip. For a thorough exploration, taking into account particularities of the professional savoir-faire, three methods were employed, workshops, interviews, and a survey. This also contributed to outweigh (as much as possible) the methodological limitations of each approach. Two questions were explored:

a) The role of mobility in design practices, and in a design process

b) How qualities and features influence modal choice, as well as perceptions and experiences of the built environment

It was hypothesized that the experience-based knowledge and the practices of urban designers can be a source of new insights and understandings, complementary to that of research. The enquiry results largely confirm this. The findings support existing mobility and transport research, but also provided new details that help address shortcomings in the scientific literature. Further explorations are required for future research, for example empirical enquiries seeking to elaborate and detail the practitioners' knowledge of urban inhabitants and their mobility. Urban practitioners have a holistic approach to urban design, looking at the built environment as a whole, and the experiences it creates. Moreover, as described in Chapter 3, they have particular, designerly way of observing urban environments and people's use of these. This 'professional eye' can provide insight into the interactions between travellers and their built environment that is less influenced by the personal context of the traveller. People's perception of their immediate surroundings is highly individual and subjective; a frequent challenge for research that surveys people's travel experiences and modal choices (Ewing and Handy, 2009; Stefansdottir, 2014a). Exploring the professional savoir-faire offered a more objective approach, based on their observations of how people interact with and are influenced by built environments.

The results support conclusions from previous studies that urban design can be a mitigation strategy, based on the reciprocal relationship between the built environment and mobility behaviours. Bridging land use and transportation planning often involves integrating one into the other – i.e. transportation planning in to land use planning or vice versa. Unfortunately, for several reasons this is often difficult, which contributes to a continued urban development that is likely to increase car-dependency (Tennøy, 2012). For urban design, however, the results show that mobility is already a significant and structuring element in professional practice. This appears to be related to the designers focusing on mobility as a kind of movement through public space, and focusing less on the trip as a whole (e.g. where start and end point; which modal choice). Consequently, it becomes one of several kinds of public space-uses they must design for, rather than an element a part that must be integrated somehow.

The role of mobility in design practices, and in design processes

The role of mobility in a project and a design process depends in part on the urban context and on the project's program, but it is always 'present' and taken into account to some extant. Daily mobility has an important, multifaceted role in the holistic, solution-based approach of urban designers (described in Chapter 3). It influences the design process instrumentally (e.g. structure and shape the neighbourhood) and perceptually (e.g. link to urban context, ensuring feeling of safety). Including mobility from the early site analyses provides a comprehension of the project site and its uses, but also of its relation to the urban context. Moreover, it contributes to going beyond the client's command – i.e. 'framing the problem' – to find how their built environment-intervention can best enhance the livability of an area; the overall objective of urban design.

The workshops and the interviews showed that mobility measures and solutions are often *win-win*, allowing the designer to address and potentially solve several issues or objectives simultaneously. This is in line with previous research findings (Dubois, 2014; Kirkeby, 2015), and reflects the holistic design approach, where the impact of a design action upon the project as a whole is an important criterion. The survey responses show a similar tendency. Implementing measures and solutions allow the designers to act upon mobility, while at the same time advancing the design process. The win-win aspect was often related to the multifunctionality of public space, where a multitude of usages – dynamic and static – must be possible at the same time. Several of the solutions and measures observed in the workshops and interviews had a mitigating potential, i.e. contributing to promoting for example walking or public transport use. However, this was rarely identified or discussed. Without further explorations it is difficult to determine if the designers are unaware of the potential, if it was merely given little or no attention during these particular explorations, or, if it is considered a 'by default' aspect of design actions. Likely, it is a mix of the above; depending on the practitioners, their governing principles, and previous project experiences. With regard to the scope of the thesis, it indicates that while mobility is integrated in design practices, mitigation seems to be less so. Consequently, rendering promotion of zero-emission mobility modes an active design objective might be one step towards enhancing urban design as a mobility-mitigation strategy.

Daily mobility was frequently described in terms of movement; how and where people move within and/or through the project site. Addressing and acting upon it often referred to the way this movement should and/or could occur, depending on the project command (e.g. reduce car use), as well as the practitioners' governing principles and objectives (e.g. prioritize pedestrians). The practitioners seemed to know how to achieve certain movement patterns or mobility behaviours through their design and organization of a site or an area. Urban design can facilitate or limit particular modes, initiate, or even force particular movement patterns through public space. Establishing paths through a building block can achieve this. Furthermore, the creation of dead-end streets or locating parking spaces some hundred or so meter away from the dwelling, to mention some examples, act similarly. The win-win element recurs. According to the enquired practitioners, the presence of people in public space is essential for good living contexts; it contributes to ensuring people feeling safe, and to building social capital. Making people move through public space contributes to this, as they are present – at least for a little moment – in the public realm. Moreover, it can enable potential encounters and interactions. Land use measures such as parking provision and solutions, the location of playgrounds, or the use of a building's ground floor, were frequently mentioned examples of how to achieve this.

The influence of qualities and features upon modal choice; perceptions and experiences of the built environment

Discussing or rating (survey) how the built environment influences urban inhabitants, the designers generally focused more on qualities and characteristics than on features and singular elements. At the same time, the design and use of a building's ground floor, or ensuring continuity of pedestrian and cyclist infrastructure, were highlighted; particularly the former. However, there was a clear emphasis upon the built environment as a whole, and the experiences and perceptions this creates for people moving within it. This illustrates how the holistic design approach translates with regard to mobility and people's use of public space; different from that of more traditional mobility and transport research approaches, which tends to have a more monocriteria focus. It should be noted though, that both in the workshops and the interviews the designers rarely referred to a quality directly (i.e. using the term defined by research and design literature), with the exception of Legibility, Human scale and Transparence. Nevertheless, they frequently described similar qualities or effects of built environment interventions; for example in reference to the kind of public spaces people want to use, or environments that can reduce perceived distances. The survey respondents seemed familiar with the kind of qualities they were asked to assess, as the answering rate for this part was good. Overall, results from the three enquiries largely correspond. Connectivity and Legibility are given most importance by the practitioners, followed by Human scale, Transparence and Enclosure. Flexibility and Hierarchy were two additional qualities that emerged as important from the interviews, particularly for the relationship between different modes and usages. According to the interviewees, Connectivity is particularly important to reduce distances; this is supported by much of the research literature (Saelens and Handy, 2008). Furthermore, Connectivity can help satisfy individual travel needs and preferences, as it gives people more route choice. Legibility helps travellers orient themselves, geographically, culturally, and concerning usages. This can reduce perception of distance, and increase feeling of safety and perception of traffic safety. Interestingly, the latter was itself little mentioned by the practitioners; it appeared to be considered a 'default' quality of public space. The qualities are strongly interrelated: a high level of Connectivity simultaneously produces Transparency; Complexity is necessary to achieve Legibility. A certain differentiation between more instrumental qualities and more perceptual qualities was observed, but this distinction is not absolute; Legibility is for example both.

Urban practitioners considering mobility primarily as movement within public space of a site was equally observed for this second research question. The designers focused on the importance of creating spaces people want to be present in, for example during a trip to or from public transport. These spaces have qualities and characteristics that make people want to move within or through them, many of which corresponds to qualities enquired in the survey, for example Legibility. The level of influence of urban qualities upon modal choice seems to decrease with increasing travel speed. This is in line with previous studies, who found that travel speed influences a person's interaction with their immediate surroundings (Pucher and Buehler, 2010; Stefansdottir, 2014a). The neighbourhood-scale built environment is therefore, generally, more influential upon pedestrians than public transport riders. At the same time, walking is an important part of the overall transit trip. This underlines the importance of a holistic approach to daily mobility, considering the whole trip, from door to door. The neighbourhood-scale built environment influences not only at the beginning and the end, but also – or perhaps even more so – during the trip, moving through different parts of a city.

PART 3
HARMONIZING INSIGHTS FROM RESEARCH AND PRACTICE

INTRODUCTION PART 3

The reciprocal relationship between the built environment and mobility behaviours dictates that urban design can be a mitigation strategy to curb emissions from daily mobility– in theory. But how does this translate to concrete urban development projects? How can urban design be a mitigation strategy to promote zero-emission mobility modes? Answering this necessitates an in-depth understanding of how people interact with and are influenced by their built- environment surroundings for daily travels. This understanding is lacking in current scientific literature due to the knowledge gaps discussed in Part 1. To remedy this, the present thesis explored evidence-based and experience-based knowledge in parallel through theoretical and empirical enquiries to provide new insights into the interactions between people and their surroundings. Part 1 presented an initial analysis of the scientific literature in the literature review in Chapter 1.2. Findings and observations were then pursued from a more holistic perspective, e.g. by including often referred to works within urban design literature, for a more detailed theoretical basis (e.g. Carmona (2010), Gehl (2010)). Part 2 presented the design and execution of the empirical enquiries of the practitioners' savoir-faire. Findings from these were explored in a descriptive manner.

The following combines the theoretical and the empirical findings, and discusses the obtained results from a holistic and interdisciplinary viewpoint to answer the research question of the thesis. To simplify, the workshops participants, the survey respondents, and the interviewees will be referred to as the **'surveyed practitioners'**. It also debates how to overcome observed barriers for mobility-mitigation through urban design as highlighted in Part 1, as well as others observed through the investigations. In Chapter 6, the research question is approached in two phases. The first phase explores what can be achieved through urban design, i.e. what it can contribute to for promoting zero-emission mobility modes. A permanent, large-scale modal shift requires zero-emission mobility modes to be perceived by users as more attractive than driving. What this involves will vary from one traveller to another. As seen in Chapter 1, a positive trip-experience is key for a high level of travel satisfaction, which in turn is key for future zero-emission modal choices. To better understand how urban design can contribute to this, Chapter 6 introduces a change of perspective, based on observations from the empirical and the theoretical enquiries: at the neighbourhood scale, daily mobility should be considered as a kind of use of public space. One of the many, daily uses that occurs in urban areas, and that public spaces must have the capacity to accommodate and facilitate. This shift strengthens the holistic approach discussed in Chapter 1.3, which considers the neighbourhood-scale built environment as a whole. Urban design structures and creates public space, i.e. the space between buildings. Therefore, exploring how urban design can be a mobility-mitigation strategy involves exploring how public space can be such a strategy. Considering mobility as a kind of use of public space centres the focus accordingly. Additionally, it emphasizes that mobility is an integral part of everyday life in a city, not a separate activity. Promoting a sustainable modal shift needs to take this into account; a zero-emission daily mobility should be an advantage, not a hassle. To ensure this, Chapter 6 presents a series of properties that public spaces must encompass to make zero-emission modal use possible and pleasurable.

Part 1 explored some of the barriers that currently hinder mitigation action through urban design. The second part of Chapter 6 pursues this based on insight from the thesis investigations. The observed knowledge gaps are a significant challenge, and are further discussed here with the objective of identifying potential countermeasures. The enquiries indicate that the mobility-mitigation potential of urban design is often overlooked and/or underestimated by research and practice. This was discussed in Part 1 as a possible explanation, and the thesis results support it. The findings in Part 2 imply that designers can be pivotal actors to realizing the mitigation potential of urban design, as mobility is integrated in their practices. For example, measures held up by research and practice as important for promoting walking, cycling, and public transport often mirror frequent design actions for improving urban living contexts.[68] However, if practitioners are unaware of this potential and/or lack knowledge about climate change and mitigation, they are not capable of undertaking this role. As a response to this, Chapter 7 introduces the outlines of a future design framework, intended to strengthen mitigation efforts through urban design. This framework draft is based on a systematic analysis of the thesis enquiries, harmonizing insights from research and practice. It aims to make the mitigation potential of urban design more apparent, and to enhance designers' knowledge of the topic, thus enabling them to become mitigation actors. Chapter 7 is an initial draft. It presents the properties introduced in Chapter 6 in relation to the urban qualities explored in Chapter 5, and how urban designers can act upon/realize these through built-environment interventions. A design-aid tool must be understandable and useable for practitioners. The intended organization of the framework reflects that of the CapaCity tool (see Chapter 4), which was developed with close attention to design practices. It could be envisioned integrated in a future version of CapaCity that addresses both adaptation and mitigation. The two are essential if cities are to remain good places to live despite global warming and climate change. Urban design can contribute to this, but it requires both research and practice to be aware of and to explore its potential in a holistic, interdisciplinary manner.

[68] The overall objective of urban design, as a reminder see Glossary

CHAPTER 6

URBAN DESIGN AS A MOBILITY-MITIGATION STRATEGY

6.1 ZERO-EMISSION MOBILITY MUST BE POSSIBLE AND PLEASURABLE

6.1.1 Positive trip experiences for a permanent modal shift

6.1.1 a) **Combining 'carrots and sticks'**

People tend to be creatures of habit. Repeating actions such as everyday travel can form patterns of behaviour that simplify the process of decision-making (Busch-Geertsema and Lanzendorf, 2015; Gardner, 2012). As an example, modal choices for daily trips to work or to school, or for weekly activities such as grocery shopping, or sports and culture related activities. Achieving a larger-scale sustainable modal shift requires a change of daily travel routines among the majority of urban inhabitants. But habits can be hard to change, and likely more so when the change is for options perceived by many as less efficient, more time consuming, and more of a hassle. First, the traveller has to be convinced to try a different mode; second, the change must stick for new habits to be made. Bigger life events such as change of residence, work, or work location can spur modal changes (Busch-Geertsema and Lanzendorf, 2015; Clark et al., 2016). However, such events are not frequent (hence the term 'bigger life events'). Limiting measures directed towards car use such as pricing or reduced parking availability is necessary to induce a sustainable modal change (Piatkowski et al., 2017). Yet it seems unlikely that changes which primarily make everyday travel more of a hassle will lead to a permanent shift if the measures are removed, or if the traveller changes jobs and driving and public transport become equally practical. For a permanent, zero-emission modal shift, walking, cycling, and public transport must be perceived as better options than driving, not just the lesser of two evils. Evidence from previous studies indicates that a larger-scale modal shift necessitates both ‘carrots and sticks’: combining facilitating/enabling measures with limiting/deterring measures to make driving less attractive, and zero-emission alternatives such as walking, cycling, and public transport more attractive (Piatkowski et al., 2017). This requires cities to aim beyond basic accessibility, reliability, and provision of zero-emission mobility services like public transport (Redman et al., 2013). They must equally act upon aspects such as quality, comfort, and aesthetics (Johansson et al., 2016; Redman et al., 2013; Stefansdottir, 2014). As the experience of such elements is highly individual, a broad range of measures and solutions is needed. The updated utility model in Chapter 1 explained how travel satisfaction influences remembered utility, which in turn can influence future modal choices and everyday travel habits. Remembered utility represents the retrospective evaluation of an experience: the better the experience, the higher the remembered utility; the worse the experience, the lower the remembered utility. For new habits to stick, the remembered utility of a zero-emission mode must be high. Travel satisfaction is the result of several variables including price, travel time, and trip experience. Like most aspects of mobility behaviour, what constitutes a positive trip experience varies among travellers.

6.1.1 b) **A positive trip experience for a high level of remembered utility**

When undertaking a trip, a traveller’s modal choice is the result of a series of decisions and judgments, all of which ought to lead towards a zero-emission option. Modal choices are influenced by several contexts, external as well as personal (see Figure 33) in addition to remembered utility. The influence of the external contexts is filtered by the traveller’s personal context. The thesis explorations indicate that urban design likely influences modal choice the most through its impact on trip experience. City-scale structures establish initial premises and conditions for daily mobility and modal choices, for example for getting to school. If public transport is not available for a particular trip, the traveller simply cannot choose it. If the distance from starting point to destination is too far, walking and cycling are less likely modal choices. From the city to the neighbourhood scale, there is an increased level of detail; streets change from lines on a map to three-dimensional scapes that consist of sidewalks, buildings facades, vegetation, street furniture, intersections, lighting, etc. The sum of these creates the surroundings people move through for their daily travels. Their interaction with these environments contributes to trip experience, the nature of which depends in part on travel speed. While driving, the interaction with immediate built-environment surroundings is relatively low; when walking or cycling, the interaction is higher. To ensure a default zero-emission modal choice, these interactions must produce a positive zero-emission trip experience.

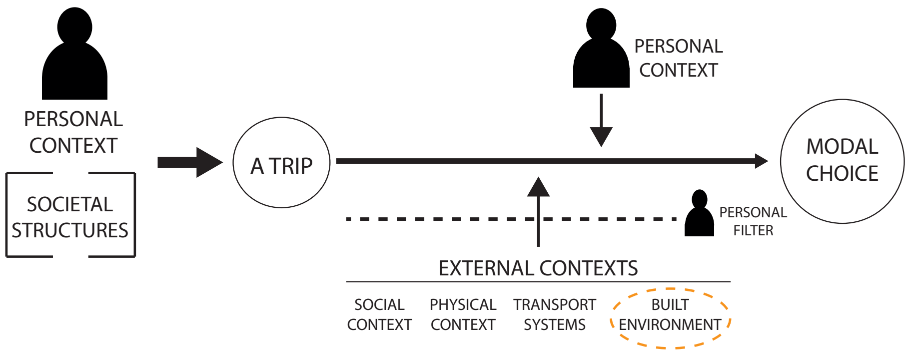


Figure 33 Modal choice as a sum of internal and external contexts, introduced in Chapter 1.2, figure by author

During a trip, the traveller moves through various areas and neighbourhoods of a city. He or she constantly interacts with the neighbourhood-scale built environment that constitutes the immediate surroundings at any given moment of the trip. How these interactions are experienced depends on personal context, and influences the overall travel satisfaction (Hillnhütter, 2016; Stefansdottir, 2014). Narrow, unkempt and/or lack of separate cycling infrastructure are likely to be higher barriers for inexperienced and/or insecure cyclists. A bad travel experience can also be the result of feeling unsafe (from crime) during parts of a trip, for example a portion of a walk involving a pedestrian underpass, or a dark path.

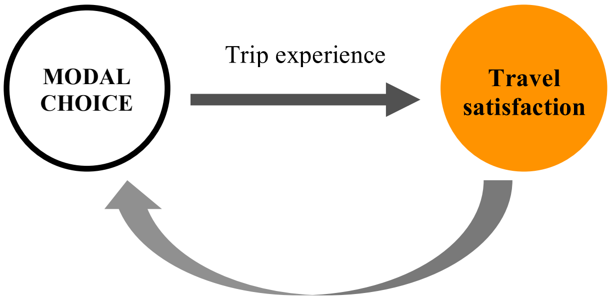


Figure 34 A simplified figure on the influence of trip experience upon travel satisfaction, which in turn influences future modal choices through remembered utility, figure by author

Findings from behavioural sciences indicate that unpleasant or negative aspects of an experience can displace positive or pleasant aspects, even if the latter represent the majority of the experience (Kahneman and Krueger, 2006). This can influence the remembered utility of the experience and, in turn, future choices. These findings likely apply to daily mobility and travel satisfaction in a similar manner: although the trip is primarily a positive experience, negative parts can outdo the positive (Kahneman and Krueger, 2006). If parts of a trip pass through an area where the traveller feels unsafe due to traffic or crime, this can significantly impact the overall trip experience, and thus travel satisfaction and remembered utility. Depending on how the traveller weights the importance of feeling safety during a trip, a negative experience from previous trips might present a big enough barrier that the next trip is done by car rather than by foot, bicycle, or transit (e.g. if walk to/from transit stop felt unsafe). This reflects insights from the surveyed practitioners. According to them, areas where people feel safe are more likely to be areas they are present in or move through.

Several aspects influence travel satisfaction. This work focuses on the potential contribution of urban design and interventions upon the neighbourhood-scale built environment, for example, ensuring that travellers feel safe while present in public space. Distance is another challenge for travel satisfaction, particularly for non-motorized modes where the required physical effort tends to increase with increasing distances. The design of public spaces can make distances seem shorter and/or increase accepted travel distances (Hillnhütter, 2016). According to the surveyed practitioners, the longer the trip, the higher the requirements are for the built environment, in terms of variation and aesthetics to reduce the impact of distance upon trip experience.

6.1.1 c) **Possibility and pleasure to promote zero-emission modes**

In a city, daily mobility covers a plethora of travel routes; often no two are alike. A trip generally passes through a series of neighbourhoods of different character and design. These do not have to provide extraordinary travel experiences, but none should produce very negative ones. However, a positive trip experience requires more than simply the possibility to travel or lack of fear during the trip. Indeed, there seems to be no good reason for an activity that is repeated every day or every week to be annoying, a hassle, or just ok. Beyond ensuring that a zero-emission mode is available for a trip, urban design should contribute to its use being easy and agreeable, i.e. a pleasurable experience. This can heighten overall travel satisfaction, thereby enhancing the mode's attractiveness and increasing the likeliness of a permanent, sustainable modal shift. The observations in the opening sections of the chapter, grounded in the theoretical and the empirical enquiries, provide an initial response to the thesis research question:

> *Urban design can be a mitigation strategy to promote zero-emission mobility modes by contributing to make the use of these at once possible and pleasurable.*

The terms 'possible' and 'pleasurable' represent different aspects of a trip. The use of these terms in the context of this work is principally based on Alfonzo (2005), Krizek at al. (2009), and Stefansdottir (2014, 2015). Possible is primarily related to instrumental aspects of a trip, while pleasurable is primarily related to perceptual ones, although the two are strongly interdependent. Instrumental aspects are generally considered more fundamental than perceptual for most pedestrians and cyclists, but they alone are likely not enough to make a trip pleasurable (Stefansdottir, 2015)[69]. Lack of instrumental aspects can reinforce negative perceptions (e.g. presence of infrastructure and perception of traffic safety); conversely, the presence of perceptual aspects can enhance the influence of instrumental ones (e.g. a high level of Complexity can make distances seem shorter).

Possible refers to a mobility mode being available for a trip objectively and subjectively, i.e. the actual possibility of using a mode for a trip (objective) and the traveller perceiving the mode as possible to use (subjective). This is first and foremost related to instrumental aspects such as the presence of infrastructure. However, perceptual aspects can influence the importance of instrumental ones as shown in the examples above. Theoretically, people can walk and cycle just about anywhere in a city; the basic needs are a path, street, or road without too many obstructions. In everyday life, however, this is more nuanced (Krizek et al., 2009; Stefansdottir, 2014). A road can be safe according to traffic regulations, but still be perceived as unsafe by pedestrians or cyclists; a destination can be within reasonable walking distance, but perceived as further away due to the design of the built environment. Pleasurable refers to a person's experience of a trip, and the importance of this experience being positive and enjoyable. It is primarily related to perceptual aspects such as a feeling of safety (traffic, crime, accidents) or aesthetical experience. However, instrumental aspects also influence perceived pleasure. A well-functioning sidewalk without physical hindrances is important for many for an enjoyable walking experience. Here, the 'devil is in the details': the execution of sidewalk edges or of intersections; the placement of garbage cans and lampposts; the design and organization of pedestrian crossings. These are all elements that can separately create small and likely unimportant nuisances. Yet combined, they can make an area feel unfriendly and unwelcome for pedestrians and cyclists. Consequently, such trips can become a hassle. If this is part of a daily travel

[69] Stefansdottir (2014, 2015) uses the term 'aesthetic aspects' to describe aspects of the physical environment that creates aesthetic experiences, which can be positive or negative. This thesis uses the term 'perceptual aspects' for a broader description of the non-instrumental aspects that influence the traveller's experience of a trip; it includes aesthetic aspects as well as perception of safety, distance, etc.

route to or from a transit stop, it might contribute to the traveller choosing to drive over using public transport.

Urban design must act upon both instrumental and perceptual aspects to help make the use of zero-emission mobility modes possible and pleasurable. For example, monotonous or boring environments can make distances seem longer. Hillnhütter (2016) found the perceived distance by pedestrians to decrease up to15%, depending on the design of public space. Although the possibility of using a mode is more fundamental than whether it's pleasurable, the two overlap in several ways as seen in the previous examples (Krizek et al., 2009; Stefansdottir, 2014). Moreover, both aspects are important to motivate a permanent modal shift. This underlines the complexity of modal choices and the built environment, which is largely due to people's individuality in perceiving and experiencing their surroundings. Krizek et al. (2009) write that this subjectivity presents a limitation for influencing modal choice through the built environment. Consequently, so-called 'hard measures' (built environment) should be coupled with 'soft measures' (information, campaigns, etc.) (ibid). The overlap between possibility and pleasure (instrumental and perceptual) represents an interesting opportunity for a win-win approach. Intervening upon one can simultaneously help further the other.

6.1.2 A change of perspective to strengthen mitigation efforts

6.1.2 a) **Mobility as a kind of use of public space**

Urban design shapes, organizes, and structures the public space between buildings (Gehl, 2010; Madanipour, 2006). To better understand how urban design can influence modal choice, a change of perspective is introduced: at the neighbourhood scale, daily mobility should be considered as a kind of use of public space. In other words as one of the many kinds of uses that takes place in the public realm of a city, and that public space must accommodate and facilitate. This change of perspective positions the neighbourhood scale within the built-environment context as a whole, and situating the problem at the geographical scale of urban design: the public space between buildings. Moreover, it shifts the focus from why and where people are travelling to the trip in itself, and the influence of the areas people travel through, which is one of the principle ways in which urban design can influence daily mobility (Hillnhütter, 2016; Stefansdottir, 2014). The thesis enquiries showed that mobility is a central and structuring element in urban design practices. However, the practitioners focused mostly on people's movement within or through the public spaces, and less on why and where they are travelling. The aspect of a trip that seemed to be a focus for the practitioners was the actual travelling, during which the traveller interacts the most with the 'product' of their design, i.e. public space. According to the practitioners, interactions during a trip create perceptions that influence how an environment is experienced and consequently whether or not a person wants to be present in it, immediately and in the future. "You don't walk if you don't want to" (Interviewee 9). If a street or a public place is perceived as boring, dangerous (traffic), unsafe (crime, accidents), or unpleasant, there is less chance a traveller will to choose to walk or cycle there again. This aligns with findings by for example, Krizek et al. (2009), Loukaitou-Sideris (2006), and Stefansdottir (2014). Fear of crime is particularly important for the modal choices of women and seniors. The design of public spaces and travel routes can significantly influence this; typical examples are pedestrian underpasses, or empty public spaces after dark (e.g. transit stops) (Loukaitou-Sideris, 2006). If there are few or no adequate route alternatives (subjectively) available, this can become a barrier to walking, cycling, or taking public transport. Loukaitou-Sideris (2006) explains that not only the destination (for her, public places) but also the route to it must be perceived as safe for people to go there. This likely applies to public transport use as well, when the route includes travelling to and from transit stops.

Changing the perspective towards the use of public spaces contributes to identifying the possibilities and limits of influencing modal choices through urban design interventions. It also has implications regarding the way mobility-mitigation is addressed and explored, for example by emphasizing the need for a holistic approach. Moreover, it repositions the initial research problem, underlining the relationship between public space and trip experience for a zero-emission trip. The research question can be rephrased as follows:

How can the design of public spaces contribute to making the use of zero-emission mobility modes possible and pleasurable?

6.1.2 b) **Implications for approaching mobility-mitigation**

Considering mobility as a kind of use of public space helps identify and comprehend potential conflicts between different mobility modes, and between the needs of the different geographical scales of urban areas. While the city as a whole needs efficient transportation, its neighbourhoods, as living contexts, might benefit more from slower speeds and less traffic. Similarly, cyclists passing through an area tend to prefer few interruptions such as intersections, while pedestrians require safe places to cross the street. Different mobility modes have different needs, which are not necessarily compatible. The practitioners emphasized the need for compromise to solve such divergences. It often comes down to the use of public space, which is often scarce in urban areas. Who should have the right to use a particular space? Which modes should be prioritized? The urban designers agreed that there is no optimal solution, and trade-offs are inevitable. Interestingly, it appeared that converting parking spaces to other uses such as sidewalks or cycling lanes was less about mitigation, and more about an equitable and flexible use of public space. This is in line with their overall objective of improving living contexts. Moreover, public spaces must accommodate a series of uses in addition to mobility, which introduces yet another level of complexity. Public spaces such as sidewalks should have the capacity to simultaneously embrace dynamic uses (mobility) as well as static ones (staying in the space). Experience from numerous cities show that this is possible, but it requires a holistic design approach employing win-win solutions. For this, mobility must be considered one of the many daily activities going on in a city, not an element apart. Approaching mobility as a kind of use of public space contributes to this, and helps recognize the interdependencies within urban development. Every built-environment intervention upon public space will influence people's daily mobility systems in some way. With regard to modal choices, it is imperative for interventions upon public space to heighten travel satisfaction, not lower it. This requires practitioners and other actors in a project to be aware of and to comprehend the potential influence of public-space interventions upon daily mobility and modal choices.

6.1.3 Zero-emission friendly public spaces

Urban design aims at creating public spaces that people want to use and be present in, i.e. spaces that have the capacity to accommodate the different needs and preferences of people, for dynamic as well as static uses (Carmona, 2010; Gehl, 2010; Madanipour, 2006). A zero-emission mobility trip involves a high level of interaction between the traveller and the immediate built environment. For a positive experience, the spaces a trip passes through must be spaces the traveller wants to be present in. Chapter 1 evoked the terms cycling- and pedestrian-friendly environments, a recurring expression within research literature. These are the kind of public spaces that actively promote walking and cycling, and by correlation public transport use. The term 'friendly' rather than just 'prioritized' or 'feasible' emphasizes the importance of walking and cycling to be pleasurable in addition to possible. In the context of this thesis, the expression is expanded to *zero-emission friendly public spaces.* In the following, walking and cycling are frequently emphasized. Transit use involves at least one of them. According to Hillnhütter (2016), 90 per cent of public transport users walk to transit stops; moreover, about 45 per cent of a transit trip is spent outside vehicles. Getting to and from public transport stops is likely the part of such trips that is most influenced by the neighbourhood-scale built environment. The notion of zero-emission friendly public spaces encourages a holistic approach to the kind of neighbourhood-scale built environments that make zero-emission mobility possible and pleasurable. This contributes to enhancing the holistic, interdisciplinary shift called for in Chapter 1.3 and the kind of public spaces this creates, from singular elements to the neighbourhood-scale built environment.

6.1.3 a) **Properties of zero-emission friendly public spaces**

Zero-emission friendly public spaces contribute to a positive trip experience from an instrumental as well as a perceptual viewpoint. Hillnhütter (2016) describes them as pleasant, convenient, and attractive for pedestrians; this applies equally to cyclists. In contrast, car-oriented spaces can discourage these modal uses (Hillnhütter, 2016; Stefansdottir, 2015). Figure 36 and Figure 37 show examples of car-oriented spaces. These are not necessarily visually unpleasant spaces, but allocate most public space to cars – generally at the expanse of pedestrians and cyclists. Limiting parking availability is therefore not just an efficient measure to reduce the number of cars; it is also a clear message to pedestrians, cyclists, and transit users that they too have a right to the public space of a city.

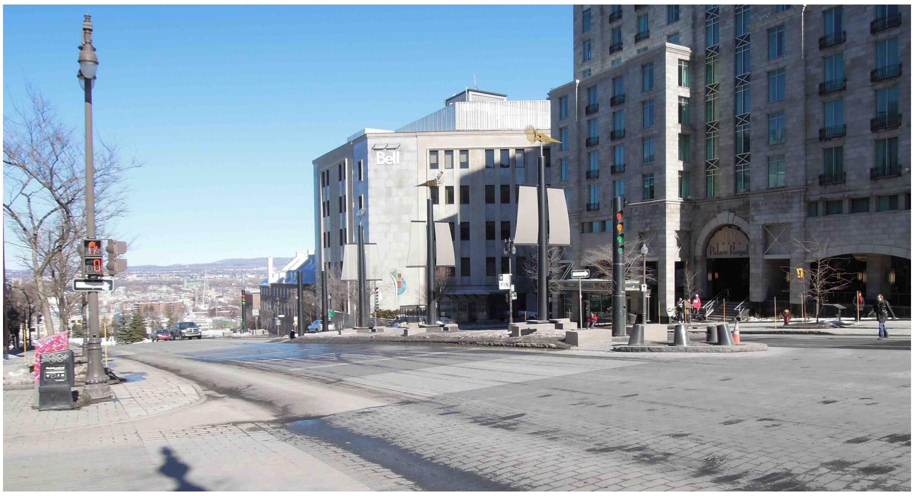
The thesis enquiries explored the following series of urban qualities for their importance in modal choice and experience of public space: Connectivity, Legibility, Human scale, Enclosure, Transparency, Complexity, and Coherence. Hierarchy and Flexibility emerged as additional qualities through the workshops and interviews (see Chapter 5). The survey respondents rated the qualities, from slightly to extremely important. When crossing these and other findings from the enquiries with research and urban design literature, certain characteristics emerge as particularly important for public spaces to ensure a pleasant and possible zero-emission trip (Alfonzo, 2005; Gehl, 2010; Hillnhütter, 2016; Krizek et al., 2009; Loukaitou-Sideris, 2006; Pucher and Buehler, 2010; Speck, 2013; Stefansdottir, 2014, 2015). They include proximity to destinations, comfort in public space, aesthetics, feeling safe, understanding how to move through an area with other mobility modes, etc. Several of these characteristics have been mentioned throughout the previous sections of Chapter 6 as examples of how public spaces can promote zero-emission modal use. Combined, the qualities and the characteristics provide a description of the kinds of spaces that actively promote walking, cycling, and public transport use. How they ‘manifest’, and which measures and solutions are most efficient to realize them, depends on the urban context. A residential street that prioritizes pedestrians typically has wide sidewalks without hindrances, narrow car lanes, low driving speeds, and many pedestrian crossings (not necessarily with traffic lights). A very central street might a completely pedestrianized, though often with some form of cycling access. The characteristics and qualities are strongly interrelated, which suggests an interesting win-win potential from an urban design perspective: designing for one tends to simultaneously contribute to realizing others. As an example, Transparency can be achieved by ensuring gaps in a continuous building block, which simultaneously can contribute to Connectivity. This interdependency supports the notion of considering the built environment as a whole. Zero-emission friendly spaces are created through a combination of these qualities and characteristics, which can be summarized as a series of properties: Safety, Distance, Orientation, Accommodating, Comfortable and Pleasure (Figure 35). They express what public spaces should provide in terms of perceptions and experiences to help ensure a positive trip experience when travelling with zero-emission modes. The properties are both instrumental and perceptual, meaning they have a functional as well as a more aesthetic (pleasurable) purpose. Table 36 is a summarized explanation of the properties.

Figure 35 Properties of public space to promote the use of zero-emission mobility modes by providing pleasure and possibility, figure by author

	PROPERTY	DESCRIPTION
Safety	Capacity of producing a ***feeling of safety***: traffic safety, safety against crime and accidents	When moving through an area, the traveller must feel safe from traffic, crime and accidents.
Distance	Capacity of ***reducing distance***, physical and perceived	When moving through an area, the traveller must experience distances as not too long, and as possible to traverse.
Comprehensive	Capacity of ***being comprehensible*** for geographical/cultural orientation, and use	When moving through an area, the traveller must be able to recognize or understand where he or she is geographically (e.g. the kind of area he or she is in) and how to move around in it (e.g. hierarchy of modes, where to cycle, etc.).
Accommodating	Capacity of ***accommodating different*** modes and uses.	When moving through an area, the traveller must feel welcome, and that he or she is supposed to be present in the space: pedestrians are intended to walk there, cyclists are intended to bike there, etc.; travellers and inhabitants must be able to coexist.
Comfortable and pleasant	Capacity of providing a ***comfortable*** and ***pleasurable*** travel experience.	When moving through an area, the traveller must be protected from weather and climate; the influence of significant topography etc. must be limited; passing through an area must be interesting and enjoyable.

Table 36 Summary of the five properties and the experiences and/or perceptions they should contribute to

Figure 36 Examples of car-oriented environments in Toulouse (France) that allocate most space to cars, generally at the expense of pedestrians and cyclists. Pedestrian-bridges are a clear message of order of priorities: cars get 'the easy way'. Photos by author



Car-lane width, particularly with regard to total street width, indicates order of priority; moreover, wide car lanes tend to privilege high driving speeds, which is generally negatively perceived by pedestrians and cyclists, and tend to reduce traffic safety – objective and subjective.

Figure 37 Examples of car-oriented environments in Quebec (Canada) that allocate most space to cars, generally at the expense of pedestrians and cyclists. Photos by author

Zero-emission friendly public spaces must satisfy many individual travel needs and preferences. Ensuring all five properties can help design public spaces that are accessible all travellers (ideally), particularly those restricted in some way. Each property cover a broad range of aspects related to modal choice and travel experience. Safety includes traffic, crime, and accidents; Accommodating includes different mobility modes, different travel groups, dynamic and static use of public space, as well as neighbourhood-scale and city-scale use of public space. They help link the overall objective of improving living contexts with promoting the use of zero-emission mobility modes. The two objectives are strongly related: acting upon urban living contexts through urban design means acting upon public space, which in turn means acting upon people's daily travel conditions – and vice versa. Qualities and characteristics described as important for mobility tend to mirror those held up by research and practice as important for 'good' public spaces people want to be present in. This reciprocity is a central aspect for urban design as a mobility-mitigation strategy. The interdependence of urban development can be seen in the five properties. Comprehensible environments allow travellers to easily orient themselves geographically and in terms of mobility use, which then contributes to enhancing perceptions of safety from crime and traffic. This in turn contributes to a more pleasurable travel experience. Furthermore, a pleasant experience contributes to reducing perceived distance. The properties are achieved through the qualities explored in Part 2. This is further explored through the framework draft in Chapter 7: how the properties relate to the qualities, and how these are realized by acting upon urban structure, land use, mobility systems, and urban features as levers of action for mobility-mitigation.

Understanding public spaces and feeling safe

The character of a public space tends to indicate how people are expected to behave (Gehl, 2010; Stefansdottir, 2015). A zero-emission friendly space must therefore be comprehensible; the traveller should easily understand where he or she is geographically, as well as how to move through the area (i.e. where to walk, where to cycle, where to cross the street). Legibility and Transparency are important qualities for this, as well as Complexity. The latter contributes, for example, to distinguishing one area from another. Understanding how to move through an area is also related to its capacity for accommodating different mobility modes. Spaces perceived as zero-emission friendly often have high-quality infrastructure for walking and cycling, in addition to well-designed transit stops (in the case of public transport). At the same time, a street is also a living context, so dynamic and static uses must co-exist. As an example of this duality, a sidewalk must have the capacity to accommodate daily pedestrian commuters as well as children playing. Co-existence and understanding a space furthermore requires a clear hierarchy between mobility modes (and uses), an aspect the interviewees particularly emphasized. Zero-emission travellers must have priority over automobiles; in some contexts it might even be necessary to prioritize cyclists over pedestrians or vice versa to avoid dangerous situations. Here, Connectivity is an important quality as it can contribute to separating different modes, and allows travellers to choose their routes according to individual preferences and needs. Prioritizing one mode does not automatically mean others are excluded, but must be adapted to the needs of the prioritized mode. The surveyed practitioners emphasized that this must be communicated in a clear and comprehensible manner. Hierarchy and comprehensibility are furthermore related to objective and subjective safety. Feeling safe from traffic, crime, and accidents, is essential for the use of zero-emission modes. This is especially pertinent for walking and cycling, when the traveller is more exposed than in a car or tram. Generally, women tend to be more concerned about safety from crime than men (Loukaitou-Sideris, 2006); similarly, seniors tend to be more concerned about the possibility of taking a break during a trip than able-bodied travellers (Gehl, 2010). These differences illustrate the importance of objective versus subjective evaluation and perception of public space. If a person does not feel safe from crime in an area, it does not help them that official statistics indicate that it is safe; the same goes for traffic safety. This again underlines the importance of acting upon instrumental as well as perceptual aspects of the neighbourhood-scale built environment when designing for zero-emission modal use. Enclosure, Connectivity, Transparency, and Legibility are important to ensure a feeling of safety, and simultaneously address both instrumental and perceptual considerations.

Relatively good size sidewalks with few obstacles on both sides, though they could be wider. A good overview of traffic from different directions.

Cars have access, but the street-cover communicates a different envrionment than the above, as seen by pedestrians in the 'car space' further down the street. Wide sidewalks accommodate both dynamic and static uses.

Though entrance to a parking garage, the sidewalk is continued, which eliminates barriers such as edges, etc. The bench offer a possibility to sit down, with weather-protection from the tree (as it gets bigger).

Figure 38 Examples of pedestrian-friendly environments in Oslo (Norway), photos by author

Clearly allocated space to different mobility modes so they can co-exists, and good pedestrian space that reduces conflicts, although the separation pedestrian/cyclist could be better (grey line on sidewalk).

A pedestrianized street where bicycles also have access, as well as delivery of goods (and some private access). This allows the pedestrian to walk freely with little attention to traffic and other potential conflicts (despite cycling access). Before transformaiton, the street had sidewalks less than 50cm wide.

Figure 39 Examples of pedestrian-friendly environments in Toulouse (France), photos by author

Avoiding hassle and nuisances in an interesting and attractive environment

Zero-emission trips such as walking and cycling require a bigger physical effort than driving (for most people). To motivate such modal choices, the trip must be perceived as easy to undertake, as opposed to being a hassle and/or a nuisance. An annoying trip will likely seem longer than a pleasurable one, both in terms of distance and required physical effort. Travel routes must have few physical barriers, which can range from bigger infrastructures (rails, trafficked roads) to smaller hindrances on sidewalks. Moreover, the traveller must be protected from weather and climate (to the extent possible), depending on geographical context. Ensuring the above requires designers to make sure that all details are taken into account. Beyond not being a hassle or a nuisance, zero-emission friendly public spaces should be visually interesting and attractive, providing a positive aesthetic experience – i.e. a pleasurable experience. This can also enhance the 'possible' aspect of a zero-emission trip. A visually varied environment can, for example, reduce perceived distances and make travel time seem shorter. This is achieved through a combination of all of the qualities, the primarily instrumental (e.g. Connectivity and Enclosure) as well as the primarily perceptual (e.g. Complexity, Legibility). Public spaces that actively promote the use of zero-emission mobility modes ideally have a high level of the qualities and characteristics above. As one practitioner put it, the longer the walking distance is, the 'better' (in terms of aesthetics) the built environment must be to compensate.

Figure 40 Examples of smaller obstacles for pedestrians that increases the level of hassle for walking, Oslo (Norway) and Toulouse (France), photos by author

Figure 41 Examples of smaller obstacles for pedestrians that increases the level of hassle for walking, Toulouse (France), photos by author

The pictures in Figure 40 Figure 41 are examples of obstacles that individually make walking a little bit more annoying or difficult. Combined, they can make a walk, for example to a transit stop, become too much of a hassle to undertake. Especially for those less able-bodied, people pushing prams, with much luggage, etc. The quality of a sidewalk contributes to how an area is perceived, e.g. as pedestrian-friendly or unfriendly.

6.1.3 b) **Hierarchy among the properties**

Could one property be more important than the others, depending on the context? It could be argued that traffic safety is more important near a primary school, where frequent travellers are likely to be children with less traffic experience (and often capabilities). However, as previously established, the whole travel route matters for a person's travel satisfaction. Traffic safety is important all along a travel route, and not just for children: a school route can likely be part of an adult's travel route to work, for whom traffic safety might be an important criterion for walking or cycling. Likewise, ensuring physical comfort is more important in very hot or very cold climates, where the geographical context causes temperatures and weather conditions to be more extreme. That does not mean comfort in public spaces should be overlooked in less challenging conditions; all the properties matter for promoting zero-emission modal use. It is the sum of them that allows public spaces to make zero-emission mobility possible and pleasurable. A prioritizing, hierarchal approach risks omitting measures and solutions that might be the push needed to motivate the less able-bodied, or simply less willing, to try. Safety, together with Distance, could be considered a more fundamental aspect than the other three. In her hierarchy for walking needs[70], Alfonzo (2005) situates the two among the more basic needs, just above feasibility (personal context, time, etc.). However, as previously explained, for a permanent modal shift, zero-emission modal use must be both possible and pleasurable. This requires the other three, Orientation, Accommodating, Comfortable, and Pleasant to be fulfilled as well. Moreover, due to the high level of interdependence among the properties, designing for one will contribute to designing for others. Feeling safe from crime in public space is necessary for a pleasant trip, and traffic safety is closely related to the accommodation of different modes and users. In the subsequent section, Safety is further explored as an example of how the properties influence modal choices, and how urban design can influence their effect. This is a preliminary summary, based on the enquiries, as well as an initial literature review of the topic. The long-term objective is an in-depth exploration of all five properties for the framework initiated in Chapter 7

[70] Her hierarchy is as follows (bottom to top): Feasibility; Accessibility (including distance); Safety; Comfort; Pleasurability (term used by Alfonzo) (Alfonzo, 2005).

6.1.3 c) **Example of a property: Feeling of safety in public space**

Feeling of safety, or lack thereof, is a complex topic, largely due to the subjectivity of how people perceive safety. In this context, feeling of safety covers three areas: traffic danger, crime, and accidents. These are significant barriers to walking and cycling as modal choice, and consequently also for public transport (Foster et al., 2014; Krizek et al., 2009; Loukaitou-Sideris, 2006; Stefansdottir, 2014). Fear of crime as a barrier to modal choice is primarily related to people's perception of being safe from crime in public space (i.e. not being attacked by other people). The social and cultural nature of an area should not be ignored as sources of insecurity. Urban design cannot solve the issue or source of insecurity in itself, but it can contribute to addressing it. In some countries, simply using public transport is perceived as dangerous, particularly in terms of crime, but this is not addressed here. The question of safety is simultaneously subjective and objective. However, a person's own perception and evaluation of risk-level will likely take precedence over statistics or city authorities claiming a street is safe for pedestrians. This is a challenge, for example, to enhancing traffic safety through built-environment interventions. Although many riders perceive separate cycling infrastructure as safer, statistics tend to indicate otherwise (Krizek et al., 2009). This is largely due to conflicts that often arise at intersections where cyclists meet pedestrians and other vehicles (ibid), a situation that occurs frequently in a city. Høye et al. (2015) write that the efficiency of various cycling infrastructures depends more on the implementation of intersections than on the solution itself.

According to Gehl (2010), "much of modern traffic planning continues to pay far too little attention to the quality of city life". For traffic safety, ensuring adequate solutions according to traffic regulations, technical guides, and research is not enough; the traveller must also perceive public spaces as safe. A clear priority of pedestrians and cyclists is important, creating environments where travellers feel prioritized and as a result, safer. This is likely to make a trip more pleasant, thereby enhancing the overall travel satisfaction. It is particularly important to address the needs of travel groups that are less able (e.g. physically), more disposed to fear of crime or traffic (women, seniors), etc. These are groups that tend to walk and/or cycle less, and so become an important target for promoting the use of zero-emission modes. Designing public spaces that make all travellers feel safe – on every level – necessities a wholesome approach to the subject, i.e. a holistic, win-win approach. Improving street lighting to enhance a feeling of safety against crime can simultaneously reduce risk of accidents; widening sidewalks can provide additional space for café terraces or public benches; adding trees provides a positive aesthetic element, which can simultaneously provide protection from weather (sun and rain). These are examples of how acting upon traffic safety can simultaneously contribute to improving living contexts. The surveyed practitioners all emphasized the importance of the presence of other people, which Jacob (1961) defined as 'eyes on the street'. This requires public spaces to be spaces people want to be present in, that are attractive and interesting beyond simply feeling safe; another example of the many interrelations within and win-win potential of urban development.

The tables below summarize how lack of safety (objective and subjective) influences modal choices, and how urban design interventions can help counter this. Table 37 is a non-exhaustive summary of how fear of traffic, crime, and accidents pose significant barriers to the use of zero-emission modes. Table 38 presents design objectives for urban design interventions to enhance the feeling of safety among daily travellers, combining insights from the theoretical and empirical enquiries. Loukaitou-Sideris (2006) developed a series of design principles for urban design to help reduce fear of crime. They were originally directed at pedestrians, but largely apply to cyclists as well as they represent general aspects of how urban design can enhance a feeling of safety in public space, regardless of mobility mode. Several of her principles align with measures and solutions held up by the surveyed practitioners with regard to feeling safe from crime.

<table>
<tr><th colspan="2">HOW FEAR OF TRAFFIC, CRIME, AND ACCIDENTS INFLUENCES DAILY MOBILITY</th></tr>
<tr><td>Traffic safety
Risk of collision with other modes with a potentially fatal outcome</td><td>• Varies among population groups, mobility modes, and travellers' traffic capacity and experience. Children and seniors are potentially high-risk travel groups (Krizek et al., 2009; Pucher and Buehler, 2010).
• Design of public space can increase or reduce traffic danger directly and indirectly (Gehl, 2010; Loukaitou-Sideris, 2006; Stoker et al., 2015).
• Intersections where mobility modes meet are particularly high risk (Høye et al., 2015; Krizek et al., 2009).
• Increased number of cyclists have created new situations of conflict to be addressed by public space: cyclists/cars but also cyclists/pedestrians. The latter is particularly important for promoting zero-emission modes.</td></tr>
<tr><td>Crime
Risk of being attacked by others, verbally or physically</td><td>• Appears to be most important for walking, when travel speed is the slowest (i.e. traveller most exposed); thus by correlation important for transit use (walk to/from stop).
• Varies among population groups (age; gender; income; ethnicity), seniors and women tend to be most concerned about safety when walking (Loukaitou-Sideris, 2006).
• Built-environment interventions can contribute to reducing fear of crime (see further below), but must be coupled with other measures (information campaigns, policies, etc.), and needs of specific segments must be addressed in particular (Adkins et al., 2017; Loukaitou-Sideris, 2006).
• Fear of crime can reduce the overall impact of built-environment interventions, for example, to enhance accessibility for walking and cycling (e.g. aesthetically nice spaces that are perceived as unsafe; parents' worry of 'stranger danger') (Krizek et al., 2009).</td></tr>
<tr><td>Accidents
Risk of falling, being hit in the head by falling objects, etc.</td><td>• Appears to be primarily related to physical capacities: the lower the capacity the higher the awareness of such risks is likely to be.
• Presumably particularly relevant for seniors and the less able-bodied (Gehl, 2010; Loukaitou-Sideris, 2006). For those concerned, however, it can be a highly significant barrier to walking and cycling.
• Strongly related to climate and weather, in some cities (often Northern ones) icy streets and sidewalks are a prominent source of accidents during winter months.</td></tr>
</table>

Table 37 A summary of ways in which traffic danger, fear of crime, and fear of accidents pose significant barriers to the use of zero-emission modes

<table>
<tr><th colspan="3">DESIGN OBJECTIVES FOR ENSURING A FEELING OF SAFETY IN DAILY MOBILITY</th></tr>
<tr><td>Traffic safety</td><td colspan="2">• A comprehensible hierarchy between mobility modes: who goes where?
• Clear priorities when necessary, for example transit first, pedestrians second; pedestrians first, cyclists second, cars third
• A pedestrian- and cycling-friendly environment, where cars have to adapt to other mobility modes
• Limit situations of conflict between mobility modes, for example at intersections and crossings
• Provide adequate environments for walking and cycling that meet the needs of those less capable of walking or cycling
• Reduce travel speeds, primarily for cars, but depending on context also for cyclists</td></tr>
<tr><td>Accidents</td><td colspan="2">• Public space that is physically accessible and useable for all mobility groups, where travellers do not risk stumbling, falling, or being hit by falling objects, etc.
• Aim for high quality sidewalks with good surfaces, avoid small tripping-related obstacles such as unnecessary steps, careful design of edges (sidewalks/street; street walls, etc.).</td></tr>
<tr><td rowspan="5">Crime</td><td>Eyes on the street</td><td>• Having people present in public space. Creating public space where people want to be present and move through contributes to this.
• Entrances facing street to heighten pedestrian traffic, and transparent facades: windows facing the street; shop fronts facing the sidewalk
• Situating transit stops in central areas if possible, near shops and activities
• Eliminate ‘scary’ situations created by shadowy corners, dark passageways, narrow alleys with bad lighting, dents in building-block facades, etc.
• Avoid blocking sightlines that reduce transparency.</td></tr>
<tr><td>Lighting the way</td><td>• Adequate street lighting;
• Use ground floors as additional sources (transparent facades with lights on); 3-4 stories above street level can also contribute.</td></tr>
<tr><td>Time-share of public space</td><td>• Overlap functions day and night to make public space attractive and useable for different groups, ensuring a continued use and thus presence of people.</td></tr>
<tr><td>Eliminating bad neighbours</td><td>• Avoid businesses near public spaces and transit stops that tend to attract shady activities and actors, and contribute to a negative image of an area.
• Abandoned buildings must be given a use, preferable housing for on-going use throughout the day.</td></tr>
<tr><td>Other</td><td>• Public spaces that also feel safe when people are not present (evening, night, during winter time, etc.)
• Eliminating negative built environment-situations that produce feelings of non-safety (e.g. pedestrian underpasses)
• Ensuring that getting to and from transit stops, as well as waiting at them, feels safe
• Design for easy maintenance of public space to ensure well-kept public spaces</td></tr>
</table>

Table 38 Summary of objectives for a public space that ensures feeling of safety

6.2 MOBILITY-MITIGATION MUST BE AN ACTIVE OBJECTIVE FOR RESEARCH AND PRACTICE

6.2.1 An overlooked mitigation potential

6.2.1 a) A lack of connection despite an acknowledged influence

Mitigating greenhouse gas emissions from urban mobility implies either travelling less or travelling differently. The latter requires a change of travel habits towards zero-emission mobility modes. Modal choice is a result of decisions and judgments. From the moment a person decides to undertake a trip, several choices are made, all of which ought to lead the traveller towards a zero-emission mode. The previous subchapters discussed urban design as a mitigation strategy, promoting such choices by creating zero-emission friendly public spaces to render zero-emission trips possible and pleasurable. The thesis enquiries found that urban design can be a mitigation strategy, but that this appears to be relatively overlooked and/or underutilized, by research as well as by practice.

Studies have shown how interventions on the neighbourhood-scale built environment can improve walking experience, for example, when pedestrians access public transport. A street with active facades and varying land uses can reduce perceptions of distance (Hillnhütter, 2016); well-maintained, well-lit, and well-used public spaces can increase a feeling of safety (Loukaitou-Sideris, 2006). However, a systematic approach is lacking, combining previous findings, and exploring them from an interdisciplinary and holistic perspective. It is the sum of the elements described above that constitutes the environment experienced by a traveller. Stefansdottir (2012) writes how "the importance of the surrounding character of public spaces, i.e. the context of the infrastructure and its aesthetic aspect, is often underestimated. (…) If people are supposed to feel invited to walk…or cycle, public spaces have to express this over the entire urban landscape".

This lack of exploring mobility-mitigation through urban design, in research and in practice, is somewhat surprising, particularly in light of the reciprocal relationship between the built environment and mobility behaviours. Research and practice largely agree that mobility behaviours can be influenced through interventions upon public space. As one practitioner phrased it, “the city plan is the most low-tech solution we have”. What appears to be missing is the link between urban design interventions and an active promotion of walking, cycling, or transit use. One explanation is that research and practice appears to perceive mitigation primarily as a city-scale issue. The monocriteria approach[71] to the topic frequently found within research relates to this. Another explanation is lack of knowledge among practitioners regarding climate change and climate mitigation, in addition to a lack of awareness about the mitigation potential of their work (i.e. urban design). These aspects are further detailed in the sections below, followed by a discussion on how the mitigation potential of urban design can become more apparent for research as well as practice. Enhancing practitioners’ knowledge on climate change, adaptation, and mitigation is an important change, combined with a shift within research towards a holistic, interdisciplinary perspective.

6.2.1 b) **Mitigating mobility-related emissions seen as a city-scale issue**

There appears to be a tendency within practice and research to consider mobility-mitigation first and foremost as a city-scale issue to be addressed through city-scale measures. To illustrate, daily mobility tends to be addressed primarily as a question of getting people from A to B, preferably as efficient as possible. The main focus is generally upon the starting and ending points, and how trip length and available modes influence mitigation options. Consequently, the influence of the neighbourhood-scale built environment, and the effect of smaller interventions, is often disregarded. Hillnhütter (2016) notes a lack of connecting urban design to promoting transit use, concluding that the importance of urban design for trip experience to and from transit stops is underestimated by research. Stefansdottir (2014) similarly calls for a stronger emphasis on the value of aesthetics in enhancing cycling and walking experiences.

[71] See Glossary

A large body of research exists on city-scale transport and land use-planning as a mitigation strategy for mobility-related emissions (see Chapter 1.2). Fewer studies explore how the neighbourhood-scale built environment as a whole, i.e. the sum of singular elements and aspects, can be a mitigation strategy, for example, to actively promote zero-emission modes. Literature searches for works on urban design and mitigation – in general and particularly for mobility – were met with little success. This does not indicate that no books or articles exist on the topic but, despite extensive efforts, very little was found during the course of this thesis. The works addressing the neighbourhood-scale environment mostly explore which built environment elements or measures matter the most for modal choice. This includes both singular studies and reviews (see for example Badland et al., 2012; Ewing and Cervero, 2001, 2010; Rodríguez and Joo, 2004; Saelens and Handy, 2008). There are some exceptions, for example, the doctoral thesis of Hillnhütter (2016) who explored pedestrian access to public transport, or Stefansdottir (2014) who explored the importance of aesthetic experience for cycling commutes. Both conclude that the neighbourhood-scale is generally underestimated as a strategy to promote zero-emission mobility modes. This is thought to occur in part because of a lack of focus upon, or acknowledgement of, perceptual aspects and how they influence trip experience. Another example is concepts or movements such as Compact Walkable Neighbourhoods or New Urbanism. Both of these support the notion of urban design as a strategy to promote zero-emission modes such as walking, but were not pursued in the context of this thesis as explained in Chapter 1.

With regard to practice, mitigation of greenhouse gases from urban transport might be perceived as outside the scope of an urban design project. Travel destinations and distances are often determined by factors exogenous to the work of design practitioners; similarly, implementation of public transport offers is generally decided at a city's higher administration level. In some projects, the surveyed practitioners said they worked on so-called master plans, outlining the development of a city centre or an entire neighbourhood (refurbishment or new construction). In such cases, the designers can influence the implementation of larger structures and services or the availability of parking spaces. However, the increase of scale reduces the level of detail, such as the design of streets and public spaces. This is the main scale of the present thesis, and wherein the lack of mitigation focus appears the most prominent. For projects concerning streets and public spaces, the negative effects of daily mobility primarily highlighted by the surveyed practitioners tended to be local aspects such as noise, use of space, and traffic safety. It is possible that the designers see these aspects as more addressable and tangible, as something urban design can actually influence. At the same time, several of the interviewees underlined the potential of ensuring the continuity of pedestrian and cycling infrastructures when intervening upon urban space, from the implementation of singular buildings to projects developing a whole building block. But according to them, there is a lack of incentives or regulations for clients to do so, and to ensure that a project's implementation does not negatively impact pedestrian and/or cycling conditions. This seems to demotivate designers to work for continuity, even if deemed important; it becomes one of many aspects to advocate for. Whether or not the practitioner does so might then depend on his or her governing principles. Furthermore, the lack of regulations or incentives seems to strengthen practitioners' impression of mobility-mitigation being outside the urban design scope. It sends a signal about the city's priorities, and what it sees as efficient measures to promote a modal shift.

6.2.1 c) **A monocriteria versus a holistic research approach**

As discussed in Chapter 1, research tends to approach the issue from a monocriteria perspective, focusing on the influence of singular built environment elements upon mobility behaviours and modal choice. The majority of the explored research literature attempts to identify which elements are most influential. Only a minority addressed concepts like streetscapes or environments, and their design with regard to modal choices and trip experience. Despite a large body of research the evidence remains inconclusive, indicating the limitation of a monocriteria approach. A reason for this is that people tend to experience their surroundings as an environment, not as singular elements. Some elements might stand out more than others, but it is the sum that creates the surroundings people perceive and interact with during a trip. Moreover, a monocriteria approach often fails to properly take into account the many interdependencies related to urban design and modal choice. There is, for example, a constant overlap between instrumental and perceptual aspects of the built environment that can have significant consequences for how an area influences trip experience. This can be expected to influence research results, but is difficult to test or control for. Instead, a holistic approach to the topic could be more adapted to its complexity. This has been explored by, for example, Ewing and Handy (2006), Hillnhütter (2016), Stefansdottir (2014), or Vos et al. (2016), with interesting results.

> "(…) physical features individually may not tell us much about the experience of walking down a particular street. Specifically, they do not capture people's overall perceptions of the street environment, perceptions that may have complex or subtle relationships to physical features."
>
> (Ewing and Handy, 2009)

Although the holistic approach to the neighbourhood-scale built environment remains less common within mobility and transport research, a shift is gradually taking place (Stefansdottir, 2015). There seems to be raised awareness regarding the importance of perceptual aspects such as aesthetics upon cycling satisfaction (ibid). As discussed in Chapter 1.3, a holistic shift of research perspective can help address current knowledge gaps within the scientific literature. It allows a different take on context, acknowledging its significance for how the neighbourhood-scale built environment and urban design influence mobility behaviours and modal choice. Additionally, it can make research more understandable and useable for practice. A holistic perspective is more in line with the urban designer approach to the built environment, which in turn relates to them seeing how people usually experience and use it.

6.2.1 d) **Lack of knowledge and awareness among practitioners**

In contrast to research, urban design literature, from Lynch (1960) and Jacobs (1961) to Carmona (2010) and Gehl (2010), tends to approach the neighbourhood-scale built environment from a holistic perspective: how to design neighbourhoods where people want to live and public spaces they want to be present in. However, this is rarely linked to mobility-mitigation. Urban design literature generally addresses mobility in terms of how people move in and through public spaces. Modal choices, and the potential of urban design to influence them, are less addressed. As an example, the works of Gehl[72] (1987, 2010) are frequently used by practice and by decision makers as a guide to creating attractive cities that provide good living contexts. Gehl emphasizes the importance of walking, and the need for public spaces where people want to walk. Several of his principles mirror findings from the scientific literature and the empirical enquiries. However, he does not discuss how cities can utilize urban design projects to enhance public space as an opportunity to actively promote walking (and cycling) for daily mobility. It cannot be deducted if this is due to lack of awareness, or to Gehl seeing the connection as obvious. Yet in light of the popularity works by Gehl and colleagues have gained among practitioners and decision makers, this connection must be rendered more apparent.

The empirical enquiries showed that while mobility is a central and structuring element in design projects, it is primarily seen as movement through public space. According to the surveyed practitioners, how people use the neighbourhood-scale built environment is influenced by how it is organized and shaped . Through the design of public spaces, certain modes can be facilitated or limited. The designers displayed knowledge of how to do this, for example, using the location of facilities and/or parking space to encourage walking. Acting upon parking availability or location was a recurrent measure to influence car use, but rarely expressed as a mitigation measure. The aimed for effect was generally to increase pedestrian activity and thereby the number of people present in public space, frequently related to creating a feeling of safety and to building social cohesion. Overall, mitigating greenhouse gas emissions from transport did not seem to be an objective for the majority of the surveyed practitioners, overlooking the potential influence of their work upon a person's daily mobility. Their emphasis was on the interaction between people and the public space resulting from their design

[72] Highly acknowledged Danish architect and urbanist, particularly as an advocate of cities giving more emphasis and attention to their public spaces as important areas of urban life.

interventions. Previous studies have similarly found a lack of awareness among practitioners regarding the potential of urban design to address climate change, for example supporting climate adaptation through urban design (Dubois, 2014; Dubois et al., 2016). Though they may see urban development as a strategy in general, there seems to be a lack of further connecting the opportunity to address and tackle climate change to their own practice (ibid). Reasons for this are diverse, and can be related to their savoir-faire or their governing principles. If the practitioner does not see adaptation or mitigation as important aspects of urban development, he or she is probably less likely to seek out knowledge on the topic. If the practitioner does not have sufficient knowledge about climate change and the principles of adaptation and mitigation, it is difficult to efficiently take action such as implementing solutions and measures in a project. Similarly, if the practitioner is not aware of the potential urban design contributions, there is little chance of this becoming a design objective. Climate adaptation and mitigation can become active design objectives through the client's command (order), and/or through regulations, but this is not the focus in this context. Changing perspective, as established in Chapter 6.1.1, can help render the link between urban design and modal choice more apparent for practitioners, as well as the contributing potential of their design to promote zero-emission mobility modes. Another important measure is to enhance knowledge transfer between research and practice, to strengthen practitioners' understanding of climate adaptation and mitigation through urban design.

6.2.2 Towards an interdisciplinary, holistic, and operational approach

6.2.2 a) **The mitigation potential of urban design must be made more apparent**

All neighbourhood-scale built-environment interventions, big and small, influence public space in some way: a new city bike station or a transit stop; planting trees along a street; the realization of a new building. Throughout this work it has been show how this can impact people's daily travel conditions, sometimes just a little, sometimes a lot.

This is both a challenge and an opportunity. On one hand it is essential that urban design interventions do not make walking or cycling (more) difficult, i.e. by increasing the hassle of daily trips. The design of a building's entrance area can introduce physical barriers for pedestrians or cyclists; the design of transit stops might ensure accessibility for its users, but simultaneously create barriers for pedestrians walking by. Such temporary or permanent barriers created by the built environment can represent the final push towards the automobile as primary modal choice, particularly for those less able-bodied. On the other hand, interventions upon public space also represent opportunities to act upon existing barriers, from smaller measures such as sidewalk edges, to bigger ones such as insufficient street lighting, or lack of continuity in pedestrian (and cycling) infrastructure; i.e. a possibility to enhance public space for zero-emission daily mobility. The impact of a project depends on its size, but there is always some level of influence that can tip modal choices in a sustainable direction. Consequently, urban design can be a mobility-mitigation strategy. Yet, as discussed in the previous sections, it is apparently not seen as such, despite a consensus among researchers and practitioners that the neighbourhood-scale built environment influences modal choice. To remedy this, the mobility-mitigation potential of urban design must be rendered more tangible and comprehensible.

> "(…) we need to be more innovative, multidisciplinary, humanistic and critical in the methods we employ, and the theories we advance – and only then may we start to make some significant progress towards more sustainable behaviours."
>
> (Hickman, 2017)[73]

Utilizing urban design as a strategy to achieve "more sustainable behaviours" requires research and practice to become fully aware of its potential, which in turn necessitates 1) a change of perspective as previously discussed, and 2) a change of methods as outlined by Hickman.

[73] From a book review by Robin Hickman, quoting Mimi Sheller from the book *Transport, mobility, and the production of urban space*, edited by Julie Cidell and David Prytherch (Cidell and Prytherch, 2015).

For research, changing the perspective involves approaching the neighbourhood-scale built environment and its modal influence holistically, as a whole. It should aim at identifying spaces that further the use of zero-emission modes, and exploring why and how they do so. Context is highly significant in how the neighbourhood-scale built environment influences trip experience; there is no one solution that fits all. A daily trip usually passes through a series of contexts, which further emphasizes the need for a holistic shift. The change of perspective introduced in Chapter 6.1, considering mobility as a kind of use of public space, contributes to this. The changes described here might furthermore induce a change in research methodology, as a holistic approach increases the number of factors and variables to test for and to take into account. A mix of methods must be employed, combining, for example, people's survey responses with observation of their use of public space. Hillnhütter (2016) employed direct surveys with video-observation; Stefansdottir (2014) used bike-throughs (term defined by Stefansdottir) where she followed cycling commuters on their daily journey, both observing and (subsequently) interviewing them. This work has explored the experienced-based savoir-faire of urban designers as a new source of insight, based on the idea that designers observe the city and its uses by inhabitants through their professional practice. These observations could represent valuable knowledge for understanding people's interactions with built environments, largely complementary to that of research. By 'translating' these interactions, professional savoir-faire contributes to further interpreting previous research findings, for example, by identifying the influence of urban context. Combining scientific protocol with professional experience in a more joint knowledge production for urban development could be an interesting approach to pursue further. In addition to strengthening knowledge in itself, this could help strengthen the reciprocal knowledge transfer between research and practice.

Mitigation of mobility-related emissions must become an active design objective in practice. Both recent studies and the thesis results indicate that, despite knowledge about sustainable development, urban design practitioners tend not to perceive their own work as contributing to climate change adaptation or mitigation (Dubois, 2014; Dubois et al., 2016). Hence, increasing knowledge among practitioners about the mitigating potential of urban design interventions is an important step to mend this.

Research has an important role as knowledge producer and communicator, but current knowledge transfer between research and practice is lacking. Barriers include disparities between the two, as well as the perception of research literature as inaccessible (too technical; too expensive; too precise but also too general, etc.). Another challenge in strengthening climate knowledge among practitioners is their dependence on projects as sources of new insight. Personal experience, or that of colleagues, is a practitioner's premier source of knowledge. If an issue has not been encountered in a project, the practitioner is less likely to have knowledge about it. Therefore, research should aim at communicating knowledge through an operational approach, linking findings and results to urban design projects and current practices. The CapaCity project concluded that efficient climate adaptation through urban development (here: urban design) requires the topic to be present from the early stages of a design process. Furthermore, that knowledge is best rendered available and applicable by building upon the win-win knowledge of practitioners. Urban designers know how to achieve objectives through manipulating built-environment structures using a holistic, win-win approach, where a solution or measure addresses several issues simultaneously. Hence, if they have proper knowledge of how projects can be adaptive – or in this case mitigating – they can incorporate it into their methods and practices. It is likely more efficient to indicate what a project should achieve or contribute to, rather than simply saying which solutions and measures to implement. With regard to mobility-mitigation, this could be achieved by emphasizing the connection between improving public space as urban living contexts and improving public space to promote zero-emission mobility modes – as seen in the previous subchapters. This represents important win-win potential that practitioners have the savoir-faire to implement projects. Moreover, addressing daily mobility as a kind of use of public space can help show that mobility-mitigation does not present a significant change or additional burden to their practices. Mobility already has a central and structuring role in design projects, and practitioners have the savoir-faire to act upon people's mobility behaviours as illustrated through the enquiries. Making the link between urban design and modal choice more apparent can help urban practitioners recognize the potential role of urban design as a strategy to mitigate mobility-related emissions. This calls for a more operational approach to knowledge production and communication, harmonizing insights from research and practice.

6.2.2 b) **A strengthened collaboration between research and practice**

Enhancing mitigation action through urban design necessitates a strengthened collaboration research between and practice, to strengthen and improve knowledge production, knowledge transfer, and knowledge application (see Figure 42). The three areas should be considered simultaneously. For example, a reinforced knowledge transfer from research to practice is necessary to strengthen the use of evidence-based knowledge in projects. It should equally take place from practice to research, as previously discussed.

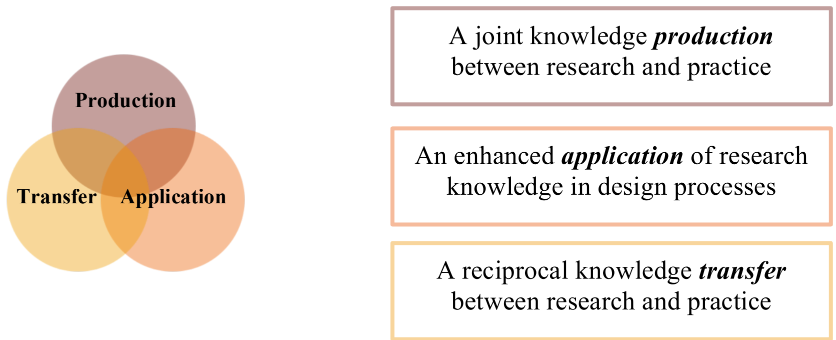


Figure 42 Collaboration and exchange between research and practice requires a strengthening of these three aspects of knowledge production and use, figure by author

Cities are systems of organized complexity where everything is related and interdependent (Jacobs, 1961); acting upon one part of a city will influence other parts of it in some kind of way. According to Rittel and Webber (1973), cities produce wicked development problems that can never be fully understood nor fully solved; yet, they must be addressed and acted upon. Doing so requires an in-depth understanding of the city and its functionings, beyond the easily measurable and observable. Experience has shown that this is best obtained through an interdisciplinary approach, for example combining transport- and planning-research with research within social sciences. Another interesting source of insight are urban practitioners – here urban designers. As shown through this thesis, their experience- and observation-based knowledge is often complementary to that of research. Combining the two can significantly strengthen knowledge on how to address urban development problems, for example mobility-mitigation. Knowledge production for urban development should therefore (ideally) take place jointly through collaboration and exchange between research and practice, as shown by Figure 43 (exemplified by climate change).

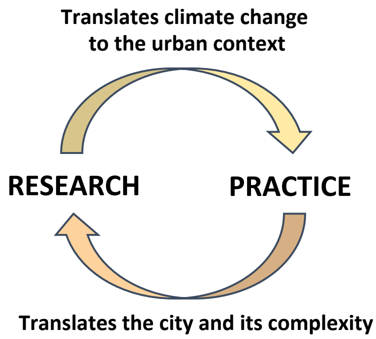


Figure 43 A constructive dialogue between research and practice to strengthen knowledge production, figure by author

Research has knowledge on how global warming and climate change will affect cities, and what they must adapt for or to; for climate change mitigation, knowledge on how to reduce energy consumptions, and how to switch to renewable and/or zero-emission alternatives. This is knowledge that urban development projects needs to incorporate to tackle climate change. To achieve this, practitioners must have access to the knowledge, but they must also be able to understand it, and easily implement it in a project. Practice, on the other hand, can have valuable knowledge about and understanding of how a city 'works'; from its structures and mechanisms, to the way people use it. This is often difficult to measure and quantify, but practitioners can translate these aspects to research, making them more tangible and concrete. A better understanding of how people interact with and are influenced by their built-environment surroundings can help explain findings from previous research, for example why commuters walk a specific route to a transit stop. The experience-based knowledge of practitioners offers no 'absolute truth', as discussed on Part 2. It is based on own experience and observation, as well as their governing principles and savoir-faire. The latter can be highly subjective, influenced by for example by personal values and beliefs. Nevertheless, it offers valuable insights into urban living that should be incorporated into mobility and transport research.

Barriers for knowledge transfer from research to practice were addressed throughout this work; the findings equally apply to knowledge transfer from practice to research. Research and practice differ on many levels, which is a significant challenge to establish the necessary dialogue for collaboration. A better understanding of each other's constraints and professional 'everyday life' can help improve this. In addition to mitigation-insights, the empirical enquiries provided new insight into design practices, particularly on the role of mobility in a design process, and how designers consider and address it. These results can strengthen a joint knowledge-production between research and practice. Collaboration must be based on a continued dialogue, as well as openness to different results and outcomes than envisioned and/or intended. Moreover, it must be adapted to the needs and constraints of each. It could be argued that ultimately, knowledge production (for society) falls upon research, and so has a particular responsibility to facilitate collaboration and exchange with practice. For example, strive to make results accessible by using other communication channels than scientific publications, which often require expensive subscriptions. Through CapaCity and this thesis, three approaches were explored: workshops, interviews, and a survey. An important aspect was the possibility to include practice periodically, often in short time intervals, which is often more adapted to their constraints (time pressure in projects, economy, etc.). The workshops-participants reported, for example, that a full-day session would have been impossible to attend due to time and money constraints. Another interesting aspect of the enquiry methods explored in this context is the direct exchange, for example during a workshop or an interview. This can in itself contribute to an increased understanding of each other's 'field': for research, rendering the design process more transparent; for practice, rendering the 'making' of research more comprehensible. The latter is likely important for research knowledge to become more accessible to practitioners. Furthermore, the possibility of direct contact with a researcher has been shown to facilitate the implementation of evidence-based knowledge in design projects. Relations established during collaborations such as workshops and interviews can contribute to this.

However, practice also has a responsibility to enhance its use of scientific knowledge. Urban designers need to actively seek out and incorporate research knowledge in projects. This can be done in several ways, from reading research articles to inviting researchers to present their work. Studies indicate that designers often prefer in person communication, but it is unrealistic as a primary means for knowledge transfer between research and practice. Other measures are necessary. Raised awareness among practitioners regarding the kind of information research can offers, and the value of employing it in projects, can likely help increase its implementation in projects. Design education offers an opportunity to achieve this, as discussed by for example Lawson (2013) and Tennøy (2012). Many urban design studies are includes studio projects where students work on hypothetical development problems. This could be an interesting arena to teach future designers to actively seek out and implement research in projects. Doctoral students could assist studio teachers as part of their course work, combined with students being required to document design actions with research (when possible). Per today, the extent to which research is used in projects, or researchers are included in a studio teacher-team, likely varies among schools (and studios) – from actively to not at all. Teachers with a background from practice, many of which are often still practicing, generally direct studio works. This is important for developing the students' Process, Methodological, and Design savoir-faire, but can present challenge with regard to knowledge transfer between research and practice – which is important for the Technical savoir-fare. Studio teachers often play a significant role in students' development of savoir-faire and governing principles (Eikseth, 2009), further reinforced by the lack of a General Design Theory. This is likely to apply to the use – or non-use – of research knowledge in projects. A structured emphasis on incorporating research in design studies could help balance this. The education of future designers represents an opportunity to strengthen collaboration between research and practice that should be further explored as part of the overall efforts to strengthen urban design as a mobility-mitigation strategy.

6.2.2 c) **A design framework to strengthen mitigation efforts**

How can urban design be a mitigation strategy to promote the use of zero-emission mobility modes? Throughout this chapter, two responses have been explored. First, the use of zero-emission mobility modes must be possible and pleasurable. Urban design can contribute to this through built-environment interventions upon public space, thereby enhancing trip experience and travel satisfaction for zero-emission modal choices. Practitioners can play a pivotal role in realizing the mitigation potential of urban design. They have an interdisciplinary, holistic approach to urban design projects; moreover, mobility is already a central and structuring element in the design process. The professionals know how to address and act upon it, for example how to promote particular mobility behaviours. However, there is a lack of connecting this to actively promoting zero-emission modes for mitigation purposes. Overall, the mitigation potential of urban design appears underestimated or overlooked by research and practice. This leads to the second response: mitigation of greenhouse gas emissions from urban mobility must become an active objective for designers and researchers. For research, this requires a holistic shift in how the topic is approached, as well as more interdisciplinary research methods. For practice, an important change is to enhance knowledge about climate change and mitigation, and about the connection between mobility-mitigation and improving living contexts. Climate change mitigation though urban development necessitates the use of both evidence- and experience-based knowledge, equally so for mobility-mitigation through urban design. Achieving this requires knowledge to be accessible and applicable in projects and design processes, the main activity of urban design practitioners. Through the thesis investigations, a large body of knowledge on urban design and mobility-mitigation has been compiled. The properties previously introduced are an initial synthesis of this, summarizing the necessary capacities of zero-emission friendly public space in a concrete and comprehensible manner. The five principles demonstrate what urban design projects should achieve, in terms of perceptions and experiences of public space, to actively promote the use of zero-emission modes. Through a systematic approach, this can be further explored to render scientific knowledge more available and applicable to practitioners, but also to render professional savoir-faire more understandable and useable for research. As an initial attempt at this, the outlines of a future design framework are introduced in the following chapter.

The draft explores the thesis results from a holistic, mitigation-focused perspective. The five properties, together with the urban qualities explored in Part 2, constitute the foundation for the intended framework. It should be structured and organized in relation to design practices in order to enhance its usability in projects. As an draft, the initial focus has been on how the properties relate to the urban qualities, and how these in turn are realized through four principal levers of action: urban structure, land use, mobility systems, and urban features. The latter are the aspects upon which practitioners can act in an urban design process. The intended framework is initially directed towards practice. The aim is to develop the draft towards a design framework through future research projects, preferably in collaboration with students and practitioners to ensure its relevance and applicability for practice. Ideally, the future framework can equally benefit mobility and transportation research, providing a basis for a more interdisciplinary and holistic research approach. One objective is to clarify what the urban design ‘product’, i.e. public space, must provide in terms of trip experience to make zero-emission mobility possible and pleasurable. This can help practitioners identify concrete design objectives to implement in their design process. For mobility and transportation research, this might help identify other research fields to collaborate with. Another objective is to provide the foundation to strengthen knowledge transfer between research and practice, by providing a mutual platform for collaboration and exchange. Joint knowledge production between research and practice will strengthen the understanding of the reciprocal relationship between the built environment and mobility behaviours at the neighbourhood scale. This is key to fully exploiting the mitigation potential of urban design as a contributing strategy for a zero-emission modal shift.

CHAPTER 7

A FRAMEWORK DRAFT LINKING URBAN DESIGN AND MODAL CHOICE

7.1 INTRODUCTION

The mitigation potential of urban design seems largely overlooked and/or underestimated by research and practice. Mobility is a central element in design practices, and practitioners have the savoir-faire to address and act upon it. However, there is an apparent lack of awareness about the mitigation potential of urban design. Mitigation must become an active design objective. As a response to this, the following chapter outlines the draft for a future design framework, using the evidence-based and experience-based knowledge from the thesis. It builds on the properties introduced in Chapter 6 and the urban qualities explored in Part 2, together with frequent built-environment levers of action in design projects: urban structure, land use, mobility systems, and urban features. The objective is to make mobility-mitigation more apparent, tangible, and comprehensible for urban design practitioners. The future framework is intended to support practitioners in design projects. Its objective is to help identify opportunities and challenges for mobility-mitigation through urban design interventions, by increasing their knowledge and awareness about the topic. Moreover, it is important to provide practitioners with sound arguments and evidence to ensure that necessary mitigation measures are implemented, despite the many constraints and actors in a project. Tennøy (2012) found that in urban development projects the knowledge of practitioners was easily ousted, i.e. overlooked or overruled, for questions related to transport and land use planning. There are several explanations for this, one being a lack of understanding and use of research-based knowledge among practitioners (Tennøy, 2012). In her work, Tennøy suggested a series of measures to strengthen urban development as a mitigation strategy. The thesis findings with regard to knowledge production and transfer mirror her observations. To become active agents for mitigation, urban design practitioners must have a thorough understanding of the structures and mechanisms shaping the reciprocal relationship between mobility behaviours and the built environment (Bertolini, 2012; Forsyth and Krizek, 2010; Tennøy, 2012). A future version of the framework should include an introduction to this reciprocal relationship, explaining how this dictates that urban development can be a mobility-mitigation strategy at the city scale and at the neighbourhood scale. This includes how and why land use, mobility systems, mobility behaviours and traffic volumes are interrelated, and why different development strategies produce specific mobility patterns. Insights from behavioural sciences, sociology, environmental psychology, and other fields, can further help understand how the reciprocal relationship works, and how it can be influenced though urban design – as exemplified by this thesis. Presenting this in a manner accessible and useable for practitioners is highly important. For now, such a summary is not included, but it is envisioned based on an elaborate synthesis of the literature review in Chapter 1.2.

The framework is initially directed towards students and young/less experienced practitioners. First of all, they will have less deeply grounded governing principles (see Chapter 3) than more experienced practitioners, and are therefore more likely to be open to new ideas and perspectives. Second, because of their lack of experience they are likely to have less knowledge on addressing and acting upon daily mobility. Third, these are the designers of tomorrow; their work will influence the built environment of cities for many years to come. It is essential they become active and aware mitigation (and adaptation) agents. Providing these groups with a framework that combines evidence- and experience-based knowledge is an important step to increase their knowledge about the mitigation potential of urban design. Building on the 'learning by doing' aspect of urban design, the framework is intended to be used actively in studio work[74] and actual projects, not as a catalogue to consult periodically. The framework can be an aid for more seasoned designers as well, as the observed lack of mitigation focus was not limited to young or inexperienced practitioners. Having accumulated knowledge of solutions and measures that create good public spaces people want to use through previous projects, these designers could be expected to know how to achieve the properties and the qualities. For them, the framework might primarily be an aid to implementing the mitigation aspect in their overall ambition of creating good living contexts.

The framework is additionally envisioned as a mutual platform to enhance collaboration between research and practice. A joint approach to knowledge production is necessary to properly address climate change mitigation (and adaptation) through urban design. A constructive dialogue between research and practice is needed in order to better integrate scientific knowledge into the design process. The framework can contribute to bridging the gap between research and practice and enabling reciprocal knowledge transfer by establishing a common vocabulary and objectives (properties; qualities) to structure the cooperation, and thereby strengthen climate adaptation actions. Practice must learn from research, but as has been shown throughout this work, research must also learn from practice. This framework might contribute to the necessary holistic shift within mobility and transport research. Furthermore, the properties could help identify other research fields to look to for particular questions or issues, or mechanisms that can shed new light on previous findings.

Mobility-mitigation and urban design is a complex topic. Different aspects of the reciprocal relationship between the built environment and modal choice can easily get muddied. A first step towards a design framework is to create a systematic overview of the potential actions and measures designers dispose of to act upon mobility. The aim of this chapter is to establish a sound foundation for the intended framework by combining the evidence- and experience-based knowledge from the thesis investigations. The first part is a summarized explanation of how the properties introduced in Chapter 6 relate to

[74] A common term for classes on design project in many urban design education programs

the urban qualities from Chapter 5, and how the latter ones are realized by acting upon the four levers of action., Examples of possible solutions and measures are provided for these levers of action. A future version of the framework should encompass further detailing of these, as well as examples of projects that incorporate several of the design actions, ideally from a win-win perspective.

PROPERTIES	URBAN QUALITIES		LEVERS OF ACTION
• Safety • Distance • Orientation • Accommodating • Comfort & Pleasure	• Connectivity • Legibility • Human scale • Enclosure • Transparency	• Complexity • Coherence • Hierarchy • Flexibility	• Urban structure • Land use • Mobility systems • Urban features

Table 39 The properties, the urban qualities, and the levers of action that constitute the foundation for the framework

The second part of the chapter discusses the envisioned use of the framework. To create a framework that is understandable for designers and applicable in projects, it must reflect design practices. The theoretical insights from Chapter 3, combined with observations from the CapaCity project provide a solid basis to ensure this. The prototype version of the CapaCity tool offers a concrete example of how a design-aid tool can be structured and of its intended use. A design framework such as the one outlined here can contribute to making mobility-mitigation an integral part of the design practices of future practitioners – something they ‘just do’ in the same way they ‘just know’.

7.2 DESIGNING PUBLIC SPACES TO ENSURE A POSSIBLE AND PLEASANT ZERO-EMISSION DAILY MOBILITY

7.2.1 Five principles for zero-emission friendly public spaces

The following sections provide an initial structure for the future framework, organized around the properties. Zero-emission friendly public spaces needs to encompass these properties to actively promote zero-emission modes. Here, the emphasis has been on clarifying how the properties, the qualities, and the levers of action are related from a design perspective. From the properties to the levers of action, there is a gradually increasing level of detail as regards the designers' action space, i.e. what designers can act upon and influence in a design project. While the properties and the qualities establish design objectives for a project, the levers of action are the means to achieve them – which the designers generally know how to do. Through the levers of action, the framework indicates not only what they can act upon, but also how they might do so. The properties are flexible depending on urban context. A project's urban context is highly influential throughout the design process, from establishing initial conditions and premises to determining how the inhabitants and others receive the end result. Hence, it influences how the properties and qualities can best be achieved in a project. In a city with a prominent harbour, Orientation can be achieved through high levels of Connectivity and Transparency offering frequent views of the water. This evidently depends on the size of the city, again underlining the influence of context. In cities with less dominating natures, noticeable built structures can offer points of reference. Context further influences the actual impact or efficiency of potential design actions. A successful cycling solution in Amsterdam is not necessarily directly replicable in Toulouse; replicability can even suffer between neighbourhoods within the same city. But the design objectives behind a choice of solutions are often transferable, i.e. what the public spaces being created should provide in terms of trip experience –. Looking at other cities or situations can provide practitioners with ideas and concrete examples of how a quality can manifest in public spaces and built environment elements. For such purposes, the future framework can provide a supporting structure to help analyse examples.

The properties were developed from an operational perspective: five easily retainable topics that cover the most frequent or dominating aspects of zero-emission mobility from research and practice (see Figure 44 and Table 40). They are intentionally expressed in a straightforward manner to further strengthen their applicability in projects. An important function is to emphasize the need for zero-emission mobility to be not only possible, but also pleasurable. Feeling safe, feasible distances (perceived), and the trip not being a hassle, are the base requirements for ensuring pleasure. Feeling invited, accommodated, and preferably prioritized, e.g. as a pedestrian or cyclist, is furthermore important. Outdoing potentially negative aspects of a trip is necessary to ensure a high level of travel satisfaction. Travellers tend to prioritize different properties. To achieve a permanent modal shift, public space must have the capacity to offer a range of possible and pleasurable modes to a large majority of urban populations. This can be ensured by the properties as a whole, as they complete and enhance each other, but all five are necessary to create zero-emission friendly spaces. Additionally, the properties help link mobility-mitigation to improving living contexts, the overall goal for urban design. They mirror aspects that practitioners and literature frequently refer to as significant for achieving good living contexts for urban inhabitants. Rendering this connection more apparent can contribute to showing urban design practitioners that mitigation does not necessarily represent an additionally burden; the property aspects are for the most part already present in design projects. The intended framework could add a ‘mitigation layer’ to current practices to fully exploit the overlooked potential as identified through the thesis investigations.

	PROPERTY	DESCRIPTION
Safety	Capacity of producing a ***feeling of safety***: traffic safety, safety against crime and accidents	When moving through an area, the traveller must feel safe from traffic, crime and accidents.
Distance	Capacity of ***reducing distance***, physical and perceived	When moving through an area, the traveller must experience distances as not too long, and as possible to traverse.
Comprehensive	Capacity of ***being comprehensible*** for geographical/cultural orientation, and use	When moving through an area, the traveller must be able to recognize or understand where he or she is geographically (e.g. the kind of area he or she is in) and how to move around in it (e.g. hierarchy of modes, where to cycle, etc.).
Accommodating	Capacity of ***accommodating different*** modes and uses.	When moving through an area, the traveller must feel welcome, and that he or she is supposed to be present in the space: pedestrians are intended to walk there, cyclists are intended to bike there, etc.; travellers and inhabitants must be able to coexist.
Comfortable and pleasant	Capacity of providing a ***comfortable*** and ***pleasurable*** travel experience.	When moving through an area, the traveller must be protected from weather and climate; the influence of significant topography etc. must be limited; passing through an area must be interesting and enjoyable.

Table 40 Summary of the five properties and the experiences and/or perceptions they should contribute to

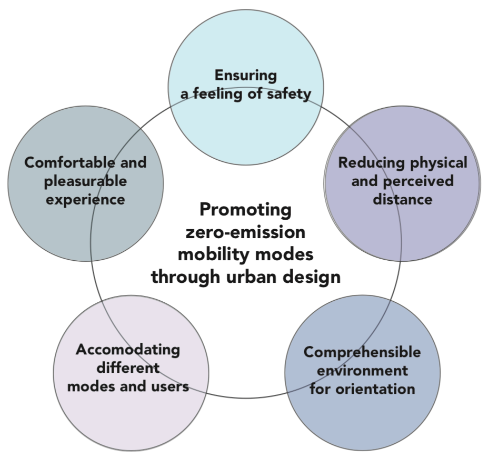


Figure 44 Properties of public space to promote the use of zero-emission mobility modes by providing pleasure and possibility, figure by author

Figure 45 illustrates how the properties, the urban qualities, and the built-environment levers of action are related, here described from a 'bottom-up'-perspective: by acting upon the levers of action, the designer can realize the qualities necessary to achieve public spaces that encompass the properties. This creates public spaces that contribute to making zero-emission mobility possible and pleasurable. As an example, public spaces that allow people to know where they are (Orientation) typically have high levels of the qualities Legibility, Complexity, and Transparency as can be achieved through urban features and land use.

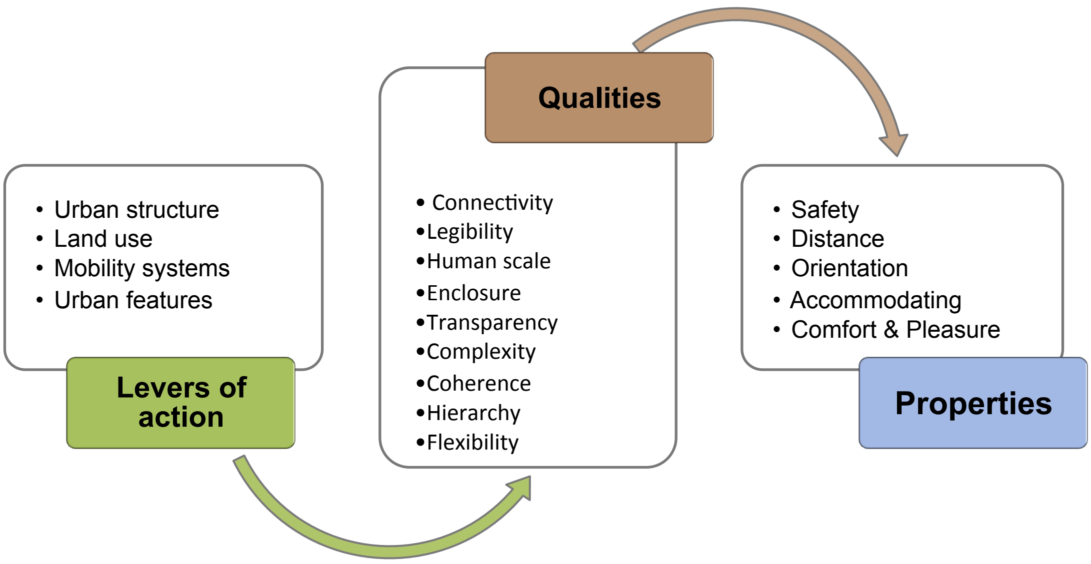


Figure 45 Properties are achieved by designing for qualities, which in turn are realized by acting upon levers of action

7.2.2 Qualities and levers of action

Table 41 summarizes how the five properties of public space relate to the urban qualities explored in the thesis. The terms in the table are primarily found in research and design literature, and appear to be used less frequently by practitioners. Nevertheless, they are included in the framework as they provide a potentially common vocabulary to describe important characteristics for ensuring the properties. This can help facilitate collaboration between research and practice

LINKING QUALITIES AND PROPERTIES FOR ZERO-EMISSION MODAL CHOICE					
	Safety	**Distance**	**Comprehensive**	**Accommodating**	**Comfortable and pleasant**
Connectivity	x	x	x	x	x
Legibility	x	x	x	x	x
Human scale		x	x	x	x
Enclosure	x	x	x		x
Transparency	x	x	x		x
Complexity	x	x	x		x
Coherence		x	x		x
Hierarchy	x		x	x	x
Flexibility	x			x	x

Table 41 Matrix detailing how the qualities are related to the five properties of the framework draft. Only direct connections are indicated, although most of the qualities are indirectly related to the properties.

Some of the qualities are more instrumental, such as Connectivity and Human scale; others, such as Complexity, Coherence, and Enclosure, are more perceptual. As explained earlier, how a quality manifests, i.e. how it is realized, will vary according to urban context, i.e. the nature of a neighbourhood or its proximity to the urban centre. The more central an area is, the denser it tends to be. This influences how qualities such as Complexity or Legibility are best achieved. The qualities are strongly related due to the high level of interdependence between different aspects of a city, particularly in relation to the built environment. Designing for Connectivity will almost certainly involve designing for Transparency; designing for Legibility generally includes Complexity. This underlines the futility of defining one quality (or property) as more important than another. It is their sum that creates zero-emission friendly public spaces; moreover, the qualities are all connected directly or indirectly. To create public spaces that enable possible and pleasurable zero-emission mobility all nine qualities must be ensured, as they are all necessary to ensure the five properties. Table 42 is an example of how designing for the qualities can contribute to achieving a property. In a developed version of the framework this should be available for all five properties. It is worth noting that the qualities can to some extent contribute to reducing risk of accidents as well, but this is not explored in-depth here.

HOW QUALITIES CONTRIBUTE TO ACHIEVE FEELING OF SAFETY IN PUBLIC SPACE		
Connectivity	*Traffic safety*	• Helps separate modes, which can reduce conflicts; intersections are a significant source of accidents • Provides route choices to adapt trip to personal preferences and perceptions of traffic safety
	Fear of crime	• Ensures possible escape from dangerous situations • Provides route choices to adapt trip to personal preferences and perceptions of danger of crime
Legibility	*Traffic safety*	• Helps a traveller's orientation for use: which modes can be used here, priority among modes, etc.

	Fear of crime	• Helps a traveller's geographical and cultural orientation, which can increase feeling in control
		  • Geographical orientation: "Where in the city am I?"
		  • Cultural orientation: "What kind of people live/tend to hang out here?"

Enclosure	*Traffic safety*	• Contributes to communicating the nature of an area, e.g. pedestrian-oriented, car-oriented; clear priority of pedestrians and/or cyclists can help make drivers slow down compared to vast, open spaces
	Fear of crime	• Can provide a feeling of protection and security, especially for pedestrians; however, must be balanced with Connectivity to not make travellers feel trapped
Transparency	*Traffic safety*	• Provides an overview of the traffic situation beyond the immediate surroundings; also important at intersections/street corners
	Fear of crime	• Having an overview of what is going on beyond the immediate surroundings can similarly enhance a feeling of safety from crime • Facades with levels of transparency on the ground floor (e.g. windows), but also first 3-4 floors, provides light at night, as well as eyes on the street (actual and perceived)
Complexity	*Traffic safety*	• Varied streetscapes require travellers to pay more attention to surroundings, this can reduce travel speeds • Helps making an area pedestrian- and/or cycling-friendly; monotone and/or boring environments often seen as car-oriented
	Fear of crime	• Interesting and active areas attract people (or at least make area feel occupied), public presence contributes to feelings of safety
Hierarchy	*Traffic safety*	• Contributes to communicating priority between mobility modes, as well as their place on a street (where to walk, ride, etc.)
Flexibility	*Traffic safety*	• Ensures harmony between mobility modes and between static/dynamic uses of public spaces, e.g. sidewalks
	Fear of crime	• A multitude of potential uses for a continued occupation of public space ('time-share' of public space, see Chapter 6.1)

Table 42 How the urban qualities relate to feeling safe from traffic and crime with regard to daily mobility

In a project, urban designers intervene upon public space by organize and manipulating neighbourhood-scale built environment elements categorized as urban structure, land use, mobility systems, and urban features. These are the designers' four levers of action for realizing urban qualities in the framework.

LEVERS OF ACTION FOR URBAN DESIGNERS	
Urban structure	**The fabric of the city** The geometrical organization of built-environment elements such as road and street networks, the shape and size of building blocks, the location of bigger activities or services (e.g. industry, hospitals, administration buildings), and so forth. The resulting urban fabric constitutes the urban structure.
Land use	**The repartition of functions and the characteristics of a neighbourhood** 1) The geographical distribution of functions within an urban area (e.g. location of residence, of schools); 2) the character assigned to a neighbourhood (e.g. residential, mixed use, business).
Mobility systems	**The infrastructure for urban travels** Presence and design of built-environment infrastructures for urban travels: roads and streets; parking facilities; bicycle infrastructure (lanes, paths, parking, etc.); pedestrian infrastructure (sidewalks, crossings, etc.); transit stops; rails for trams; separate lanes for buses; etc.
Urban features	**Singular elements or aspects** E.g. sidewalk width, vegetation, facade design, etc., that, together with the above, constitutes the neighbourhood-scale built environment, which in turn produces the public spaces people move through in their daily trips.

Table 43 The four levers of action upon which practitioners can act in order to realize urban qualities

Each lever of action is associated with a broad range of measures and solutions that the designer can implement in a design process to realize the qualities. Table 45 is a non-exhaustive summary of some measures and solutions, although many more can be found; the built environment offers an almost unlimited number of possibilities depending on the urban context, the project command, the client, and the urban designer. Through their professional experience, practitioners accumulate knowledge of potential measures and solutions they can employ to achieve design objectives, such as the qualities explored here. This constitutes part of their savoir-faire, as explained in Chapter 3. This savoir-faire further helps identify which measures and solutions might be a good fit for a particular project. Each lever does not directly apply to each quality. Some constitute a premise for realizing a quality, rather than directly contributing to it. Complexity, as a quality, is first and foremost realized by acting upon urban features (e.g. implementing elements for variation) and mobility systems. However, the urban structure and land use establish important premises. An area with a gridlike structure requires different urban-features or mobility-systems measures and solutions than a cul-de-sac structure. Several of the solutions and measures in Table 45 apply to more than one quality, again emphasizing the level of interrelation between qualities. An important aspect to keep in mind is that creating one quality can simultaneously reduce another: Enclosure is achieved through vertical built-environment elements, e.g. building walls or hedges, but this can reduce Connectivity and/or Transparence. The influence of urban design upon the levers of action depends on the project. In bigger projects the designer might influence urban structure and land use (e.g. location of public services, number of parking spaces, etc.), i.e. if developing the building regulation for a neighbourhood. In smaller projects, the scope might be limited to a specific street, part of a street, or a public place. In such cases, the urban designer might primarily have the possibility to act upon urban features, and to some extent mobility systems (e.g. sidewalks, cycle paths).

HOW THE URBAN QUALITIES ARE REALIZED THROUGH LEVERS OF ACTION				
	Urban structure	**Land use**	**Mobility systems**	**Urban features**
Connectivity	x	x	x	
Legibility		x	x	x
Human scale	x			x
Enclosure			x	x
Transparency	x	x	x	x
Complexity			x	x
Coherence			x	x
Hierarchy	x	x	x	x
Flexibility	x	x	x	x

Table 44 Matrix summarizing the relationship between the urban qualities and the four built-environment categories from Chapter 1 and 5. Only direct connections are indicated, although most of the qualities are indirectly related to the properties.

The following tables provide further detail on how the urban qualities can be realized through the levers of action, based on findings from practice, research and design literature. As the two tend to overlap, urban structure and mobility systems are combined in the tables to simplify the framework. Some levers of action are recurring, such as use of ground floors and facade design, or a finely meshed urban fabric (i.e. many connections and paths). These are often solutions and measures that contribute both directly and indirectly to the qualities. As emphasized initially, this is the outline of a framework. In addition to further detailing the tables, it would be interesting to include concrete examples of solutions, particularly for more abstract ones. This is not intended as a catalogue, but as inspiration to make the qualities more tangible for practitioners. The idea is to help identify possible measures and solutions that fit the on-going project, ensure the end product encompasses the qualities and thus the properties, and can be implemented in a win-win fashion.

CONNECTIVITY			
Connections between streets, pedestrian networks, etc. for connections within a neighbourhood and/or between several neighbourhoods		**Urban structure**	• A finely meshed urban fabric with a high number of connections • A grid-like network can enable connectivity • Informal paths between buildings or through building blocks • Extension of streets, paths, etc. to link pedestrian and cycling networks • Design at a human scale, for example breaking up continuous building blocks
		Mobility systems	
		Land use (programming)	• Public places and similar structures can be part of pedestrian and/or cycling network
		Urban features	• Transparent facades can enhance visual Connectivity at street corners

LEGIBILITY			
How easily one can recognize and understand a neighbourhood, for instance for orientation		**Urban structure**	• Easily recognizable structures like grid-network • Indirectly through the possibilities enabled by the urban fabric
		Mobility systems	
		Land use (programming)	• Transition private/public space: comprehensible? • Use of the ground floor of buildings • Location of services and amenities, from playgrounds to grocery stores
		Urban features	• Design of facades on ground floor • Openings in buildings to create visual connectivity towards other areas, other streets • Signage and other traffic communication

HUMAN SCALE			
Dimension of built environments relative to human dimensions (e.g. street width, block size, building height)		**Urban structure**	• A finely meshed urban fabric with a high number of connections to reduce size of building blocks • Informal paths between buildings or through building blocks helps break up continuous facades and blocks • Indirectly through the architectural design of building, particularly bigger structures
		Mobility systems	
		Land use (programming)	• Building height • Width of street and sidewalk, some works recommend a ratio of 1:1 building height/street width[75] • Design of facades on ground floor: e.g. variation and transparent versus monotone and closed-off
		Urban features	• A finely meshed urban fabric with a high number of connections to reduce size of building blocks • Informal paths between buildings or through building blocks helps break up continuous facades and blocks

[75] See for example Loukaitou-Sideris (2006)

<table>
<tr><th colspan="3">ENCLOSURE</th></tr>
<tr><td rowspan="4">To what extent buildings and other elements define and shape spaces[76]</td><td>Urban structure</td><td rowspan="2">• Indirectly through the possibilities enabled by the urban fabric
• Design of transit stops and parking facilities can influence enclosure
• Design (structure and shape) of roads and streets, tram-paths, etc.
• Indirectly through the architectural design of buildings
• Transition private/public space: e.g. walled off/open</td></tr>
<tr><td>Mobility systems</td></tr>
<tr><td>Land use (programming)</td><td>• Building height
• Width of street and sidewalk
• Use of other vertical elements to create sense of defined space
• Design of transition public/private space (fences/walls/vegetation)</td></tr>
<tr><td>Urban features</td><td>• Indirectly through the possibilities enabled by the urban fabric
• Design of transit stops and parking facilities can influence enclosure
• Design (structure and shape) of roads and streets, tram-paths, etc.</td></tr>
</table>

<table>
<tr><th colspan="3">TRANSPARENCY</th></tr>
<tr><td rowspan="4">The possibility to see what goes on at the end of a street and past it, for example human activity or particular buildings</td><td>Urban structure</td><td rowspan="2">• A finely meshed urban fabric with a high number of connections to reduce size of building blocks
• Informal paths between buildings or through building blocks helps break up continuous facades and blocks
• Design of transit stops, parking facilities, and other mobility systems can reduce/hinder visibility
• Use of the ground floor of buildings: does it allow for open and transparent facades (windows), or does it require opaque facades (e.g. covered windows/no windows)?
• Indirectly through the architectural design of buildings, particularly bigger structures</td></tr>
<tr><td>Mobility systems</td></tr>
<tr><td>Land use (programming)</td><td>• Design of transition public/private space (fences/walls/vegetation)
• Design of facades on ground floor
• Use of vegetation, can reduce/hinder visibility</td></tr>
<tr><td>Urban features</td><td>• A finely meshed urban fabric with a high number of connections to reduce size of building blocks
• Informal paths between buildings or through building blocks helps break up continuous facades and blocks
• Design of transit stops, parking facilities, and other mobility systems can reduce/hinder visibility</td></tr>
</table>

[76] Hillnhütter (2016) defines enclosure as building height divided by street width, with buildings and walls representing the edges of the public space in which people walk. This ratio influences how pedestrians observe and interact with edges: « only when edges are close, as in narrow pedestrian streets below 15 metres in width, all details become visible and increase the amount of visible sensory stimuli”. The level of interaction gradually decreases as the street widens. In broad streets over 40 metres wide, or in very large squares, the visual stimuli and thus level of interaction is very low as the edges are too far away for pedestrians to perceive details.

<table>
<tr><th colspan="3">COMPLEXITY</th></tr>
<tr><td rowspan="4">How a rich variety of buildings and other elements create a diverse visual impression</td><td>Urban structure</td><td rowspan="2">• Indirectly through the possibilities enabled by the urban fabric
• A meshed urban fabric with a high number of connections and informal paths to offer variation in travel routes
• Use transit stops, parking facilities, and other mobility systems to create variation
• Indirectly through the architectural design of buildings: the program of a building tends to influence its external design
• Use of the ground floor of buildings
• Location of services and amenities, from playgrounds to grocery stores</td></tr>
<tr><td>Mobility systems</td></tr>
<tr><td>Land use (programming)</td><td>• Design of transition public/private space (fences/walls/vegetation)
• Use of street furniture, vegetation, and similar elements in public space
• Design and transparency of facades on ground floor</td></tr>
<tr><td>Urban features</td><td>• Indirectly through the possibilities enabled by the urban fabric
• A meshed urban fabric with a high number of connections and informal paths to offer variation in travel routes
• Use transit stops, parking facilities, and other mobility systems to create variation</td></tr>
</table>

<table>
<tr><th colspan="3">COHERENCE</th></tr>
<tr><td rowspan="4">To what extent the built environment creates an overall, wholesome impression (not uniform), e.g. through shapes of building structures or facades</td><td>Urban structure</td><td rowspan="2">• Indirectly through the possibilities enabled by the urban fabric
• Easily readable and comprehensible structures like grid-network
• Implementation and design of transit stops, parking facilities, and other mobility systems
• Indirectly through the architectural design of buildings: the program of a building tend to influence its external design
• Use of space, public and private, in accordance (or not) with surroundings (e.g. implementation of a high-rise structure in a low-rise neighbourhood)</td></tr>
<tr><td>Mobility systems</td></tr>
<tr><td>Land use (programming)</td><td>• Design of transition public/private space (Use of features to tie together public space, create a wholeness e.g. through smaller actions that complete the overall picture</td></tr>
<tr><td>Urban features</td><td>• Indirectly through the possibilities enabled by the urban fabric
• Easily readable and comprehensible structures like grid-network
• Implementation and design of transit stops, parking facilities, and other mobility systems</td></tr>
</table>

HIERARCHY		
To what extent public space accords different areas and priority to mobility modes, and/or uses of public space (dynamic/static), and to what extent this is clearly communicated	**Urban structure**	• A finely meshed urban fabric with a clear allocation of space to different modes • Clearly marked priority at intersections • Width of sidewalks and streets • Parking provision and solutions • Relationship and transition private/public space • Use of public space (parking, playgrounds, etc.)
	Mobility systems	
	Land use (programming)	• Signs and other traffic communication • Legal travel speeds
	Urban features	• A finely meshed urban fabric with a clear allocation of space to different modes • Clearly marked priority at intersections • Width of sidewalks and streets

FLEXIBILITY		
The capacity of public space to accommodate different mobility modes, travel speeds, and mobility preferences and needs, as well as dynamic and static use	**Urban structure**	• A finely meshed urban fabric • Convert roads to streets (i.e. from being a physical barrier to becoming a 'seam') to increase 'transformation capable' areas that have flexibility • Win-win solutions, mutualizing land use can enable multiple uses • 'Time-share' of public space: design for different uses throughout the day, for example pedestrianized street during day/car access during night
	Mobility systems	
	Land use (programming)	• Place buildings at edge of sidewalk to avoid 'residual' private space between sidewalk and building • Wide sidewalks to allow dynamic and static uses simultaneously
	Urban features	• A finely meshed urban fabric • Convert roads to streets (i.e. from being a physical barrier to becoming a 'seam') to increase 'transformation capable' areas that have flexibility

Table 45 A compilation of solutions and measures related to the four levers of action that help practitioners realize the urban qualities in a design project

7.3 DEVELOPING THE FRAMEWORK AROUND DESIGN PRACTICE

7.3.1 A user-oriented design-aid tool

Enhancing the complementarity between mobility-mitigation and improving urban living contexts is key to strengthening mitigation efforts through urban design. The latter is an essential objective for urban design, and practitioners often have the savoir-faire to ensure this (depending on their experience). Their knowledge of how to manipulate built-environment structures, for example, to induce particular movement patterns through land-use measures to build social cohesion, is an important reason why practitioners can be pivotal mitigation actors. Their interdisciplinary, holistic, and solution-based approach to projects and design processes is another reason, as well as the win-win aspect that allows practitioners to tackle several issues in parallel. For example, they can act upon traffic safety while simultaneously improving a neighbourhood's public spaces for collective use. This shows that mobility-mitigation strategies are compatible with improving urban living contexts. To better exploit this potential, the envisioned framework must be developed in relation to current design practices and methods. The prototype tool developed in the CapaCity project was designed from a similar perspective, and provides an example of the user-oriented approach this framework should undertake. It is possible that a completed framework could be integrated in an expanded version of CapaCity, to support mitigation as well as adaptation.

The CapaCity tool is organized following the main phases of a typical design process: (i) Analysis and Diagnostic, (ii) Programming, and (iii) Design. Its intended purpose is to support practitioners in designing climate adaptive projects. One aspect of this is enhancing practitioners' understanding of how climate change manifests in an urban context, and how their design can contribute to adaptation. The focus is on guiding the designers towards adaptive measures, not simply presenting a series of solutions and measures to implement. The tool presents scientific information in a varying levels of detail, allowing the designer to choose how in-depth to go. The CapaCity tool has a distinct focus on simplifying scientific knowledge to strengthen its use by practitioners.

One example is the identification of adaptation-relevant precedents and rules of thumb, which can facilitate the integration of adaptive solutions into a design process. Designers frequently use rules of thumb in projects to rapidly assess measures and solutions, or to evaluate the impact of a design action upon the project as a whole. A future version of CapaCity will include an adaptation database containing exemplary projects and concrete levers of action. In the current tool, the adaptation knowledge is presented as: (a) fact-sheets providing knowledge on environmental issues related to climate adaptation; (b) solution-sheets that provide in-depth information on particular themes and possible solutions, including strengths and weaknesses of these solutions; (c) project-sheets that presents detailed, well performing case studies. The Analysis and Diagnostic phase is used to further explain the tool: The site analysis seeks to obtain a broad picture of the site and its context, including opportunities and challenges, interdependencies, significant aspects, etc. Implementing adaptation at this early stage is key to fully exploiting the adaptive potential of a site. The tool provides a multiple-choice questionnaire for an adaptive-oriented site analysis, intended as complementary to a traditional site analysis. It is designed to help the designer gain the necessary knowledge to determine the adaptation profile of the site (requirements and potential), centred on seven environmental themes. For the prototype, these correspond to adaptation challenges in the Toulouse region. Each theme is explained (e.g. why important), with information on how to obtain the necessary data to answer the questions. Answers are weighted according to the importance of the questions/answer for adaptation. At the end of the questionnaire, the tool presents an environmental profile, where the themes are ranked according to their scores: High Priority, Medium Priority, and Low Priority. The tool suggests focusing on the three most dominant (highest score), but the designer can choose to include other aspects and constraints. The next phases present important issues to act upon for the chosen environmental themes, as well as potential solutions and measures, emphasizing interdependencies and potential trade-offs. This helps designers identify win-win potentials, thus facilitating the implementation of suggested solutions and measures. The prototype tool's official launch is planned for January 2018. Initial tests with practitioners have been promising; fitting the tool to frequently observed design practices was particularly appreciated. This supports the choice to focus on usability, efficiency, and comprehension.

Figure 46 Screen shot of the CapaCity tool: Questionnaire for an environmental site analysis

Figure 47 Screen shot of the CapaCity tool: Results of the environmental site analysis with the score for each theme

CapaCity has been developed with close attention to being understandable and useable for practitioners. Therefore, it presents an interesting example of how to structure design aids for mitigation and adaptation that seek to render complex topics accessible and applicable for urban designers. A future mobility-mitigation framework could be similarly structured to CapaCity. The first phase of CapaCity (the analysis questionnaire) is especially interesting as a gentle nudge to better integrate mitigation and adaptation from the early stages of a design process. Through 'learning by doing' designers could eventually integrate the environmental themes of CapaCity into their Methodological savoir-faire (see Chapter 3). This in turn can empower the designers to implement mitigation or adaptation as a constructive and even inspirational issue that strengthens their design. Further development of the framework should have the same focus upon usability, tested at frequent intervals with future users, students and practitioners.

The present chapter has presented one approach to structuring knowledge on urban design and modal choice from an operational perspective. The focus has been on relating mobility-mitigation to design practices, focusing on what designers can influence and implement in a project. As an example, the properties provide five principles to help practitioners ensure that projects contribute to making walking, cycling, and public transport use possible and pleasurable. A future version of the framework must further develop each property as illustrated in Chapter 6, exploring how it influences modal choice and how the qualities contribute to achieving each property. Additionally, it must provide examples of levers of action with concrete case studies as inspiration for practitioners. Emphasizing interdependencies between possible measures and solutions is important to help designers identify win-win possibilities, but also potential trade-offs. Ideally, further development might aim at creating a series of concepts for each property, as Loukaitou-Sideris (2006) did for a feeling of safety. She identified eight thematic levers of action to improve feeling safe through urban design, for example 'Lighting the way', or 'Fixing broken windows'. Loukaitou-Sideris presents some concrete measures, but for the most part focuses on what can be achieved (or avoided) through urban design interventions. Developing such concepts is an interesting strategy for the framework that could further strengthen its operational aspect and ensure its applicability.

Finally, it is important not to overwhelm practitioners with an abundance of tools and guides. Despite being user-oriented, this can quickly lead to the designers not employing any tool as they do not know which one is ‘the right’ tool; this is largely the case in adaptation and mitigation knowledge today. Integrating the framework in a tool such as CapaCity is therefore an interesting possibility, as that enables the designer to address both simultaneously, preferably in a win-win strategy, as well as increasing the chance that it will be used.

7.3.2 Combining the framework with other outputs

To fully undertake the role of mitigation actors, urban designers must have sound knowledge of the reciprocal relationship between the built environment and mobility behaviours. This includes knowledge about the relevant mechanisms, structures, interdependencies, , and how they influence the mitigation potential of urban design. The framework is a contribution towards this, and future versions should include more information on these topics. A design framework has a highly operational profile, and is intended for ‘on the go’ use in projects; too much detail can be counterproductive. At the same time, for designers to properly integrate mitigation in their practices and build win-win approaches, a more in-depth understanding is necessary. Combining an operational approach with a more theoretical and detailed one could be an interesting and more complete strategy. Based on this, an additional approach to knowledge transfer could be envisioned, for example a book (or similar) aimed at education and students. The literature search for this work was rather unsuccessful in finding literature that specifically addresses urban design and mobility-mitigation. At the city scale, there are several interesting books and articles, but when zooming in on the neighbourhood scale and urban design, the selection is slim. There seems to be a need for explaining the reciprocal relationship between the built environment and in a manner accessible to urban designers. An output like this might also serve educational purposes, enabling teachers at urban design institutions (architecture, landscape architecture, urban planning and design) to better integrate mobility-mitigation in their courses. Based on the investigations in this thesis, it cannot be concluded whether or not there is a lack of this in current education. However, previous works have pointed out a need to strengthen urban design education with regard to adaptation and mitigation (Dubois, 2014; Tennøy, 2012). Furthermore, in light of the significant knowledge gaps in the scientific literature and the lack of mitigation focus observed in practices in Norway and in France, it seems likely that there is an overall need to strengthen design education on mobility-mitigation. How it is addressed today likely varies from institution to institution, and from teacher to teacher. Design has no General Theory, as discussed in Chapter 3, and so architectural education, for example, is often closely related to the teacher or professor; design studios are an example of this. It is at once a strength of and a challenge for urban design education; for mitigation and adaptation, it is more of a challenge. These are topics where general knowledge and theory exist, and future professionals must have both to fully meet the adaptive and mitigating responsibility of urban development. Changing this will not happen instantly, but through slower, incremental measures. Research has an obligation to contribute by making findings and insights accessible and useable for practice . An easily applicable design framework or tool to be used in design studios, combined with operationally oriented support, for example a textbook, could provide support for this change, thereby contributing to enabling the practitioners of tomorrow to become pivotal actors for climate action through urban development in planning and design.

CONCLUSION PART 3

How can urban design contribute to a change of daily travel habits for the majority of people through the promotion of zero-emission mobility modes? In Part 3, this question was approached from different angles, based on the results from the thesis investigations of research knowledge (evidence-based) and practice knowledge (experience-based). Chapter 6 discussed the mitigation potential of urban design, i.e. how it can contribute to promoting a sustainable modal shift, and possible reasons for why, as yet, this potential is seemingly underexploited. Chapter 7 outlined the draft of a future mitigation design framework, directed towards design practitioners.

Positive trip experiences

Positive trip experiences are important for walking, cycling, and public transport to be seen as the best alternative for daily travels. A sustainable modal shift should be an advantage, not an additional hassle, to a busy, everyday urban life. To achieve this, zero-emission mobility use must be possible and pleasurable. Possible refers to a mode being available for the planned trip, objectively and subjectively; i.e. the actual possibility of using a mode for a trip (e.g. presence of a tram line), and the traveller perceiving the mode as possible to use (e.g. feeling physically capable). Pleasurable refers to a person's experience of a trip, and the importance that this experience be positive and enjoyable; feeling of safety (traffic, crime, accidents) and perception of distance, but also aesthetic experience, are very important. Possible and pleasurable constantly overlap, and though instrumental aspects are often considered more fundamental for pedestrians and cyclists than perceptual ones, they alone are not enough to make a trip pleasurable. A road can be safe according to traffic regulations, but still perceived as unsafe by insecure pedestrians or cyclists; a destination can be within reasonable walking distance, but perceived as further away due to the design of the built environment. Going back to the research problematic, how can urban design influence this, i.e. how can urban design contribute to making the use of zero-emission modes possible and pleasurable?

A change of perspective

A change of perspective was introduced, based on observations from research and practice: at the neighbourhood scale, daily mobility should be considered as a kind a use of public space. This is an interesting shift on several levels. First of all, it emphasizes daily mobility as an integral part of the everyday urban life in the public spaces of a city. It is an essential xaspect of daily routines, but it is not the only activity happening in public space. Public spaces such as sidewalks must simultaneously accommodate dynamic uses (e.g. people passing by on their way somewhere), and static uses (e.g. people stopping to talk, children playing, cafes). These uses must coexist, as must different mobility modes. How all of this is managed contributes to the overall trip experience. Second, the change of perspective highlights how public spaces constitute a city's mobility system, e.g. streets, sidewalks, tram lines, pedestrian shortcuts, etc. Consequently, every intervention upon public space will to some extent influence the city as a mobility system, and by correlation people's daily mobility. This can be exploited in a win-win perspective, as it indicates that theoretically, every project represents an opportunity to make zero-emission mobility use a bit better, a bit more attractive. In light of this, the research question can be rephrased, asking how to create public spaces that contribute to making the use of zero-emission modes possible and pleasurable. Third, shifting the attention to public space situates the research topic at the scale of urban design, i.e. the neighbourhood scale. Urban design is about public space, and creating or enhancing spaces in a manner that provides good living contexts for urban inhabitants. As seen in Chapter 6, this is complementary with mobility-mitigation through urban design, another win-win potential to explore. Finally, considering mobility as a use of public space supports the holistic and interdisciplinary approach called for in Chapter 1.3. Public spaces are the sum of built environment elements from sidewalks, streets, and building facades, to benches and vegetation. To explore its influence upon modal choice necessarily implies exploring how the sum of such elements influences modal choice. Moreover, it opens the door to insights from other fields such as microclimate (e.g. physical comfort in public space), or environmental psychology. These fields may at first glance seem less relevant for transport and mobility, but previous studies have found them to be very informative with regard to people's interaction with and experience of the neighbourhood-scale built environment.

Zero-emission friendly public spaces

Urban design interventions seem to influence modal choice most through the influence of the neighbourhood-scale built environment on trip experience. During a trip, the traveller generally passes through different neighbourhoods, while constantly interacting with the immediate surroundings. The sum of these interactions, the perceptions and experiences they create, influences overall travel satisfaction and in turn future modal choices. A negative aspect of an experience can overshadow the positive ones, even if the latter constitute the large majority of the experience (Kahneman et al., 1997; Kahneman and Krueger, 2006). This is a challenge for promoting zero-emission modal change, especially when the interaction with the built environment is quite more direct, e.g. walking and cycling versus driving or taking public transport. A traveller is more likely to feel unsafe from traffic or crime when walking down a street than when driving down it.[77] Likewise, the perception of distance is more significant when travelling by non-motorized modes than by motorized ones. With regard to personal context, a less able-bodied traveller is likely to be more hindered by a narrow and/or unkempt sidewalk than an able-bodied traveller; this equally applies for a person pushing a pram. Public spaces designed to promote walking and cycling (and public transport use) must be conceived with close attention to detail; moreover, zero-emission modes must be given a clear priority, i.e. zero-emission friendly public spaces. These spaces actively promote the use of zero-emission mobility modes, giving them priority over private cars, while ensuring that their use is also pleasurable, for as much of the general population as possible. Five properties were

[77] This naturally depends on the geographical context, but this is not further pursued here.

identified as important for this. They describe what public spaces must provide in terms of experiences and perceptions to be zero-emission friendly (see table below). Through urban design interventions acting upon urban structure, land use, mobility systems, and urban features (levers of action), practitioners can design public space to reflect these properties.

PROPERTIES	
Safety	Capacity of producing a *feeling of safety*: traffic safety, safety against crime and accidents
Distance	Capacity of *reducing distance*, physical and perceived
Comprehensive	Capacity of *being comprehensible* for geographical/cultural orientation, and use
Accommodating	Capacity of *accommodating different* modes and uses.
Comfortable and pleasant	Capacity of providing a *comfortable* and *pleasurable* travel experience.

Table 46 Summary of the five properties of a zero-emission friendly space

An overlooked and/or underestimated mitigation potential

Despite general consensus among both research and practice that the neighbourhood-scale built environment can influence modal choice, the represented mitigation potential appears relatively overlooked and/or underestimated, by research as well as by practice. The second part of Chapter 6 discussed possible explanations for this, and what – if anything – can be done about it.[78] Three aspects were explored. First, mitigation appears to primarily be seen as a city-scale issue in research and practice. This is not surprising, as climate change and its consequences are often addressed at the larger scales (city, national, global). However, this contributes to the potential at the neighbourhood scale – and thus urban design – being overlooked. It is seen as potentially influential, but the extent to which this is true remains underexplored. Second, research tends to approach the question of the neighbourhood-scale influence through a monocriteria approach; for example, attempting to establish which built-environment elements are the most

[78] Tip of the hat to Tennøy (2012)

important for walking and cycling. With regard to the individuality of travellers, and how people tend to perceive surroundings as environments and spaces (i.e. the sum of singular elements), this approach appears somewhat limited. Moreover, it fails to properly take into account the many interdependencies related to urban design and modal choice. As explained in the previous sections, there is a constant overlap between instrumental and perceptual aspects of the built environment, which can have significant consequences for how an area influences trip experience. This can be expected to influence research results, but is difficult to test or control for. A holistic shift, considering mobility as a kind of use of public space and focusing on zero-emission friendly public spaces, might help remedy this. A third and final aspect is a apparent lack of knowledge among practitioners regarding climate change and climate mitigation, as well as a lack of awareness about the mitigation potential of their work (i.e. urban design). Dubois (2014) and Dubois et al. (2016) found this to be the case for climate change adaptation through urban development. Based on the thesis findings, it seems very likely that this also applies to mitigation of emissions from daily mobility.

To overcome these barriers, the mitigation potential of urban design must be rendered more apparent and the use of research in design processes strengthened. Mitigation of greenhouse gas emissions from urban mobility must become an active objective for designers and for researchers. For research, the holistic shift described above can contribute to this. For practice, an important change is to strengthen knowledge about climate change and mitigation, and to emphasize the connection between mobility-mitigation and improving living contexts. As a step towards this, a framework draft was introduced in Chapter 7.

Introducing a framework

Urban design practitioners can be key actors to better exploit the mobility-mitigation potential of urban design. They have a holistic and interdisciplinary approach to projects, and know how to work with built-environment structures to create public spaces people want to use, for example in daily travels. Mobility is a central element in design practices, and practitioners have the savoir-faire to address and act upon it. To strengthen their role as mitigation actors, Chapter 7 contains the outlines of a future design framework, based on the evidence-based and experience-based knowledge explored in the thesis. It is initially directed towards students and younger/inexperienced designers, as they are likely to have less knowledge than experienced ones on how to achieve the five properties. The intended use is in design processes, to build on practitioners' common 'learning by doing' approach. The objective is to make mobility-mitigation more apparent, tangible, and comprehensible for urban design practitioners. As an initial setup, Chapter 7 focused on systematically structure the thesis findings on zero-emission friendly public spaces, to establish a sound basis for an operational approach. The chapter moreover envisioned how the framework could be further developed. A future version should, for example, include a throughout – but easily understandable – explanation of the reciprocal relationship between the built environment and mobility behaviours, including the relevant different mechanisms and dependencies. This is fundamental for practitioners to properly implement mitigating measures in their projects. It might be interesting to include the outlined framework in a future version of the CapaCity tool, to consolidate adaptation and mitigation efforts through urban design, as both are essential to ensure the continued liveability of urban living.

General conclusion

Cities represent possibility and prosperity, but also significant environmental challenges. The most pressing of these are greenhouse gas emissions from human activities. This work addressed emissions related to daily mobility in urban areas. The majority of these stem from private car use; replacing this by walking, cycling, and public transport represents a substantial mitigation-potential. Curbing mobility-related greenhouse gas emissions is challenging as modal choice is closely related to people's daily routines. It is unrealistic to change the travel habits of all, but reaching the 2°C target – preferably 1,5°C – requires the vast majority of urban dwellers to opt for zero-emission options. The reciprocal relationship between the built environment and mobility behaviours dictates that urban development can, in theory, be a mitigation strategy. The thesis asked: **How can built-environment interventions at the neighbourhood scale – i.e. urban design – be a mitigation strategy to promote a zero-emission modal shift?** Despite a large body of research, significant knowledge gaps remain within the scientific literature. The evidence is particularly inconsistent at the neighbourhood scale, which in turn creates barriers for mitigation action. The use of evidence-based knowledge in projects is important for sound mitigation efforts, but the uncertainty of the scientific evidence hinders its implementation in projects.

To promote the use of zero-emission mobility modes, one can address the supply or the demand – i.e. the user. **This work focused on the travellers and their choice of mobility mode for daily trips, and how urban design can contribute to promote zero-emission modal choices.** Here, daily mobility was considered as more than merely getting from one place to the other, but rather as a daily use of the city; moreover, as a regular daily or weekly activity, similar to work, school, or grocery shopping. This emphasizes the importance of daily travels in everyday urban life. Exploring the mobility-mitigation potential of urban design requires better insight into the relationship between urban design and modal choices, but also into how and why people make choices and decisions. The thesis therefore includes insights from behavioural sciences, which contributes to explain, for example, why many travellers opt for driving despite being stuck in traffic every day. Chapter 1.2 introduced a model explaining modal choices as the sum of contexts, based in part on an updated utility approach. The model situates the built environment among the many contexts that influences modal choices, and show the importance of personal context (e.g. personal needs, preferences, physical capacity). Exploring the neighbourhood scale implies a high level of detail regarding the built environment, but also regarding the travellers. Individual differences become more apparent and important than at the city scale, for example with regard to how the neighbourhood-scale built environment is experienced and perceived. This in turn influences the potential impact of built-environment interventions upon mobility behaviours, here modal choices. **Research has found that how an experience is recalled (e.g. a trip) can significantly influence future choices; in this case, future modal choices** (Kahneman et al., 1997; Vos et al., 2015). A high level of travel satisfaction, for example for walking or bicycling, can contribute to a similar choice for future trips. The interaction between the traveller and the built environment is more direct when walking and bicycling than when driving, as travel speeds are lower and there is less distance between the traveller and his or her immediate surroundings. For public transport use, this primarily applies to getting to and from transit stops. **Hence it was posited that urban design likely influences travel satisfaction for zero-emission modal use the most during a trip, when a traveller moves through the city and its built environments.** Moreover, that an enhanced understanding of how people experience and perceive their built-environment surroundings – i.e. public spaces, and how they interact with them, can further the knowledge on how urban design can be a mobility-mitigation strategy. Exploring this required a holistic approach to the neighbourhood-scale built environment, considering it as a whole, i.e. the space between buildings. These are the travellers' immediate surroundings during a trip, with which they interact constantly. A holistic perspective furthermore implied studying the importance of characteristics and qualities of neighbourhood-scale built environments as a whole upon mobility behaviours and modal choice. As this is seemingly less explored by transport and mobility research, new sources for insights was needed. This approach differs from much of current research literature, which at the neighbourhood scale tends to explore the influence of particular aspects or elements.

A challenge to exploring the influence of urban design upon people's behaviour is the subjectivity of perceptions. How people experience their built environments is not necessarily in line with how it actually is (Krizek et al., 2009). Urban design intervenes upon the neighbourhood-scale built environment; its practitioners shape and structure the public spaces where daily activities takes place, for example daily mobility. These designers are expected to have knowledge on how to create spaces that people want to be present in and use – spaces that contribute to a good urban everyday life. Which in turn implies having a thorough understanding of how people perceive, interact with, and are influenced by their built-environment surroundings. Based on this, **it was hypothesized that the experience-based knowledge of urban design practitioners could provide new insights to the relationship between urban design and modal choices**. Moreover, that the professional observations of practitioners could help better understand previous research findings, for example why people tend to choose a particular route for daily walks to transit stops. This contributed to the general research design of this work, which combines the experience-based knowledge of urban design practitioners with the evidence-based knowledge of research. The two were hypothesized as complementary; harmonizing them ought to provide an enhanced comprehension of how urban design can be a mobility-mitigation strategy.

The professional *savoir-faire*[79] was investigated through a series of empirical enquiries of urban design practitioners in France and Norway. Experience-based knowledge is often tacit; the practitioner 'just knows' it, but can have difficulties expressing and explaining it (Eikseth, 2009). Accessing and assessing such knowledge is best done with a mix of methods, for example combining interviews and surveys. Through the CapaCity project this work additionally explored a third method: workshops. They allowed studying the professional savoir-faire from a more observational perspective, which proved to be an interesting approach. The experience-based knowledge of

[79] See Glossary

designers can be assessed from what they do (i.e. how they design), as well as from what they say. Observing them in action, discussing, for example, design strategies with other designers, provided different and complementary insights to that gained from interviews and surveys. The enquiry results were combined with findings from a holistic and interdisciplinary cross-analysis of current research and urban design literature. The literature review found that one explanation for the significant knowledge gaps in current transport and mobility research is a lack of interdisciplinarity. Aspects that are relevant for mobility behaviours, for example feeling of safety in public space or perception of distance, have been explored by other disciplines, and should be better implemented in mobility and transport research. The cross-analysis provided interesting findings, supporting the importance of a more holistic, interdisciplinary approach to the topic of urban development and mobility behaviours. As an example, three doctoral theses that have been very informative for this work, were all written by researchers educated within urban design fields, and with professional experience: Hillnhütter (2016), Stefansdottir (2014), and Tennøy (2012).

Based on the findings from the empirical enquiries, a change of perspective was introduced: at the neighbourhood scale, daily mobility should be considered as a kind of use of public space. This is a continuation of the initial approach to daily mobility as an everyday use of the city, and aligns with how urban design tends to approach the topic. Moreover, it has implications for how to address and understand the research question. Firstly, it centres the focus upon the trip itself, i.e. when the traveller moves through the city and its different built environments. Secondly, it positions daily mobility as one of several uses that public spaces must accommodate and encompass, both dynamic and static. The extent to which a public space succeeds in this will necessarily influence how a trip is experienced. Thirdly, it supports the idea that understanding how people experience and perceive their built-environment surroundings can help understand the influence of urban design upon modal choice. For example, it seems likely that public spaces people like to be present in are places they would prefer passing through for daily commutes. Exploring daily mobility as a kind of use of public space it opens for integrating insights from other fields researching people's perception and use of public spaces.

Mobility behaviours are complex to study, much due to the high level of individuality with regard to mobility needs and preferences. Daily modal choices are a result of habits and routines, which are by nature difficult to alter. Changing travel habits demands a broad range of strategies, combining 'carrots' and 'sticks' (i.e. facilitating and limiting measures). Limiting car use, for example through pricing and reduced parking offers, is often unpopular among urban inhabitants, which can make it difficult for city authorities to implement such measures. Behavioural sciences have established that people tend to experience loss (e.g. restrictions) more deeply than gain (e.g. a new transit offer) (Kahneman, 2012; Thaler and Sunstein, 2009). This can heighten barriers to adopt zero-emission travel routines that many perceive as an annoyance or a hassle, and by some even as unsafe. Restrictions are often necessary to induce a modal shift. It is questionable, however, whether they alone are enough to change daily travel habits in the long run, especially if the restrictions disappear, or people's life-situation changes. For a permanent shift, **zero-emission mobility modes must be perceived and experienced as the better alternative**, or at least as equal, to the private car. Positive trip experiences are important for people to continue to choose zero-emission alternatives. A permanent, large-scale modal shift necessitates zero-emission trips to be experienced as **possible and pleasurable**. Urban design can contribute to this by creating **zero-emission friendly public spaces**. These are spaces that actively promote walking, cycling, and public transport use, for example by prioritizing pedestrians and cyclists. The thesis investigations identified five properties of public spaces that are zero-emission friendly (see Figure 48).

Figure 48 Properties of public space to promote the use of zero-emission mobility modes by providing pleasure and possibility, figure by author

Every neighbourhood-scale built-environment intervention – of a bigger or smaller magnitude – represents an opportunity to ensure that public spaces encompass these properties, i.e. a mobility-mitigation opportunity. Interestingly, this is often compatible with other urban design objectives, in particular the overall urban design goal of enhancing an area's liveability. Indeed, urban design practitioners tend to have the necessary savoir-faire[80] to actively promote zero-emission modes through their work. They know how to manipulate the neighbourhood-scale built environment to achieve design objective, by acting upon urban structure, urban features, etc. For example, to implement measures and solutions that create the zero-emission properties. This represents a win-win opportunity for mobility-mitigation through urban design interventions. However, the findings indicate that this mitigation potential is often overlooked and/or underestimated by research as well as by practice. As a result, cities likely miss out on prospects that can strengthen their mitigation efforts towards a large-scale zero-emission modal shift. To counter this, **the mitigation potential of urban design must be made more apparent, for research and for practice.** For research, this necessitates an enhanced focus upon the neighbourhood scale with regard to mitigation of greenhouse gas emissions, particularly from daily mobility. **For practice, mobility-mitigation must become an active design objective.** To help achieve this, a

[80] The urban design practitioner's 'know-how', see Glossary

future design framework was outlined in Chapter 7. It is intended to enhance the use of evidence-based knowledge in design projects, but also to render more apparent the win-win potential between current design measures and solutions, and mitigating actions. Hopefully, the current draft can be further developed through future research projects, preferably in collaboration with practice. This is discussed more in detail under *Research perspectives*.

On a more general level, **collaboration between research and practice must be strengthened, in order to enhance knowledge production, transfer, and application.** As discussed in Chapter 6, knowledge production for urban development – particularly for mitigation and adaptation – should be done jointly by research and practice. This is necessary to enhance adaptation and mitigation efforts through urban development. Practice can translate the functionings of cities and urban living to research, who in return can translate the consequences and implications of climate change to practice – a reciprocal knowledge transfer between research and practice. Practice must enhance their use of evidence-based knowledge, but research should equally implement insights from practice. The present work has shown how this can not only help explain existing findings, but also provide new understandings of how the built environment influences people's perception and use the city – in this case for daily mobility.

Contributions and research perspectives

The thesis contributes to research and urban design through the new insights and understandings it has produced, as well as its approach to the topic, and its exploration of research methods for investigating experience-based knowledge. Approaching the research problematic from the perspective of the user, considering daily mobility as an everyday activity and use of the city, puts the focus upon the link between urban design and modal choice. An approach strengthened by the introduction of a different perspective, **daily mobility as a kind of use of public space**. This helps **identifying the aspects of a trip and modal choices that urban design influences the most**. Moreover, it emphasizes the potential of every urban design project as a mitigation opportunity. Modal choices are a sum of decisions, all of which must lead to a zero-emission alternative to curb emissions from daily mobility. How a trip is remembered influences future modal choices, and urban design can help ensuring a high level of travel satisfaction. **The five properties of zero-emission friendly spaces underline the importance of acting upon instrumental as well as perceptual aspects of the built environment.** To do so requires knowledge on how the latter influence trip experience, and by correlation modal choices. The properties offer an initial structure that can support future research, outlining issues or subjects to explore more in detail. This work has furthermore argued for a more holistic and interdisciplinary research approach to mobility-mitigation. Exploring the neighbourhood-scale built environment and its influence upon modal choice from a perspective is more akin to how people tend to perceive and experience it. To understand the influence of example feeling of safety or physical comfort in public space upon modal choice, and how this differs among travel groups, it is necessary to 'zoom in' on certain aspects or parts of public spaces. However, findings must then be situated in a bigger perspective, i.e. 'zoom out', to detect possible overlaps and/or interdependencies that can explain, support, or sometimes refute results. The outlined framework offers a structure to do so in a holistic manner.

Another contribution of the thesis concerns knowledge transfer, in particular from research to practice. Through the outlined the design framework in Chapter 7, together with the model for modal choice introduced in Chapter 1.2, **the thesis has established a basis for rendering research knowledge more accessible and applicable for urban designers.** Dissemination of findings is a common challenge for research. The framework offers a systematic approach to the relationship between urban design and modal choice, which can help researchers situate their findings in a broader, more holistic perspective. It also provides ways in which to present and communicate the knowledge in a manner easily accessible and useable for practitioners. **Reciprocally, the framework can strengthen knowledge transfer from practice to research.** This work has shown the value of implementing experience-based knowledge in transport and mobility research. The framework can facilitate this, by helping research identify concrete areas where it could/should seek out practice-knowledge. As an example, primarily perceptual aspects, such as ensuring a pleasant zero-emission trip, or ensuring an area's legibility, are often less quantifiable, but significant for trip experience. Insights from practice could help research identify important aspects and/or elements to further pursue. Experiences from the empirical enquiries provide a better understanding of how to explore the experience-based knowledge of urban designers. Chapter 3 provided a thorough theoretical foundation for understanding design practices, while chapters 4 and 5 showed how a mixed-methods approach is necessary for in-depth insights. The use of workshops as enquiry methods, as done in the context of the CapaCity project, is a relatively novel approach that should be further pursued. It allows observing the designers in situ, for example how they interact, and how they discuss design strategies. Although a hypothetical design situation, the CapaCity workshops provided valuable knowledge, thereby confirming the role of **workshops as an interesting research method**. The empirical enquiries furthermore provide an enhanced understanding of urban design practices – on a general level, and more specifically with regard to daily mobility. This appears to have been given less attention by transport and mobility research, despite being important for efficient knowledge dissemination, as well as collaboration between research and practice. Hopefully, the insights from the thesis can strengthen this, in turn strengthening mitigation efforts through urban design.

An interesting path for further research is to pursue the zero-emission properties. They sketch out five concrete themes, which could help structure and coordinate collaboration across disciplines. As seen through this work, **an interdisciplinary approach is necessary for researching urban design and modal choice**. The properties should be pursued theoretically and empirically. On a theoretical level, an in-depth, cross-disciplinary exploration of existing literature is needed, analysing different topics related directly and indirectly to daily mobility and modal choice. An important take away from the thesis is the need to **better exploit the large body of knowledge within fields often considered as non-related to daily mobility**, here illustrated by implementing insights from behavioural sciences. This contributed to a better understanding of people's judgement and decision-making, key to linking urban design and modal choices. The works of Hillnhütter (2016) and Stefansdottir (2014) has similarly showed the possible gain from implementing insights from psychology. The review by Loukaitou-Sideris (2006) on feeling of safety in public space (primarily from crime) is another interesting example, and builds upon a broad variety of field. This allowed her to identify several concrete measures and aspects urban design can act upon to enhance actual and perceived safety in public space. The close link between daily mobility and the liveability of an area, of a city, supports the need for an interdisciplinary approach. This could help address the observed knowledge gaps in current mobility and transport literature. Moreover, contribute to further develop the outlined framework.

In parallel to theoretical explorations, **further empirical studies are needed**. Especially field observations, **studying how people interact with and move through different built environments**. The urban practitioners role as ‘observers’ was an important rationale for exploring their experience-based knowledge. Much can be learned through modelling, but human behaviour is irrational and difficult to predict. Theory and models must therefore be coupled with actual observation. As an example, Ewing and colleagues have undertaken several empirical explorations, studying, for example, which routes people tend to walk for daily commutes in a city (Ewing et al., 2015). Analysing the built environment of these routes is assumed to indicate which kind of areas people tend to prefer walking through for daily commutes. This is the sort of empirical studies that must be pursued, in different cities as well as in different areas of a city, to better understand the influence of context. A challenge with regard to the latter is the need to repeat studies, rather than designing completely new ones. This might be seen as less interesting by those financing research, for example municipalities. Therefore, it is important to find ways to efficiently communicate the value and importance of understanding how, for example, the identified properties influence modal choices in different contexts. This reflects back to the discussion on knowledge dissemination, and ensuring the accessibility of scientific findings for non-researchers. As empirical observations are often tedious and time consuming – as discussed in Part 2 – there should also be a focus on method-development, such as coupling GIS-software with improved picture-technologies. Simplifying the observation part of empirical studies could make it possible to do more and longer observations, as well as allocating more time to analysis and discussion, which can often be cut somewhat short.

The outlined framework should be further developed and detailed, with particular attention to how the research knowledge is presented. A solid and useable design framework is best achieved in collaboration between research and practice, as discussed in Chapter 7. The model for modal choice introduced in Chapter 1 should be further detailed and included in the framework. In parallel to this, it could be interesting to explore the possibilities for a textbook (or other formats), directed towards design students, that addresses urban development and daily mobility. The objective would be to render this complex topic accessible to students that do not have a technical or a research background, but whose future work requires such insights. The development of a framework and other communication means should be coupled with a more active dissemination of research findings. For example, transport and land use-researchers partaking periodically in design education, organizing workshops and seminars directed towards students and young professionals. (Sallis et al., 2016) furthermore highlight the importance of researchers participating in design conferences and similar areas to display their work towards practice, and establish contacts fur future collaborations.

Finally, a particular outlook, based on the experiences from this work, is to **pursue experiments inspired by – and preferably in collaboration with – behavioural research**. These fields often test aspects of judgment and decision-making through experiments, which are then tested in 'real life'. For example, asking people to choose between options given certain constraints or background information. It seems likely that similar experiments could provide more insight into modal-choice making, for example, contributing to better understand modal preferences for particular segments of the population, or in particular contexts. The 2015 World Development Report by the World Bank, *Mind, Society, and Behaviour*, explored how incorporating insights from behavioural sciences can render policy making more efficient and influential. It seems likely that findings and experiences from behavioural sciences could similarly be employed for an efficient mobility-mitigation through urban design. This work has incorporated some behavioural knowledge, but more should be explored. This could help cities identify new win-win measures and approaches to promote zero-emission mobility modes. The inertia in urban development (see Chapter 1 and 3) makes it difficult to rapidly test solutions and ideas, but also enhances the importance to attempt doing so, as finished projects tend to remain for several decades.

This thesis has produced new insights into how urban design – as a kind of urban development – can be a mobility-mitigation strategy, but also insights to strengthen collaboration between research and practice. The empirical enquiries of urban design practices provide a better understanding of how practitioners consider daily mobility in a design project, and how it influences the design process and the final outcome. These observations can help research identify new channels and means to better communicate results towards urban design practices. The draft-framework introduced in Chapter 7 is intended as a primary step towards this; one manner in which research knowledge can be systemized and rendered more operative. Whether this way, or completely different, research and practice must strengthen their collaboration and exchange to better exploit the mitigation potential of urban design. A large-scale zero-emission modal shift is necessary to limit urban greenhouse gas emissions, in turn to reduce global warming and future climate changes. Cities have so far failed to achieve the necessary reductions, and so new strategies and approaches are needed – it is 'all hands on deck'. **Urban design can be a mobility-mitigation strategy, urban practitioners can be pivotal actors to ensure this, and mitigation measures and solutions simultaneously contribute to creating good urban living contexts.** This represents a win-win opportunity for cities worldwide to exploit in order to still be liveable places of opportunity and innovation in an increasingly hotter world.

GLOSSARY

A

Adaptation (climate change adaptation)
Adaptation – adapt, adapting – means adjusting to some kind of change by transforming part of or a system as a whole. In this context it signifies adapting to changes resulting from climate change (see below), primarily changes to the climate system and the extreme weathers that leads to, i.e. climate change adaptation. This work mostly employ the term 'adaptation' to simplify.

The Intergovernmental Panel on Climate Change defines adaptation as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (Parry et al., 2007). For example cities anticipating increased rainfalls or extreme temperatures in planning regulations, or in emergency response planning.

Aesthetic(s), aesthetic experience
Aesthetic generally means something that is visually beautiful and/or pleasing to look at. Stefansdottir (2014) defines an aesthetic experience as the "relationship between a person's sensuous perception, cognitive understanding and interpretation of the physical environment, which ends with responses to subjective thoughts and feelings during the course of an experience".

Architecture, architects
See comparative explanation under *Urban design*

B

Built environment
Physical structures that are constructed by humans, and that are a part of people's environments. In a city this typically includes buildings, streets, sidewalks, benches, transit stops, etc. Aspects such as topography, climate, rivers, etc., are considered physical context, established/created by nature. Vegetation is more vague as it can be both: a 'natural' presence of trees; planted by people, e.g. a row of trees or a city park. Indeed, parks can be considered as 'natural' by urban inhabitants, especially if large, but were often constructed and planted at some point in the city's history.

C

Car-oriented public space
Publicly available spaces (as opposite to private) in a city that clearly favours cars, for example by wide streets, few and/or complicated pedestrian crossings, and easily available parking.

Carbon footprint
The United States Environmental Protection Agency defines carbon footprint as:
"The total amount of greenhouse gases that are emitted into the atmosphere each year by a person, family, building, organization, or company. A person's carbon footprint includes greenhouse gas emissions from fuel that an individual burns directly, such as by heating a home or riding in a car. It also includes greenhouse gases that come from producing the goods or services that the individual uses, including emissions from power plants that make electricity, factories that make products, and landfills where trash gets sent." (United States Environmental Protection Agency, 2016)

City scale
In the context of this work, city scale refers to looking at the city as a whole, or parts of it but from a highly 'zoomed out' perspective. At this geographical scale the level of detail decreases, and one often considers the city in terms of transport systems and areas, rather then streets and individual buildings.

Characteristic
A trait or a property that distinguishes an element from others. In this context used primarily to describe aspects of a public space that distinguishes it from another, for example pedestrian-friendly versus car-friendly space.

Climate
According to the World Meteorological Organization (WMO), there are several understandings of the word climate, depending on if used in a narrow or wider sense. It can be understood as the 'average weather', i.e. the statistical measurement of variation of weather related variables such as temperature, rainfall, wind, etc., over a given period of time(World Meteorological Organization, 2017). The WMO defines a 'classical' measuring period as 30 years.

Climate change
The Intergovernmental Panel on Climate Change (IPCC) defines climate change as "any change in climate over time, whether due to natural variability or as a result of human activity" (Parry et al., 2007). The United Nations Framework Convention on Climate Change (UNFCCC) are more specific with regards to the source/reason for climate change, and defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (Parry et al., 2007).

CO_2-equivalents
Eurostat, the statistical office of the European Union, defines CO_2-equivalents as: "a carbon dioxide equivalent or CO_2 equivalent, abbreviated as CO_2-eq is a metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential" (Eurostat, 2017).

Cycling-friendly public space
Spaces that clearly favours bicycles, often in combination with pedestrians. They are experienced as easy and enjoyable to cycle through, and facilitate cycling for all levels for cycling experience. These public spaces generally have infrastructure for cyclists such as separate lanes, and easy cycle parking. If bicycles and cars are mixed in the street then the cyclists are prioritized in terms or placement in the street, as well as at crossings (see cycling infrastructure).

Cycling infrastructure
Infrastructure directed at cyclists in order to facilitate cycling as a mobility mode, for example separate bicycle lanes, bicycle ‘boxes’ at intersections, bicycles lights at intersections that turn green some seconds before those for cars, etc. Stefansdottir (2014) defines cycling infrastructure as “all infrastructure cyclists may use” with the exemption of sidewalks. Here, the term is used for infrastructure directed specifically at cyclists.

D

Daily mobility
The everyday travels of urban inhabitants going to work, to school, to weekly activities, grocery shopping, etc.

Designerly ways of knowing and observing
Urban designers (see below) usually develop a particular way of observing and understanding the city and its uses by urban inhabitants; how they interact with and influenced by the built-environment surroundings; how different kinds of built environments produce different experiences and perceptions; etc. This provides them with a particular knowledge of cities and urban areas, which differs from urban development actors without such expertise.

F

Fossil fuels
Fossil fuels are carbon-based energy sources such as coal, oil, and gas, whose use results in the emission of greenhouse gases. For mobility and transport this generally includes motorized vehicles such as cars, buses, and bigger vehicles (trailers, trucks, etc.) running on diesel or gasoline. Additionally, many countries still depend on fossil fuels for electricity production (EEA, 2013), which means that rail-based transport running on electricity also involves greenhouse gas emissions.

G

GIS – Geographic Information System

A GIS-system is a computer-based system that collects, stores, analyses and presents geographic data, i.e. information that is geographically referenced. GIS-software often represents information about maps in the form of data layers used for analysis and visualization. In a GIS-model, a broad variety of data can be combined and linked to geographical locations, for example income in a residential area, or frequent ravel times. (Bonhomme, 2013; Department of Physical Geography and Ecosystem Science, 2017)

Global warming

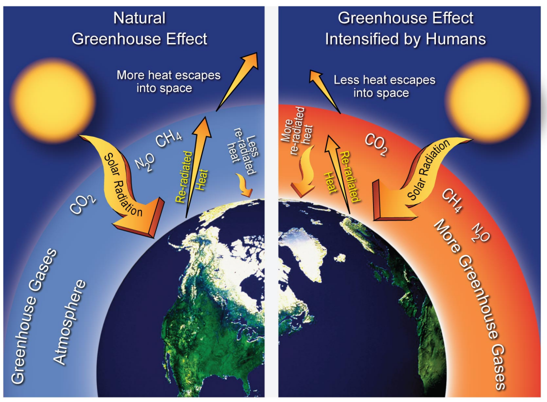
The Merriam-Webster dictionary defines global warming as an "increase in the earth's atmospheric and oceanic temperatures widely predicted to occur due to an increase in the greenhouse effect". Global warming has been shown to cause significant changes to the Earth's climate system, resulting in more extreme weather, e.g. increased precipitations (rainfall) and more extreme temperatures.

Greenhouse effect

From the International Panel on Climate Change:

"The process in which the absorption of infrared radiation by the atmosphere warms the Earth. In common parlance, the term 'greenhouse effect' may be used to refer either to the natural greenhouse effect, due to naturally occurring greenhouse gases, or to the enhanced (anthropogenic) greenhouse effect, which results from gases emitted as a result of human activities" (Parry et al., 2007).

Human Influence on the Greenhouse Effect



(National Climate Assessment, 2012)

Greenhouse gases

From the IPCC:

"Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds. This property causes the greenhouse effect" (Parry et al., 2007).

I

Instrumental
The Merriam-Webster dictionary defines instrumental as something serving as a means, agent, or tool. An instrument can be a means whereby something is achieved or performed. Here the term is used for urban qualities of a more concrete or quantitative nature, for example Connectivity or Human scale, as opposed to more perceptual ones such as Complexity.

L

Landscape architecture, landscape architects
See comparative explanation under *Urban design*

Land use, land use planning
In the context of this work defined as the repartition of functions and the characteristics of a neighbourhood, 1) the geographical distribution of functions within an urban area (e.g. location of residence, of schools); 2) the character assigned to a neighbourhood (e.g. residential, mixed use, business).

Land use planning is hence understood as urban planning that addresses how the above should be organized. It can be done at the city and the neighbourhood level – although the term most appears commonly used for city scale planning.

Liveability
Here, liveability is understood as a describing to what extent an area is good to live in, i.e. the quality of urban living contexts.

Living context
Living context is employed as an overall term for neighbourhood and areas where people live, here often in relation to 'quality of'. This encompasses the physical, social, cultural, economical, and built environment contexts that influence the 'nature' of an area or a site, e.g. how people tend to experience it. The overall goal or objective of urban design is often referred to as ensuring and/or improving the quality of people's living context.

M

Metropolitan area, metropolitan centre, metropolitan scale
Metropolitan area and metropolitan scale is an example of terms that can vary significantly among studies and reports. In this context it is used relatively freely, indicating a city and the urbanized areas around it, for example suburbs or smaller cities that are influenced by the larger

city on many levels. Many cities similarly differentiate between the *city* and the *metropolitan area*, for example Toulouse, France. Metropolitan area refers to the city and its surrounding areas; metropolitan scale refers to studying an area at this geographical scale, i.e. looking at the city and its surrounding areas as a whole (a 'higher' geographical scale than city or neighbourhood scale). Metropolitan centre refers to the central area of a metropolitan area, typically the city centre.

Mitigation
According to the International Panel on Climate Change, mitigation is a human-initiated intervention (i.e. produced by or resulting from human activity) to reduce the influence of human activates upon the climate system (Parry et al., 2007). This includes reduction of greenhouse gas emissions, which is the understanding in the context of this work. Similar to climate change adaptation, mitigation is often referred to as 'climate change mitigation', but here the term 'mitigation' is the primary use.

Mobility
Here understood as the movement of people, by foot or using some kind of means, motorized or non-motorized.

Mobility-mitigation
Mitigation of the emission of greenhouse gases from mobility. In this context the daily mobility of urban inhabitants. These emissions generally stem from the use of motorized vehicles running on fossil fuels, or electric vehicles whose electricity is produced using fossil fuels (e.g. coal or gas).

Mobility systems
Here defined as the presence and design of built-environment infrastructures for urban travels: roads and streets; parking facilities; bicycle infrastructure (lanes, paths, parking, etc.); pedestrian infrastructure (sidewalks, crossings, etc.); transit stops; rails for trams; separate lanes for buses; etc. In the context of this work, mobility systems do not include mobility services such as public transport services, etc.

Monocriteria research approach
In the context of this work, monocriteria refers to research, for example within mobility and transport fields, that tends to approach the built environment in a rather 'deconstructed manner', focusing on singular built environment elements as opposed to environments and spaces.

N

Neighbourhood scale, neighbourhood-scale
In the context of this work, neighbourhood scale or neighbourhood-scale built environment indicates the scale at which the city is studied, the immediate the immediate built-environment surroundings/context of a person travelling through a city on the way to a specific location, they

generally vary over the course of a trip. It does not refer to a specific size of an area, or to neighbourhoods as an entity. Another way of describing it could be *pedestrian scale* or *human scale*, but the latter is used differently here.

P

Pedestrian-friendly public space
Similarly to cyclist-friendly public space, these are publicly accessible spaces that clearly prioritize pedestrians, often in combination with cyclists. It can range from adequate and well-designed sidewalks and other important urban features (see below), to a completely pedestrianized street.

Pedestrian infrastructure
Infrastructure destined to facilitate walking, for example sidewalks and pedestrian crossings.

Perceptual
The Merriam-Webster dictionary defines perceptual as something relating to, or involving a perception, especially in relation to an immediate sensory experience (e.g. audio-visual, auditory). In this context it refers, for example, to urban qualities such as Complexity and Coherence, or to other aspects of the built environment that are often less measurable but important for the overall experience of an environment, for example aesthetics.

Planners
See *Urban planners*

Practitioner, Professional
Practitioner and professional are often understood as someone with an education and/or specialization within a specific field, and working with it/within it. In this context the use is narrower, it specifically refers to practitioners and professionals within urban design and/or planning.

Public space
Spaces in a city accessible and available to all (in theory) as opposed to private spaces that often have restricted access. Some spaces are in between, semi-private and semi-public, and the use of these can be somewhat more vague. The design, organization, and maintenance of public space are generally the responsibility of the city, but different agreements can exist, for example between a city and a developer.

Q

Quality (urban)
In this quality is used to designate specific characteristics of public spaces, for example Connectivity or Complexity.

R

Renewable energy
The IPCC defines renewable energy as "any form of energy from solar, geophysical or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use. Renewable energy is obtained from the continuing or repetitive flows of energy occurring in the natural environment and includes low-carbon technologies such as solar energy, hydropower, wind, tide and waves and ocean thermal energy, as well as renewable fuels such as biomass." (Verbruggen et al., 2011)

Research, research literature
In this context generally refers to research within mobility and transport; research literature is primarily published works, e.g. books, articles, from this research.

S

Savoir-faire
In the context of this work, savoir-faire is considered as the sum of the knowledge, theoretical and practical, the skills, and the experiences the urban practitioner.

According to Merriam-Webster[81] and the Oxford English Dictionary[82] the word *savoir-faire* stems from French and literally means "knowing how to do". It is used in English, although more in the context of an appropriate social behaviour, a "capacity for appropriate action; *especially:* a polished sureness in social behaviour" (Merriam-Webster). The French dictionary Larousse[83] defines savoir-faire as "competence acquired by experience within practical problems, in the execution of a trade", and as the synonym of the English term *know-how*. In the Petit Robert ("Le nouveau petit Robert," 1994) (French dictionary) savoir-faire in defined as[84]

[81] www.merriam-webster.com, searched *savoir-faire* 27/01/2017

[82] www.oxforddictionaries.com, searched *savoir-faire* 27/01/2017

[83] www.larousse.fr, searched *savoir-faire* 27/01/2017, translation by author

[84] Translation by author

1) The ability to succeed that which one takes on, to solve practical problems; competence, experience within the execution of an artistic or intellectual activity, and
2) The ensemble of knowledge, experiences, and techniques accumulated by an individual or a business.
("Le nouveau petit Robert," 1994)

A more elaborate definition of savoir-faire, or know-how in English, can be found in Article 101(3) of the *Treaty on the Functioning of the European Union to categories of technology transfer agreements*, in the Commission Regulation No 316/2014, March 21 2014. The article states that savoir-faire, or know-how as it is referred to in the English version of the document is "a package of practical information, resulting from experience and testing, which is:

- Secret, that is to say, not generally known or easily accessible,
- Substantial, that is to say, significant and useful for the production of the contract products,
- Identified, that is to say, described in a sufficiently comprehensible manner so as to make it possible to verify that it fulfills the criteria of secrecy and substantiality.

(European Union, 2014) [85]

Sustainable development
The concept of 'sustainable development' was introduced by the Brundtland Commission in 1987: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (World Commission on Environment and Development, 1987)

Economical, environmental, and social sustainability are often referred to as the main components, or pillars, of sustainable development. While environmental sustainability is relatively straight forward, the two others are often less clearly defined. In short, they refer to social and economical impact of development, which must contribute to equality and a long-term prosperity for all. For example, businesses must take into consideration the influence of investments, etc., upon their workers, but also other people potentially affected by their decisions.

T

Transport
In the context of this work understood as the movement of people and/or goods by some kind of means, generally motorized.

Transport planning
Here understood in a relatively broad sense, as the planning and organization of a city's transport systems and services.

[85] www.eur-lex.europa.eu/legal-content, site on 32014R0316, visited 27/01/2017

U

Urban area

In this context used relatively freely, generally to indicate that an area or a project site that is situated in an urban setting (in or right outside a city) as opposite to a rural setting.

Urban context

The physical, cultural, economical, social, and built-environment context of an urban area, which in turn influences its nature – i.e. how people living in it or being temporarily present experience and perceive it.

Urban design, urban designer

The below is a comparative explanation based Carmona (2010). As seen through this work there are many crossovers between the disciplines; both urban planners and architects work on urban design projects, and urban designers can work on a larger area of a city. The table is meant to provide a simplified overview to better situate each profession.

	Architecture	Urban Design	Urban Planning	Landscape Architecture
Description (simplified)	The design of individual buildings, new and refurbishment/ rehabilitation	The design of the public space between buildings, 'using' built-environment elements and to some extent vegetation, though the latter quickly involves landscape architects	The structuring and organization of bigger parts of – or the whole – city; primarily land uses, but should include the plannification/ organization of transport systems (which is gradually becoming more common)	The design and structuring of bigger and smaller areas of vegetation (e.g. parks), implementation of vegetation in an urban design project, etc.
Primary geographical scale	Building scale; whole building blocks if a bigger construction	Street scale; neighbourhood scale – primarily the level of the city observed by a person moving through it	City scale; metropolitan scale	From the building scale to the city scale

Urban Energy paradox

From Bonhomme (2013):

"The energy paradox is a concept suggested by Quenard et Arantes (Arantes, Baverel, Rollet, & Quenard, 2011), and describes the fact that though a compact urban form allows reducing energy consumptions, it also generates constraints in terms of solar contribution (i.e. received/captured solar energy)."

A compact urban form can for example reduce travelling distances, and increase density, which in turn tends to enhance the number of services and facilities in an area. However, the same compact form can enhance the urban heat island-effect, which tends to increase cooling needs for buildings; this, in turn, can increase energy consumptions.

Urban features

Singular built-environment elements or aspects such as façade design, vegetation, sidewalk width, etc., which combined with urban structure, mobility systems, and land use constitutes the neighbourhood-scale built environment. This, in turn, produces the public spaces people move during in their daily trips.

Urban heat island (-effect)

Urban heat island effect describes the phenomenon of temperatures in the city being higher than in rural areas in close proximity. Differences of 12°C or more has been measured for million-size cities. Three principal categories of contributing factors can be identified: geographical localizations; urban fabric (materials, form, vegetation, water management, etc.); buildings (materials, form, etc.) (Bonhomme, 2013).

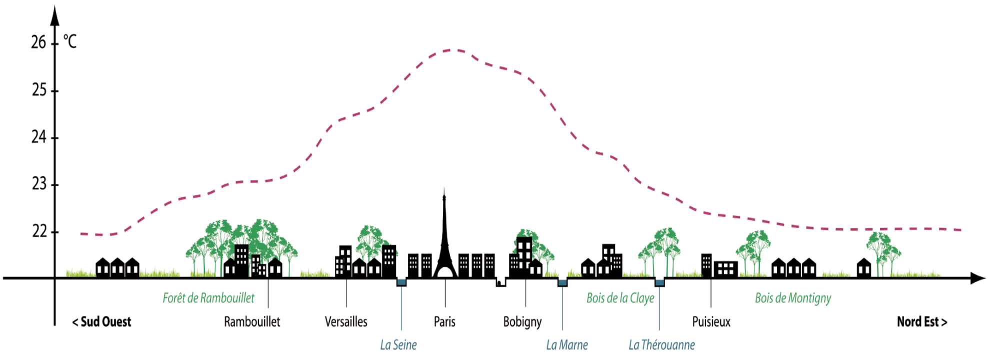


Figure 4: Coupe schématique des températures en 2008 pour une nuit de canicule.

Source : Groupe DESCARTES, 2009.

Figure from Dubois (2014)

Urban planner, urban planners

See comparative explanation under *Urban design*

Urban structure

The fabric of the city: the geometrical organization of built environment-elements such as road and street-networks, the shape and size of building blocks, the location of bigger activities or services (e.g. industry, hospitals, administration buildings), and so forth. The resulting urban fabric constitutes the urban structure.

Z

Zero-emission friendly public space

Public spaces that facilitate the use of mobility modes with zero emission of greenhouse gases, primarily walking, cycling, and public transport. It is particularly important for these spaces to ensure the needs of pedestrians and cyclists.

Zero-emission mobility

Mobility – movement of people – that does not lead to the emission of greenhouse gases. Arguably, every human activity includes some emissions; one could for example include production of shoes to walk with, or production of bicycles. This is, however, outside of the scope of this thesis; furthermore, it does not tend to be included when discussing mobility alternatives. Zero-emission mobility generally includes walking, cycling, public transport (on zero-emission energy), and cars without emissions (electricity, hydrogen, biofuel/-gas?). Cars are not included in the definition for this work, as they represent additional environmental and spatial issues.

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Annex

A.1
PHOTOS OF URBAN QUALITIES

URBAN QUALITIES	
Legibility, Imageability	How easily one can recognize and understand an area, a neighbourhood. A legible area/neighbourhood has easily identifiable elements that aid orienting one-self.
Human scale	The dimension of built environments in relation to people and the perceptions, experiences this creates. (street width, building height, block size, etc.) For example: (1) relationship street width/building height: balanced, towering, or wide; (2) large blocks that create long distances.
Enclosure	To what extent buildings, vegetation, and other vertical elements define and shapes streets and other public spaces. [86]
Connectivity	Connections between streets, cycle and pedestrian networks, etc., in order to connect parts of an area/neighbourhood or different neighbourhoods.
Transparence	To what extent one can see or perceive what goes on at the end of a street and past it, for example human activity or particular buildings.
Coherence	Whether the built environment creates an overall impression, e.g. through shapes or facades.
Complexity	How a rich variety of buildings and other elements create a diverse visual impression.

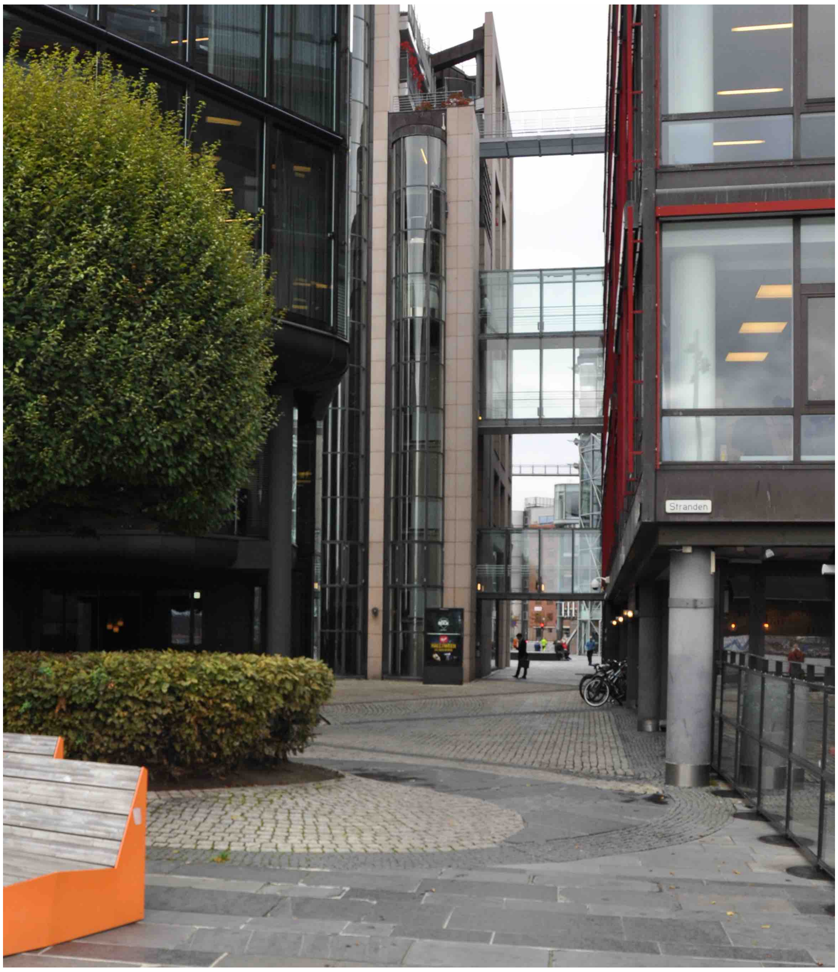
Added based on findings from the empirical enquiries:
Hierarchy To what extent public space accords different areas and priority to mobility modes, and/or uses of public space (dynamic/static), and to what extent this is clearly communicated
Flexibility The capacity of public space to accommodate different mobility modes, travel speeds, and mobility preferences and needs, as well as dynamic and static use

The following photos illustrate the urban qualities in various ways. Several are combined, as a public space generally encompasses more than more quality. Not all the qualities present in a photo are underlined or emphasized, so as to focus on a few at a time. It is important to precise the subjective nature of urban qualities. Some is relatively easy to agree upon (e.g. how they manifest), while others are more frequently subject to debate and interpretation. The photos are not absolute; a quality is likely manifest differently in different contexts.

[86] Hillnhütter (2016) defines enclosure as building height divided by street width, with buildings and walls representing the edges of the public space in which people walk. This ratio influences how pedestrians observe and interact with edges: « only when edges are close, as in narrow pedestrian streets below 15 metres in width, all details become visible and increase the amount of visible sensory stimuli". The level of interaction gradually decreases as the street widens. In broad streets over 40 metres wide, or in very large squares, the visual stimuli and thus level of interaction is very low as the edges are too far away for pedestrians to perceive details.

CONNECTIVITY AND TRANSPARENCY

Oslo (Norway)



Oslo (Norway)

Edinburgh (Scotland)

Formal and informal connections that enhance the Connectivity of the urban structure, and offer short cuts for pedestrians and cyclists. Additionally they create Transparency, which allows seeing what goes on further down the street. This is important for orientation, as can be seen in the picture above where the possibility to see a well-known landmark – Arthur's Seat – helps people know where in the city they are.

Figure 49 Pictures illustrating Connectivity and Transparency, photos by author

HUMAN SCALE AND ENCLOSURE

Amsterdam (Netherlands)

These are different manners in which Human scale and Enclosure can manifest. The picture from Amsterdam and Toulouse show how variation in the relationship between street width and building height influences perception of Human scale. The picture from Oslo shows how vegetation can contribute to Enclosure. The position of the houses on the right, somewhat pulled back from the street creates more a more open space compared to the picture from Amsterdam; the vegetal 'wall' ensures the space is clearly defined.

Toulouse (France)

Oslo (Norway)

Figure 50 Pictures illustrating Human scale and Enclosure, photos by author

LEGIBILITY, COMPLEXITY AND COHERENCE

Oslo (Norway)

Toronto (Canada)

Examples of Complexity and Legibility, and to come extent Coherence. A varied street environment can be achieved in different manners, not just with shops and other activities. Facades and street cover is equally important as seen by the pictures below. Façade design at the first floors, together with the ground floor use, can be particularly important for how an environment is perceived. Individual ‘episodes’ (e.g. street furniture, wall decorations) creates Complexity, and help orientation (though somewhat challenging if temporal).

Toulouse (France)

Figure 51 Pictures illustrating Legibility, Complexity, and Coherence (1), photos by author

The pictures on the following page show different facade designs, the photos are all from Oslo (Norway). The presence of a store on the ground floor, picture (a) does not guarantee a rich and open ground floor façade; pictures (b) and (c) equally show a store on the ground floor, but here the windows are covered in different manners making the facade opaque. Pictures (d) and (e) show residential buildings with different uses of the ground floor, which influences the experience of the pedestrians passing by.


(a)

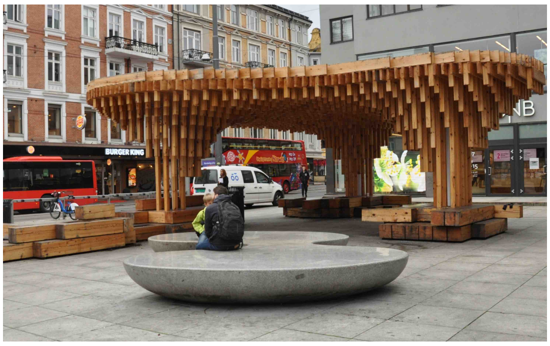

(b)


(c)


(d)

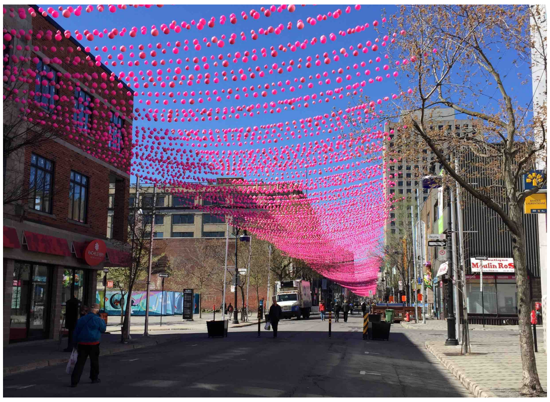

(e)

Figure 52 Pictures illustrating Legibility, Complexity, and Coherence (2): different façade designs, photos by author

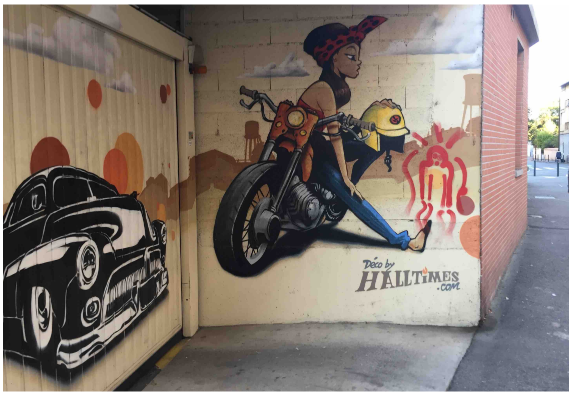


(a) – Oslo (Norway)

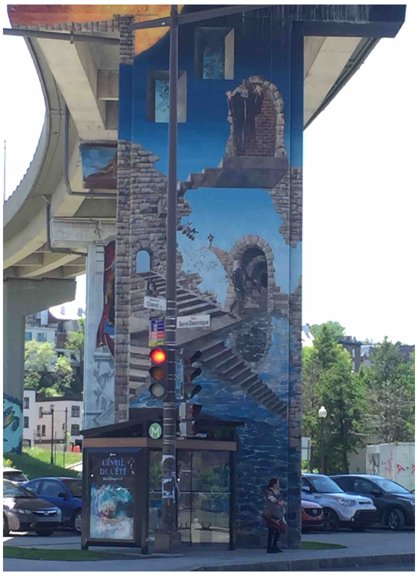
(b) – Oslo (Norway)



(c) – Montréal (Canada)



(d) – Toulouse (France)

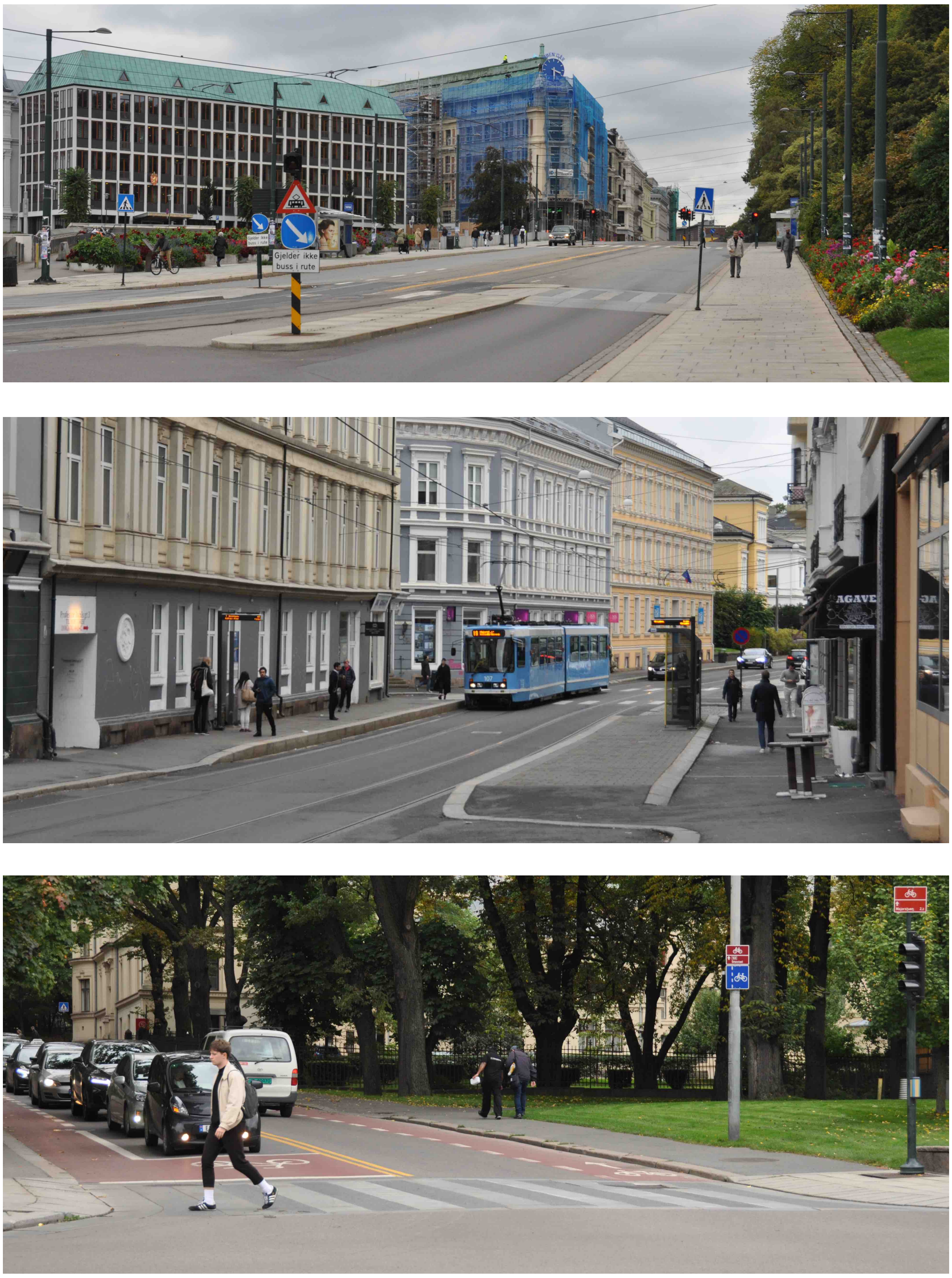


(e) – Québec (Canada)

(f) – Montréal (Canada)

Figure 53 Pictures illustrating Legibility, Complexity, and Coherence (3): ‘episodes’ in public space, photos by author

HIERARCHY AND FLEXIBILITY



Examples of Hierarchy (and to some extent Flexibility), all pictures from Oslo (Norway). With traffic signs, street covering, height differences, geometrical shape of the street, etc. the built environment communicates the Hierarchy between different mobility modes. This contributes to communicating the allocated space for each mode, important, for example, for traffic safety.

Figure 54 Pictures illustrating Hierarchy and Flexibility, photos by author

A.2
Interview guide for interviewing practitioners

INTERVIEW GUIDE FOR EXPLORING THE SAVOIR-FAIRE OF URBAN DESIGN PRACTITIONERS

The purpose of the interviews is to explore the professionals' opinion on the questioned elements below in relation to design projects and design processes. In this context, professional refers to urban planners, urban designers, architects, and landscape architects.

1) The relationship between the built environment of neighbourhoods/areas and the mobility behaviours of residents, especially modal choice. What is the influence of
    a. Physical elements
    b. Qualitative aspects (design aspects)

2) In a design process and for design decisions, what is the relationship between (a) the client's program and objectives (internal constraints), (b) the physical, cultural, socioeconomic context (external constraints), (c) the professional's expertise and experience-based knowledge (savoir-faire).

Presentation of the interviewee (preface**)**

- Career?
    - Graduated when and where
    - How many years of experience
    - Continued education, courses, etc.

- Is there something that has shaped or that characterizes the career so far?

- Practice
    - Kinds of projects, most frequent
    - Geographical scale(s)
    - Typical client (private/public/developers)
    - Where does a project usually come from? (Direct missions, competitions, etc.

1. Urban development projects

Goals/objectives

1. What is the primary objective in a project (most important to achieve)?
    a. Are there some elements that weight heavier than others?

2. Are these elements you use to judge the success (or not) of a project?

3. As a professional, what are your objectives? (*Might differ from those of the agency)*

4. Would you say that these are objectives or aspects that you frequently work towards?

Beginning of project

5. How does a project typically start? What are the first steps or phases?

Design process: the 'sketch' phase (early phases)

6. What does this phase include/represent for you?

7. How do you start this phase/How does this phase begin?

8. Are there specific aspects or issues that tend to emerge in this phase?
    a. Any examples?
    b. If yes, are there particular reasons?

9. What is the role of (people's) daily mobility in these early stages? *(If necessary specify understanding of daily mobility)*

10. Generally speaking, when you design a neighbourhood or work on a project, are there particular impressions, perceptions, or ambiances you aim at creating/achieving?

2. Mobility in a design project and the sketching phases (early phases)

11. In a project, to what extent do you have the opportunity to address and potentially act upon (work with, solve, etc.) daily mobility?
    a. Why?
    b. In which phases/stages?
    c. Do you have any examples?

12. Which aspect do you consider then?

13. **Case –** An example that can be seen in several cities today

❖ A former suburban neighbourhood, a residential area with mainly detached houses, approximately 15-20 minutes cycling-distance from the city centre; it is gradually "taken" (engulfed) by the city that is in full growth. To avoid urban sprawl it is necessary to densify and increase the number of units. These are already developed areas (not *tabula rasa*), but the development and growth of the city necessitates a change in the nature of the area, from residential to 'city'. The growth of the city furthermore brings with it new needs and expectations from residents regarding facilities and activities in close proximity to their neighbourhoods.

    a. How can you create a good transition from suburb to neighbourhood/city area?

❖ At the same time, cities are trying to reduce car-use for environmental considerations and because of spatial concerns; alternative mobility behaviours are desired. Densification and population growth can not result in more private cars in the city

    b. In your opinion, what are the main steps to facilitate and encourage the use of environmentally friendly mobility, i.e. walking, cycling and public transport?
    c. Why?
    d. Do you believe these actions and the solutions it involves have other benefits? Can they help solve other issues?

14. In the literature (research and urban design) we see that feeling of safety and security (not just infrastructure) as well as perceived distance, are particularly important for walking and cycling. In your opinion:
    a. What characterizes a safe neighbourhood?
    b. How can built environments help to create such an impression/feeling?
    c. As a designer, which measures and action would you take/include to achieve this?

(*Comment: question asked primarily regarding feeling of safety)*

3. Mobility in general

15. In your experience, how does mobility affect/influence a design project?
    d. In the sketching phases (early)
    e. More specifically: the inhabitants' mobility behaviour and modal choices

16. In your opinion, what is the relationship between daily mobility and an area or a neighbourhood's quality as a living context?

17. For some professionals, mobility is both a function/utility that needs to be solved, AND a means of achieving/solving other issues. What do you think about this? Can you identify? Do you agree?

Reminder:

- *Not all the questions were asked of every interviewee; it generally depended on the interview situation (time, place), and the direction the interview took*
- *Equally so for order of questions: the order depended on each interview so as to ensure a good flow*
- *The majority of the questions were asked, but some might be less relevant, or omitted due to time constraints; however, those deemed most important were asked to all (e.g. questions 19, 20, 21)*

A.3
SURVEY QUESTIONS

Survey on daily mobility and neighbourhood design and development

This survey is part of a doctoral research project on urban design and daily mobility Its overall topic is urban development at the neighbourhood scale, and it is directed towards urban planners, architects, landscape architects, and urban designers. The aim is to explore professional knowledge and experience: practices and methods, and design and planning principles.

It takes about 25 minutes to complete the survey. A sound research-basis relies on a high number of participants, so we hope you'll stick it out!

The survey is anonymous, and the results will be used in the context this research. If you have any questions please do not hesitate to contact us.

Definitions for the survey

Mobility behaviour

Mobility mode and the trip length (distance between starting point and end point)

Daily mobility, daily trips

Trip to and from work, school, kindergarten, grocery shopping, weekly sports/culture/etc. activities, etc. Vacation leisure trips are not included.

Remark:

This is an English translation of the Norwegian and French survey, which both had 'local adaptations' of questions according to the geographical context (e.g. differences in phrasing, examples in questions). The English translation is a mix of the two, adapted to the English language. Future uses of the survey should be similarly adapted to the local context.

1

Survey on daily mobility and neighbourhood design and development

City-development projects - objectives

1.

A city-development project can contribute to a number of changes and improvements; the list below contains some examples. According to you, how important are these improvements?

	Very important	Important	Somewhat important	Not important	Do not wish to reply
a. Limit environmental impacts such as air pollution, or detriment of biodiversity and ground water	○	○	○	○	○
b. Assure a mix of uses (housing, business, etc.)	○	○	○	○	○
c. Facilitate the use of public transport (transit)	○	○	○	○	○
d. Facilitate walking and cycling	○	○	○	○	○
e. Improve the image and the attractiveness of a neighbourhood (economic, cultural, social, etc.)	○	○	○	○	○
f. Reduce the car-use of the inhabitants	○	○	○	○	○
g. Reinforce climate adaptation, for example trough management of urban runoff (water) or adaptation of public space	○	○	○	○	○

Other – specify

2

Survey on daily mobility and neighbourhood design and development

Daily mobility in an urban development project at the neighbourhood scale (1)

Definitions
Mobility behaviour: **Mobility mode and trip length (distance between starting point and end point)**
Daily mobility, daily trips: **Trip to and from work, school, kindergarten, grocery shopping, and other weekly activities. Vacation leisure trips are not included.**

2. In a project at the neighbourhood scale, do you take into account the daily mobility of inhabitants?

- ☐ a. Yes
- ☐ b. No
- ☐ c. Do not wish to reply

Other - specify

3

Survey on daily mobility and neighbourhood design and development

Daily mobility in an urban development project at the neighbourhood scale (1b)

3. **In a project at the neighbourhood scale, which role is accorded to the daily mobility of inhabitants?**

- [ ] a. The daily mobility of the inhabitants is a part of the site analysis
- [ ] b. The daily mobility of the inhabitants is a part of the site analysis, and I/we implement measures and solutions directed towards the daily mobility of the inhabitants

4

Survey on daily mobility and neighbourhood design and development

Daily mobility in an urban development project at the neighbourhood scale (2)

4. **If you do not take into account the daily mobility of inhabitants in a project at the neighbourhood scale, what are the reason(s) for this?**
Choose the alternatives that best suit your work

- ☐ a. This is generally not demanded by our clients
- ☐ b. The daily mobility of the inhabitants is treated by other specialities (disciplines)
- ☐ c. The daily mobility of the inhabitants is not relevant for the geographical scale at which I/we work (region, city, neighbourhood, street, building)
- ☐ d. The daily mobility of the inhabitants is not something I/we have the possibility to influence through our position in a project
- ☐ e. Do not wish to reply

Other - specify

5

Survey on daily mobility and neighbourhood design and development

Daily mobility in an urban development project at the neighbourhood scale (2)

5. **In a project at the neighbourhood scale, if you take into account the daily mobility of the inhabitants, at which geographical scale is this generally done?**
Choose the alternatives that best suit your work/practice

	Very often	Often	Seldom	Never	Do not wish to reply
a. Regional scale	○	○	○	○	○
b. City scale	○	○	○	○	○
c. Neighbourhood scale	○	○	○	○	○
d. Street scale	○	○	○	○	○
e. Building scale	○	○	○	○	○

Other - specify

6

Survey on daily mobility and neighbourhood design and development

Daily mobility in an urban development project at the neighbourhood scale (3)

6. **In a project at the neighbourhood scale, including the daily mobility of the inhabitants in the site analysis contributes to**
Assess the statements below

	Strongly agree	Agree	Agree to some extent	Disagree	Do not wish to reply
a. Identify issues and challenges beyond the client's project command	○	○	○	○	○
b. Understand the inhabitants' use of the neighbourhood	○	○	○	○	○
c. Establish an idea, a concept	○	○	○	○	○
d. Link the project to the urban context (physical, cultural, economical, social, etc.)	○	○	○	○	○

Other - specify

7

Survey on daily mobility and neighbourhood design and development

Daily mobility in an urban development project at the neighbourhood scale (4)

7. **In a project at the neighbourhood scale, implementing measures and solutions directed towards the daily mobility of inhabitants contributes to...**
Assess the statements below

	Strongly agree	Agree	Agree to some extent	Disagree	Do not wish to reply
a. Establish an idea, a concept	○	○	○	○	○
b. Structure/shape the neighbourhood	○	○	○	○	○
c. Link the project to the urban context (physical, cultural, economical, social, etc.)	○	○	○	○	○
d. Create an identity to reinforce the inhabitants' sense of belonging to the neighbourhood	○	○	○	○	○
e. Introduce measures to reduce the inhabitants' use of cars	○	○	○	○	○
f. Facilitate walking and cycling	○	○	○	○	○
g. Facilitate the use of public transport	○	○	○	○	○

Other - specify

8

Survey on daily mobility and neighbourhood design and development

Daily mobility in an urban development project at the neighbourhood scale (5)

8. **In a project at the neighbourhood scale, when implementing measures and solutions directed towards the daily mobility of inhabitants, what influences the choice of measures/solutions?** Below is a list of alternatives, which 3 do you consider most decisive?

- [ ] a. The physical context (local climate, vegetation, topography, etc.)
- [ ] b. The economical, social, and cultural context
- [ ] c. Existing structure, urban fabric and form
- [ ] d. The program (mixed use, dwelling density, parking solutions, public space, etc.)
- [ ] e. The client's objectives for daily mobility (facilitate public transport use, reduce number of parking spaces, etc.)
- [ ] f. Society's targets for reducing traffic volume growth
- [ ] g. Existing and potential access to the area/site (street network, access to public transport, active mobility infrastructure, etc.)
- [ ] Do not wish to reply

Other - specify

9

Survey on daily mobility and neighbourhood design and development

Urban qualities in a neighbourhood, modal choices, and experiences and perceptions (1)

In the following questions we ask you to rate a series of urban qualities with regard to a) the use of different mobility modes, and b) to possible perceptions and experiences of an environment.

There are three alternatives for each combination of urban quality and mobility mode, or urban quality and perception/experience: "Very influential/important", "Influential/Important", "Somewhat influential/important". If you consider an urban quality as not having any influence upon a modal choice or not important for a perception/experience you can leave that box blank. This will be considered as “No influence” or "Unimportant".

10

9. **To what extent do the following urban qualities influence the use of the following mobility modes?**

Rate according to level of influence: *"Very influential"; "Influential"; "Somewhat influential".* If you consider an urban quality as not influential upon a modal choice you can leave that box blank. This will be considered as *"No influence"*.

	Walking	Cycling	Public transport
Sidewalk width			
Building height			
Distance (real) to transit stop			
Street width			
Facade design at street level			
Size urban block			
Vegetation			
View lines/sight lines			
Physical context (e.g. climate, topography)			

Other - specify

11

10. **To what extent are the same urban qualities important for creating the perceptions/experiences below?**
Rate according to level of influence: *"Very important"; "Important"; "Somewhat important"* . If you consider an urban quality as not important for a perception/experience you can leave that box blank. This will be considered as *"Unimportant"*.

	Perceived traffic safety "I do not risk being hit by a vehicle when walking down this street"	**Feeling of safety in public space** "I do not risk being mugged in this neighbourhood"	**Reduce the perceived distance when going from one place to another**	**Comfort (physical) in public space** (protection from wind, weather, noise, etc.)
Sidewalk width				
Building height				
Distance (real) to transit stop				
Street width				
Facade design at street level				
Size urban block				
Vegetation				
View lines/sight lines				
Physical context (e.g. climate, topography)				

Other - specify

12

Survey on daily mobility and neighbourhood design and development

Urban qualities in a neighbourhood, modal choices, and experiences and perceptions (2)

The elements in the following tables are the same urban qualities from the architecture- and planning literature. As with the previous tables, we ask you to rate these urban qualities for the use of mobility modes and perceptions/experiences.

The answering-mode is the same: Three alternatives for each mode/perception/experience (level of influence).
The urban qualities you do not choose at all are considered as “No influence” or "Unimportant", i.e. if you consider an urban quality as having no influence upon a modal choice or being unimportant for creating a perception/experience you can leave that box blank.

13

11. **To what extent are the following urban qualities influential for the use of the following mobility modes?**

Rate according to level of influence: *"Very influential"; "Influential"; "Somewhat influential".* If you consider an urban quality as not influential upon a modal choice you can leave that box blank. This will be considered as *"No influence".*

	Walking	Cycling	Public transport
Legibility, Imageability How easily one can recognise and understand a neighbourhood. A legible neighbourhood has easily identifiable elements that aid one for orienting one-self.			
Human scale The dimension of built environment elements in relation to people, and the perceptions/experiences this creates, e.g. the relationship street width/building height, or large urban blocks that increase walking distances.			
Enclosure To what extent buildings, vegetation, and other vertical elements defines and shapes streets and other public spaces.			
Connectivity Connections between streets, cycle and pedestrian networks, etc., in order to connect parts of a neighbourhood, or different neighbourhoods.			
Transparence To what extent one can see or perceive what goes on at the end of a street and past it, for example human activity or particular buildings.			
Coherence To what extent the built environment creates an overall, holistic impression, e.g. through shapes or facades.			
Complexity How a rich variety of buildings and other elements create a diverse visual impression.			

Other - specify

12. **To what extent are the same urban qualities important for creating the perceptions and/or**

14

experiences below?

Classify according to level of influence: *"Very important"; "Important"; "Somewhat important"* (scroll down menu of options). If you consider an urban quality as not important for creating a perception/experience you can leave that box blank. This will be considered as *"Unimportant"*.

	Perceived traffic safety "I do not risk being hit by a vehicle when walking down this street"	**Feeling of safety in public space** "I do not risk being mugged in this neighbourhood"	**Reduce the perceived distance when going from one place to another**	**Comfort (physical) in public space** (protection from wind, weather, noise, etc.)
Legibility, Imageability How easily one can recognise and understand a neighbourhood. A legible neighbourhood has easily identifiable elements that aid one for orienting one-self.				
Human scale The dimension of built environment elements in relation to people, and the perceptions/experiences this creates, e.g. the relationship street width/building height, or large urban blocks that increase walking distances.				
Enclosure To what extent buildings, vegetation, and other vertical elements defines and shapes streets and other public spaces.				
Connectivity Connections between streets, cycle and pedestrian networks, etc., in order to connect parts of a neighbourhood, or different neighbourhoods.				
Transparence To what extent one can see or perceive what goes on at the end of a street and past it, for example human activity or particular buildings.				
Coherence To what extent the built environment creates an overall impression, e.g. through shapes or facades.				
Complexity How a rich variety of buildings and other elements create a diverse visual impression.				

Other - specify

15

Survey on daily mobility and neighbourhood design and development

Mobility behaviour and daily mobility

Definitions for the survey
Mobility behaviour: Mobility mode and trip length (distance between starting point and end point)

Daily mobility, daily trips: Trip to and from work, school, kindergarten, grocery shopping, and other weekly activities. Vacation leisure trips are not included.

13. **Assess the statements below according to your opinions**

	Strongly agree	Agree	Agree to some extent	Disagree	Do not wish to reply
a. The neighbourhood design influences the mobility behaviour of the inhabitants	○	○	○	○	○
b. Separate bike/cycle lanes (from sidewalk and road) increases the safety of cyclists	○	○	○	○	○
c. The distance from dwelling to city centre has a strong influence on the inhabitants' mobility behaviour	○	○	○	○	○
d. Solutions that promote cycling will also promote walking	○	○	○	○	○
e. Reduced access for cars will lead to more people walking and cycling	○	○	○	○	○
f. Improving infrastructure for non-motorized mobility such as walking and cycling is necessary to increase the use of public transport	○	○	○	○	○
g. Expanding of the main road-network will contribute to reducing congestion	○	○	○	○	○
h. The social, economical, and cultural context is more important for modal choice then the built environment	○	○	○	○	○
i. Neighbourhood design can contribute to reducing the car use of the inhabitants in a city	○	○	○	○	○

Other - specify

16

14. **In your opinion, how efficient are the measures below for reducing greenhouse gas emissions from road traffic (automobiles)?**

	Very efficient	Efficient	Somewhat efficient	No effect	Do not wish to reply
a. Increasing road capacity on the main road-network	○	○	○	○	○
b. Locating new housing and work places so that inhabitants are less car-dependent	○	○	○	○	○
c. Improving public transport services	○	○	○	○	○
d. Improving conditions for walking and cycling	○	○	○	○	○
e. Making it more expensive to drive a car	○	○	○	○	○
f. Limiting road capacity on main roads	○	○	○	○	○
g. Make it more expensive or difficult to park a car	○	○	○	○	○
h. Information, campaigns, etc.	○	○	○	○	○
i. Combining several measures	○	○	○	○	○

Other - specify

17

Survey on daily mobility and neighbourhood design and development

Background questions

The survey is complete!

Now we need some information about you

15. **Age**

- ◯ 18-25
- ◯ 25-30
- ◯ 30-35
- ◯ 35-40
- ◯ 40-45
- ◯ 45-50
- ◯ 50-55
- ◯ 55-60
- ◯ 60-65
- ◯ 66 or more
- ◯ Do not wish to reply

16. **Gender**

- ◯ Woman
- ◯ Man
- ◯ Other
- ◯ Do not wish to reply

18

17. **How many years of experience do you have?**

- ○ 0-5
- ○ 5-10
- ○ 10-15
- ○ 15-20
- ○ 20-25
- ○ 25-30
- ○ 30-35
- ○ 35-40
- ○ 40+
- ○ Do not wish to repy

18. **What did you study?**
Multiple choices are possible

- ☐ a. Architecture
- ☐ b. Urban planning
- ☐ c. Landscape Architecture
- ☐ d. City planning/Urbanism
- ☐ e. Urban design
- ☐ f. Engineering
- ☐ Do not wish to reply

Other - specify

19. **Where did you study?**

- ○ Do not wish to reply
- ○ Study institution

20. **Have you undertaken further studies?**

- ◯ Do not wish to reply
- ◯ No
- ◯ Yes - if so what

21. **What kind of projects do you generally work on?**

- ◯ Do not wish to reply
- ◯ Kind of project

22. **Who is your typical client?**
E.g. State, Region, Department, City, Private Developers

- ◯ Do not wish to reply
- ◯ Client

23. **Which geographical scale do you generally work on?**

	Very often	Often	Seldom	Never	Do not wish to reply
a. Regional scale	◯	◯	◯	◯	◯
b. City scale	◯	◯	◯	◯	◯
c. Neighbourhood scale	◯	◯	◯	◯	◯
d. Building scale	◯	◯	◯	◯	◯

Other - specify

20

24. **Do you wish to leave a comment?**

21

A.4
PUBLICATIONS

List of publications related to the doctoral thesis, publications in the context of the CapaCity project are not included.

1. Rencontres Interdisciplinaires Doctoriales de l'Architecture et de l'Aménagement Durable (RIDAAD) 2015, Lyon, France

2. Passive and Low Energy Architecture (PLEA) 2016, Los Angeles, USA (article and poster)

3. Passive and Low Energy Architecture (PLEA) 2017, Edinburgh, Scotland

4. European Transport Conference (ETC) 2017, Barcelona, Spain

1. Rencontres Interdisciplinaires Doctoriales de l'Architecture et de l'Aménagement Durable (RIDAAD) 2015, Lyon, France

Réduction des consommations énergétiques urbaines et des émissions de GES liées à la mobilité urbaine - vers une approche intégré entre la planification urbaine et la planification des transports

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Mots clés : structure urbaine, mobilité, énergétique urbaine, interdépendance, modélisation informatique

Nombre de mots : 4435

Réduction des consommations énergétiques urbaines et des émissions de GES liées à la mobilité urbaine - vers une approche intégré entre la planification urbaine et la planification des transports

1. Introduction

Dans son cinquième rapport d'évaluation "Changements climatiques 2014" le *Groupe d'experts Intergouvernemental sur l'Évolution du Climat* (GIEC) a constaté qu'afin de limiter l'élévation de température à 2°C en moyenne planétaire il faudrait réduire les émissions GES de 40 à 70% d'ici 2050 (1). Les villes mondiales sont parmi les plus grands consommateurs d'énergie et contributeurs des GES liés principalement aux bâtiments et à la mobilité urbaine (2)(3). Cependant, les villes sont à la fois le problème et la solution, « l'échelle de la ville permet […] de mettre en œuvre des mesures pour limiter les impacts négatifs du changement climatique. Les municipalités ont en effet à leur disposition une palette d'outils pour limiter les émissions de gaz à effet de serre (GES) » (4).

Par ailleurs, il existe beaucoup de connaissances sur les moyens de réduire les effets climatiques des bâtiments et de la mobilité urbaine (transport motorisé). C'est en combinant les deux domaines que les choses se compliquent. Les éléments à prendre en compte se multiplient, leur interdépendance rend difficile une prédiction des conséquences environnementales, et souvent il y a des contradictions entre mesures possibles. Par exemple le Paradoxe Énergétique Urbain : bien que la densification semble avoir un impact positif sur les émissions GES des transports elle peut accentuer le phénomène de l'îlot de chaleur urbain, et réduire le potentiel de production d'énergie renouvelable (5).

A l'échelle du transport il y a deux principales catégories d'approches environnementales : à travers des innovations technologiques ou bien à travers la planification urbaine. Des solutions technologiques peuvent réduire les émissions par km. La planification urbaine peut influencer le comportement de mobilité des habitants et donc réduire la somme des distances parcourues. Cet article se concentre sur ce dernier point à travers *une approche intégrée entre la planification urbaine et la planification des transports* afin de réduire les consommations énergétiques et les émissions de GES de la mobilité urbaine. En effet, la forme urbaine et la mobilité urbaine ont une relation réciproque, l'une influence l'autre et vice versa. Comment ceci se manifeste-t-il, sur quels aspects, quelles variables sont les plus importantes, quels facteurs joueront un rôle, … voilà qui est difficile à comprendre. La première partie de cet article cherche à clarifier certains points au travers d'une revue de littérature.

Dans un deuxième temps, nous présenterons la thèse *« Performance énergétique de la ville : vers une approche intégrée de la mobilité urbaine »*, qui se concentre sur le transport, la mobilité et l'énergétique urbaine. Est-il possible de développer une méthode pour combiner des calculs des consommations énergétiques des bâtiments avec ceux des transports qui soit utilisable par des professionnels de l'urbanisme ? Cette thèse cherche alors à créer un outil, une boite à outils et/ou une méthode pour une approche intégrée. La thèse se déroule dans le cadre du projet de recherche *Capacités* qui vise au développement d'un prototype d'outil d'aide à la conception durable pour les professionnels. Les outils de modélisation informatiques sont aujourd'hui devenus essentiels pour un développement durable de l'urbain. Cependant des limites existent comme le manque d'interdisciplinarité des outils et le décalage entre les réponses apportées par les scientifiques et les besoins des concepteurs. Une forte attention est portée à l'appropriation de cet outil par les concepteurs. Le projet suit une démarche transversale : recherche bibliographique, programmation, et synthèse de travaux existants, ateliers participatifs et entretiens. Les résultats de la thèse seront intégrés à cet outil.

2. Revue de littérature

2.1 Le milieu urbain et la mobilité urbaine – une relation réciproque

2.1.1 Impact de la structure urbaine existante

Plusieurs facteurs morphologiques influencent la consommation d'énergie des villes. Les différentes formes urbaines conjuguées aux différentes structures de réseaux amènent à des avantages et des inconvénients en termes d'énergétique urbaine. Cependant il peut être difficile de distinguer l'effet isolé de chaque facteur, ce qui peut être une source aux controverses qui existent sur le sujet, par exemple sur des conséquences de densification sur des aspects environnementales (6).

En effet, la densification est souvent mise en avant comme le meilleur moyen pour faire face aux problématiques environnementales liées aux transports. Newman et Kenworthy étaient parmi les premiers à mettre en évidence ceci avec leur étude de 1989 « Cities and Auto Dependency: A Sourcebook ». L'étude présentait un lien entre densité moyenne (hab/km2) d'une ville et consommations énergétiques liées au transport (GJ/capita/an). L'hyperbole montre qu'une ville dense comme Shanghai consomme beaucoup moins de pétrole pour des déplacements que la ville d'Atlanta ville très étalée[1] (7).

Cependant les bases théoriques de l'étude ont été critiquées en raison de la trop grande simplification de la problématique, par exemple par rapport à la façon dont la densité des villes a été calculée (ibid). De plus d'autres variables et facteurs joueront sur les consommations liées au transport. Selon Lefèvre « la structure spatiale d'une ville, en particulier la localisation des logements, des emplois, et des services, ont […] un impact sur le nombre et la longueur des déplacements » (ibid).

La structure actuelle d'une ville est le résultat d'une évolution au cours de plusieurs décennies, voir plusieurs siècles, influencée par un vaste nombre de facteurs. Entre autre l'évolution des modes de déplacement. De la ville du piéton à la ville de la voiture privée en passant par la ville des transports en commun, l'augmentation des vitesses des transports a rendu possible les déplacements sur de grandes distances en peu de temps. La ville s'est étalée et, en conséquence, les distances couvertes au quotidien ont augmentées, ainsi les consommations énergétiques liées au transport (ibid).

Le tissu urbain d'une ville conditionne aussi les modes de déplacement appropriés. « Il existe des liens entre forme bâti, la structuration des réseaux, et les types de flux ». (6) Une ville très étalée signifie de grandes distances à couvrir, ce qui peut être décourageant pour des mobilités douces, mais surtout défavorable pour le développement des transports en commun (7)(8). Un exemple est Barcelone et Atlanta. Ils ont quasiment le même nombre d'habitants (B : 2,8 millions ; A : 2,5 millions - 1990), ces deux villes occupent des surfaces bâties[2] largement différentes : B – 162km2, A : 4280 km2. (Figure 1) La majorité des déplacements à Atlanta se font en voiture. Barcelone a un bon réseau de métro qui couvre la majorité de la ville, et 20% des déplacements se font à pied. A Atlanta les déplacements à pied sont tellement limités qu'ils ne sont même pas enregistrés[3] (7).

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[1] Lefèvre cite ici Newman et Kenworthy 1989, voir bibliographie.

[2] Bertaud défini la surface bâtie comme la surface d'une ville (définie par ses limites municipales) moins les espaces libres supérieurs à 4 hectares, les terres agricoles, les forêts, les eaux et autres sols non-utilisés, ainsi que les aéroports, les routes et autoroutes non adjacents à des sols construits.

[3] Bertaud se base sur sa propre étude de 2003, et cite Newman et Kenworthy 1999.

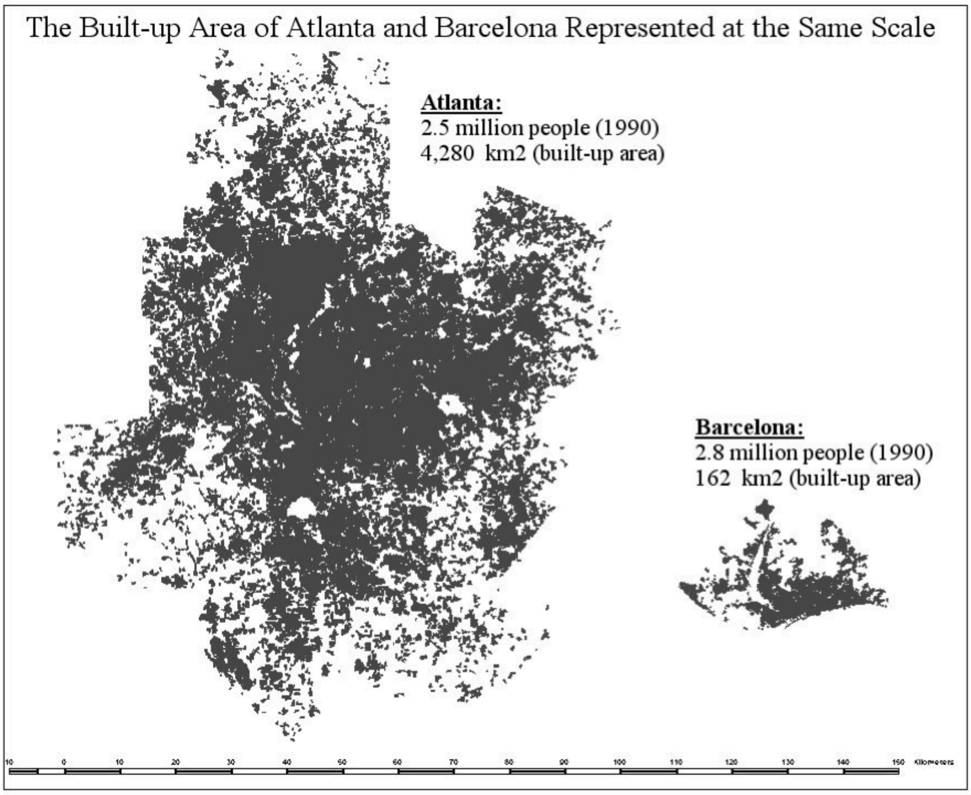


FIGURE 1 : La surface bâtie couverte par Atlanta et Barcelone représenté à la même échelle.
Source : Bertaud 2004

2.1.2 L'importance de la localisation des emplois par rapport aux logements

Bertaud propose quatre classifications liées aux localisations des emplois par rapport aux logements: mono-centrique (tous les déplacements convergent vers un centre des affaires fort) ; polycentrique (déplacements aléatoires entre un centre fort et plusieurs petits centres) ; mono-polycentrique (combinaison des deux) ; polycentrique - villages urbains (plusieurs centres indépendants – selon Bertaud inexistant outre la théorie de l'urbanisme). Une ville n'est jamais l'un ou l'autre, mais de tendance plutôt mono-centrique ou polycentrique (8). La structure de la ville influence les modes de déplacement accessibles et appropriés et donc le comportement de mobilité des habitants. Il semble alors possible d'en déduire que puisque la localisation des emplois par rapport aux logements influence cette structure, elle influence aussi le comportement de mobilité, directement lié aux consommations énergétiques.

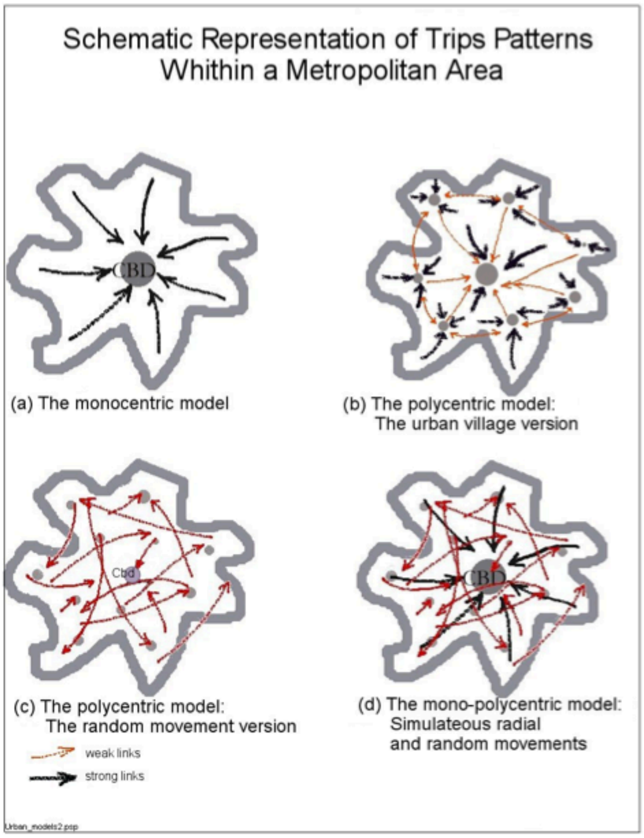


FIGURE 2 : Déplacements quotidiens selon les différentes typologies.
Source: Bertaud 2004

Effectivement un tel lien peut être trouvé, notamment lors d'une étude menée par l'institut de recherche norvégien Institute of Transport Economics (TØI). Lorsqu'une grande compagnie d'assurance à Oslo, Norvège, a déménagé de l'extérieur de la ville vers le centre d'affaires, l'utilisation des voitures privées par les employés a baissée significativement, de 48% à 9%. Parallèlement, le taux d'utilisation des transports en commun par ces mêmes employés a augmenté de 35% à 73%. Ces résultats sont liés aux offres des transports en commun, mais aussi aux possibilités de stationnement. Avant le déménagement la compagnie offrait des stationnements gratuits. Malgré la proximité d'un pôle multimodal le choix modal des employés était la voiture. En centre ville cette offre n'existait plus, en contrepartie l'offre des transports en commun était encore plus forte (9). La localisation des emplois est alors importante pour le comportement de mobilité. Cependant d'autres facteurs et variables entrent aussi en jeu pour déterminer le choix modal d'une personne. Ceux-ci sont par exemple la qualité du service proposé et la qualité des alternatives (10).

Un vaste nombre de facteurs et variables doit être pris en compte en analysant le comportement de mobilité. Banister et Hickman (11) ont étudié l'impact d'un grand nombre de variables (comme par exemple la densité de la population, la taille de la population, la disposition et la mixité des usages et l'accessibilité en transport en commun) sur les consommations énergétiques liées aux déplacements logement-emploi à Surrey en Angleterre. Ils ont conclu qu'individuellement l'impact d'une variable peut être réduit par d'autres variables, mais que prises ensembles et agrégées les variables ont un grand impact sur la consommation énergétique liées au déplacements logement-emploi. Les auteurs concluent que même si la théorie de Newman et Kenworthy était une première compréhension d'un domaine très complexe, la réalité est beaucoup plus nuancée. Il faut considérer une multitude des facteurs et variables pour comprendre le fonctionnement du lien forme urbaine et mobilité urbaine.

2.1.3 Un modèle simplifié des interconnections

La figure suivant (figure 2) proposée par Tennoey (10) modélise d'une façon simplifiée les relations réciproques entre des systèmes de transport, les comportements de mobilité (travel behaviour), les usages des sols et les volumes de trafic (vkm/jour/personne). Le modèle permet de visualiser comment la planification urbaine impacte l'usage des sols qui influence les systèmes de transport et les comportements de mobilité et donc les volumes de trafic.

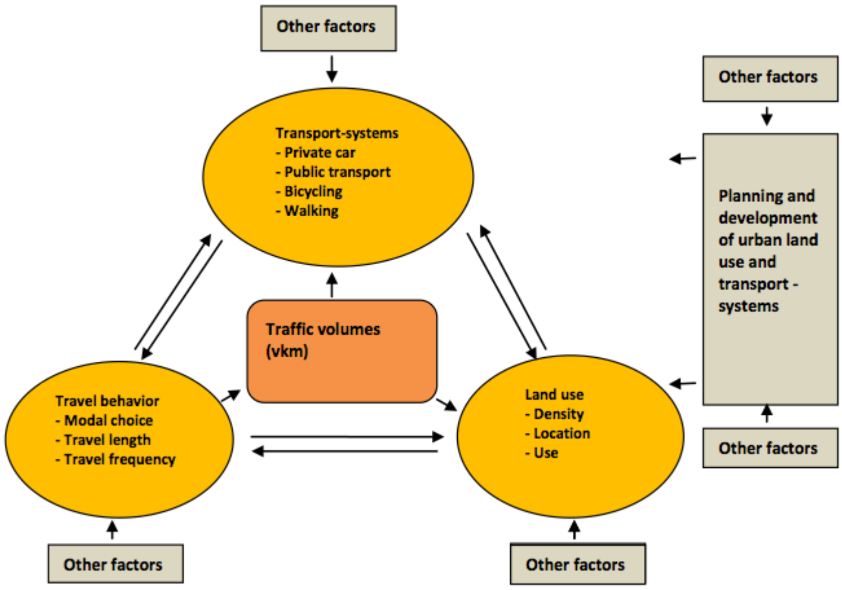


FIGURE 3 : Modèle simplifié des relations réciproques des différents éléments de trafic.
Source : Tennoey 2012

2.2 Une approche intégrée pour un développement urbain durable et cohérent à long terme

Plusieurs facteurs influencent la relation réciproque entre forme urbaine et mobilité urbaine. Des variables comme la distance logement-travail, la localisation des pôles d'emploi, ou le niveau de service des transports en commun, sont liés les uns aux autres. Ils interagissent constamment, et contribuent au comportement de mobilité de la population – et donc aux volumes de trafic total. L'inter-connectivité de ces variables fait que les deux aspects – forme et mobilité urbaine – doivent être pris en compte simultanément dans le développement de l'urbain afin de réduire les consommations d'énergie et les émissions de GES liées au transport (7)(8)(10)(11).

Une approche intégrée entre planification urbaine et planification de transport peut se traduire ainsi : dans un projet urbain (par exemple le développement d'un nouveau quartier, la réhabilitation d'un quartier, ou la mise en place d'une nouvelle ligne de tramway), les effets secondaires potentiels sur la mobilité (comportement des usagers, accessibilité) ou sur la structure urbaine (nouvelles constructions et activités proches de la ligne) sont prises en compte dès la phase d'analyse. Pour ceci il faut étudier les variables interconnectées. Les effets potentiels de ces variables seront ensuite inclus dans le projet comme objectifs à atteindre ou bien comme conséquences à éviter.

Au sujet des constructions des bâtiments et des équipements :

- Comment le projet influence la mobilité du quartier, de la ville ?
- Le projet engendrait-il plus de trafic, ou contribuait-il à une réduction ?
- Quelles mesures sont possibles pour réduire le trafic, pour encourager la mobilité douce et l'utilisation des transports en communs ?

De la même façon pour un projet d'infrastructure :

- Quel sera le résultat final au niveau de la mobilité urbaine ? Plus de trafic voitures privées ? Plus de mobilité douce ?
- Quel effet sur la qualité de vie autour du projet ?
- Est-il possible de combiner ce projet avec un développement urbain (logements, équipements, services etc.) pour restructurer des parties de la ville ou créer des nouvelles attractivités?

La littérature décrite en théorie un nombre de dispositifs qui devront êtres efficaces pour changer les comportements de mobilité des habitants, pour inciter à plus de mobilité douce et pour augmenter la fréquence d'usage des transports en commun. Il existe certaines disputes dans la recherche concernant des incohérents autour de l'importance des différents facteurs et variables (11). Cependant il est possible d'en tirer quelques principes qui semblent faire consensus. Tennoey (10) a formulé les principes suivants en citant Kenworthy 1990, Naess 1997, 2006, The Norwegian Ministry of Environment 1993, Owens et Cowell 2002, Banister 2005, Hull 2011 :

- Imposer ou encourager la densification de la ville sur elle même pour éviter un étalement urbain et l'implantation des nouvelles activités dans des lieux indépendants de la voiture privée.
- Imposer des restrictions physiques et fiscales sur le trafic routier.
- Améliorer les services de transports en commun.
- Améliorer les conditions des mobilités douces.

2.3 Quels éléments empêchent une telle approche ?

Les volumes de trafic dans les grandes villes continuent à croître malgré un consensus général, datant de plusieurs décennies, sur la nécessité de les réduire. Plusieurs raisons peuvent expliquer cette contradiction. Cet article se concentre sur les raisons liées au domaine de la planification urbaine.

Tout d'abord, Bertaud met en avant la complexité du processus de développement urbain et les nombreux acteurs impliqués (8). Par ailleurs, il semble que les liens entre des différents variables de l'urbain et l'impact potentiel des facteurs internes et externes aient étés sous-estimés. En conséquence la nécessité d'avoir une approche intégrée entre planification urbaine et planification des transports a été largement omise. Cette observation est soutenue par Banister et Hickman (11). Selon eux, ceci peut venir du fait que « (a) Les disciplines de planification urbaine et planification des transports sont traditionnellement considérés comme des aspects séparées ; mais aussi (b) à cause de la difficulté de fournir une compréhension de la relation signifiante entre l'usage des sols et mobilité ». (ibid)

Le rapport « Aspect 2050 » par le CSTB er l'ANR (6) souligne que cette division entre urbanisme et transport est un obstacle pour un développement durable. Le rapport parle de « la nécessité de repenser la relation entre transport et urbanisme. Cette relation est trop souvent pensée en termes de compatibilité et insuffisamment en termes d'influence réciproque. ». Cette analyse est confirmée par une grande majorité des professionnels de l'urbanisme.

Pour des urbanistes, le problème est souvent un manque de compétences et de connaissances face à des ingénieurs spécialisé dans les questions de transport. La planification du transport se fait alors le plus souvent au travers de modèles et estimations qui aident à décider où et comment il faut construire des infrastructures, ainsi que le dimensionnement nécessaire. Dans la plupart des cas, les professionnels de l'urbanisme ne sont pas capables d'identifier, ni d'argumenter contre, des développements qui vont engendrer plus de trafic, ni de défendre des alternatives qui pourraient promouvoir des mobilités douces (10)(12).

Concernant les professionnels, plusieurs éléments ont été identifiés comme ayant un effet négatif sur leur approche des problématiques environnementales (4)(10) :

- Leurs convictions personnelles
- Leur connaissance sur l'environnement et la durabilité, ainsi que leur connaissance des solution ou dispositifs possibles
- Leur lien avec et leur compréhension de la recherche
- Leurs outils et méthodes d'analyse et de conception

Tennoey a concentré sa recherche sur trois axes : les professionnels, la connaissance de la recherche et les processus de planification. Ses résultats ont montré que ces trois axes peuvent conduire à une planification génératrice de trafic selon différentes conditions :

- La mise en place ou pas des objectifs de réduction de trafic
- L'évincement ou pas des ces objectifs
- L'utilisation ou pas de la connaissance de la recherche

Il parait qu'une approché intégrée entre planification urbaine et planification de transport est un domaine qui nécessite encore beaucoup d'avancements pour pouvoir devenir le « standard ». C'est un vaste terrain à couvrir, mais certains points clés ont été identifiés par, entre autres, Tennoey, Bertaud, UN Habitat, et Lefèvre (2)(7)(8)(10) :

- Des études empiriques des cas d'étude afin de mieux comprendre les structures et les mécanismes qui amènent dans une direction durable ou pas.

- Une « mise à jour » du métier d'urbaniste ; les urbanistes doivent prendre un rôle plus important en tant que professionnel de planification urbaine. Selon Tennoey et Bertaud c'est eux qui doivent fournir de la connaissance aux décideurs afin que ces derniers puissent prendre des décisions qui mènent aux objectifs environnementaux.

- Une recherche sur et une description de la méthodologie des professionnels afin de mieux comprendre comment ils travaillent, pour identifier des facteurs influençant le résultat final, pour pouvoir les développer et améliorer et pour pouvoir développer des outils.

- Une meilleure communication des résultats de la recherche pour les rendre accessibles et utilisables pour les professionnels. Ceci va leur donner plus de poids en face de propositions « non environnementales » dans un projet urbain, et les aider à garder en vue les objectifs environnementaux.

3. Développement d'un outil pour une approche intégré

3.1 Les objectifs

La thèse *« Performance énergétique de la ville : vers une approche intégrée de la mobilité urbaine »* a pour objectifs :

- de créer un outil, une boite à outils ou une méthode pour un approche intégré de la planification urbaine et la planification de transport.
- de contribuer à la connaissance scientifique et professionnelle sur ce sujet.

La thèse est réalisée dans le cadre du projet de recherche Capacités qui vise le développement d'un prototype d'un outil d'aide à la conception durable pour les professionnels. Capacités a une approche pluridisciplinaire pour pouvoir prendre en compte plusieurs problématiques environnementales liées à l'énergétique urbaine au delà de la mobilité. L'outil envisagé pourra prendre la forme d'une plateforme SIG permettant de calculer et de visualiser des indicateurs simplifiés. L'outil doit permettre :

- Une analyse initiale du site du projet
- Une évaluation du projet et de ses variantes éventuelles en phase esquisse
- Une aide dans les choix de conception face à des objectifs environnementaux complexes et parfois contradictoires

Les résultats de la thèse seront inclus dans cet outil.

Les parties précédentes ont soulignées le besoin d'outils et de méthodes qui permettent aux professionnels d'agir sur des problématiques environnementales dont ils ne sont pas experts. Le rôle de l'urbaniste est de guider les décideurs dans leurs démarches pour développer la ville d'une façon durable, agréable et attractive. Ils doivent relier les nombreuses facettes afin de créer une cohérence qui respecte le plus grand nombre d'intérêts possibles. Concernant la mobilité il faut savoir reconnaître des propositions qui vont engendrer plus de trafic, ou bien savoir faire une conception qui encourage des mobilités douces. Pour faciliter cela il faut un outil qui **met en évidence le lien entre forme et mobilité urbaine**, et qui permet aux professionnels d'évaluer les effets des différents dispositifs possibles.

Aujourd'hui des outils de modélisations informatiques sont devenus essentiels à la recherche comme aux projets de conception urbaine et planification de transport. Les modèles sont nombreux mais présentent des limites :

- Manque d'interdisciplinarité / interopérabilité des outils.
- Décalage entre les réponses apportées par les scientifiques et les besoins et les pratiques des concepteurs. Les outils existants sont souvent trop compliqués, demandent trop de données, et prennent trop de temps à utiliser.

En conséquence l'intégration de ces outils dans la conception urbaine reste difficile. Il y a aussi des difficultés d'interdisciplinarité des outils liés aux différences des échelles traitées, des indicateurs utilisés pour estimer/mesurer les résultats, ou bien des méthodes de calculs. Ces éléments rendent compliqué le couplage des modèles et outils des plusieurs domaines, par exemple au sujet de l'énergétique urbaine. Il est alors aujourd'hui très difficile de faire le lien entre énergie consommée et produite par le bâti, énergie consommée par les transports et qualité des espaces publics. Ce manque d'outils intégrés peut conduire à des prises de décision contre-productives dans l'aménagement urbain. Cette thèse regarde en particulier les consommations énergétiques et les émissions GES liées au transport. L'une des pistes qui sera poursuivie est la mise en place d'une méthode d'estimation des consommations énergétiques liées au bâti et au transport. Ceci peut être un bon indicateur de la performance environnementale d'un quartier, d'une ville.

3.2 La méthode mise en œuvre dans le thèse

Formulation des hypothèses scientifiques

Afin de faire une synthèse des connaissances incontournables du champ de l'énergétique urbaine une première phase de recherche bibliographique des travaux en France aussi bien qu'à l'international est en cours. Parallèlement des outils informatiques et des modèles de la planification de transport et la planification urbaine, ainsi que des méthodes de calculs des consommations énergétiques urbaine seront étudiés. Cette étude abordera les données utilisées et leurs échelles, des indicateurs appliqués, et des méthodes de calcul etc. dans le but d'identifier des points essentiels à reprendre dans le futur outil. Ces deux phases permettront aussi de mettre en place un premier « cahier des charges » pour un futur outil.

Une étude de villes de référence sera faite pour confirmer ou invalider les hypothèses scientifiques mises en avant par la revue de littérature. Ces cas seront sélectionnés parmi des villes de structures urbaines et de qualités environnementales différentes. Les villes seront comparées à la fois en termes de consommation énergétique des bâtiments et des transports, de l'efficacité, l'usage et l'organisation des réseaux de mobilité, de la qualité des espaces urbains pour la mobilité douce etc. Ces comparaisons seront menées grâce à des études paramétriques détaillées (morphologie des bâtiments, densités urbaines, prospect, largeur et orientation des voies, etc.) menées sur une batterie d'outils de modélisation existants.

Entretiens

Puisque l'outil est destiné aux professionnels, un travail sera fait pour s'assurer de la validité et l'applicabilité du résultat. Dans le cadre de Capacités il est prévu d'interroger les pratiques des professionnels de l'aménagement urbain. Cette étape débutera par un questionnaire centré sur les besoins et attentes vis-à-vis d'un éventuel outil d'aide à la conception durable.

Ensuite, des ateliers sont prévus afin d'évaluer s'il est possible d'intégrer des savoirs issus des pratiques. Dans ces ateliers, les concepteurs seront amenés à évaluer la qualité des réseaux de transport, mais aussi la vulnérabilité de quartiers types vis-à-vis des consommations énergétiques et de l'effet d'ilot de chaleur urbain. Pour cela, ils se baseront uniquement sur des données simples, habituellement disponibles dans les projets de conception : plans, coupes, photo du site, descriptif succinct des typologies de bâtiments et des espaces publics, etc. Dans une deuxième phase, l'analyse des concepteurs sera comparée aux résultats de simulations numériques sur ces mêmes quartiers. Ces ateliers seront également l'occasion de faire un état des lieux des connaissances issues de l'expérience, de leurs méthodes de travailler et de l'intuition des praticiens.

Les ateliers seront aussi l'occasion de faire un état de lieux sur les connaissances des praticiens sur la relation forme et mobilité urbaine. Les résultats seront comparés à ceux des études bibliographiques.

Proposition des indicateurs et méthodes d'analyse et de calcul

En se basant sur les étapes précédentes, un système d'indicateurs simplifiés permettant d'évaluer un projet au regard de la mobilité urbaine sera proposé. Ces indicateurs doivent permettre de faire un lien entre consommation énergétique des bâtiments et des transports, ainsi que l'effet sur des volumes de trafic des différentes alternatives urbaines. Les indicateurs serviront l'outil ou la méthode développés. Les résultats de la thèse seront intégrés à l'outil développé par Capacités.

Validation

Pour finir, l'outil proposé sera validé (d'un point de vue scientifique et d'un point de vue opérationnel) sur un ou plusieurs cas d'étude emblématique(s), en partenariat avec les acteurs du (des) projet(s).

4. Des premiers résultats et des perspectives

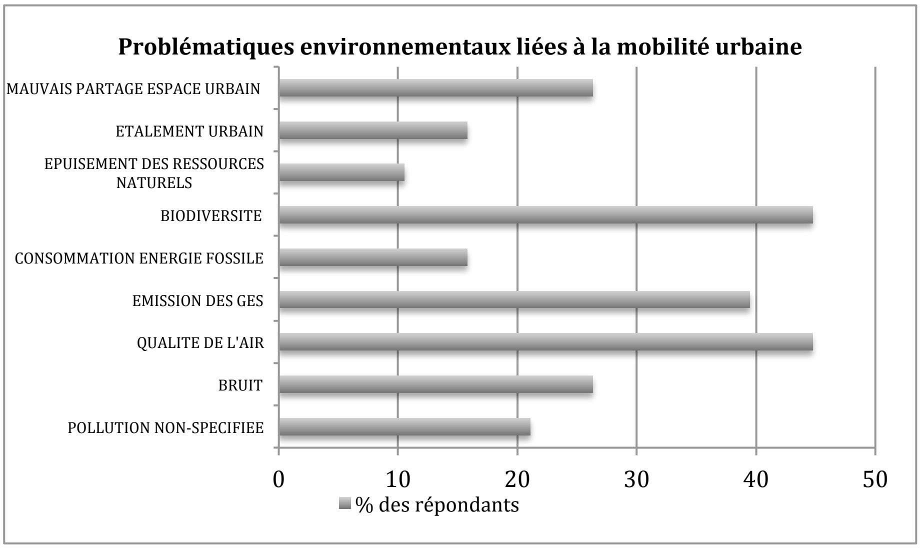
Questionnaire interdisciplinaire
Dans le cadre d'un atelier interformation entre neuf établissements universitaires et organisé par l'Institut de la Ville à Toulouse un questionnaire a été réalisé. 39 étudiants ont répondu à des questions sur les problématiques environnementales de l'urbain suivantes :

TABLE 1 : Problématiques environnementales évoquées dans le questionnaire

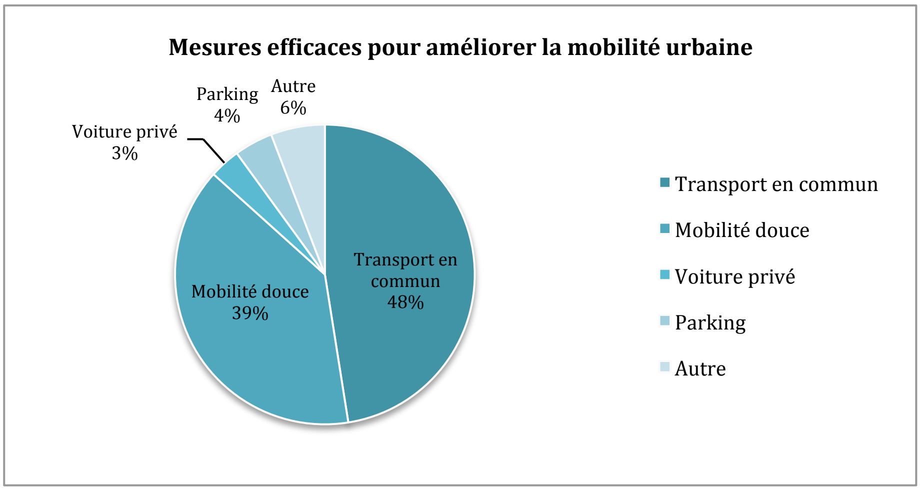
Ilot de chaleur urbain	Impacts environnementaux des transports et mobilité
Étalement urbain	Biodiversité et richesse écologique
Consommations énergétiques des bâtiments	Consommations énergétiques des villes
Gestion des eaux pluviales	Gestions des déchets
Épuisement des ressources naturelles	Qualité de l'air
Émissions des gaz à effet de serre	Nuisances sonores
Production, distribution et stockage d'énergies renouvelables	

Par ailleurs, il a été demandé aux étudiants de citer des problématiques environnementales liées à la mobilité urbaine, ainsi que des dispositifs possibles pour améliorer la mobilité urbaine.

Résultats
Les étudiants ont estimé d'avoir un assez bon niveau de connaissance des problématiques environnementales, surtout sur les impacts environnementaux de la mobilité, l'étalement urbain et la consommation énergétique des bâtiments. Concernant la mobilité, les résultats confirment que les étudiants ont cité les majeures problématiques environnementales liées à la mobilité (graphe 1). Concernant les dispositifs urbains pour améliorer la mobilité urbaine (graphe 2) les étudiants ont pour la plupart évoqué des éléments dits « positifs » comme les pistes cyclables, l'amélioration de la sécurité des cyclistes et une extension et une amélioration du système des transports en commun. Ces réponses sont tout à fait correctes. Cependant il est intéressant de noter que très peu des répondants ont mis en avant des solutions dites « négatives » qui tournent autour des restrictions de l'usage des voitures privées tel que la limitation du nombre de stationnement, les régulations fiscales, etc. Seulement quatre personnes ont proposées des dispositifs restrictifs. Il faut se demander si ce résultat est lié à un manque de connaissances parmi les étudiants sur l'efficacité des solutions « négatives » ou si cela est plutôt lié à une volonté de ne pas mettre en place ce genre de dispositifs. Les étudiants avaient des cursus universitaires très variés, de l'ingénierie aux Beaux Arts, ce qui peu expliquer ce résultat. Cependant leur niveau de connaissance totale sur des aspects de la mobilité urbaine laisse croire qu'il s'agit plus d'une réticence vis à vis des dispositifs négatifs qu'un manque de connaissances.



GRAPHE 1 : Répartition des réponses concernant des problématiques environnementales liées à la mobilité urbaine



GRAPHE 2 : Répartition des réponses sur des améliorations de la mobilité urbaine

Ce questionnaire est une première ébauche pour faire un état des lieux des connaissances et pratiques des professionnels sur le sujet de la mobilité urbaine, et peut être un indicateur des connaissances et opinions des professionnels.

La thèse se place à l'interface entre différents domaines tels que la mobilité, le bâtiment, l'urbanisme et l'analyse de modèles urbains. En les croisant nous espérons de savoir plus sur les connections entre les variables et les facteurs qui impactent les consommations énergétiques et les émissions de GES des villes liées à la mobilité, et comment exploiter leur interdépendances afin de réduire les conséquences environnementales.

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REDUCING GREENHOUSE GAS EMISSIONS FROM URBAN MOBILITY:

CHANGING TRAVEL BEHAVIOURS THROUGH AN INFORMED DESIGN PROCESS

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ABSTRACT: Reducing greenhouse gas-emissions from urban mobility is essential in limiting global warming. Changing mobility behaviour towards active mobility and public transport can contribute to this. The strategy currently explored is the influence of the built environment of a neighbourhood on choice of mobility mode, and is related to the reciprocal relationship between land use and travel behaviour. How should a neighbourhood be designed in order to encourage active mobility and public transport use? Research has identified effective measures. However, the gap between research and practice limits the use of scientific evidence in an urban design process, despite its importance to achieve mitigating objectives. A better understanding of design practices, and how mobility is solved in a design process, might improve and increase knowledge transfer. A series of design workshops with urban designers gave initial insight into these elements, and provided examples of the potentially important role mobility holds in a design process. They also indicate that professionals have knowledge and experience of potential value for research, and that a constructive dialogue should be established between research and practice.
Keywords: built environment, active mobility, urban design, reducing greenhouse gas-emissions, design processes

INTRODUCTION

Mobility is essential for a city's well-being and well-functioning. It provides access to education and economical opportunities, it enables new markets and innovation to occur, and it allows people to connect for personal and professional reasons (Ascher 1995; Givoni and Banister 2013; Glaeser 2012; Jacobs 1961). Most people are mobile in some fashion throughout a day, and expect the liberty to move around freely and simply. However, the environmental consequences of urban mobility are multiple, with greenhouse gas emissions (GHG-emissions) being the most pressing matter. Globally transport and mobility are among the major sources for GHG-emissions (Givoni & Banister 2013; IPCC 2014). In the European Union alone, transport and mobility make up 25% of total CO_2-emissions. It is the only sector with rising emissions, and a large part of this comes from cities (European Commission 2016).

Many strategies are being explored in order to reduce emissions. Two stand out in particular: a 'technological fix', and a 'planning fix'. The technological fix aims at lowering vehicles' fuel consumption and thereby the resulting GHG-emissions. However, increasing mobility demands are largely cancelling out the gains, keeping emissions rising (Tennøy 2012). The planning fix builds on the reciprocal relationship between land use and travel behaviour. Reducing travel distances and needs reduces GHG-emissions from mobility. Centrality and high density are shown to be important factors in achieving this (Aguiléra et al. 2004; Christiansen & Julsrud 2014; Ewing & Cervero 2001; Næss & Vogel 2012 ; Tennøy 2012). Such measures have to a large extent been effective, and several cities are adopting 'integrated land use and transportation planning'-approaches. But mobility numbers keep increasing, in part because of the nature of a city as a place of constant evolution (Montgomery 2013; UN Habitat 2013). New activities and jobs are created, and lifestyles change rapidly as new trends occur. As a result, mobility patterns evolve, and mobility needs today can be obsolete tomorrow. On top of this, people's travel preferences vary; what is perceived as practical for some might be considered a hassle by others. It seems there will always be mobility needs and desires that cannot be planned or built away. A higher use of environmentally friendly travel modes might therefore be another, complimentary strategy to explore.

This article presents initial findings from an on-going thesis that investigates how to increase the use of active mobility (walking, biking, etc.) and public transport[1] through the design of the built environment[2] at the neighbourhood scale. Per today these are largely the

[1] Assuming it runs on zero- or low-emission fuels, and has a high level of occupancy.

[2] The built environment at the neighbourhood scale signifies the physical structures that surround the urban inhabitant such as streets, pavements, buildings, public plazas, the urban form, etc.

most sustainable means of travel (Givoni & Banister 2013). Research has shown that the relationship between land use and travel behaviour extends to the scale of the neighbourhood, and recent years have seen a growing body of knowledge regarding how its design can influence walking or biking as primary travel modes (Ewing & Handy 2009; Gehl 2010; Speck 2013; Steffansdottir 2014). However, it is uncertain to what extent this knowledge is employed in urban design practices. Several studies conclude that evidence from climate research is little applied in urban planning and design, despite being essential for climate adaptation and mitigation (Bonhomme 2013; Dubois 2014; Eliasson 2000; Tennøy et al. 2015). It seems likely that a similar discontinuity exists regarding the topic of neighbourhood design and urban mobility behaviour. The designers are the ones to implement the scientific evidence, but it is science that communicates it. Gaining insight into the practices and knowledge of urban designers might improve this communication, and thus the transfer of knowledge from research to practice. The aim of this thesis is to strengthen the influence of a neighbourhood's built environment on its inhabitants' choice of travel modes by expanding the use of scientific evidence in the urban design process.

The current phase of the thesis focuses on two questions: i) How does the scientific evidence relate to the knowledge and practices of urban designers; and ii) How do urban professionals regard mobility within a design process. These questions are being explored through various enquiries of urban designers, combined with an extensive literature review. The findings presented here are from a series of workshops where urban designers undertook a hypothetical design situation. A brief description of the literature is given, followed by the methodology for the workshops and their analyses, and the results from the analyses. These are then discussed in light of the research problematic and the scientific knowledge. The article concludes on further perspectives and questions that these findings have lead to.

THEORETICAL FRAMEWORK

For literature on the relationship between the built environment of a neighbourhood and mobility behaviour, a differentiation must be made between planning literature and research-based literature. Although planning literature builds upon years of professional experience, it tends to lack empiric documentation. The planned literary review therefore centres on scientific studies. Some general observations can be made regarding physical features of a neighbourhood that appear to be of particular importance. These are primarily based on works by Ewing and Cervero (2001), Lynch (1960), Saelens and Handy (2008), and Steffansdottir (2014).

- Short walking distances. For distances to for instance to transit stop 300m and 500m are often used as maximum.
- Street connectivity (many possible routes in an urban structure).
- Presence of sidewalks (largely linked to pedestrian safety).
- Presence of bike lanes/bike infrastructure.
- Limiting on side parking.

Ewing and Handy explored the influence of perceptions created by urban design qualities might have on walking behaviour. "Urban design is not simply a function of population density and land-use mix" (Ewing & Handy 2009). Physical features influence mobility behaviour directly (e.g. how it allows inhabitants to move around) and through the individual's perceptions of the street environment (ibid). The latter are of a more qualitative nature. Five perceptual qualities appear to produce high quality walking environments were identified: imageability[3], enclosure[4], human scale[5], transparency[6], and complexity[7]. A common factor is how they contribute to orienting oneself in a neighbourhood.

METHODOLOGY

Workshops with urban designers were held in May and June 2015 in Toulouse, France, as a part of the research project CapaCity. The workshops had a total of 16 participants, and focused on climate adaptation through urban development. CapaCity aims to develop a design-aid tool to help urban designers improve the adaptive performance of their projects with regards to climate change. The thesis is written in parallel to the project, and its results will be implemented in the prototype tool. An essential aspect of CapaCity is to create a tool that responds to the actual needs and requests of urban designers. The initial phases therefore consisted of assessing the practices of urban designers, their use of and relation to expert knowledge, their sources for new

The following definitions are all from Ewing & Handy (2009):

[3] "The quality of a place that makes it distinct, recognizable, and memorable." Will for instance aid a person in finding their way in a city. First defined by Lynch (1960).

[4] "The degree to which streets and other public spaces are visually defined by…vertical elements", creating a "room-like feeling" in the public space.

[5] How the physical features of the built environment "match the propositions of humans", as well as human speed of walk.

[6] To what extent what lies beyond an edge of a street can be seen, particularly human activity.

[7] "The visual richness of a place", for instance type of buildings, activities, street furniture, etc.

knowledge, and their use of tools in the design process. During these sessions the designers were given the task of refurbishing a neighbourhood in Toulouse. In groups of 3-4 the designers had about two and a half hours to produce a (relatively with respects to time) detailed project proposal. Although a hypothetical design situation, the designers engaged fully in the task. Each group was filmed and recorded, and these were later transcribed in detail for analysis.

The analyses were done qualitatively with a theoretical framework based on decades of research on design practices. Certain topics were identified as particularly interesting, and to guide the analyses, a series of open questions were phrased within each of these in order to explore the transcriptions in depth. The workshops also provided an opportunity to explore the topic of mobility within the design process, and so complimentary analyses were done in the context of the thesis. A similar analysis approach was undertaken, establishing a series of open questions as a framework (see below). The aim was to explore how mobility is solved within an urban design project, and how the designers consider and regard mobility, especially in relation to other issues within a design problem. These questions permitted to identify overall tendencies, providing a beginning comprehension of how urban designers work with and solve the issue of mobility.

Questions for analysis

1. How is mobility solved in the design process?
    a. Is it given a high priority, or is it rather a consequence of other choices?
    b. How is it considered in relation to other issues and objectives in the project?
    c. How are design choices situated within the context of the city's mobility network?
    d. Do practitioners consider how their design might affect mobility behaviour (mode choice, etc.)?
2. Which design solutions are employed?

CASE PRESENTATION

The design situation was based on a current refurbishment project of a neighbourhood near the centre of Toulouse, which faces important challenges such as a high level of unemployment and drug sales. The development is part of the city's strategy to increase density. The site is 500m times 500m, and dwellings are to be increased from 100 to 400, with parking limited to 0,5 per dwelling (200 places). A centre is being developed around a nearby metro station. The client therefore did not want a mixed use-development. The program also focused on climate adaptation, in particular the Urban Heat Island-effect and water management.

RESULTS

i) Mobility within the design process

A holistic approach to the design problem

An improved life-context for the urban inhabitant is an essential aspect of the design process, and can be seen as the 'global objective' for urban designers (Gehl 2010). Such an objective was observed during the workshops. Potential measures were constantly evaluated towards its achievement. This shows a 'holistic approach' to the design problem: an overall, wholesome view of the projects, and its many facets. The designers displayed knowledge and understanding of interdependencies between the different elements in an urban development project. How the elements' interactions could affect the overall outcome was taken into account at all times. This also applied to the topic of mobility. It was often addressed separately, but always seen as closely related to and influential upon other issues. A win-win-approach was often observed, where one solution would solve a multitude of issues, and this applied in particular to mobility. For instance, certain urban qualities were expressed as important in relation to mobility solutions: *porosity, transparency, visibility, and openness*. These qualities were also said to be important for creating a "neighbourhood feeling", essential for a good life-context according to the designers.

Mobility was evoked at an early stage of the design process

A design process typically starts with a combination of a site-analysis and a discussion of conceptual solutions, through which the designers explore the problem in a bigger context, and identify potential opportunities and challenges for their future design proposal (Darke 1979; Kirkeby 2012; Lawson 2006). Mobility within the site was an important issue during this first design phase. The designers located main axes for circulation, studied how the circulation flowed within the existing structures, identified existing and potential connections to surrounding sites, nearby transit stops, and so on. In line with with the holistic approach described above, challenges regarding mobility were often related to other issues such as lack of social cohesion (e.g. an isolated site with few internal meeting points) and the inhabitants' sense of lack of security (e.g. little frequented streets, lack of sidewalks).

Mobility had a structuring role

Mobility needs and functions presented the designers with constraints they had to respect, such as access for emergency vehicles, and the number of parking places demanded by the client. At the same time, mobility was also used as a constructive element in the process. The frequent choice of prioritizing pedestrians and cyclists, leaving cars at the entrance of the site, established important premises for the subsequent phases as it both eliminated and created certain mobility requirements.

For instance, it allowed the designers to allocate more space to public places, as on-side parking was not needed. In this case, the urban form was much determined by how mobility was organized. Additionally, the main axes for circulation established the initial structure of the site. A secondary layer of streets and smaller paths gave the site further form, although at this point possible orientation of future buildings was also considered.

Mobility considered within the context of the site

The designers focused on the circulation within the project site, and existing and potential connections to surrounding neighbourhoods. The potential to influence the inhabitants' mobility behaviour when travelling outside of the site was not much debated, nor did the teams situate their project within the mobility network of Toulouse. Only one group discussed creating an easy and inviting access to the nearby metro station and bus stops in order to encourage the use of transit.

ii) Design solutions to the identified challenges

In addition to the identified urban qualities, concrete objectives were established. The main goal was to improve mobility conditions for the residents, and that of surrounding inhabitants, by making the site more inviting to cross by foot or bike, for instance to reach the nearby metro station. In line with the holistic approach described previously, these objectives were also linked to other issues of the design problem, in particular issues of social nature. In general the teams concluded that the site was isolated and enclosed. Two major traffic arteries contributed to this by creating important barriers between the site and other neighbourhoods. The decision to prioritize pedestrians and bicycles was possible since the site was viewed as small enough to be crossed by foot. To strengthen this the designers actively aimed at establishing an intricate street network to reduce distances. Interestingly the teams employed much the same measures and solutions regarding mobility. The following table is a summary of general mobility solutions.

Table 1: Mobility objectives and solutions

Objectives (O) and solutions (S) regarding mobility	
O1	• Open up the site and create connections to surrounding neighbourhoods. • Make non-inhabitants want to enter the site, for instance on the way to transit stops.
S1	• Pay attention to the edges of the site, create a proper and inviting 'urban façade'. • Avoid continuous building facades along these limits for easy access to the site.
O2	• Prioritize pedestrians and bicyclers. • An intricate network allowing pedestrians and bikers to choose different routes.
S2	• Publicly accessible paths between buildings to encourage and facilitate walking and biking, thus shortening distances. • Avoid big building lots (long, continuous facades) in order to reduce walking distances. • Create inviting and safe streets. • Place community gardens and dwellings along streets with car-traffic in order to calm speed, and to avoid an image of a 'transportation-ore'. • Collective parking to reduce consumption of space. • Use of vegetation to protect pedestrians from sun and rain (done primarily to protect buildings, identified as a positive 'side-effect' for pedestrians).

DISCUSSION

The workshops gathered a small sample of urban designers, and they were observed in a hypothetical design situation. Generalizations regarding urban design practices and mobility are therefore difficult to make. However these workshops give one example of the role mobility holds in an urban design process, and provides initial insight to how urban practitioners perceive and solve mobility.

A design process is structured by elements identified as *internal* and *external constraints* (Lawson 2006). External constraints correspond the context of the project (physical, social, cultural, etc.). The designer is relatively free to decide which ones to consider, and new ones can be established. Internal constraints are primarily the program and the client's objectives, and are imposed (ibid). During the observed design processes mobility was both an internal and external constraints. Mobility choices steered the project in a certain direction, thereby determining how other issues would be solved. Prioritizing pedestrians and cyclists, and limiting cars, is an example of an external constraint the designers established early on. The number of parking places and the non-wish for mixed use were internal constraints. According to the literature, certain parking solutions are important factors to increase active mobility. It is not clear at this point of the investigation however which solutions (e.g. on side, collective, or no parking) are most effective, but limited parking will be an influential measure. For the workshops this was demanded in the program, showing the importance of imposed premises for the environmental profile a project. On a different note, collective parking solutions at the site's entrances appeared to be done in order to strengthen the pedestrian and cycling nature of the neighbourhood. This shows how the designers used mobility solutions to improve liveability. That their choices often were in line with research knowledge is an interesting note.

However, reducing car-use within the neighbourhood was seldom expressed as an environmental measure. Rather it was done to improve the inhabitants' life-context, in part through the design qualities related to a walking- and bike-friendly neighbourhood. Mobility's role in achieving the 'global objective' of urban designers, underline its importance in a design project.

The objectives of the client can be contrary to scientific knowledge, which the lack of mixed use is an example of. Research has found that mixed use promotes walking and biking. In this case the client wanted only dwellings, and the designers complied with this, despite expressing professional experience of mixed use's importance for a liveable neighbourhood. This is an example of conflicting interests in a design process. It also shows the need to increase designers' use of scientific evidence, as adding it to their arguments might have been enough to convince the client. It is possible they had such knowledge, but it was not mentioned. As it was, their arguments remained 'just' professional knowledge. Studies have found that in situations as this one the knowledge of professionals is easily ousted (Tennøy 2012). Enhancing the knowledge and use of scientific evidence might contribute to strengthen the influence of the professional knowledge.

Mobility appeared to be considered an essential aspect of a neighbourhood's well-functioning. In the light of this, the lack of discussion of the neighbourhood's role in the mobility network of Toulouse becomes even more noticeable. If mobility is important within a neighbourhood, it would seem important at the scale of the city as well. It is difficult to make any to conclusions as to why the designers did not evoke this aspect. One explanation might be the limited time that pushed them to focus mainly on the site itself.

The urban practitioners showed knowledge of how to achieve certain mobility behaviour through the design of a neighbourhood. They used physical structures to organize mobility and solve related issues, which seems to support the notion that a reciprocal relationship between land use and travel behaviour can be found at the neighbourhood level. An example is the paths between buildings that were implemented to facilitate walking. This particular solution contributed to a high level of street connectivity and reduced walking distances, measures held up by research as important to increase walking and biking. Indeed several design solutions corresponded to some extent to the scientific evidence as explored in the theoretical framework. These observations indicate a potential within the professional knowledge and experience of urban designers that should be pursued further. One aspect to explore is how the designers perceive mobility in relations to other issues and problems. In order to implement new solutions, research needs a better understanding of the connections between different issues as seen by the designers. Studying the applied solutions from the workshops, as well as other examples of mobility solutions, might be a way to gain such insight.

FURTHER PERSPECTIVES

The thesis explores the design of the built environment as a strategy to modify travel behaviours towards less GHG-emissions from urban mobility. An understanding of the practices and principles of urban designers, particularly regarding mobility, were regarded as important in this context. The observations from the workshops have strengthened this position. Through them new questions and paths to pursue have emerged.

The displayed understanding of the relationship between the built environment of a neighbourhood and the mobility behaviour of its inhabitants should be further investigated. The professional knowledge of urban designers might provide a different insight to this relationship. There are common points between research and practice, and urban designers possess experience and knowledge that could be of value for research. At the same time the results underlined the need to increase the use of scientific knowledge in the design process. Establishing a dialogue between research and practice, rather than the traditional top-down approach, is an interesting direction to take. This could provide a double translation of knowledge: research can translate climate adaptation and mitigation to the urban context, and explain the potential influence urban design can have through the built environment; urban designers can translate the complexity of the city and its qualitative and social aspects to research. This is an important aspect of the design process that research must take in to account when communicating new knowledge and solutions.

Based on the workshops, and on other findings from the thesis, an approach for further investigations has been established. In order to go deeper in detail of design practices and design knowledge, an extensive survey is planned, and hopefully it will be conducted in Québec (Canada), Toulouse (France), and Oslo (Norway). The survey will confront designers with the observations from the workshops, and with evidence from research. The potential impact of the built environment on mobility behaviour, and to what extent this is a part of design objectives will also be evoked through the survey. The survey will be completed with a series of interviews with practitioners. In parallel, an extensive literary review of the existing research on the relationship between urban mobility behaviour and the built environment has been undertaken. Confronting the knowledge and opinions of designers with scientific findings will hopefully provide new insights; on how to implement research in the design process, but also on how the built environment influences mobility behaviour. By doing so, research and practice might strengthen their strategies to encourage and facilitate the use of walking, biking, and other low- or zero-emission mobility modes.

ACKNOWLEDGEMENTS

This thesis is conducted through the research-project CapaCity: from Knowledge to Action for a Proactive Adaptation of Cities, which is supported by ADEME, the French Environment & Energy Management Agency.

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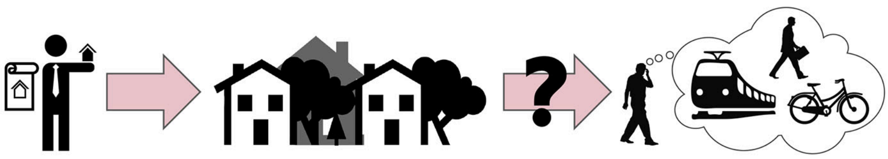
plea 2016
Los Angeles, July 11-13

Reducing Greenhouse Gas Emissions from Urban Mobility: Changing Travel Behaviour Through an Informed Design Process

Context: Exploring the relationship between travel behaviour and neighbourhood design

How can the design of a neighbourhood encourage modes of sustainable mobility?



Using the practices and insights of urban design professionals to expand on the existing research, we explore the reciprocal relationship between the built environment and travel behaviour at the neighbourhood level. However, there is an important gap between research and practice.

CapaCity, a French research project, investigated the knowledge of urban professionals and the use of scientific research in their design practices through a series of workshops. CapaCity's aim is to strengthen knowledge-transfer between research and practice. These workshops also generated insights into:

i) How urban professionals consider and solve mobility within a design process

ii) How the scientific evidence relates to their knowledge and practices

Design workshops to observe practitioners in action

Two half-days, 18 participants

A hypothetical design project

Observation of methods, approaches, use of knowledge

Qualitative analysis of recordings and findings

Additional analysis focusing on mobility and design practices

Two cohorts of Architects, Urban Designers and Planners, all without explicit mobility expertise, participated in workshops focusing on climate adaptation.

On-going urban renewal in Toulouse provided a case study that allowed CapaCity to observe design practices and the application of scientific knowledge in a design process.

Mobility objectives and solutions

Open the site to its surrounding context, and invite non-inhabitants to cross the site to get to transit stops

- Establish visual and physical connections
- Create a proper and inviting urban façade
- Improve the public image of the neighbourhood

Prioritize pedestrians and cyclists

Reduce distances

- An intricate network allowing different routes
- Publicly accessible paths between buildings
- Avoid big, closed-off building lots
- Avoid continuous building facades for easy site access

Enhance the feeling of safety

- Create inviting streets and public places
- Place community gardens and dwellings along streets with car-traffic in order to calm speed
- Collective parking at the site's entrances to reduce internal driving

- The designers recognized interdependencies between elements, and constantly considered how mobility solutions might affect the overall project.
- Several design solutions corresponded to the literature, but were rarely identified as such.
- Mobility was seen as an independent objective and as a means to enhance liveability in a holistic approach to the design problem.

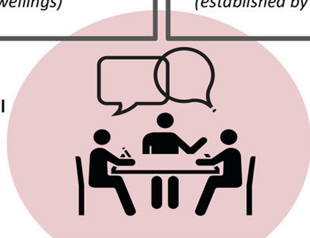
Mobility within the design process

According to the literature, *internal* and *external constraints* are elements that structure a design process and provide a design framework. In addition, the designer's skills – their *savoir-faire* – play an important role in the direction a project takes, and the final decisions they make.

Internal Constraints
- Imposed, primarily from the client's demands and objectives.
- *I.e. restricted number of parking places (0,5 per dwelling for 400 dwellings)*

External Constraints
- The project's context (physical, social, cultural, etc.)
- Established through specific design choices
- *I.e. prioritizing pedestrians, reducing car use (established by the designers)*

Mobility was both an internal and an external constraint



Mobility provided initial structure to the site and guided the process.

The Designers' *Savoir-Faire*
- The sum of previous experiences, acquired knowledge, values, beliefs, and design principles
- The designers' primary source of knowledge and potential solutions, their "intellectual luggage" (Lawson, 2006)
- *I.e. encouraging people to cross the site in order to increase metro use by enhancing the percieved safety; enhancing internal circulation to strengthen social cohesion*

Conclusion: Urban design professionals hold valuable insight and knowledge to be further explored

- The designers seemingly knew how to use both physical and qualitative measures to encourage particular modes of mobility (i.e. walking)
- They utilized their existing knowledge and land use strategies to affect mobility on a neighbourhood scale.
- This indicates that the reciprocal relationship between land use and travel behaviour at the neighbourhood level can be a strategy for changing mobility behaviours

- Further exploring designers' *savoir-faire* might enhance our understanding of people's mobility behaviour at the neighbourhood level, thus strengthening the effect of measures and solutions. Surveys and interviews are on-going.
- The findings underline the importance of a dialogue between practice and research in order to facilitate a two-way knowledge transfer. Better insights into design practices will also be a step towards this.

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3. Passive and Low Energy Architecture (PLEA) 2017, Edinburgh, Scotland

PLEA *2017* EDINBURGH
Design to Thrive

Towards an integrated urban design approach for a sustainable modal shift: Presenting insight from design practices

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Abstract: Reducing greenhouse gas emissions from urban mobility are a major challenge for cities, in part because of its importance for everyday life. Promoting sustainable modes through neighbourhood design is an interesting strategy. However, uncertainties in the scientific evidence on neighbourhood-built environment and modal choices complicate its use in design practices. Disparities between research and practice further hinder knowledge-transfer. The experience-based knowledge of urban design professionals could be a source for new insights; preliminary investigations gave promising results. Further investigations included surveys and interviews in Norway and France. Survey-elements are presented here, compared in part to current scientific evidence. Results from these investigations, in combination with scientific literature, provide the basis for a framework for an integrated urban design approach. Linking modal choices to urban design qualities, it weaves together evidence-based and experience-based knowledge for a holistic approach; a step strengthening mitigating efforts upon urban mobility.

Keywords: Urban design, Modal choice, Experience-based knowledge, Urban mobility, Mitigation

Introduction

Urban mobility represents a multifaceted problem for cities. It is essential for a city to function (Ascher, 1995; UN Habitat, 2013), but produces greenhouse gas emissions (GHG-emissions) that leads to global warming and climate change (IPCC, 2014; New Climate Economy, 2014). Reducing mobility-related emissions (mitigation) calls for a variety of approaches, and for interdisciplinary collaborations. One strategy is to promote a sustainable modal shift towards zero- and low emission mobility modes[1] (New Climate Economy, 2014). An on-going doctoral thesis (Rynning, foreseen 2017) explores how to achieve such a modal shift through urban development at the neighbourhood scale (i.e. urban design), by combining experience-based knowledge (from practice) and evidence-based knowledge (from research).

There is a reciprocal relationship between the urban built environment and mobility behaviours (Næss, 2006). How a city is planned and designed influences how people move around in it, and vice versa. Consequently, integrated land-use and transport planning is an important mitigation strategy at the city scale (Tennøy, 2012). At the neighbourhood scale however, a similar approach appears less explored. One explanation is a significant knowledge-gap in literature regarding the neighbourhood-built environment and modal

[1] Per today these include primarily walking, cycling, and public transport (assuming it runs on low- or zero-emission fuels, and has a high level of occupancy) (New Climate Economy, 2014).

choices (Krizek et al., 2009; Næss, 2012); making it difficult to provide urban designers with concrete knowledge on how to promote sustainable mobility modes through urban development (Krizek et al., 2009). More insight is necessary, perhaps from exploring other sources. Furthermore, disparities between research and design-practice often complicate the use of scientific knowledge in development projects (Eliasson, 2000; Dubois, 2014). A reinforced dialogue between research and practice is needed in order to strengthen interdisciplinary co-operations and reciprocal knowledge-transfer (Rynning, 2016).

This paper explores the knowledge and experience of urban design practitioners for new insights into the reciprocal relationship between neighbourhood-built environment and modal choices. Preliminary investigations through a series of workshops implied that mobility has a central role in a development project (Rynning, 2016); integral to assure good living contexts for urban dwellers (ibid). To further explore, surveys and interviews were conducted with urban practitioners in France and in Norway. This article focuses on survey-findings, compared to previous findings and to relevant scientific evidence. These enquiries also provide an improved understanding of the methods and practices of urban design professionals; insights which can enhance reciprocal knowledge exchange research-practice – key to reinforcing adaptation and mitigation efforts through urban development (Eliasson, 2000; Tennøy, 2012; Dubois, 2014).

Theoretical framework: The built environment and mobility behaviour

Mobility behaviours are influenced by contexts (physical, built environment, social, cultural, economical, etc.), and by personal preferences and capacities (Næss, 2006; Krizek et al., 2009). It tends to be highly different from one person to another, though common traits can be found for segments of a population, for instance age-groups (children, elderly, etc.) (Bull and Bauman, 2007). Krizek and Forsyth (2009a) found presence of pedestrian infrastructure to be critical for elderly's decision to walk, while able-bodied adults relied less upon this. Similar tendencies were found regarding experienced and inexperienced cyclists and the presence of cycling infrastructure (ibid). Neighbourhood-built environment is particularly important for walking and cycling (Saelens and Handy, 2008; Krizek et al., 2009). By correlation, it influences transit use as well, as people mostly walk or cycle to and from transit stops (Mees, 2010). Several built environment elements have been found to influence modal use at the neighbourhood scale, for instance sidewalk width, number of intersections, and view-lines. (Alfonzo, 2005; Ewing et al., 2016). However, which factors influence the most remains unclear (Krizek et al., 2009). In part, because people's experience and perception of a built environment depends on context, physical as well as social and personal (Cho and Rodriguez, 2015). Based on these findings, a holistic strategy might be more beneficial, directing the focus towards the kinds of urban environments or scapes a combination of factors and elements create. One example are streetscapes – the space between buildings (Gehl, 2010; Ewing et al., 2016). Different built environments can be perceived as more or less welcoming for walking and cycling, thereby encouraging or discouraging their use (Stefansdottir, 2014). Three built environment-components have been identified as particularly influential upon modal choices: *Destination* (location of a trip's objective), *Availability* (if a mode is compatible with a trip), and *Annoyance* (barriers for using a particular modal choice). They are interdependent, and the built environment's influence on a modal choice is the sum of all three. Together they form a holistic framework, linking modal choices to urban environments, scapes, and to qualities. Such a framework can render scientific evidence more relatable and useable for urban design practitioners.

Urban qualities such as human scale, legibility, and connectivity, are often expressed by urban practitioners as particularly important for creating good, urban living contexts (Gehl, 2010; Rynning, 2016). Through the holistic framework, they can be linked to a potential influence upon modal choices as well. This can strengthen urban design as a strategy to promote a sustainable modal shift in order to curb mobility-related GHG-emissions.

Method: Interview and survey design

Studies have shown that workshops, interviews, and surveys are particularly interesting for exploring the experience-based, often tacit, knowledge of design professionals (Schön, 1983; Lawson, 1993; Skogheim, 2008; Dubois, 2014; Kirkeby, 2015). In the context of the doctoral thesis all three have been employed; the focus here in on the survey results. The workshops, a simulated design situation, served as a case study of urban design practices, and provided initial insights (Rynning, 2016). Through the survey, workshop observations regarding mobility in a design process were pursued in a more quantitative manner. It also enquired how practitioners relate urban qualities to modal choices, based on findings from the literature (see above). The targeted respondents were primarily professionals with an education within Architecture, Landscape Architecture, Urban Planning or Design. The survey was held in Norway and France, from November 2016 to January 2017, using SurveyMonkey. Respondents were recruited via social media forums for professionals, and through personal invitations. The analysis comprised both qualitative and quantitative methods. The questions were all close-ended, asking respondents to rate the influence of an element, or to what extent they agreed to statements (four grades, no neutral). A rating average was calculated with coefficients, e.g. 2 = strongly agree, 1 = agree, -1 = agree to some extent, -2 = disagree. The results are presented in the tables below, total rating average for Norway and France combined.

Results

A total of 112 practitioners commenced the survey and 71 (63,4%) completed it, of which 67 (59,8%) provided information about their practice. The majority of Norwegian respondents had 10-20 years of experience (15 of 31), none more than 30 years. Most of the French respondents had 0-5 years of experience (15 of 36), the rest were quite evenly spread between 5 to 30 years of experience. The respondents were also asked about educational background, for which several choices were possible, as this tends to vary for urban practitioners. Architecture (39 of 67) was the most common education, followed by Urbanism (26 of 67), Planning (17 of 67), and finally Landscape Architecture (10 of 67). A few had other backgrounds, for instance Sociology (2 of 67), Geography (2 of 67), or Engineering (2 of 67). The most common combination was Architecture and Urbanism (17 of 67).

Mobility in an urban design process

This part primarily tested the workshop observations. The vast majority of the respondents (101 of 109) consider the daily mobility of inhabitants in a project. Some only in the site analysis, but most implement measures and solutions directed towards daily mobility (25 versus 72 of 97). The survey asked what considering daily mobility in the site analysis contributes to (Table 1), likewise for the implementation of mobility solutions and measures (Table 2). Exploring elements that influence the choice of mobility solutions and measures, respondents were asked to choose the three most influential from a list of suggestions (Table 3).

Considering mobility in the site analysis contributes to (87 responses)	Analysis (19 resp)	Analysis+Solution/Measure (66 responses)
1. Link the project to the urban context	1,63	1,52
2. Understand the inhabitants' use of the neighbourhood	1,47	1,69
3. Identify challenges and issues beyond project description	1,37	1,37
4. Establish an idea, a concept	0,79	0,90

Table 1 What mobility in the site analysis contributes to, ranked score (min. -2, max. +2)

Implementing mobility solutions/measures in a project contributes to	
1. Facilitate walking and cycling	1,66
2. Facilitate the use of public transport	1,52
3. Link the project to the urban context	1,44
4. Introduce measures to reduce the inhabitants' use of cars	1,39
5. Structure/shape the neighbourhood	1,38
6. Create an identity to reinforce the inhabitants' sense of belonging to the neighbourhood	0,86
7. Establish an idea, a concept	0,73

Table 2 What implementing solutions/measures contributes to, ranked score (min. -2, max. +2)

Elements that influence choice of mobility solutions/measures (%)	
1. Existing and potential access to area (street network, access to public transport, active mobility infrastructure, etc.)	81,0
2. Existing structure, urban fabric and form	55,6
3. The program (mixed use, dwelling density, parking solutions, public space, etc.)	50,8
4. The physical context (local climate, vegetation, topography, etc.)	39,7
5. The client's objectives for daily mobility (facilitate public transport, reduce n° parking spaces, space for various modes, etc.)	33,3
6. Society's targets of reducing traffic volume growth	28,6
7. The economical, social, and cultural context	14,3

Table 3 What implementing solutions/measures contributes to, ranked score (min. -2, max. +2)

The survey confirmed that mobility has a central and structuring role in an urban design process, as was seen during the workshops. According to the respondents, in a site analysis mobility contributes to link a project to its urban context. It provides an understanding of both context and site, and a broader comprehension of the project. Implementing solutions and measures is understandably done to act upon mobility, but also aids the practitioner in establishing a relation between a neighbourhood and its urban context. Examples of this were observed in the workshops, where participants used pedestrian infrastructures to interrupt existing barriers (e.g. a large road) between a project site and its surroundings. Survey respondents further reported that mobility solutions and measures contribute directly to the design of a neighbourhood, for example its shape and structure. Similarly, in the workshops prioritising pedestrians had important influence upon the street network. Elements that influence choice of solutions and measures appear in line with the role accorded to mobility in a design process. Context, in a broad sense, influence choice of solutions and measures the most, in particular immediate and surrounding context (1., 2., 4., Table 3). This is in line with findings from literature. The influence of built environment elements on modal choice depends on urban and physical context. This also shows the importance of existing context for urban practitioners' design actions, especially mobility structures and systems. The program and the client's objectives are also reported as having some influence (3., 5., Table 3), indicating the importance of such constraints for promoting or limiting mobility modes through urban design. Finally, mobility solutions and measures were said to contribute somewhat to creating an identity for a neighbourhood. This might be related to the design of public places. In the workshops, good public places with a clear usage were said to encourage pedestrian activity within a neighbourhood, important to establish social cohesion through encounters among inhabitants. Vice versa, prioritizing pedestrian and cycling activity was a means to ensure good public space, illustrating thus the reciprocal relationship mobility/built environment design.

Built environment and modal choices

Respondents were asked to rate the influence of the urban qualities in Table 4 on the use of mobility modes. These are urban qualities often related to the quality of living contexts (Carmona, 2010; Gehl, 2010).

URBAN QUALITIES AND MODAL CHOICE (68 responses)	**Walking**	**Cycling**	**Public transport**
1. Connectivity - Connections between streets, pedestrian networks, etc. within and/or between several neighbourhoods	1,79	1,62	0,49
2. Legibility - How easily one can recognize and understand a neighbourhood, for instance to orient one-self	1,76	1,22	-0,01
3. Human scale - Dimension of built environments relative to human dimensions (e.g. street width, block size)	1,63	0,54	-0,62
4. Enclosure - To what extent buildings and other elements define and shape spaces	1,53	0,44	-0,57
5. Transparence – The possibility to see what goes on at the end of a street and past it, e.g. human activity or particular buildings	1,26	0,50	-0,71
6. Complexity - How a rich variety of buildings and other elements create a diverse visual impression	0,85	0,21	-0,97
7. Coherence – To what extent the built environment creates an overall impression, e.g. through shapes or facades	0,72	0,12	-1,03

Table 4 Survey results regarding urban qualities and modal choices

Connectivity was reported as most influential for both walking and cycling, and for the use of public transport. This is likely related to the link between connectivity and distance. Studies have found that actual and perceived distance is important for modal choice, especially walking and cycling (Krizek et al., 2009). A high level of Connectivity can reduce the distance to cover by breaking up urban blocks. This can also increase the range of route choices for a trip, allowing a person to adapt a trip to their modal needs, for instance choosing a pedestrian-friendly route. Connectivity is to some extent related to *Human scale*, as a high level of Connectivity tends to produce smaller blocks divided by streets and paths. However, Human scale was reported as little influential upon transit use, so it is possible the respondents relate it more to the perception of a pedestrian-friendly environment. Connectivity is a result of the structure and shape of a neighbourhood. These are elements that according to the respondents, implementing mobility solutions and measures can contribute to. Moreover, Connectivity can assure connections between neighbourhoods, also related to the consideration of mobility in a design process. This illustrates the reciprocal relationship between mobility-related actions and objectives in a design process, and the multifaceted role of mobility in a design process. *Legibility* was also reported as influential for all three mobility modes, although most importantly for walking (-0,01 for transit use indicates an approx. 50/50 split on level of influence). It is particularly important for orienting one-self in an environment, for instance via sight lines that allows a person to easily see further ahead (Lynch, 1960). Legibility is related to Transparence and Connectivity. The level of the latter can influence sight lines and the possibility to see what goes on beyond a street (Transparence), which can contribute to reducing the experience of distance (Gehl, 2010). Transparence in itself was given less influence on modal choice then Connectivity and Legibility. This could indicate that for practitioners, actual distance (Connectivity) is more important then perceived, and that Legibility influences modal choice in ways that could be further pursued. Finally, *Complexity* and *Coherence* were said to be somewhat influential for walking, a bit less for cycling, and not much for transit use. These urban qualities are most likely more important for visual experiences and perceptions of a built environment, then for physical aspects such as distances. That they are given a lower level of influence is therefore understandable, although they are not entirely un-influential. The relationship between these qualities and other aspects of a neighbourhood, such as quality of public places, is an interesting aspect for future analyses.

Discussion

Mobility is integral to city life (Ascher, 1995; Gehl, 2010). It is therefore not surprising that it holds an important position in an urban design process. The surveys, combined with the previous workshops, provided further insight to this. Mobility has a multifaceted function in a design process; it influences and is influenced by design actions. Considering mobility in a design process was related to the overall, physical design of a neighbourhood, and to creating perceptual characteristics. It also contributes to identifying issues beyond a project description. Schön (1983) refers to this as a practitioner identifying what a problem "really is", and finding a way to properly "frame it", displaying an understanding of urban development projects as societal problems (Rittel and Webber, 1973). Through a city's many interdependencies, projects are influenced by and influence aspects beyond their limits. This was equally seen in the workshops, where a reported lack of social cohesion was an important issue. Interestingly, encouraging walking within the site was seen as a contributing remedy to this. Thus underlining the multiple functions of mobility for the quality of a neighbourhood as a living context. During the workshops mobility appeared to be seen as a function to resolve, and simultaneously as a means to achieve/resolve other objectives and issues. The results from the survey seem to confirm this observation, providing an interesting aspect for further developing the holistic framework (see above).

The survey results indicate a holistic approach to mobility in an urban design process, in line with findings from literature and observations from the workshops. According to planning literature, an improved living context for urban inhabitants is a common, 'global objective' (Madanipour, 2006; Carmona, 2010; Gehl, 2010). This was seen in the workshops, where participants displayed a holistic approach to the project at hand (Dubois et al., 2016). Every action or solution for a particular issue was evaluated iteratively in light of its potential effect on the totality of the project. Illustrating an understanding of the interdependencies and connections between elements of the built environment. Furthermore, win-win solutions were often employed, to resolve or to achieve several issues/objectives at once. For example when establishing urban qualities expressed as important for creating "a neighbourhood feeling", but also for promoting walking: *porosity, transparency, visibility,* and *openness* (Rynning, 2016). The survey responses similarly showed that mobility solutions and measures are implemented to act upon mobility, and to advance the design of a neighbourhood.

Combining responses on the role of mobility in a design process with urban qualities said to matter for modal choices, might indicate the kind of qualities or scapes practitioners aim for when implementing mobility solutions and measures. Integrated in to the holistic framework in progress, this could further the understanding of the relationship between the built environment and modal choices. The respondents related the suggested urban qualities more to walking and cycling then to transit use. However, as explained previously, walking is a part of most transit trips, and so by correlation these qualities should have a certain influence on transit use as well. In the suggested framework, Destination represents the influence of the built environment at the end of a trip. If that built environment does not support or invite to walking, it can contribute to a person choosing to drive rather then public transport, despite a sufficient transit offer (Mees, 2010). Promoting sustainable mobility behaviours therefore requires a holistic take on a trip, from beginning to end. As practitioners have a holistic approach to urban design projects, there are evident profits from integrating evidence-based and experience-based knowledge. As an example, combining the empirical findings with scientific evidence can contribute to render the connection neighbourhood urban qualities/transit use more apparent for practitioners, making them more aware of the potential influence of their design actions. Together, this could help address the 'last mile'-issue, an important barrier for transit use (UN Habitat, 2013).

Conclusions and future perspectives

Through the results from the empirical enquires so far, the experience-based knowledge of urban design practitioners has provided interesting insights in to the relationship between the built environment and mobility behaviours; insights complementary to that of research. The findings emphasize the importance of a holistic approach to urban development, and to the mitigation of mobility-related emissions. The experience-based knowledge contributes to situate mobility within the totality of an urban development project, linking it to the overall goal of an improved living context. Thereby contributing to identifying more efficient solutions and measures for promoting sustainable mobility modes, and to bridge current knowledge-gaps. The findings also show that urban design can be a strategy towards a sustainable modal shift. Mobility is integral in a city's functioning, and thus integral in people's way of urban life. A sustainable modal shift therefore requires important changes on several levels. The built environment can contribute by facilitating the use of sustainable modes, while limiting GHG-emitting ones; urban design practitioners display knowledge on how to do so. As mobility has a central and structuring role in a project, adding mitigation as an additional objective seem quite possible. To further this, a framework for an integrated urban design and mobility approach is currently being developed, based on evidence-based knowledge from research and experience-based knowledge from practitioners. Moreover, the framework can reinforce the dialogue between research and practice by translating scientific evidence to urban design practices and vice versa, thereby strengthening a much-needed reciprocal knowledge-transfer.

Acknowledgements

This thesis is conducted through the research-project CapaCity, which is supported by ADEME, the French Environment & Energy Management Agency.

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4. European Transport Conference (ETC) 2017, Barcelona, Spain

URBAN DEVELOPMENT AT THE NEIGHBOURHOOD SCALE AS A STRATEGY TO PROMOTE SUSTAINABLE MOBILITY MODES: INSIGHTS FROM PLANNING AND DESIGN PRACTICES

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1. INTRODUCTION

Research has shown that urban development can be a strategy to mitigate greenhouse gas emissions from daily mobility. There is a reciprocal relationship between the built environment and mobility behaviour (Næss, 2006; Strand et al., 2010; UN Habitat, 2013): how a city is organized and designed influences the way people move around in it, and vice versa. Yet emissions keep rising. One reason for this is knowledge gaps in the related scientific evidence, particularly at the neighbourhood scale. This complicates its use within urban development practices, key for sound mitigation efforts (Krizek et al., 2009; Tennøy et al., 2015). The research is relatively consistent at the city scale with regards to the kind of development that can reduce mobility related emissions (Næss, 2012). At the neighbourhood scale, however, looking at individual travellers and mobility patterns, the evidence is less certain (Handy et al., 2014; Krizek et al., 2009). In part because of a higher level of detail – of the built environment and of people's travel needs and preferences – that brings another level of complexity.

An ongoing PhD-thesis (Rynning, forthcoming) explores how urban design – development at the neighbourhood scale – can be a mitigation strategy to promote zero-emission mobility modes[1]. Addressing the knowledge gaps that limit mitigation-action, the thesis explores the experience-based knowledge of urban practitioners (urban planners and designers, architects, landscape-architects) as a source of new insight. They have a unique understanding of the city and it functionings, hypothesized as complimentary to that of research. An improved understanding of the practices of urban design professionals can furthermore enhance a reciprocal knowledge exchange research-practice. Enquiries were undertaken in France and in Norway in the form of workshops (France only, 18 participants), interviews (19 participants), and surveys (>100 participants). This paper presents some of the main results, with reflections on how to better link urban design and modal choice to promote a sustainable urban mobility.

2. THEORETICAL FRAMEWORK

Modal choice is a sum of contexts: *external* contexts such as physical context, the built environment, transport services, and social context; *personal* context such as needs, preferences, values, and physical capacities (Rynning, forthcoming). The personal context influence modal choice directly and indirectly, as it 'filters' the influence of external contexts. As a result, travel preferences are highly individual, though common traits can be found for segments of a population, for example age-groups, or level of cycling experience (Bull and Bauman, 2007; Stefansdottir, 2014). The importance of individual characteristics has lead to recent research taking a broader approach to mobility behaviour and modal choice, looking towards disciplines like Sociology, Environmental Psychology, and Behavioural Sciences (Al-Chalabi, 2013; Schwanen et al., 2011). One example is the use of an updated utility approach that includes *experienced utility* – how the experienced quality of an outcome influences future choices (Kahneman et al., 1997; Schwanen et al., 2011). A recent study found that this applies to travel and modal choices; remembered travel satisfaction can influence future modal choices (Vos et al., 2016). Travel satisfaction is based on the whole trip, the sum of perceptions, impressions, and potential nuisances, which form the overall experience of the traveller. The neighbourhood-scale contributes to this, for example through the presence (or not) of infrastructure for pedestrians, or the traveller's perception of traffic safety (Alfonzo, 2005; Krizek et al., 2009; Stefansdottir, 2014).

The neighbourhood-scale built environment is particularly important for walking and cycling (Krizek et al., 2009). By correlation, it equally influences transit use; people generally walk or cycle to and from transit stops. Hillnhütter (2016) showed how the neighbourhood-scale built environment can influence pedestrian access to public transport, for example by reducing perception of distance, or augmenting accepted walking distance. Several built environment elements have been found to influence modal choice at the neighbourhood scale, for instance sidewalk width, number of intersections, and view-lines (Alfonzo, 2005; Ewing et al., 2016). What influences the most, however, remains unclear, illustrating the knowledge gap within the research literature. Based on findings regarding the importance of travel experience and satisfaction, a holistic approach might be more beneficial. This could direct the focus towards urban environments and scapes, and the experiences these create.

3. ENQUIRING EXPERIENCE-BASED KNOWLEDGE

3.1 General methodology

Design knowledge is often referred to as tacit or silent (Eikseth, 2009). It is difficult to express or explain verbally, to quantify or even define; the practitioner "just knows it" (Schön, 1983). The design project therefore offers an interesting entry point for explorations, as it is the practitioner's principal professional activity, and their main source for new knowledge (Dubois, 2014; Kirkeby, 2012). Experience has shown that workshops, interviews, and surveys are particularly interesting methods for enquiring experienced-based design knowledge (Dubois, 2014; Kirkeby, 2015; Lawson, 1993). In the context of the thesis-project, all three methods were employed for an in-depth approach. A total of 149 practitioners were enquired (some potential overlap interviews/survey). The main thesis research question is how urban design can be a mitigation strategy to promote zero-emission mobility modes. For the enquiries two sub-questions were developed, based on findings from design research. 1) What is the influence of urban qualities and urban features upon modal choice, and on people's perceptions of a built environment? 2) What is the role of mobility in urban design practices, particularly in the design process?

3.2 Workshops: observing practitioners in action

The workshops were organised in May and June 2015, in the context of CapaCity, an international research project. Its objective was to develop a prototype design-aid tool to strengthen climate adaptation through urban development. The workshops were part of the first phase, which sought better insight into the practices of urban designers. Workshops are a flexible method that can be adapted to particular research objectives. Here, to observe how urban designers work, and how they seek and apply knowledge, focusing particularly on climate adaptation. The main activity was a case study where the participants in groups of 3-4 conceived a design proposal for the renewal of a neighbourhood in Toulouse. Each group was filmed and recorded, which was later transcribed for analysis. For more about the organization and execution of the CapaCity-workshops, the workshop results with regards to climate adaptation, and its impact on the prototype tool see Dubois et al. (2016) and Bonhomme et al. (2017). For the thesis, the workshops provided initial insight into how designers address and deal with daily mobility.

3.3 Interviews and survey

The interviews and surveys pursued observations from the workshops, as well as findings from research literature. The interviews were semi-directive with a prepared interview guide, organized from September to December 2016. Interviewees were recruited by personal invitation; the primary requirement was having over 5 years of professional experience. The survey had mainly close-ended questions with a series of answering alternatives. It asked practitioners about i) mobility in a design process (table 2, table 3), and ii) how urban features and qualities influence modal choice and perceptions of the built environment (table 4). Qualities and features were selected based on research literature and urban design literature (see for example Carmona, 2010; Ewing and Handy, 2009; Gehl, 2010; Saelens and Handy, 2008). The perceptions and experiences correspond to aspects often held up by research as important for modal choices. SurveyMonkey© was used as an online platform, and the survey was held from November 2016 to January 2017. Participants were recruited through personal invitation, as well as online forums for practitioners.

4. RESULTS FROM THE ENQUIRIES

4.1 Participants

Table 1 presents the educational repartition of the enquired practitioners. The workshops were held in Toulouse with a total of 18 participants from urban planning and design; aged approximately between 35 and 55. The interviews and the survey were organised in France and Norway, primarily in Toulouse and Oslo. A total of 112 practitioners commenced the survey and 71 (63,4%) completed it, of which 67 (59,8%) provided information about their practice. The respondents were from 18 to 55+ years old; 66% between 25 and 45, and 21% between 45 and 55. 31% had 0 to 5 years of experience, while 57% 5-25 years of experience. 19 practitioners were interviewed, aged mainly between 35 and 50, working primarily on different size projects at the neighbourhood-scale. Some were also involved in bigger planning projects.

Table 1: Educational background of enquired practitioners (67 survey respondents provided this information)

Educational background	Workshops	Interviews	**Survey** (several choices possible)
Architect	9	6	40
Architect and urban designer/planner	2	4	-
Urban designer/planner, Urbanist	2	5	43
Landscape architect	1	4	10
Other (primarily Sociology, Engineering, Geography)	4	-	12
Total	**18** (10M, 8F)	**19** (10M, 9F)	**67** (31M, 36F)

4.2 Mobility in the design process

The enquiries show that mobility has a central and structuring role in design practices, and the design process in particular. The vast majority of the survey respondents (101 of 109) consider the daily mobility of inhabitants in a project. Some only in the site analysis, but most implement measures and solutions directed towards daily mobility (25 versus 72 of 97). During the workshops, mobility was similarly evoked early in the site analysis. Likewise, the interviewees described mobility as a significant element that contributes largely to the design process in every phase. Its role depends on a project's context, but it is always present and taken in to account. Mobility appears to have an important role in the holistic, solution-based approach of urban designers (see for example Lawson, 2006 for description of a solution-based approach). The survey asked what considering daily mobility in the site analysis contributes to (table 2), likewise for the implementation of mobility solutions and measures (table 3). Observations from the workshops and the interviews support the survey results. Daily mobility has a multifaceted role in a design process, instrumentally (physically, e.g. structure, shape the neighbourhood) as well as a perceptually (e.g. link to urban context). It can provide a comprehension of the project site and its usages, as well as its relation to the urban context. Moreover, it helps the designers go beyond the client's command to find how their intervention can best enhance liveability ('framing the problem', Schön, 1983).

Table 2: What mobility in the site analysis contributes to, percentage of respondents who "Strongly agree" or "Agree"

Considering mobility in the site analysis contributes to (87 responses, "Strongly agree" and "Agree")		
	Analysis (19 resp.)	Analysis+Sol./Meas. (66 resp.)
1. Link the project to the urban context (physical, social, economical, etc.)	100 %	91 %
2. Understand the inhabitants' use of the neighbourhood	95 %	96 %
3. Identify challenges and issues beyond project description	89 %	88 %
4. Establish an idea, a concept	79 %	78 %

Table 3: What implementing solutions/measures contributes to, percentage of respondents who "Strongly agree" or "Agree"

Implementing mobility solutions/measures in a project contributes to (65 responses, "Strongly agree" and "Agree")	
1. Facilitate walking and cycling	95 %
2. Facilitate the use of public transport	91 %
3. Link the project to the urban context	91 %
4. Introduce measures to reduce the inhabitants' use of cars	91 %
5. Structure/shape the neighbourhood	91 %
6. Create an identity to reinforce the inhabitants' sense of belonging to the neighbourhood	75 %
7. Establish an idea, a concept	74 %

The workshops and the interviews showed that mobility measures and solutions are often *win-win*, allowing the designer to address and potentially solve several issues or objectives simultaneously. This is in line with previous research findings (see for example Dubois, 2014; Kirkeby, 2015), and largely reflects the holistic approach where the total impact of a design action is an important criteria. The survey responses show the same tendency. Implementing measures and solutions allow the designers to act upon mobility, while at the same time advancing the design process (table 3). The win-win aspect was often related to the multifunctionality of public space, where a multitude of usages – dynamic and static – must be possible at the same time. Several of the solutions and measures observed in the workshops and interviews had a mitigating potential, meaning they can contribute to promote walking or public transport use. However, this was rarely identified or discussed. Without further explorations it is difficult to determine if the designers are unaware of the potential, if it was merely not given attention during these particular explorations, or if it is considered as a 'by default' aspect. Likely, it is a mix of the above, depending on the practitioners, their design principles, as well as previous experiences.

Interestingly, daily mobility was often referred to in terms of movement; how and where people move around within and through a site. Addressing and organising mobility in a design process often referred to how this movement should and/or could occur, depending on the project command (e.g. prioritize pedestrians), as well as the practitioners' design principles and objectives. Urban design can facilitate or limit different movements, for example by establishing paths through a building block, or the location of parking spaces. The win-win approach is recurring for mobility and movement. According to the enquired practitioners, the presence of people in public space is essential for good living contexts; contributing for example to a feeling of safety, and helps build social capital. Improving people's living contexts is a somewhat global objective for urban design (Carmona, 2010; Madanipour, 2006). Initiating or even forcing movements through public space helps ensuring this, and can enable potential encounters and interactions. Situating parking spaces some hundred metres or so away from an apartment was a frequently used example of how to achieve this.

4.3 Mobility and the neighbourhood-scale built environment

A series of features and qualities were explored regarding i) modal choices, and ii) perceptions and experiences of the built environment. In the survey, respondents were asked to rate their importance and influence (see table 4). These are aspects often referred to as important for modal choices, particularly walking and cycling (see for example Krizek et al., 2009). During the interviews and the workshops, similar elements, and other, were discussed or described, for example with regards to public spaces people feel safe in. In line with the holistic design approach, qualities had more importance then singular features, and this is the focus here.

In the workshops and the interviews the designers rarely referenced a quality directly (i.e. using the term defined by research and design literature), with the exception of Legibility, Human scale and Transparence. They did, however, frequently describe similar qualities or effects of built environment interventions; for example in reference to the kind of public spaces people want to use, or environments that can reduce perceived distances. The survey respondents similarly seemed familiar with the kind of qualities enquired, presented equally to table 4, as the answering rate was good. Overall, results from the three enquiries largely correspond. Connectivity and Legibility are given most importance by the practitioners, followed by Human scale, Transparence and Enclosure. Flexibility and Hierarchy were two additional qualities that emerged as important from the interviews, particularly for the relationship between different modes and usages. According to the interviewees,

Table 4: How the survey respondents rated the importance/influence of urban qualities upon i) modal choice, and ii) perceptions and experiences of the neighbourhood-scale built environment, 68 responses

URBAN QUALITIES, MODAL CHOICE, AND PERCEPTION/EXPERIENCES (survey, 68 responses)						
	Walking	**Cycling**	**Public transport**	**Perceived traffic safety**	**Feeling of safety in public space**	**Reducing the perceived distance going from one place to another**
1. Connectivity - Connections between streets, pedestrian networks, etc. for connections within a neighbourhood and/or between several neighbourhoods	Extremely influential	Extremely influential	Influential	Important	Very important	Very important
2. Legibility - How easily one can recognize and understand a neighbourhood, for instance to orient one-self	Extremely influential	Very influential	Moderately influential	Important	Very important	Very important
3. Human scale - Dimension of built environments relative to human dimensions (e.g. street width, block size)	Extremely influential	Influential	Moderately influential	Important	Very important	Very important
4. Enclosure - To what extent buildings and other elements define and shape spaces	Extremely influential	Influential	Moderately influential	Important	Very important	Important
5. Transparence – The possibility to see what goes on at the end of a street and past it, for example human activity or particular buildings	Very influential	Influential	Slightly influential	Important	Very important	Important
6. Complexity - How a rich variety of buildings and other elements create a diverse visual impression	Very influential	Influential	Slightly influential	Slightly important	Moderately important	Important
7. Coherence – To what extent the built environment creates an overall impression, e.g. through shapes or facades	Very influential	Influential	Slightly influential	Slightly important	Moderately important	Moderately important

Connectivity is particularly important to reduce distances. This is supported by much research literature (see for example Saelens and Handy, 2008). It can help satisfy individual travel needs and preferences, as it gives people more route choice.

Legibility helps travellers orient themselves, geographically, culturally, and for usage. This can reduce perception of distance, and increase feeling of safety and perception of traffic safety. Interestingly, traffic safety was in itself little mentioned by the practitioners; it largely appeared to be seen as a required 'default' quality of public space. There was a certain differentiation between more instrumental qualities and more perceptual qualities. This distinction is not absolute; Legibility is to some extent both. However, it seems to parallel for example Stefansdottir (2014) and her results regarding cycling and aesthetics. She found that a certain level of instrumentality (e.g. infrastructure) is necessary for aesthetic aspects (perceptual) to influence travel experience. At the same time the qualities are strongly interrelated: a high level of Connectivity simultaneously produces Transparency; Complexity is necessary to achieve Legibility.

The idea of urban practitioners seeing mobility primarily as movement within the public space of a site was much confirmed through these analyses. The designers focused on the importance of people wanting to be present in a public space – for example during a trip to and from public transport. Such public spaces have qualities and characteristics that make people want to move within or through them; many of which correspond to aspects enquired in the survey, for example Legibility. As can be seen from table 4, the level of influence of urban qualities upon modal choices appears to decrease with an increasing travel speed. This is in line with other studies, which have found that travel speed influences a person's interaction with their immediate surroundings (Pucher and Buehler, 2010; Stefansdottir, 2014). The neighbourhood-scale built environment is therefore, generally, more influential upon pedestrians then public transport riders. At the same time, walking is an important part of the transit use. Hillnhütter (2016) found that it represents over 40% of the average transit trips, and that it corresponds to more then 60% of the parts of a trip that people remember. Which in turn is what primarily influence their overall travel experience (Hillnhütter, 2016). This underlines the importance of a holistic approach to daily mobility, considering the whole trip, from door to door. The neighbourhood-scale built environment influences not only at the beginning and the end, but also – or perhaps even more so – during the trip, moving through different parts of a city.

4.4 Methodological limitations

For a project like a doctoral thesis, the possible cohort is necessarily limited; the enquiries represent a selection of urban design practitioners. They are a highly heterogeneous group, design principles, objectives, and convictions vary; years and kind of experiences equally differs. The total of 149 practitioners is relatively good, but in no way representative for urban design as a discipline, which was also not the research objective. The results provide an insight into practices, and the experience-based knowledge of designers. Still, it is interesting to note parallels between the Norwegian and French practitioners; confirming an initial supposition that a common design culture and knowledge exist among urban designers. A part of which can be observed here.

5. DISCUSSION: MOBILITY AS A KIND OF USE OF PUBLIC SPACE

Daily mobility generally has a purpose; the traveller is going from somewhere to somewhere. What appears to be of focus for the enquired urban designers is the in between, the part of the trip where the traveller moves through the city and its different neighbourhoods; seeing it as a use of public space, like kids playing or people staying in public places. This way of considering mobility – as a kind of use of public space – shifts the attention towards the traveller's experience during the trip, the aspects of daily mobility and modal choice that urban design might influence the most. The neighbourhood-scale built environment constitutes the immediate surroundings at any given moment of a trip. The traveller influences and is influenced by the environments and scapes he or she passes through, as there is a constant interaction going on. According to the practitioners, the nature and the extent of this interaction depends on travel speed, nevertheless, it is always taking place. It produces perceptions and impressions that greatly influence the overall travel experience. Which in turn is important for future modal choices (Kahneman et al., 1997; Vos et al., 2016), an aspect the designers seemed aware of. Considering mobility at the neighbourhood scale as a kind of use of public space, indicates that design principles for spaces people want to use equally applies to spaces people want to move through; spaces they want to include in their trip. The enquiry results support this. Qualities, features, and characteristics described as important for mobility uses resonates with those said to be important for 'good' public spaces people want to be present in (see above). “People must want to use public space” (Interviewee A); similarly, “people must want to walk” (Interviewee B), and "cycling must be a pleasant experience” (Interviewee C).

Considering mobility as a usage of public space provides further understanding of the enquiry results regarding mobility's role in a design process. The qualities, features, and characteristics for good spaces and for mobility usages are likewise said to be important for creating good living contexts. By correlation, then, it appears that for urban designers, acting upon mobility equally means acting upon an area's qualities as a living context. An observation supported by enquiry findings, for example the close link between people's movement within or through an area and potential for building social capital. This illustrates how mobility for urban designers is both a means and a function. It is a daily need that must be satisfied, must work. At the same time it can be an entry point to address other issues or achieve other objectives.

Through the enquiries, four qualities were identified as particularly important for mobility-usages of public space. They address significant elements for people's mobility behaviour according to the practitioners as well as research literature, both with regards to mobility and to spaces people want to use. (see table 5). Moreover, they encompass the other qualities found to be important such as Transparence and Complexity. Carmona (2010) and Gehl (2010), for example, emphasize the importance of spaces people want to use, achieved through a mix of functionality and aesthetics (perceptual); the importance of Connectivity to reduce distances and increase proximity is a relatively well-established element within transport and mobility research (see for example Hillnhütter, 2016; Krizek et al., 2009; Saelens and Handy, 2008). The synthesis provides a basis for further linking urban design and modal choice.

Table 5: Identified requirements for good public spaces people want to move through, and how they contribute to mobility and modal choices

QUALITIES FOR GOOD PUBLIC SPACES FOR MOBILITY-USAGES	
Connectivity	*A high number of connections between street networks, buildings blocks, etc.* • Reduces distance (objective and subjective) • Increases access and proximity (i.e. available destinations) • Increases route choices • Increases mode choices (e.g. closer to transit)
Legibility	*Orienting oneself in an area: geographically, culturally, usage* • Clarifies how to behave, how to move, etc. within or through an area • Increases traffic safety (e.g. which mode has priority when and where) • Increases feeling of safety (e.g. understand the nature, culture, of an area) • Reduces perceived distance (recognition helps evaluate how long to destination)
Hierarchy	*Order of priority between mobility modes; different uses of public space, etc.* • Addresses and reduces conflicts between usages, mobility modes, speeds, etc. • Increases traffic safety (objective and subjective)
Flexibility	*A site's capacity to handle different mobility uses, travel speeds, and needs.* • Satisfies (to extent possible) individual characteristics • Increases traffic safety (objective and subjective) • Increases feeling of safety • Enables future mobility developments (transit offer; cycle infrastructure, etc.)

6. CONCLUSIONS AND PERSPECTIVES

The enquiry results provide new insights into the relationship between modal choices and the neighbourhood-scale built environment. The findings support existing research, while further detailing it. This seems to confirm that the experience-based knowledge and the practices of urban designers can be a source of new insights and understandings, complementary to that of research. Further explorations are required, for example empirical enquiries confirming (or not) the practitioners' observations of urban inhabitants and their mobility. The results establish that urban design can be a mitigation strategy; mobility is already a significant element in design practices. Yet there is an apparent lack of relating it to climate mitigation. Favoring walking seemed primarily related to enhancing the quality of a living context, rather then mitigation. Based on the results, however, the two are compatible; zero-emission mobility modes largely correspond to the kind of public space usages deemed positive for a good living context. Urban design as a mitigation strategy to promote sustainable mobility modes seems promising. What is missing is for mitigation to become an active design objective.

The enquiry results also establish a basis for *how* urban design can be a mitigation strategy. Overall qualities and characteristics were identified as important, according to practitioners, for mobility-usages of public space. However, this remains a somewhat semi-holistic perspective, continuing in the 'traditional' approach of focusing on individual aspects (here: qualities). Additionally, the quality-terms in table 4 do not seem to actually correspond to the general vocabulary of urban designers. The qualities are frequently found in design practices, but refereed to or described differently. It might be more beneficial to build upon this, rather than the names defined by research. This means shift from qualities and characteristics to *properties*; capacities a public space should have to adequately welcome zero-emission mobility modes. Example of public space-properties could be "capacity of reducing distances, objectively and subjectively", or "capacity of providing a comfortable experience (physical)", or yet "capacity of accommodating different usages, static and dynamic". Such properties might also provide a common basis for research and design to jointly construct knowledge for mitigation through urban development. A shared vocabulary describing what to achieve in a manner easily understood by both parties, allowing each to contribute with their expertise to promote a zero-emission urban mobility.

ACKNOWLEDGEMENT

The author would like to thank the CapaCity-team for support and contributions, and for the collaboration for the workshops. The thesis is financed via the CapaCity-project, funded by the ADEME[3].

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NOTES

[1] Here walking, cycling, and public transport; zero-emission cars are not included as they represent other environmental challenges for cities such as spatial use, and air pollution from road abrasion.

[2] Interview guides, survey questions, and more, can be provided upon request to author.

[3] ADEME - French Environment & Energy Management Agency