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Title:

Dutch Urban Policies that Promote Pedestrian and Bicycle Mobility: Case Studies of Rotterdam, Groningen, and Delft

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Executive Summary

Key Words: Bicycle, Pedestrian, Mobility, Policy, the Netherlands.

In the United States, decreased physical mobility and increased automobile dependence is a significant problem. Current regulations and policies promote urban environments that adversely impact residents' health. In fact, there is a growing body of evidence which documents the adverse health impacts of common land use patterns in the United States. A wide range of zoning, development, and transportation regulations and guidelines that restrict mixed-use development and compact urban design result in travel distances that are often too great to walk or bike. On the other hand, nearly half of all automobile trips in the United States are two miles or shorter. Yet, due to the fact that current regulations and policies do not even require pedestrian or bicycle facilities to be constructed, the option to walk or cycle to a destination is severely inhibited. Given the growing health, environmental, and economic externalities associated with this type of urban environment, a change in regulations and policy is needed.

After examining the above mentioned problems in the United States, I formulated the objective to learn from the Netherlands, which has succeeded in making cycling and walking a safe and attractive alternative to driving. Living in the Netherlands and experiencing this first-hand furthered my interest in learning how the Dutch had achieved such high cycling rates and contributed to pedestrian oriented development. Therefore, I decided to look at Dutch policies that promoted pedestrian and bicycle mobility. Moreover, I wanted to not only explore the urban policies in the Netherlands to gain a critical understanding of how these policies promote pedestrian and bicycle mobility but also to see what provisions could be used as examples for improving walking and cycling conditions in the United States. Accordingly, the most transferable measures that were found are applied to the Sustainable Community Development Code (SCDC) of the Rocky Mountain Land Use Institute in the United States.

In order to gain a critical understanding of the Dutch approach, I chose to do case studies of three cities in the Netherlands: Rotterdam, Groningen, and Delft. These three cities all have different contexts and approaches for facilitating pedestrian and bicycle transit. Therefore, it was beneficial to research the various perspectives. Rotterdam, Groningen, and Delft were also beneficial cities to study based on their varying sizes: respectively large, medium-size, and small based on Dutch standards. The theoretical framework for the research was established by conducting a literature review on urban policies that contribute to bicycle and pedestrian mobility. The literature review revealed two broad categories for consideration: the built environment (transportation systems; land-use patterns; and urban design) and policy instruments (hard and soft). These two categories, along with the location, established the scope for my research.

I established an analytical framework to define how the data would be collected and subsequently analyzed. The data collection has two components and is the same for each of the three cities. The components are: (1) fieldwork, consisting of interviews and observations; and (2) desk research which is a review of the policies collected as well as a literature study. Once the data was collected, I applied the SCDC attributes to it to determine which measures are applicable to the United States. The SCDC is structured by policies provisions, which can be an approach to removing obstacles, suggesting incentives that might be created, or focusing on enacting standards that might be adopted to ensure progress in a particular area. Levels of effort are then assigned are assigned to these innovative approaches.

While several differences exist between the Netherlands and the United States, the Dutch approach provides many invaluable lessons for improving bicycle and pedestrian infrastructure in the United States. Conventional wisdom might suggest that the differences in history, culture, topography, and climate are responsible for the success in the Netherlands, however, this research as well as other studies done in this field reveal that polices are the impetus for making cities either people-friendly or car-friendly. Notably, most of the data collected pertains to bicycles as much more is needed for these systems as opposed to pedestrian facilities. The case studies revealed that the promotion of bicycle use requires political support and continuous attention. This not only means specific bicycle policy, but that the bicycle is applicable and supported by all policies. The bicycle should also be regarded as a main transport mode, being taken into account along with motorized transport and public transport. Additionally, municipalities in the Netherlands uniformly use the guidelines published in the Design Manual for Bicycle Traffic, which describes what is required for the creation of bicycle-friendly infrastructure.

The Design Manual for Bicycle Traffic developed by CROW provides numerous guidelines that if applied can assist in making the bicycle a full fledge participant in an overall traffic and transport system. In the context of the Netherlands, these guidelines demonstrate that if good functional policy guidelines are available, then they will be used and it is not even necessary to make them compulsory. The lesson for the United States is that a uniform, functional, and knowledgeable set of policy guidelines like the one provided in the CROW manual can be the starting point for changing legislation in this field. A small project which incorporates the necessary measures for bicycle traffic can be initiated, then if successful, can be applied in other communities and in this way standards can be developed that promote the bicycle as a main mode of transport. The other benefit to creating a set of regulatory standards is that uniformity in these systems creates a seamless system for users, meaning that if the system is easily recognizable, then it is more comfortable to use, and thus will gain more participants and in addition increase safety as users will know how to behave.

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Chapter One: Introduction

1.1 Research Rationale

In the United States, automobile dependence is at an all time high. This is in spite of the fact that alternative forms of mobility are of ever increasing importance due to, among other things, the adverse health impacts of inactivity and growing environmental concerns. According to the U.S. Department of Transportation, the average American driver spends 335 hours, the equivalent of 8.4 work weeks, in their car a year. While more than 25% of all trips are easily walkable and 63% of trips are bikable, more than 90% of all trips take place by automobile (LEED ND Core Committee 2006). In the Netherlands, however, 27% of all trips are by bicycle and 18% are by walking (Netherlands Ministry of Transport 2007). This high proportion of trips made by cycling and walking in the Netherlands is a result of policies which have made these modes of transport a safe and attractive alternative to driving. In many areas of the United States, there is a lack of alternative travel modes. Accordingly, this thesis will draw on examples from the Netherlands that can be used for improving walking and cycling conditions in the United States. Furthermore, walking and cycling have many health related advantages over driving. These include physical, mental, social, environmental, and economic health benefits and will be discussed further below.

Physical Health

There is a growing health epidemic related to physical inactivity in the U.S. According to the Center for Disease Control (CDC), physical inactivity increases the risk for heart disease, diabetes, colon cancer, high blood pressure, obesity, osteoporosis, muscle and joint disorders, and symptoms of anxiety and depression. The U.S. Department of Health and Human Services guideline recommends that adults get a minimum 30 minutes of moderate intensity physical activity at least five times per week (LEED ND Core Committee 2006). However, over 50% of Americans do not engage in the recommended amount of physical activity, and 25.4% do not get any leisure-time physical activity (CDC 2005). Communities that develop pedestrian and bicycle-friendly infrastructure can boost the physical activity levels of its residents (Brownson et al. 2001).

One of the largest health concerns for Americans is obesity. Nearly one in three Americans is obese (Flegal 2002). Physical activity is necessary for the prevention of obesity and its associated adverse health consequences[1] (Dannenberg et al. 2003). Urban design affects the ability of people to be physically active in their communities. Multiple studies have demonstrated that people were more likely to be physically inactive and/or obese if they lived in less walkable areas[2]. Nevertheless, in the United States a wide range

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[1] Obesity causes Osteoarthritis, Stroke, Cancer, Diabetes, Hypertension, Dyslipidemia, Sleep Apnea and Respiratory problems, Coronary Heart Disease, and Gallbladder Disease (CDC).

[2] An Atlanta study found significantly lower obesity rates for those who reside in more compact, denser, more pedestrian friendly and transit supportive areas of the Atlanta region (Frank et al. 2003). Additionally, the authors of a pilot study comparing activity levels between residents of two different

of zoning, development, and transportation regulations and guidelines favor less walkable land use patterns (Frank et al. 2006). For example, modern exclusionary zoning practices require greater travel distances between where Americans live, work, and play, decreasing the ability to walk and bike (the most common forms of physical activity) and increasing automobile dependence (Frank & Engelke 2001). Improving conditions for walking and bicycling in communities is imperative for reducing the rate of obesity and its associated health problems.

Mental Health

The built environment within which individuals interact can directly affect their mental health (Dannenberg et al. 2003). Large amounts of driving, especially in congested traffic conditions, may have mental and psychological costs (LEED ND Core Committee 2006). Direct health outcomes of the stress of driving include aggressive driving and road rage, which are linked to both traffic injuries and fatalities (LEED ND Core Committee 2006). However, more research is needed to learn more about the impact of the built environment on mental health. Nonetheless, walking and cycling result in a significant improvement in physical fitness which in turn provides a greater feeling of well-being and more immunity to stress (Ice 2000).

Social Health

Social capital can be affected by automobile dependence. Social capital refers to connections among individuals, social networks and the norms of reciprocity and trustworthiness that arise from them (Putnam 2000). These networks and resulting trust and reciprocity can be adversely affected by spending a lot of time in the car. For example, persons with long commutes may have lowered social capital because they have less time for civic engagement (Dannenberg et al. 2003). Likewise, people in their cars are far less likely to engage in social interaction than people out on the sidewalk (Frumkin et al. 2004) Low social capital may also contribute to poor physical and mental health (Dannenberg et al. 2003). On the other hand, people with strong social networks live longer and social capital has been shown to confer other health benefits, better functioning governments, more prosperity, and less crime (Frumkin et al. 2004). Moreover, there is evidence that walkability within a community promotes social capital (Frumkin et al. 2004).

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communities in San Diego found that residences of the more walkable neighborhood were more physically active overall than residence of the less walkable neighborhood (Frank et al. 2003). Additional data collected within the context of a different city (Seattle) supported these findings (Frank et al. 2003). At least five other studies have demonstrated that people were more likely to be overweight or obese if they lived in less walkable areas [Ewing et al., 2003; Frank et al., 2004; Giles-Corti et al., 2003; Saelens et al., 2003; Lopez, 2004] (Frank et al. 2006). Finally, a study done in King County, Washington, found that people living in more walkable neighborhoods did more walking and biking or transportation, had lower BMIs (Body Mass Index)drove less, and produced less air pollution than people living in less walkable neighborhoods (Frank, et al. 2006).

Environmental Health

Zoning, a legal tool for local governments to specify how land is to be used, was adopted to improve the health, safety, and welfare of urban residents (Frank et al. 2003). The intent was to control industrial development because of the public health problems associated with the pollution, overcrowding, and unsanitary environments that followed such development. However, proponents of zoning used the tool to completely separate resident, industrial, and commercial uses as well as segregating uses within these districts, for instance segregating single-family and multi-family housing within residential zones. In the landmark 1926 Supreme Court case of *Village of Euclid v. Ambler Realty Company*, the Court upheld zoning laws, holding that it was constitutional for a municipality to create and maintain separate districts though zoning if it had a substantial relation to the public health, safety, morals, or general welfare. The Court found that zoning provided many health and safety benefits (Frank et al. 2003). While this is true to an extent, the practical effect of zoning has been a rigid segregation of land use and social class as well as the creation of long distances between different uses, which, in turn, contributes to a heavy reliance on automobile travel (Frumkin et al. 2004).

Automobile dependence contributes to poor air and water quality. For instance, many watersheds have been covered by impervious surfaces such as pavement, from which storm water runoff carries sediment, oil, brake dust, lawn chemicals, and other toxins that are the primary sources of water pollution (ARHF and ARC 2006). Vehicle emissions degrade air quality by contributing to the major air pollutants: Carbon monoxide, sulfur oxides, nitrogen oxides, particulate matter, ozone, lead, volatile organic compounds, air toxics, and carbon dioxide (Frumkin et al. 2004). There is not only environmental degradation resulting from automobile dependence, but also increased health problems that arise from pollution. Poor air quality has a direct influence on health, causing mortality, respiratory and cardiovascular disease, and cancer. Clean water is also essential for health as water contamination is linked to viruses, gastrointestinal illnesses, cancer, miscarriages, and birth defects (Frumkin et al. 2004).

Economic Health

The automobile contributes to economic development as it increases total personal mobility as well as access to urban fringe and remote areas (VTPI 2007). The automobile can also be an affordable means of travel as vehicle ownership is relatively affordable to even lower-income households (VTPI 2007). However, the promotion of cycling and pedestrian facilities also contributes to both individual and societal economic health. For example, the bicycle is a low-cost means of transport, both for the individual and for society as a whole and does not carry with it the high external costs associated with motorized transport (Ice 2000). Not only is the bicycle cheap to buy, maintain, and use, but the construction and maintenance of cycle paths and the construction of bicycle parking facilities cost much less than roads and parking facilities for cars (Ice 2000).

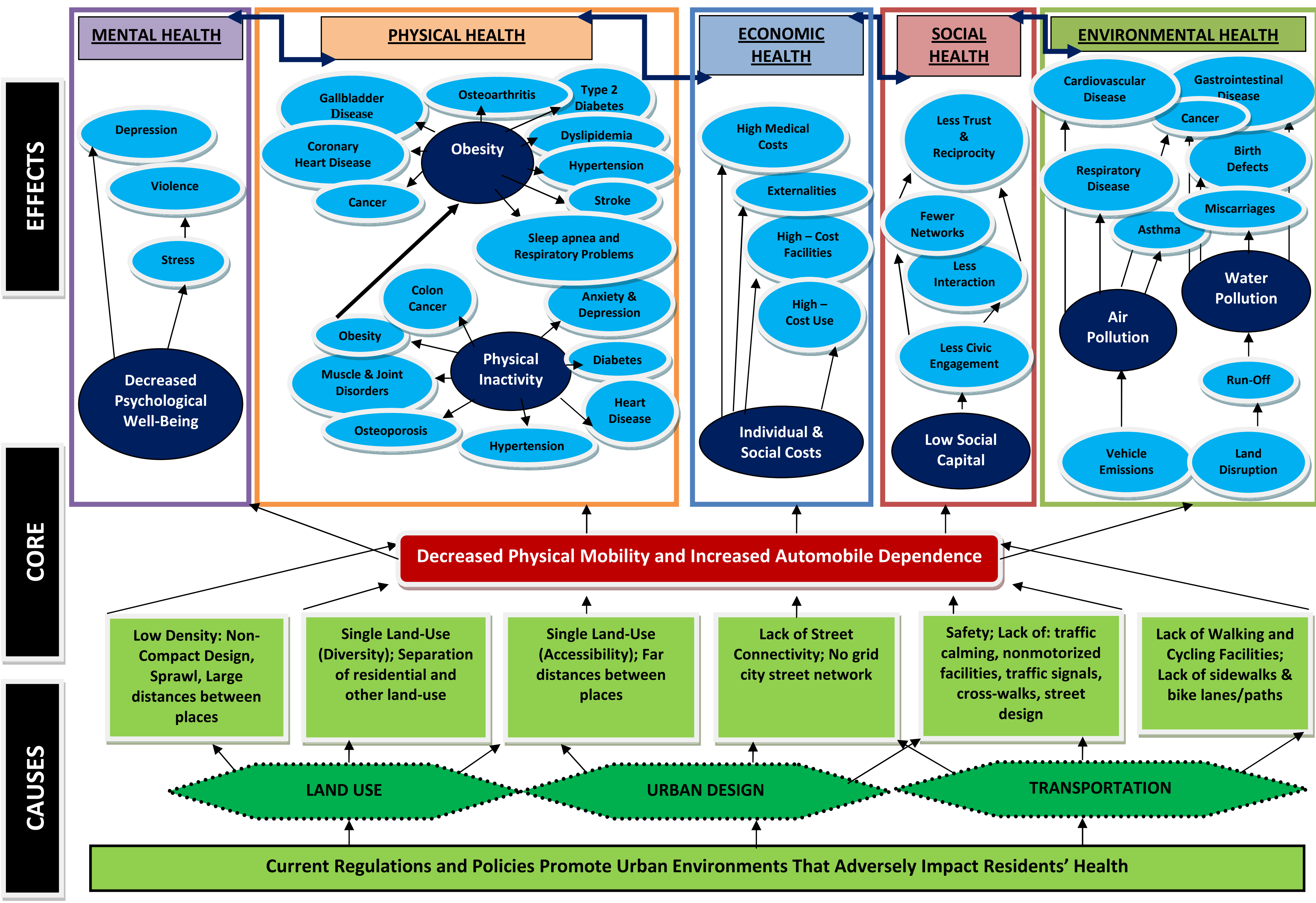
Furthermore, the promotion of walking and cycling contributes to the accessibility and quality of life in a city and therefore also contributes significantly to the urban economy (Ice 2000). In numerous American cities, increasing car use has made city centers unappealing and difficult to access, leading to an exodus of shopkeepers, companies, and people in the higher income brackets. However, pedestrian zones and bicycle facilities can help restore a city's heart and bring the city back to life. Cycling and walking not only provide external economic effects for businesses, but internal economic effects as well. For instance, where cycling and walking results in a significant improvement in physical fitness, businesses can expect a better work atmosphere, higher productivity, and reduced staff turnover (Ice 2000). Moreover, the improvement in physical fitness can also have an enormous impact on health care costs. According to the CDC, in 2000, the direct medical cost of physical inactivity was nearly $76.6 billion. The CDC forecast this figure to grow to $2.8 trillion by 2011.

1.2 Problem Statement

In the United States, decreased physical mobility and increased automobile dependence is a large problem. I believe that current regulations and policies promote urban environments that adversely impact residents' health. In fact, according to Frank and Engelke there is a growing body of evidence which documents the adverse health impacts of common land use patterns in the United States (2005). A wide range of zoning, development, and transportation regulations and guidelines that restrict mixed-use development and compact urban design result in travel distances that are often too great to walk or bike (Frank et al. 2006). Typically, roads are designed to carry high-speed, high-volume traffic between major destination points as opposed to a city street network with a greater number of short blocks and intersections to increase the level of connectivity so that residents can have greater mobility within their communities (ARHF and ARC 2006).

Moreover, in many places current regulations and policies do not even require sidewalks and/or bike paths to be constructed. Additionally, one of the biggest impediments to more walking and cycling is the applying unsafe, unpleasant, and inconvenient conditions faced by pedestrians and bicyclists in most American cities (Pucher 2003). All of these issues lead to a built environment which favors the automobile and discourages walking and cycling. Moreover, there are numerous externalities associated with this effect, most of which are discussed above. Thus, new policy measures, which enhance the feasibility of walking and cycling, need to be developed. A problem tree depicting these problems and associated adverse effects is presented in Figure 1.1 on the following page.

Figure 1.1: Problem Tree



1.3 Research Motivation

While several differences exist between the Netherlands and the United States, there is still a lot to learn from the Dutch planning experience. This is particularly true for cycling and pedestrian friendly transit as the Dutch have achieved some of the highest cycling rates in the world and contributed significantly to pedestrian-oriented development (Beatley 2000). Conventional wisdom might suggest that the differences in history, culture, topography, and climate, are responsible for this, however, it also government policies that are responsible for making cities either people-friendly or car-friendly (Pucher and Beuhler 2008). The Netherlands has focused on the former while the United States has focused on the latter. Interestingly, both countries are democratic, capitalist, affluent societies with nearly universal car ownership, yet there are vast differences in cycling and pedestrian levels for both countries. In fact, there has been a growing demand for automobiles in the Netherlands. Despite this it has still been able to sustain its high cycling levels (Pucher and Buehler 2008).

There are cities in the United States – such as Davis, California; Eugene, Oregon; and Boulder, Colorado – that have demonstrated that the right investments in bicycle infrastructure and facilities can create a cycling culture (Beatley 2000). Other larger cities like Portland, Chicago, and Houston have also made notable contributions toward creating a bicycle-supportive city. Nevertheless, only a few, typically smaller, American cities, have achieved the conditions of bicycle ridership and mobility approaching levels in the Netherlands (Beatley 2000). Therefore, I believe it will be not only beneficial to examine the Dutch policies that have created a pedestrian and bicycle friendly environment, but even more to understand how these modes of transit have been maintained as feasible alternatives despite growing automobile dependence. Additionally, the most transferrable provisions will be applied to the Sustainable Community Development Code, which is an initiative at the Rocky Mountain Land Use Institute in Colorado, U.S (explained further below in 2.4 Research Context).

1.4 Research Objectives

The following are the main objectives of this research:

1. To explore urban policies in the Netherlands to gain a critical understanding of how these policies promote pedestrian and bicycle mobility.

2. To identify the most transferrable measures so that they may be applied to the Sustainable Community Development Code in the United States.

1.5 Research Questions

The purpose of this research is to answer the following questions:

1. *How do urban policies promote pedestrian and bicycle mobility in the Netherlands*?

2. *Which of these policy provisions can be applied to the Sustainable Community Development Code?*

1.6 Research Justification

Pucher has conducted extensive research on transport policies in Europe, Canada, and the United States. Pucher has carried out research on walking and bicycling in many European countries, including the Netherlands. His main objective has been to determine what lessons can be learned from Europe. His most recent findings are reported in "Making Cycling Irresistible: Lessons from the Netherlands, Denmark, and Germany" (Pucher and Buehler 2008). The research that he has conducted in the Netherlands is very helpful for the research I will conduct. He also has a lot of good data from the United States. Therefore, I will be utilizing a lot of his data, especially comparing cycling in the United States with that of the Netherlands.

As Pucher and Buehler report, in the Netherlands, cycling levels are more than ten times higher than in the United States. In the United States, the bicycle is used for less than 1% of all trips, while on average; the Dutch choose the bicycle for 27% of their journeys (Pucher and Buehler 2008; Netherlands Ministry of Transport 2007). In the United States bicycling is a marginal mode of transport, sometimes used for recreational purposes bur rarely used for everyday travel needs. On the other hand, in the Netherlands cycling is distributed evenly across all income groups (Pucher and Buehler 2008). Moreover, as shown in Table 1.1, in the Netherlands, the bicycle is highly used for shopping, transporting children, sports and associated visits, going out, and commuting (Netherlands Ministry of Transport 2007).

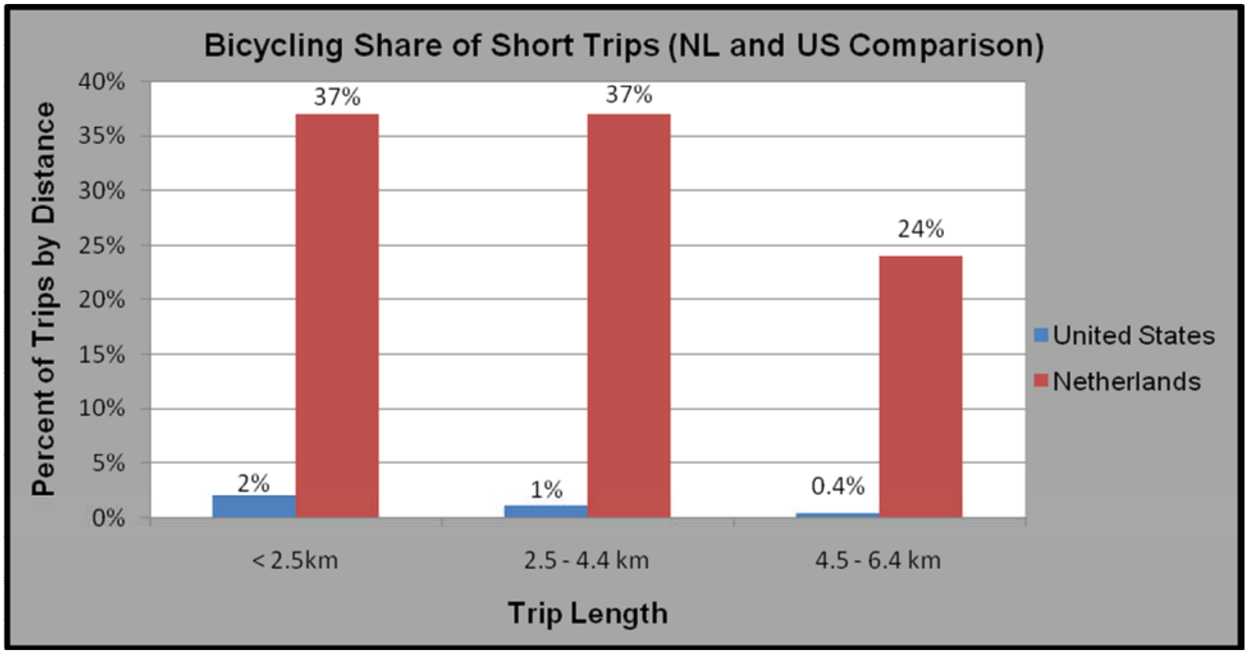
Table 1.1: Choice of car or bicycle for journeys up to 7.5 km per travel reason (Netherlands)

Travel Reason	Never Car	Sometimes car, sometimes bicycle	Never Bicycle
Doing Shopping	12%	59%	30%
Transporting Children	6%	70%	24%
Sports and associated visits	28%	41%	30%
Going Out	12%	48%	39%
Commuter travel	29%	40%	31%

(Source: Netherlands Ministry of Transport 2007)

One notable difference between the United States and the Netherlands is that cities in the Netherlands are more compact, resulting in shorter trip length (Beatley 2000). However, Pucher and Buehler note that while there are a higher percentage of trips shorter than 2.5 km in the Netherlands (44%) than in the U.S. (27%), the Dutch still make a higher percentage of their shorter trips by bike. As shown in Figure 1.1, Americans cycle for only 2% of their trips shorter than 2.5km, compared to 37% in the Netherlands. Similarly, for trips between 2.5 km and 4.4 km American make just 1% of their trips by bike, compared to 37% in the Netherlands. The Netherlands still has a very high percentage of trips by bicycle for even longer trips as shown in Figure 1.2. For trips between 4.5 and 6.4 km, the Dutch make 24% of their trips by bicycle, while Americans make less than 0.5% of their trips by bike (Pucher and Buehler 2008).

Figure 1.2: Bicycling Share of Short Trips

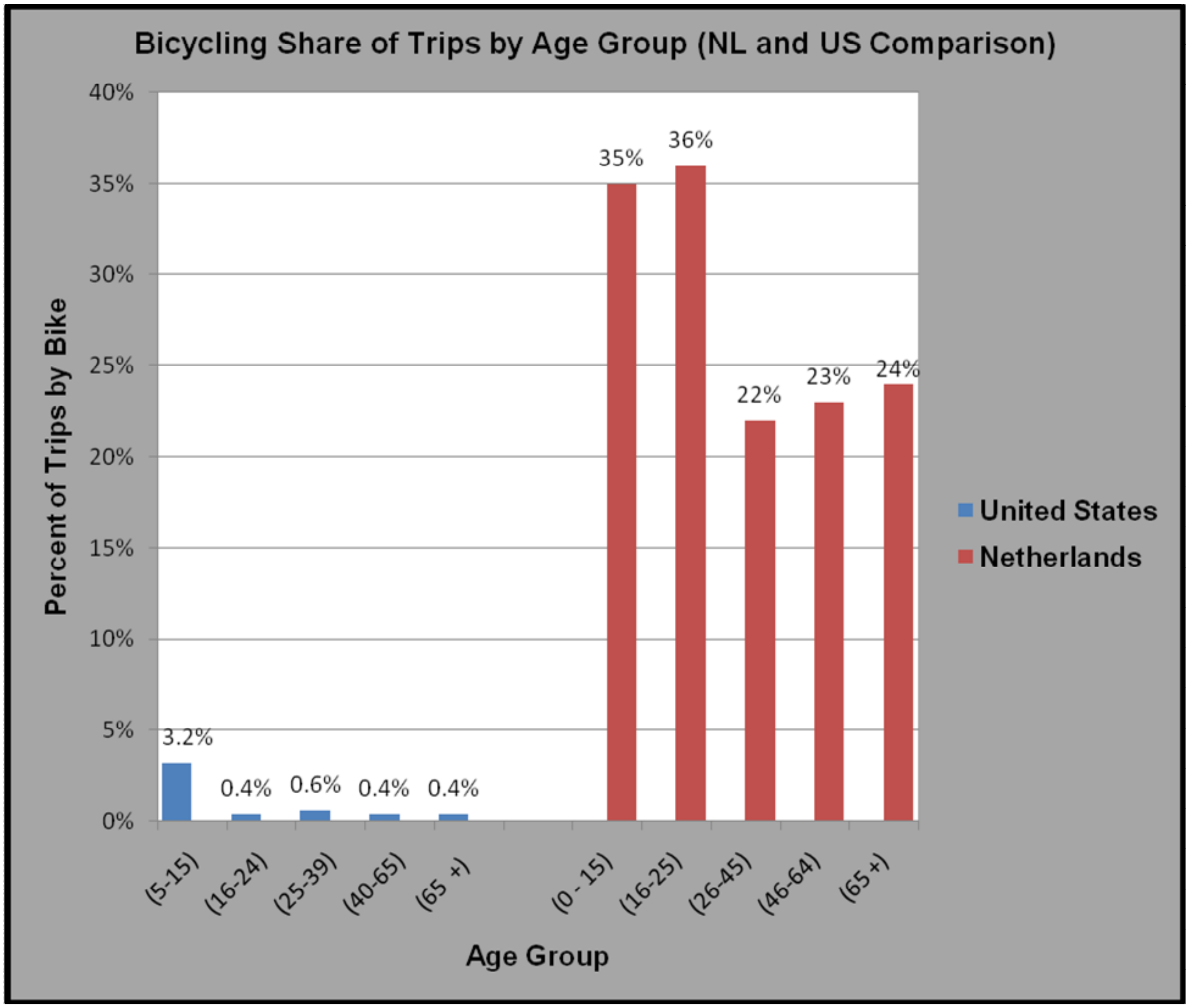


(Source: Pucher and Buehler 2008)

In addition to the high levels of cycling, there is a remarkable level or cycling for all age groups in the Netherlands. As shown in Figure 1.3, the Dutch elderly make 24% of all their trips by bike. On the other hand, cycling rates in the United State decline with age, and constitute only 0.4% of trips for those 40 and older. Additionally, in the United States, it is young men who do most of the cycling, while women cycle far less. However, in the Netherlands, women cycle as often as men (Pucher and Buehler 2008).

One contributing factor to this high use of bicycles in the Netherlands in comparison to the United States may be the fact that cycling is much safer in the Netherlands. Cycling is over five times safer in the Netherlands than in the United States; per 100 million km cycled, the number of bicyclist fatalities was 5.8 in the United States compared with 1.1 in the Netherlands between 2004 and 2005. Per 10 million km cycled, the number of non-fatal injuries was 1.4 in the Netherlands compared with 37.5 in the United States between 2004 and 2005. These rates from the United States only include injuries resulting from crashes with motor vehicles and reported by the police whereas the CDC reports ten times more cycling injuries (479,963 vs. 45,000 in 2005) based on emergency room reports. The statistics from the Netherlands may be underestimated as well and there are also differences in data collection and reporting (Pucher and Buehler 2008).

Figure 1.3: Bicycling Share of Trips by Age Group



(Source: Pucher and Buehler 2008)

Nevertheless, the data available indicates that cycling in the Netherlands is much safer than in the United States. Long term data from the Netherlands dramatically portrays a strong relationship between cycling safety and levels of cycling (Pucher and Buehler 2008). As shown, Pucher and Buehler have conducted extensive research, which provides a good foundation for the research I will conduct. I want to gain a deeper understanding of how three different cities (Rotterdam, Groningen, and Delft), promote bicycle and pedestrian mobility in practice. I also want to find more specific examples for the SCDC.

Chapter Two: Research Methodology

2.1 Research Type

Due to the nature of the problem and the subsequent research objectives, the research will be exploratory. This research does not seek to establish any causal relationships, but rather seeks to explore Dutch policies that promote pedestrian and bicycle transit to see how these provisions can be transferred to the United States and applied to the SCDC. The research approach used is a case study of three cities in the Netherlands (Rotterdam, Groningen, and Delft). The data collected from these case studies will require a qualitative assessment.

2.2 Research Strategy

Table 2.1 on the following page is a summary of the research strategy, outlining the research questions, variables, indicators and expected data sources.

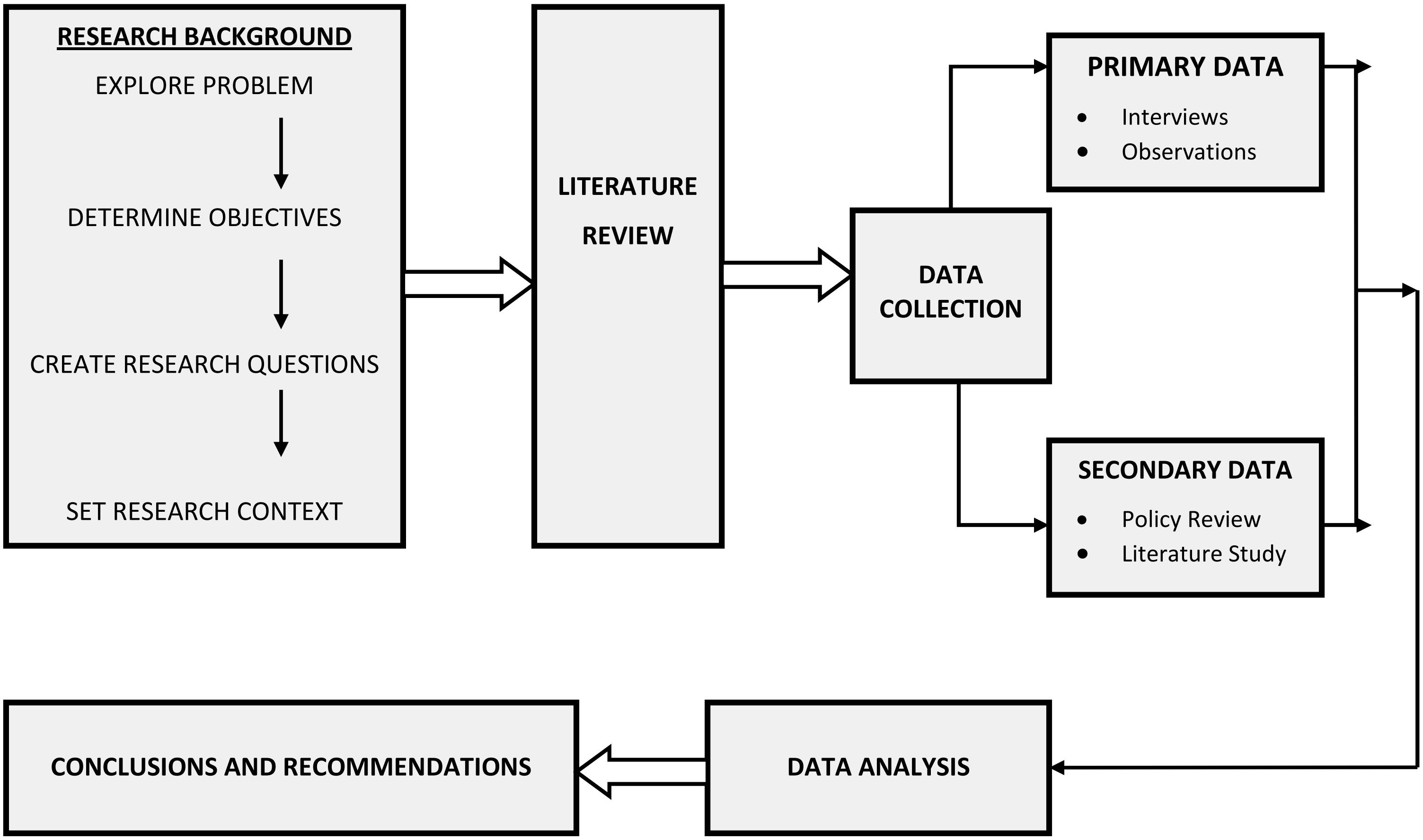
Table 2.1: Summary of the Research Strategy

Research Question	Variables	Indicators	Data Source
***How do urban policies promote pedestrian and bicycle mobility in the Netherlands*?**	**Urban policies that promote pedestrian and bicycle transit**	• **Urban policies [spatial; transportation; urban design]** • **Promotional tools** • **Cycling and Waling statistics from Rotterdam, Groningen, and Delft**	• **Policy documents from Rotterdam, Groningen, and Delft** • **Semi – Structured Interviews** • **Literature Review**
Which of these policy provisions can be applied to the Sustainable Community Development Code?	**Provisions applicable to the SCDC**	• **Key policies** • **Policy elements** • **Innovative measures** • **Hard instruments** • **Soft instruments**	• **Policy documents from Rotterdam, Groningen, and Delft** • **Semi – Structured Interviews** • **Literature Review** • **SCDC**

2.3 Research Design

The research for this thesis is done in multiple phases. The first part of the research began with an exploration of the problem. From this exploration, an objective was determined and research questions were created. The research context was also set by determining where the research was going to take place and what type of research would be conducted (case study). Following this, a literature review was undertaken to gain a deeper understanding of the subject to be studied. The research continued and data was collected and analyzed from which conclusions and recommendations were made. This process is demonstrated by Figure 2.1 below.

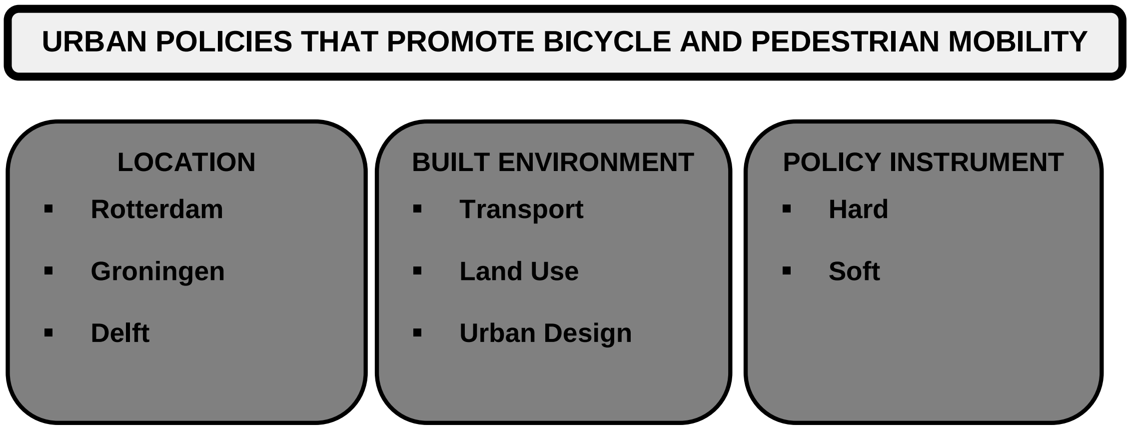
Figure 2.1: Research Design



2.4 Research Scope

The research scope is the theoretical framework within which this research took place. The research scope includes three attributes: Location, Built Environment, and Policy Instrument. These categories have been established to ensure that I have covered all relevant considerations. Figure 2.2 on the following page depicts the theoretical framework.

Figure 2.2: Research Scope



2.4.1 Location

This research will focus on urban policies that promote pedestrian and bicycle mobility in the Netherlands. I will do a case study of three cities that are notable for their promotion of walking and cycling: Rotterdam, Groningen, and Delft. These three cities all have different contexts and approaches for facilitating pedestrian and bicycle transit. Therefore, it will be beneficial to research the various perspectives. Rotterdam, Groningen, and Delft are also beneficial cities to study based on their varying sizes: respectively large, medium-size, and smaller.

Rotterdam is located in South Holland. Rotterdam is home to one of the largest and busiest ports in the world and is the second largest city in the Netherlands, with a population of 600,000 (City of Rotterdam 2008). I have chosen to study Rotterdam because the bicycle has been an integral part of urban design in Rotterdam (Buningh and Smidt n.d.). Rotterdam has also fostered pedestrianism by restricting automobile use and making several safe pedestrian-only areas. Additionally, my own observations are strong because I move around this city on a daily-basis.

Groningen is the major city of the Northern Netherlands (City of Groningen 2008). Groningen has a population of 180,000 (City of Groningen 2008). I have chosen to study Groningen because it has been a top ranking city in the Netherlands for bicycle use for many years. In 2002, Groningen was awarded “City of the Year” by the “Fietsersbond” (Netherlands Ministry of Transport 2007). Groningen has also created many pedestrian friendly areas throughout the city.

Delft is located approximately 14 km north of Rotterdam, in South Holland. Delft has a population of 96,000 (City of Delft 2008). I have chosen to study Delft because it is one of the original model locations that implemented a systematic network of bicycle paths (Director-General of Transport South Australia 1995). The network had a very positive impact on a local and national level (Director-General of Transport South Australia 1995). Delft has also created a walkable community throughout which its residents have a great level of mobility.

2.4.2 Built Environment

The three major categories that the Dutch policies will be associated with – transport, land-use/spatial, and urban design – have been adopted from a conceptual model of linkages between the built environment and activity patterns developed by Frank et al. Transportation systems connect places, determining how feasible it is to use different types of transportation, including walking and bicycling, to get from one place to another (Frank et al. 2003). Land use patterns consist of the arrangement of residences, offices, restaurants, grocery stores, and other places within the built environment of which the proximity determines the practicality of traveling by foot or by bicycle between these destinations. Urban design characteristics influence whether the built environment is perceived as hostile or friendly, attractive or ugly, and vibrant or dull (Frank et al. 2003). The data will be researched within these three core categories to gain an understanding of how and to what extent each sector contributes to the promotion of physical mobility, specifically walking and bicycling. These three categories are further explained in the Literature Review (Chapter 3).

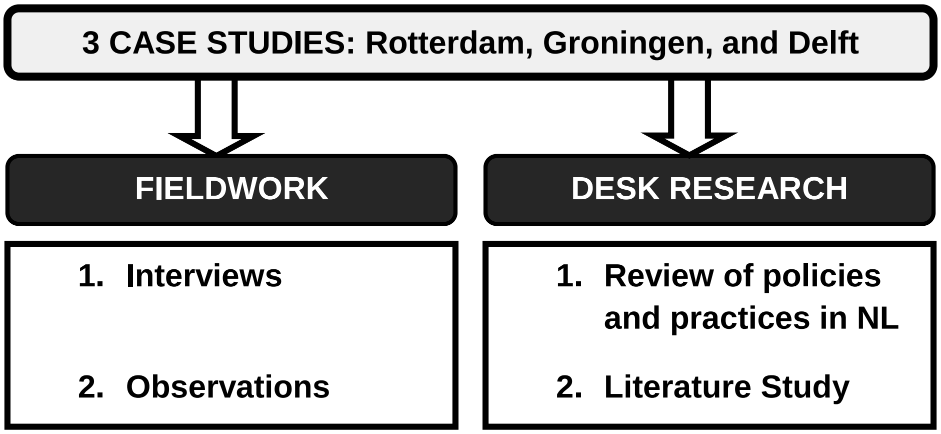
2.4.3 Policy Instruments

The Policy Instrument category is comprised of Hard Instruments and Soft Instruments. Hard instruments include investment, government support, infrastructure, accessibility, and traffic. Soft instruments include marketing, incentives, disincentives and integration. The Policy Instrument attributes have been given broad classifications based on a literature review of important policy provisions for promoting safe and convenient walking and cycling as well as a personal observation of necessary components. These classifications are further explained in the Literature Review (Chapter 3).

2.5 Data Collection

The data collection will have two components and will be the same for each of the three cities. The components are (1) fieldwork, consisting of interviews and observations and (2) desk research, which will be a review of the policies as well as a literature study. This collection is depicted in Figure 2.3 below.

Figure 2.3 Data Collection:



The following is a list of the semi-structure interviews that were completed. The objective of these interviews was to gain a deeper understanding of the factors that promote pedestrian and bicycle mobility in the Netherlands. For the municipal interviews, specific questions regarding the city's policies were asked. For the remaining interviews, more general questions were asked. (See Annex 1 for a list of interview topics).

1) Menno van der Woude, Urban Traffic Planner, City of Rotterdam
2) Jeroen Maijers, Bicycle Coordinator, City of Rotterdam
3) Sacha Jenke, Urban Planner, City of Rotterdam
4) Martin Guit, Urban Planner, City of Rotterdam
5) Nico Tillie, Landscape Architect, City of Rotterdam
6) David Polman, Policy, City of Delft
7) Jaap Valkema, Traffic Engineer, City of Groningen
8) Neeske Abrahamse, Consultant, MuConsult
9) Hans Nijland, Senior Researcher, Netherlands Environmental Assessment Agency
10) Eva Heinen, Department of Urban and Regional Development, OTB Research Institute, Delft University of Technology
11) Marien Bakker, Advisor, Senternovem
12) Hillie Talens, Project Manager, CROW
13) Ineke Spape, Consultant, SOAB
14) Daan Drenth, Professor of Urban and Regional Planning, Nijmegen School of Management
15) Frank Borgman, President, Fietsersbond

I was able to interview more people in Rotterdam because the department is much larger so there were more people working on the issues in which I was interested. Nevertheless, from each of the municipal interviews, I was able to gather a lot of information regarding the municipality's policies and approaches toward pedestrian and bicycle mobility. I was also provided with relevant documents. From the other interviews, I was able to gain a broader insight into how urban issues operate in the Netherlands, especially regarding the different levels of government, the hierarchy of policies, and the types of policies which contribute to the bicycle and pedestrian friendly environments in Dutch cities. I was able to gain a lot of knowledge from these interviews as well, and the people I interviewed provided me with relevant literature.

For the observations, I walked and biked around each city. I went to specific places that the interviewees identified as notable for its effectiveness in stimulating pedestrian and/or bicycle transit. I also took photographs.

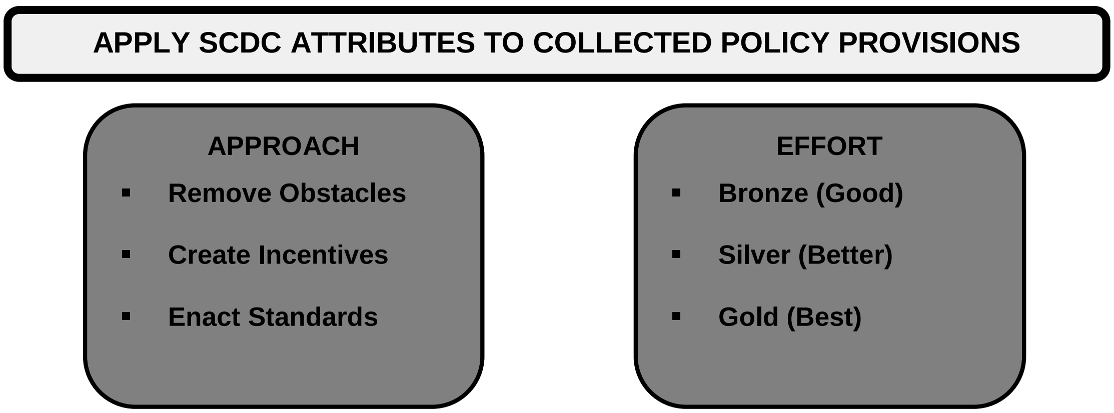
2.6 Data Analysis

Once the data was collected, it was applied to the Sustainable Community Development Code (SCDC). The SCDC is an initiative at the Rocky Mountain Land Use Institute (RMLUI) in Colorado that seeks to draw a nexus between sustainable land use planning and regulation, drawing upon examples from progressive communities that have adopted sustainable land use provisions. The initiative is a response to community development code frameworks in operation in the United States that are deficient with respect to sustainability. The RMLUI has found that the creation of a model sustainable community development code is needed, which broadly incorporates the following:

1. It must be comprehensive;
2. It must artfully and intelligently integrate natural and man-made systems;
3. It must be progressive, drawing upon useful features of other code types already proven and in use – e.g., in the areas of design, procedures, performance standards, and incentives;
4. It must be based on a sustainable comprehensive policy plan and long term civic engagement; and
5. It must be tailored to local and regional climate, ecology, and culture (van Hemert 2007).

The topics covered in the SCDC are Energy; Healthy Neighborhoods, Housing, Food Systems; Environmental Health and Natural Resources; Mobility; Natural Hazards; Urban Form/Community Character. The Framework for the SCDC is organized into 3 rows and five columns. The organization and approach to each of these topics is to identify and examine obstacles to achieving stated goals that might be found in a zoning code (row 1), and then suggest incentives that might be created to achieve said goal(s) (row 2), and finally focus on regulations that might be adopted to ensure progress in a particular area (row 3). Each row is divided into five columns. The first three columns suggest levels of effort for the three basic approaches, denoting a good (bronze) level, a better (silver) level, and the highest (gold) level. The fourth and fifth columns in each section provide key references and code examples/citation with hyperlinks (SCDC Beta Version 1.1)[3]. My research supports the Mobility section of the SCDC. The data analysis is depicted in Figure 2.4.

Figure 2.4: Data Analysis



2.7 Data Quality

The reliability of the data collected was enhanced by collecting data from multiple sources: literature, policy documents, and interviews with knowledgeable persons, including those involved in the policy process. The validity of this research was enhanced by interviewing key actors involved in policy-making and planning. From these interviews I was able to gain a deeper understanding of how urban policies in the Netherlands promote walking and cycling.

Given the time scale and resources, it was possible and feasible for me to obtain the data I needed to conduct the research. Though, many of the people that I contacted were on holiday given the time period of the fieldwork (July). The biggest limitation I ran into was that many of the relevant documents, mainly government documents, were only available in Dutch. Nevertheless, I was able to translate the documents electronically, and get clarifications when needed. The clarifications came from my supervisor as well as the persons whom I interviewed.

[3] See Chapter Six for my contribution.

2.8 Research Framework

To conclude this chapter, I will describe the entire research framework. This framework can be divided into four different steps: (1) Research Topic; (2) Theoretical Framework; (3) Analytical Framework; and (4) Lessons Learned.

This research topic – Dutch policies that promote pedestrian and bicycle mobility – was decided upon after doing extensive background research on problems in the United States regarding decreased physical mobility and increased automobile dependence. After examining this problem, I formulated the objective to learn from the Netherlands, which has succeeded in making cycling and walking a safe and attractive alternative to driving. Living in the Netherlands and experiencing this first-hand furthered my interest in learning how the Dutch had achieved such high cycling rates and contributed to pedestrian oriented development. Therefore, I decided to look at Dutch policies that promoted pedestrian and bicycle mobility. I wanted to not only explore the urban policies in the Netherlands to gain a critical understanding of how these policies promote pedestrian and bicycle mobility but also to see what provisions could be used as examples for improving walking and cycling conditions in the U.S. The most transferable measures that will be found will be applied to the SCDC in the United States as explained above.

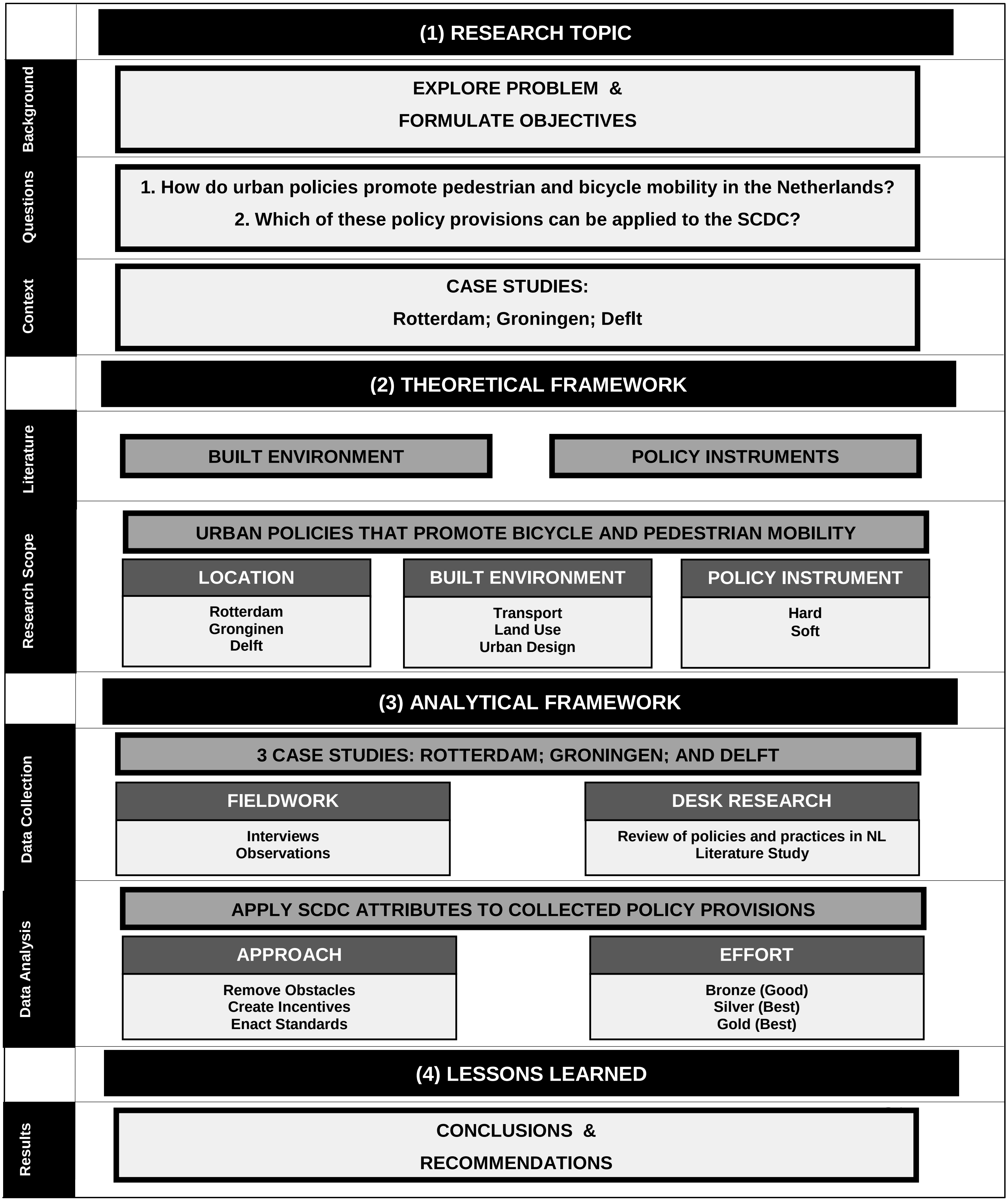
Upon identifying these objectives, I was able to formulate research questions. After formulating the research questions, it was necessary to set the research context. In other words, I needed to define the parameters of how I would examine Dutch policies. I chose to do case studies of three cities of varying sizes with different approaches to cycling and pedestrian measures. The context of these three cities and reason for choosing them is explained further above. Once the context was set, I needed to begin an in-depth study to find out what contributes to bicycle and pedestrian mobility in order to know what to look for in examining the three cities.

For this in-depth study, I embarked on the second-phase of the research – the theoretical framework. The theoretical framework was established to define the scope of the research that I would conduct. The theoretical framework was developed by conducting a literature review on urban policies that contribute to bicycle and pedestrian mobility. The literature review revealed two broad categories for consideration: the built environment and policy instruments. These two categories along with location established the scope for my research. The scope helped me to determine what I needed to inquire about in the third phase of the research – the analytical framework.

The analytical framework was established to define how the data would be collected and subsequently analyzed. The data collection has two components and is the same for each of the three cities. The components are: (1) fieldwork, consisting of interviews and observations; and (2) desk research which is a review of the policies collected as well as a literature study. Once the data was collected, I applied the SCDC attributes to it to determine which measures are applicable to the United States. The SCDC is structured by policies provisions, which can be an approach to removing obstacles, suggesting incentives that might be created, or focusing on enacting standards that might be adopted to ensure progress in a particular area. Then levels of efforts are assigned to these innovative approaches (See Chapter 6).

After analyzing the data and identifying the most transferable measures, the fourth and final phase of the research took place. This fourth and final phase is the lessons learned from which I was able to make conclusions to answer each of the research questions and recommendations based on these conclusions (See Chapter 7). This research framework is depicted below in Figure 2.5.

Figure 2.5 Research Framework



Chapter Three: Literature Review

3.1 Built Environment

Frank, et al., have written extensively on the impact of the built environment on physical activity. Their research was published in “Health and Community Design: The Impact of the Built Environment on Physical Activity” in 2003. In this book, they utilize three broad categories – transportation systems, land use patterns, and urban design – to explain the link between the built environment and physical activity. I have adopted these three categories to support my data analysis. Accordingly, portions of their research will be described below. However, to support my research and understanding of the topic, especially in relation to the Netherlands, I will also refer to additional work that has been done in this field.

3.1.1 Transportation Systems

Various transportation networks contain physical pieces that are relevant for travel by pedestrians and bicyclists. The most comprehensive transportation system is a city’s street network, which is also an important component of an urban fabric because it contributes to a city’s sense of place or lack thereof. Street networks also influence trip route and mode choice through the way destinations are connected; high connectivity networks contain a large number of blocks and intersections per some unit of area whereas low connectivity networks have fewer blocks and intersections over the same area. More intersections increase the ability to travel a more direct and shorter route between two destinations. This reduction in trip distances is critical for traveling on foot or by bicycle, as long trips are rarely taken by such mode (Frank et al. 2003).

There are three general types of street networks: organic, grid, and hierarchical. Organic networks result from unplanned changes made to street settlements over time whereas grid and hierarchical networks are planned. Organic street networks, which can be seen in older European, Asian, and African cities, are narrow and winding, with small, tight blocks that allow for short distances and multiple linkages between destinations. The grid pattern is a system of two parallel streets crossing at right angles, which form square or rectangular blocks. The pure grid has no differentiation between its streets either by traffic volume or street width, however, modifications of the pure grid do exist which have irregularly sized blacks of some differentiation by street width. Overall, the grid pattern allows for high connectivity (Frank et al. 2003).

The third type of street network – the hierarchical system – has a number of variations in street type, which are arranged into a hierarchy based on traffic movement. At the top of the hierarchy are major arterial roads designed primarily for high-volume automobile traffic, which often do not have facilities for bicyclists or pedestrians. At the bottom of the hierarchy are local residential streets designed for low-volume automobile traffic. Typically, a residential subdivision will have a network of residential streets that that have few blocks and intersections per unit of area and only join at a single point along the arterial system. The significance for modes of transportation is that such networks increase trip lengths and decrease the number of choices available, such as cycling or walking (Frank et al. 2003).

Beyond street networks, a second type of transportation network exists, which consists of those facilities that are both off-street and those dedicated to nonmotorized modes of transport. These networks can include bicycle and/or pedestrian facilities as well as shared facilitates to accommodate multiple recreational uses, such as trails for bicycles, joggers, and rollerbladers. Regarding bicycles, the Netherlands is responsible for the most aggressive development of these networks as they have created systems of lengthy networks of separated bike paths as well as bike paths along streets, included bus lanes that can be used for bicycles but not cars, provided streets that give bicyclists right-of-way priority over cars, and developed a series of street designs that provide short-cuts for bicyclists but not for motorists. Other countries in Europe, such as Germany, have instituted policies that have contributed to making the bicycle a safe and attractive mode of transport. In the United States, facilities for bicyclists are much more limited than in Europe and a more oriented toward recreational bicycling than day-to-day urban travel (Frank et al. 2003).

Additionally, according to Beatley, significant steps have been taken in many European cities to restrict automobiles and create attractive walking environments for citizens. For example, many Dutch cities have created and continue to expand pedestrian-only or pedestrian-priority areas. In fact, in most Dutch cities, major portions of the central shopping areas are pedestrian-only. Similarly, what has been coined as the “permeability” of places can be seen in Dutch cities such as Delft, where there is a dense network of streets, providing a great variety of routes and a diversity of sights and sounds for pedestrians and bicyclists. Research has shown that people experience more enjoyment and feel safer where alternative routes can be chosen (Beatley 2000).

Safety is a large component of Dutch transportation policy. In fact, the Dutch approach follows the philosophy of “sustainable road safety”, which recognizes the vulnerability of non-motorized road users and gives priority to their safety needs (Parker 2001). In practice, there is a road hierarchy in the central area of cities in the Netherlands. This hierarchy involves most roads having separate bicycle paths, separated both from footpaths and road lanes, and where it is not possible to have separated bicycle lanes, undivided bike lanes are provided on the road subject to their being a maximum speed limit of 50km/hr. This hierarchy as well as the integration of bicycle and pedestrian facilities as of an overall plan to constrain car use, restrict car parking, and provide short cuts for walkers and cyclists has made cycling and walking more safe and convenient. Furthermore, the designation of bicycle and pedestrian facilities as part of road function has been crucial in managing road traffic and improving safety (Parker 2001).

3.1.2 Land Use Patterns/Spatial Structure

Based on the research performed by Frank, et al., the second major category of the built environment is land use patterns. Land use patterns represent the arrangement of structures and features, such as buildings and parks, within the built environment. This arrangement determines the degree of proximity between trip origins and destinations, regardless of how well or poorly transportation systems connect them. In other words, it is possible to have destinations that are proximate but poorly connected or destinations that are well connected but not proximate. Two urban form variables that are commonly used as indicators to understand travel patterns are density and land use mix. Density is a measure of compactness while land use mix refers to the composition of uses within a geographic area (Frank et al. 2003).

It is reasoned that high density levels affect travel behavior by locating activities close together, which reduces the need to use a vehicle and increases mode choice options. Similarly, it is widely believed that reducing distances between destinations increases the attractiveness of bicycling and walking. Different countries have different cultural standards for classifying densities into “high,” “medium,” and “low” categories. In the Netherlands, there is a high population concentrated over a small area, so the numbers attached to high, medium, and even low population densities are higher than in other countries. Applied to the American context, the Dutch levels are unbelievably high. For instance, low densities in the Netherlands would in many situations be at the high end of the density scale in America (Frank et al. 2003).

The hypothesized relationship between mixed-use development and physical activity runs parallel to the relationship between density and physical activity, meaning that mixing land uses decreases the distance between destinations and increases the ability to travel by bike or by foot. The mixing of uses can be measured at different spatial levels. At the smallest level, uses can be mixed vertically within a single building, such as an apartment unit over a small retail shop. At the next spatial level, is the mixing of uses within a large parcel such as a suburban office development. Typically, large office developments can contain services such as banks, hair salons, retail destinations, and lunch counters, which allow employees to make at least a portion of their midday trips on foot as opposed to large office developments containing no service destinations where people have no choice but to drive during their work day in order to shop, eat lunch, and run errands, which contributes greatly to local traffic congestion (Frank et al. 2003).

The most common level for analyzing mixed or separated uses is the neighborhood because mixing uses at this level can shift travel from outside of one’s neighborhood to within neighborhood boundaries. For example, a residential neighborhood with a shopping district would provide the opportunity to shop within easy reach. Empirical studies indicate that these neighborhoods produce the greatest amount of physical activity, particularly walking.

However, in many parts of the United States, zoning ordinances make single-use development the only legally allowed type of development, which offers little opportunity for running practical errands on foot or bicycle because there are no destinations easily reachable from where housing is located. The mixed-use concept can also be used at larger scales, up to and including segments of a metropolitan region. The most valuable mix of uses at this scale is a balance of employment and residential development, which can shorten commute trips (Frank et al. 2003).

In the Dutch context, land-use patterns and planning fall into the broader category of “spatial planning”. As reported by Siy, to most, the Netherlands is regarded as “the world’s flagship of national spatial planning”. The Netherlands is renowned for its vigilant efforts to have a sustainable society, maximizing the appeal of cities for living and working while minimizing dependence on automobiles. In 1965, the Dutch Parliament adopted the first Spatial Planning Act. Succeeding its passage, a basic tenant of policymaking in the Netherlands has been “concentration of urbanization”. This embodies the creation of thriving, healthy communities with quality housing, efficient and convenient public transport, recreational opportunities, and protected open space. Under the Spatial Planning Act, the national government prepares Spatial Planning Reports to establish directions and innovations. The Fifth NDP was released in 2001, however, due to early elections; it was not approved by parliament. Nevertheless, the Fourth (NPD), which was release in 1990, continues to influence spatial development. The Fourth NDP promotes “compact city” development, containing the following criteria:

- Keeping development within a minimal distance from major city centers;
- Good accessibility for bicycle and public transport;
- Superior amenities for pedestrians, bicycles, and public transport;
- Mandatory mixed use development that combines residences, recreation and work;
- Reduction of automobile traffic;
- Extensive networks of green open spaces for recreation and nature within urban regions;
- Siting that concentrates high intensity uses (industry, offices, hospitals, etc.) around railway stations and major transportation nodes while limiting availability of parking to compel use of public transportation; and
- Solid financial backing, both public and private

Complementing this criteria are policies that restrict development of rural areas, expand public transportation, subsidize urban renewal, and redevelop cleaned up brownfields. To fulfill these objectives subsidies are given to development within designated urban regions in combination with enforced restrictions on development outside of metropolitan areas (Siy 2004).

Moreover, the compact cities concept and restrictive building policies have been the major mechanisms responsible for the prevention of uncontrolled urban sprawl in the Netherlands (van der Valk 2002). As such, these instruments have allowed the Netherlands to maintain rather high population densities: 466 inhabitants/km2 in 2000 (van der Valk 2002). Beyond land intensification, the Dutch spatial policy is also aimed at promoting mixed land use. More specifically, the spatial policy is aimed at achieving an efficient spatial coordination of homes and place of employment as well as other facilities (Meurs and Haaijer 2001). A study conducted by Henk Meurs and Rinus Haaijer in the Netherlands found that reduced car mobility can be achieved when facilities for daily trips, mainly shopping and schools, are located close to the home and that this reduction is greatest when this occurs in a densely built area (2001). However, it was also found that these spatial planning measures could not have a significant impact on decreasing automobile use and increasing physical mobility without other planning variants, including a road network in the neighborhood that is laid out for low traffic (bike and foot) and is therefore unsuitable for the car as well as having locations outside the neighborhood less accessible by car. Thus, the study concluded that an integrated approach to the planning of residential areas is required to achieve any significant changes in mobility patterns (Meurs and Haaijer 2001).

3.1.3 Urban Design

According to Frank, et al., the third major category of the built environment is urban design. Urban design characteristics influence an individual’s perception about the desirability of walking, bicycling, or engaging in recreational activities within a particular place. Streets may be the most important element of urban design as they not only connect destinations to each other but are also the places where most of the social and physical activity in the built environment occurs. Moreover, the extent to which activities can occur on streets is directly affected by the desirability of the area. For example, a street’s design can discourage walking or bicycling if it is perceived as unsafe or unattractive (Frank et al. 2003).

“Streets” include the carriageway (lanes dedicated to moving traffic), special purpose lanes (for parking and/or bicycling), and medians (tree planting strips immediately adjacent to the street surface, sidewalks, and all spaces up to the private property lot line). Most streets in the United States have been designed for the use of motorists and to the detrimental of all others. As a result, anyone who attempts to walk, jog, or bicycle on most streets will face unpleasant and unsafe conditions. Thus, a (re)design of streets for multiple uses and modes needs to be considered. This consideration requires an understanding of how different users perceive street design features and what needs arise from these differences (Frank et al. 2003).

The design of the street surface itself, including its width, number of lanes, provisions for on-street parking, and the type of paving materials used, will determine the speed and volume for automobile traffic. These conditions will impact the nonmotorist’s perceptions of safety. For instance, high-volume, high-speed traffic will negatively affect the nonmotorist’s sense of safety, and thus, ability to use nonmotorized modes of transit. On the other hand, to enhance the nonmotorist's sense of safety, design elements that slow traffic speed, reduce traffic volumes, and provide specific nonmotorized facilities such as sidewalks and bike lanes can be utilized. There are many other design elements that do not involve a complete redesign of autocentric streets, but simply can be added thereto to make them safer for the nonmotorists. These design treatments include pedestrian-friendly medians, traffic signals, well-marked cross-walks, and traffic calming (Frank et al. 2003).

Traffic calming can be very successful at making driving more difficult and walking and bicycling less difficult (Frank et al. 2003). Research performed by Beatley states that the Netherlands has implemented many successful traffic-calming and car-limiting strategies. One strategy he identifies is the *woonerf* ("living street or yard"), which is a residential street where, through bends and curves in the roads, tree planting, and brick and stone designs, car traffic is significantly slowed and the roadways are shared with pedestrians, bicyclists, and children. In fact, cars are not to move faster than the walking pace of a pedestrian and traffic lanes are intentionally narrow, leaving just enough room for a car and a bicycle to pass by one another. In a designated *woonerf* area, under the national Traffic Act, the legal relationship between cars, pedestrians, and bicycles changes and each mode is considered equal (Beatley 2000).

The *woonerf* has some perceived limitations, including a diminution of space from parked cars, the problem of providing adequate access for fire trucks, garbage trucks, and other large vehicles, and public acceptance of the concept. These areas also cost more to build and require additional maintenance due to the vegetation planted thereon. Delft was one of the first communities to apply the *woonerf* concept and the shift in attitudes about the *woonerven* can be seen in the cities' Tanthof district. In the 1970's Tanthof-east, one of the largest *woonerven* areas was built. This area is comprised of an extensive network of low-rise, attached homes, connected by both its *woonerven* and an intricate network of paths and footbridges. However in the 1980's, when Tanthof west was built, the spatial organization shifted towards a more conventional grid street layout. Nevertheless, the area contained many traffic-calming measures such as extensive speed bumps (Beatley 2000).

Beyond street design, Frank, et al., also believe that site design is an important urban design component as sites contribute to the basic attractiveness of a street. This is based on the principle that the streetscape is not just a corridor that connects destinations, but rather, a multidimensional space that shapes, and is shaped by, objects on its periphery. In other words, the placement and orientation of objects that border the street, such as buildings, squares, lawns, parking lots, and trees, give it a frame a reference and influence the behavior of street users. It is also important to consider the size of the building (width and height) the building's façade, the building's orientation to and setback from the street, the placement of parking spaces, and the design of spaces between the building and the street. Like street design, site design impacts perceptions of how safe and attractive a place may be, thereby effecting a person's decision to walk, jog, or bicycle (Frank et al. 2003).

A general design principle for buildings to encourage pedestrian activity is for them to sit close to the edge of the sidewalk, have an interesting façade that encourages interaction between the interior and exterior of the structures, such as doors, windows, and porches, and not be inordinately tall or wide. Similarly, where multiple buildings exist along a street, there should be small or no gaps between them and the styles should not be uniform, but rather, complementary. However, in many places in America, these design principles were not heeded. For example, office and retail complexes are oriented toward the needs of the automobile user and not the pedestrian, containing bland building exteriors, large building setbacks, significant distances between buildings, and enormous parking lots (Frank et al. 2003). Moreover, the shopping centers, which are commonly referred to as "strip malls" and "big-box" retail, are actually the product of developers following the rules and codes, building retail the only way it is allowed (Duany et al. 2000).

On the other hand, the policies for town centers in the Netherlands have severely restricted out-of-town shopping centers, office parks, and entertainment centers (Needham 2007). Town centers are important places for living, shopping, recreation, the arts, and serve a symbolic function as the seat of the local government as well as a meeting place for citizens and the journeys that people make to fulfill these functions can be made by foot or by bike. In order to realize this, the Netherlands pursues two complementary policies. The first policy is continuing improvement and redevelopment, where streets are pedestrianized, multi-story parking garages are built on the edge of the center, bicycle parks are built under the ground and guarded, buses are given priority in the center, street signs are renewed and made uniform, agreements are signed with shopkeepers that they will not clutter the pavements with their advertisements and special offers, and shared spaces are repaved or replanted as well as many other measures. The second policy is to restrict competing developments outside the center (Needham 2007).

3.2 Policy Instruments

While it could be easy to dismiss the high cycling levels in the Netherlands as a result of culture and the flat topography, it is actually more a result of policy. According to the Fietsberaad, various studies have shown that cycling policy does play a rather prominent role in travel behavior and bicycle use (2006). In fact, this can be demonstrated by how bicycle policy, and consequently bicycle use, varies among municipalities in the Netherlands (Fietsberaad 2006; Rietveld and Daniel 2004). A study conducted by Rietveld and Daniel found that municipal policies do influence individuals' transportation choices and can improve the competitiveness of the bicycle vis-à-vis the car for trips up to 7.5 km. The study found that a combination of push and pull policies is the most influential way to encourage bicycle use; thus, improving the attractiveness of cycling by reducing its generalized costs while also making competing modes more expensive are the two ways to encourage bicycle use (Rietveld and Daniel 2004).

Moreover, from about 1950 to 1975, when car ownership surged and cities started spreading out, cycling levels plummeted in the Netherlands (Pucher and Buehler 2008). More specifically, the bike share of trips fell from about 50-85% of trips in 1950 to 14-35% of trips in 1975. However, in the mid-1970's transport and land use policies shifted from accommodating and facilitating car use to favoring walking, cycling, and public transport over the private car. Through this massive reversal in policies, the Netherlands was able to revive cycling to its current state. Notably, this rebound in cycling was achieved concurrently with growth in per-capita income, car ownership and suburban development (Pucher and Buehler 2008).

Naturally, the question arises: how can the Netherlands achieve such high bicycle use? Beatley has carried out extensive research on sustainability, including bicycle mobility, by conducting field visits and interviews in approximately thirty cities in eleven European countries from 1996 – 1998. The findings of his research were published in "Green Urbanism: Learning from European Cities". His conclusions on bicycles as a legitimate form of mobility are somewhat non-specific as pertaining to "European cities" or "Dutch cities". However, he does provide examples from Utrecht, Amsterdam, Leiden, Delft, Groningen, and Amersfoort on this topic.

From his research, I have identified four major policy instruments that are responsible for making pedestrian and bicycle-friendly cities in the Netherlands. Based on this, I have entitled these four policy instruments broadly as: (1) Investments; (2) Government Support; (3) Infrastructure/Accessibility; and (4) Traffic. Each of these is what I classify as "hard" policy instruments, which will be explained in further detail below.

3.2.1 Hard Instruments

First, Beatley found that cities with high bicycle use had shown a willingness to make the basic ***investments*** necessary to accommodate the bicycle. To that end, he found that Dutch ***government support*** both in policy and in finance have gone toward improving bicycle facilities and safety. For the Netherlands, he also found that the ***infrastructure and accessibility*** provided to cyclists also had promotes bicycle mobility. This includes bicycle networks, separated bicycle lanes, separate traffic signals for bikes, and extensive parking facilities. Moreover, cyclists have direct routes to major destination and connectedness within and between cities, making the bicycle the fastest and easiest way to get somewhere (2000).

For pedestrians, the infrastructure needed to create attractive walking environments can include a variety of decorative measures such as artwork, sculptures, fountains, tiling, brickwork, or street-furniture. However, it can simply be a pedestrian-only area, which is typical for most central shopping districts in Dutch cities. Furthermore, ***traffic*** initiatives in many Dutch cities, such as traffic calming, provided better accommodation for bicycles and pedestrians. Short of complete pedestrianization, restricting, discouraging, or otherwise calming automobile traffic can greatly enhance the safety, and therefore the attraction to walk. Each of these hard policy instruments will be discussed more deeply below with the support of additional research that has been conducted in the Netherlands (Beatley 2000).

Government Support and Investment

Pucher remarks that most policies and programs to promote safe and convenient cycling are carried out at the municipal level in the Netherlands. Local governments are responsible for making the specific plans, constructing, and funding bicycle facilities. Similarly, cycling training, safety, and promotional programs are carried out at the local level as well; however, they may be funded by higher levels of government – provincial, regional, or national. In some cases, these higher levels of government also provide policy guidance and coordination as well as direct planning and construction of facilities that serve rural areas and/or link municipalities. Overall, the central government in the Netherlands has provided goals, design guidelines, research support, model projects, coordination, and funding for cycling initiatives (Pucher and Buehler 2008).

More specifically, in efforts to secure a “sustainable society”, the Dutch Ministry of Transport, Public Works, and Public Management formed a project group to create a Bicycle Master Plan (Welleman 1999). The Bicycle Master Plan (BMP) (1990 – 1997) had the universal objective of “promoting bicycle use while simultaneously increasing bicycle safety and appeal”. From this universal objective, the following five spearheads for bicycle policy were formulated:

1. The switch from the car to the bicycle
2. The switch from the car to public transport and the bicycle
3. Cyclist Safety
4. Bicycle parking facilities and theft prevention
5. Communication

The policy presented targets for both 1995 and 2010. The aim of the central government was to act as a catalyst to stimulate local bicycle policy plans and activity programs as well as to resolve existing bottlenecks at local and regional levels. To achieve this, the central government wanted the BMP to be an integral part of provincial and municipal traffic and transport plans. This also entailed establishing pre-conditions for specific target groups, with municipalities forming the most important target groups (Welleman 1999). Overall, the BMP project has been successful in achieving its objectives and the central government has played a strong role, nevertheless the important tasks have been decentralized and the main efforts lie with the municipalities (Welleman 1995).

The BMP’s influence was quite significant in that by 1996 nearly all municipalities had developed their own bicycle plans (ECMT 2004). In the developing and implementing the

BMP, the bicycle became regarded as an inextricable part of transport policy as a whole. Additionally, spatial, environmental, and recreational aspects were integrated in to the BMP. The success of the BMP can also be attributable to the decentralized approach taken by the Dutch central government in the development and implementation of the BMP. The project group recognized early on that the municipalities needed to be responsible for the details of their local cycling policies and plans as cycling is a short-distance travel mode, and therefore, municipalities were better placed to design and implement cycling measures (ECMT 2004).

Although Dutch bicycle policy is highly decentralized, the Federal government in the Netherlands provides continual support to provinces and municipalities. Pucher notes that the Dutch Central government fosters research, disseminates best practice information, and funds a wide range of projects. For example, from 1990 to 2006, the Dutch Central Government contributed an average of €60 million each year for cycling projects. Additionally, the European Union (EU) has been playing a growing role in promoting cycling throughout Europe. The EU has provided funding for infrastructure, such as bike route connections between countries and cycling facilities in underdeveloped regions, as well as facilitating research and the exchange of best practice information (Pucher and Buehler 2008).

Infrastructure and Accessibility

Like Beatley (2000), Pucher and Buehler also found several innovative infrastructure measures that are utilized in Europe, specifically, the Netherlands, Denmark, and Germany, to promote safe and convenient cycling. First, he determined that extensive systems of separate cycling facilities promote safe and convenient cycling. These facilities include bicycle networks, which are well maintained, fully integrated paths, lanes, and special bicycle streets in cities and surrounding regions. These facilities also include fully coordinated systems of color coded direction signs and paths for bicyclist (Pucher and Buehler 2008).

Next, intersection modifications and priority traffic signals promote safe and convenient cycling by providing priority traffic signals just for bicycles. Additionally, traffic signals that are synchronized at cyclists speed assure consecutive green lights through intersections for cyclists. Furthermore, a large supply of convenient, secure, and sometime sheltered bicycle parking facilities throughout the city promotes convenient cycling. Local governments provide a large number of bike parking facilities, however, private developers and building owners are required by local ordinance to provide a specified minimum amount of bike parking both within and adjacent to their building. Moreover, many cities offer high-capacity bike parking facilities at their train stations, which is one of many measures that has allowed integration with public transport (Pucher and Buehler 2008).

Similarly, Pucher and Buehler discovered that the bicycling networks include numerous off-street shortcut connections for cyclists enabling them to take the most direct route possible between destinations. Accessibility for cyclists is also increased by advanced green lights for cyclists at intersections as well as other priority given at intersections. Another way accessibility is enhanced for a cyclist is bike-transit integration at nearly all train stations. Not only are cyclists provided with parking facilities at train stations, they are also allowed to take the bicycles on trains during permitting times. Moreover, in the Netherlands, over a hundred railway stations provide quick and easy discount bike rentals (Pucher and Buehler 2008).

Traffic

Pucher and Buehler also observed that traffic calming measures greatly enhanced the ability to cycle safely. First, he noted it is neither possible nor necessary to provide separate bike paths on lightly residential streets, although they are a necessary component of the overall cycling network. Therefore, traffic calming, reducing the legal speed limit to 30 km/hr (19mph) and/or prohibiting through traffic, greatly enhances the flexibility of bike travel. Additionally, alterations to the streets themselves, like road narrowing, raised intersections and crosswalks, traffic circles, extra curves and zigzag routes, speed humps, and artificial deadends (mid-block street closures), contribute to creating a safe and convenient place to cycle. Another type of traffic calming measure is the "bicycle street", which is a narrow street where cyclists are given absolute traffic priority over the entire width of the street. Cars are permitted on these streets, but their speed is limited to 30 km/hr or less and they must yield to cyclists. Furthermore, for pedestrians there are many car-free zones in city centers (Pucher and Buehler 2008).

Another component of traffic as a policy instrument is traffic training, education, and laws. In the Netherlands, as part of their regular school curriculum, children receive extensive training in safe cycling techniques. This includes both classroom instruction and "on the road" lessons, first on a cycling track, and then on regular facilities throughout the city. Upon passing a test, children receive official certificates, pennants, and stickers from police offers. On the other side, motorists also get specific training on how to be aware of cyclists on the roadway and to avoid endangering them. Motorists are generally assumed to be responsible for collisions with cyclists and unless it can be proven that the cyclists causes the crash. To that end, having the right of way by law does not excuse motorists from hitting cyclists. Motorists are also legally responsible for collision with children and elderly cyclists regardless of their following traffic regulations (jaywalking, cycling the wrong direction, ignoring traffic signals, etc.). Motorists are legally required to pay special attention to nonmotorists. Overall, the traffic laws for both motorists and nonmotorists are strictly enforced, contributing to safer behavior by both (Pucher and Buehler 2008).

3.2.2 Soft Instruments

Beyond the hard policy instruments discussed above (government support, investment, accessibility, and traffic) are many soft policy instruments that also contribute to promoting a safe and convenient environment for both pedestrians and cyclists. Based on a literature review, I have identified four soft policy instruments responsible for making pedestrian bicycle-friendly cities in the Netherlands. I have entitled these four soft policy instruments broadly as: (1) Marketing; (2) Disincentives; (3) Incentives; and (4) Integration.

Marketing

First, there is a wide variety ***marketing*** events that cities can take on to stimulate interest and enthusiasm for cycling and walking. Communication and campaigns are important tools for the promotion of cycling and road safety (Jensen et al. 2000). For instance, campaigns can focus on traffic, the environment, health, road safety, or education, and depending on the focus, a wide range of administrations and organizations may be interested in participating in or initiating a campaign. Generally, there are three types of campaigns: campaigns to raise public awareness, campaigns to targeted groups and settings, and campaigns to individuals and households. It is necessary to know at what stage the public has reached in the process of behavioral change[4] so that money is not wasted on campaigns that miss their target (Jensen et al. 2000).

To carry out a successful public awareness campaign it is essential to have basic knowledge concerning people's attitudes to and acceptance of car use and cycling. Awareness campaigns reach the largest number of people with the use of the media and hosting events. Campaigns to targeted groups and settings aim at demonstrating how citizens can promote more and safer cycling in practice, which can be done at schools, universities, companies, medical clinics, shopping streets, sports clubs, etc. Rewards are often a catalyst for behavioral changes and can be utilized. For example, rewards could be company bikes, bicycle lamps, or helmets. The motivation parameters for individualized campaigns are primarily a matter of promoting individual benefits, such as financial savings, health, reduced risk, and/or enjoyment. Even minor changes in individual travel behavior can make a difference in the overall scenario. For example, Dutch experience from travel plans for companies has shown that 0-8% of all employees can become new cyclists (Jensen et al. 2000).

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[4] The 5 stages of change are as follows: (1) Awareness: knowledge of the problems/solutions; (2) Acceptance: of the need for change; (3) Attitudes: to cycling and other transport modes; (4) Action: try to cycle; and (5) Assimilation: maintain behavioral changes (Jensen et al. 2000).

Disincentives

Disincentives for driving can also stimulate cycling. Generally, these disincentives can include speed limits, turns, direction of travel, car-free zones, and reduced parking (Pucher and Buehler 2008). For example, at urban rail way stations there are often very few car parking spaces whereas there are many bicycle parking spaces (Parker 2001). Similarly, rail way stations are designed to give pedestrians who or walk to or access stations by other public transport more convenient access than automobiles. The national car parking manual, which has been successful, is aimed at providing for bicycle parking while constraining car use. It states:

"*Definition: A coordinated car parking policy is directed to restricting car use. The aim is to encourage selective car use so as to make a favorable contribution to accessibility and the living environment by reducing car mobility which reduces congestion while at the same time stimulates alternative modes of transport. It also plays a part in the sharing of scarce space.*"

An additional means of constraining car use are "green taxes", which have reduced greenhouse gas emissions and oil dependence. The greening of the tax system is designed to shift the taxation of labor to the taxation of environmentally harmful activities. Thus, taxes on unsustainable transport consumption have been increased. This increase has been on fuel tax rates as well as an excise levied on new vehicles and an annual vehicle tax (Parker 2001). Generally, sales taxes on petrol and new car purchase, import tariffs, registration fees, license fees, driver training fees, and parking fees are generally higher in Europe than in the United States (Pucher and Buehler 2008).

Incentives

Alternatively, there are ***incentives*** that cities can give to people or businesses to encourage cycling (or walking if feasible). The greening of the tax system as identified above not only provided disincentives for unsustainable transport, but also, incentives for sustainable transport modes (Parker 2001). These incentives included the following:

1. Value-added tax incentives for employers to provide bicycles.

2. Reimbursement of cycle commuting costs in wages and income tax.

3. Increase in scope and magnitude of the tax allowance for trips to work by means of public transport.

4. Tax free reimbursement of public transport costs in wages and income tax.

5. Increase public transport allowance.

6. Incentives for tele-working in wages and income tax.

7. More wages and income tax concessions for car pooling.

8. Tax incentives for the purchase of clean, energy-efficient cars (Parker 2001).

Beyond the tax incentives, there are other cycle projects, which have been initiated. One project is a cyclist reward system where a cyclist rides past a recording station, for example at his or her place of work, and the use of the cycle is automatically recorded (MOVE 2002). The user can then get rewards of cash or gifts. Other incentives to take the bicycle include allowing the bicycle onto public transport, the public transport bicycle, park and bikes, and safe cycle storage (MOVE 2002).

Integration

Integration has also been identified as a key factor for success in the promotion of cycling and pedestrian mobility. The aspects of an "integral policy" include integration in the overall policy cycle, from political commitment to planned implementation and assessment (Fietsberaad 2006). Integral also refers to the complement of the push-pull policy of restricting car use and encouraging cycling. An additional aspect of integration includes the gradual realization and the improvement of infrastructural facilities as well as projects revolving around technical innovation, service and promotion (Fietsberaad 2006). More generally, integration among planning fields, integration among various policies, as well as integration at several levels of government is necessary (Pucher and Buehler 2008). Pucher recognized that the coordinated implementation of mutually reinforcing policies is a large factor of the success in the Netherlands. As acknowledged by he and others, there are lessons to be learned from this experience.

3.3 Conclusion

The research will look at how the three categories of the built environment – transport, land-use/spatial, and urban design – contribute to the promotion of physical mobility, specifically walking and cycling. However, to gain a deeper understanding of what is most significant at the policy level, the matrix set forth in Table 3.1 will describe what policy instruments are utilized in each of the three cities.

Figure 3.1 Exemplar Matrix

City	Hard Instruments				Soft Instruments			
	Investment	Government Support	Infrastructure/ Accessibility	Traffic	Marketing	Incentives	Disincentives	Integration
Rotterdam								
Groningen								
Delft								

Chapter Four: Design Manual for Bicycle Traffic[5]

4.1 Overview of Design Manual

Bicycle-friendly infrastructure is a prerequisite to the bicycle becoming, and retaining, a full status position in a traffic system. Bicycle-friendly infrastructure is that which enables cyclist to make direct and comfortable bicycle journeys in safe and attractive traffic surrounding. It is then and only then that the bicycle can compete with the car. According to CROW, various studies have demonstrated that good-quality cycling infrastructure does in fact lead to a higher proportion of bicycles in the modal split[6]. Generating large-scale bicycle use by means of a high-quality network is not a simple task and requires patience and continuous attention in policy.

The CROW is the Netherlands national knowledge platform for infrastructure, traffic, transportation and public spaces. It makes knowledge applicable in practice through widely supported recommendations and guidelines. A number of these guidelines and recommendations are published. One such publication is the "Design manual for bicycle traffic" (CROW 2000). This manual is a predecessor to "Sign up for the bike" which is regarded as the most authoritative manual on bicycle traffic in the world. This manual is based on "Sign up for the bike' and is supplemented with new information. This manual provides the information designers need to make the bicycle a fully fledged participant in the traffic and transport system.

Municipalities in the Netherlands uniformly use the guidelines published in this manual. In fact, every person I interviewed, including those who work for the municipality, embrace the recommendations set forth in this design manual. This manual is not a legislative or regulatory instrument, and as such, has no binding effect on the national, provincial, regional, or local government entities in the Netherlands. Nevertheless, it is adhered to as if it did. Notably, while this manual does not set forth any legal requirements, should a conflict arise, the Court will defer to these guidelines. Due to the regard of this manual as well as the fact that the three cities studied follow the principles within, this chapter will consist of a summary of the Design manual for bicycle traffic.

This design manual describes all steps required for the creation of bicycle-friendly infrastructure, starting with the policy proposal, continuing with the design of infrastructure,

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[5] This entire chapter is based on the "Design Manual for Bicycle Traffic" published by CROW in 2000.

[6] One of the most recent studies in this area is the "Fietsbalans" (Bicycle Balance), which shows that towns and cities that scored high in their project, which measures, among other things, the directness, comfort, attractiveness, and safety of cycling infrastructure in many municipalities, have more active cyclists than towns and cities that scored low.

and concluding with a discussion of the inspection, maintenance, and management of bicycle facilities. This design manual contains a continuous theme that asks designers to study the cyclist as the future user of the design, define their goals, and balance function, form, and use. This approach requires designers to think and to formulate the consequences of their design choices.

4.2 Integral Design

It is impossible to design for the bicycle solely on the drawing table or computer, but rather, it is necessary to have a look at the real world situation. One reason for this is due to the fact that cyclists are so flexible so it is possible that cyclists use designs in different ways than intended. Thus, actual behavior on the street is an important input for design.

4.2.1 Network Level

Integral thinking starts in the spatial planning phase because the ability to make short journeys is vital for the bicycle to be used as a means of transport. In fact, people who live within three kilometers of a center or sub-center make more frequent journeys by bicycle than people who live further away. Therefore, it is recommended that new residential areas should not be built more than three kilometers from a town or city center. In practice, traffic planners and urban planners can work together to cut distances, reduce the number of barriers, and deal with special densification to improve the position for the bicycle. For short distances, it is also financially sensible to invest in bicycle infrastructure over public transport as an alternative for the car.

4.2.2 Connection Level

In most situations, cyclists have the ability to choose how they travel. Often, people will choose other means of transport over the cycle when directness, safety, and comfort of cycling are not ideal. Cyclists are also very vulnerable when it comes to encounters with fast-traffic. Thus, avoiding conflicts by separating traffic types is an essential measure. Other measures, to be used in conjunction with or as alternatives to separating traffic types, include reducing the speed of motorized traffic and limiting the amount of motorized traffic on major cycle routes.

4.2.3 Facility Level

The quality of facilities offered to cyclists should be assessed with the same criteria as the quality offered to other road users. In this regard, integral thinking means that traffic is viewed as an interaction between road users that are theoretically ready to comply with the rules. Conditions for conflict avoidance are necessary for a safe environment. For example, conditions for conflict avoidance are present if a cyclist can establish eye contact with a motorist. On the other hand, a condition where eye contact is not possible is inherently unsafe. Infrastructure design impacts the ability of road users being able to see one another.

4.3 Requirements for a Network

A cycling network is a collection of routes and connections. There are five major requirements for the development of a cycle network: (1) cohesion; (2) directness; and (3) safety; (4) comfort; and (5) attractiveness. A table with a summary of these requirements is located in Annex 2.

4.3.1 Cohesion

At the network level, cohesion means that connections have to link up from a cyclist’s point of departure to their destination. Thus, cohesion involves the construction of a complete system of connections, providing access to all points of departure and destination so that every home, business, or other attraction point is accessible by bicycle. The most fundamental indicator for cohesion is the physical presence of infrastructure that is accessible by bicycle. A network indicator for the extent of cohesion is the mesh width of the network, where a value of no more than 250 meters applies as a guide value for inside built-up areas. It is also important that cyclist can choose among alternative routes. If the mesh width requirement is met, then an alternative route will be available within 250 meters.

Apart from the internal cohesion of a cycle network, the cohesion with other networks for cars, public transport, and pedestrians is also important. For instance, it is important that park and ride facilities for the car are accessible by bicycle. Similarly, tailoring the cycle network to the public transport network is relevant because the bicycle can a vital role to pre and post public transport journeys. A link to pedestrian networks is also relevant, especially for city centers and pedestrian precincts. Ultimately, it must be possible for the bicycle to use these areas and get as close to them as possible.

4.3.2 Directness

Two components are important for directness at the network level: directness in terms of distance and directness in terms of time.

Directness in terms of distance

Directness in terms of distances is the extent to which a network provides the opportunity to cycle between a departure point and destination point via the most direct route possible. Regarding policy, the bicycle should be a good alternative to the car, especially inside the built-up area. If the bicycle is quicker than taking the car, then motorists will be more disposed to using the bicycle instead of the car, particularly for short trips.

Directness in terms of time

Directness in terms of time concerns connections that optimize traffic flow. An important aspect is the possibility to carry out unimpeded cycling, which can be assessed by the number of intersections per kilometer at which a cyclist does not have the right of way. For main cycle routes, that number should either be zero or as close to zero as possible.

4.3.3. Safety

At the network level the following requirements are necessary to ensure safety: avoidance of conflicts with crossing traffic, separating vehicle types, reducing speed at points of conflict, ensuring recognizable road categories, and ensuring uniform traffic situations.

Avoiding conflicts with crossing traffic

Each encounter with a passing flow of traffic presents a potential conflict. Therefore, the higher number of encounters, the higher the danger of the network becomes. To minimize the number of encounters, the number of intersections should be kept to a minimum. A measure that takes into account both the number of intersections and the traffic load is calculated by totaling the number of crossing movements made by cyclists' times the intensity of the passing flow of motorized traffic for each intersection, which is mathematically expressed as follows:

$\sum$ (Intensity of crossing cyclists at intersection) * (Intensity of the flow of traffic to be crossed at intersection)

This figure is summed up for all intersections. This figure should be weighted for speed. When the amounts are totaled for all road sections the amount could be expressed as follows:

$$\sum \text{(Density of motorized traffic)} * \text{(Density of bicycle traffic)} * \text{(The speed difference)}^2 * \text{(Length of road section)}$$

This figure should be summed for all road sections. The density is equal to the intensity divided by the speed. The network variant with the lowest risk of encounter will be the safest.

Separating vehicle types

The safety of cyclists is also improved when they are separated from motor vehicles travelling at high speed. Bicycles should be guided via their own network of connections. Separating vehicle types also enhances comfort.

Reducing speed at points of conflict

Points of conflict arise where the cycle network crosses other vehicle networks. At these points, the speed differences between the two should be minimized. The speed of the slowed means of transport (typically the bicycle) should be used as the basis.

Ensuring recognizable road categories

For road sections and intersections, specific traffic provisions should be recognizable. Recognizability at the network level is important for the application of specific traffic provisions. Simply, every provision should be recognizable to each road user.

Ensuring uniform traffic situations

Uniformity in traffic situations at the network level is important in the application of certain solutions that should be specific to road function. For example, bicycle facilities and intersection solutions are related to the function of roads for car and bicycle traffic. In other words, solutions that are characteristic of a certain type of road should not be used on other types of roads.

4.3.4 Comfort

At the network level, comfort concerns the extent to which cyclists can comfortably use the connections. One important way to enhance comfort is to prevent traffic nuisance. This means that when designing a cycle network longitudinal or lateral combination of cycle connections with busy flows of motorized traffic should be avoided where possible because the fumes emitted by motorized traffic can cause health problems. Another element for enhancing comfort is optimizing the ease for cyclists to find their way. At the network level, a system of bicycle signposts should be utilized to ensure that cyclists can easily find their way.

Comprehensibility of a network also enhances comfort. This means that a network should be geared to the logic of the user by using natural points of recognition. For example, in the past, routes between villages ran from church steeple to church steeple since these were a natural signpost. If cyclists have these types of orientation points they can use them to make a mental map of the vicinity, which improves the overall comfort and attractiveness of the network. Thus, designers can try to plan a route in such a way that it passes recognizable, notable, and attractive urban design and landscape elements.

4.3.5 Attractiveness

While attractiveness is more subjective than the other network requirements, in general, pleasant cycling depends on the attractiveness of the vicinity and on public safety. At the network level, this means that functional connections should run through built-up areas in varied surroundings with well-maintained public space. The connections should also be lit as well as possible.

4.4 Utilitarian Cycle Network

The utilitarian cycle network comprises the connections required for functional reasons, such as shopping, living, working, education, and socio-cultural visits. This design manual looks at two different methods that can be applied when designing a utilitarian cycle network: the traffic model and adapted grid method. The traffic model is dependent on there already being some multi-modal car/bicycle/public transport interaction and typically where cycle network is already available. The adapted grid method is useful where no model is available and an entire network needs to be created. This summary will focus only on the adapted grid network.

4.4.1 Adapted Grid Method

The adapted grid method is based on the original grid method, which presumes that cyclists benefit from as full and complete a network of connections as possible. Depending on the grid size (mesh width), if a grid of connections is laid out over an area (neighborhood, district, village, town, or city), it will produce a complete infrastructure. The adapted grid method has two steps: (1) charting the main departure and destination areas and links; and (2) converting preference lines into routes.

Step 1: Determining the main departure and destination areas and links

This first step charts the main departure and destination areas. For this step, the size of the study area plays a decisive role. For example, at the provincial level, a center can be regarded as a single departure area, while for the network inside the center, various neighborhoods and districts are individual departure areas. Departure areas are typically cohesive residential areas of all sizes. On the other hand, destination areas are all those functions, buildings, activities, and amenities that may attract a lot of cyclists, such as the following destinations:

- Shopping areas and city, district, and village centers;
- Government and other building with a major public function;
- Schools and universities;
- Sports amenities, such as swimming pools, sports fields, recreational areas, and activity centers;
- Concentrations of employment, such as large companies or business parks;
- Main public transport hubs (railway, bus, tram, and underground terminals);
- Links to the surrounding regional or provincial cycle network and the recreational cycle network; and
- Activities that do not occur every day, such as markets, theatres, cinemas, churches, and catering facilities.

It is also important to consider any new developments that are planned for the coming five to ten years in which case those departure and destination areas should be considered. Once the departures and destinations have been determined, the links are plotted between them. Preference lines are used to mark the ideal links between the two areas. The preference lines form an abstract representation of the journey pattern, without taking the spatial structure or traffic network into account. In an urban environment, where there is a high number of links, it is possible to combine preference lines that are in close proximity to each other.

For a large city, preference lines can be initially plotted at a high scale level (i.e. the whole city), including the centers and sub-centers. After plotting the preference lines at a high scale, details can be added at a lower scale (i.e. district/neighborhood). Important considerations include cross-linking the various levels of scale, such as neighboring municipalities. It may be advisable to create a hierarchy in the network, which distinguishes quality levels within the cycle network. If such a distinction is deemed necessary, step one should be repeated to ascertain what specific links it involves.

Step 2: Converting preference lines into routes

In this step, the departure and destination links converted into preference lines are converted into possible routes. This entails making as much use of the existing infrastructure as possible. There are also often several routes between departure and destination points, in which case the most direct route in terms of distance is the preferred route. The shortest route is then checked on the basis of the set route criteria. If it meets the criteria, it is included in the network. If the route does not meet the criteria but can be improved, it should still be included in the network. On the other hand, if the route does not meet the criteria and cannot be improved, designers should look for the next best route, keeping in mind that the second choice cannot be much longer in terms of distance than the first one. The levels of quality for the routes are similar to the requirements for the cycle network and are described further below.

4.4.2 Levels of Quality

The power of the bicycle is its flexibility, speed, and convenience, however, these advantages can only be exploitable if as many roads, streets, and tracks as possible are made suitable for cycling. Routes should offer cyclists the highest level of quality, achieving the five main requirements set forth above. This manual distinguishes between two basic levels of cycle connections: basic network and cycle routes. Inside the built-up area, the basic network concerns the access connections at the neighborhood level, corresponding in practice with almost every track and street that can be used by a cyclist (a mesh width of no more than 250 meter). Outside the built-up area, the basic network concerns the network of roads and tracks that provide access to the outlying area. Cycle routes concern the connections at the district level that provide access to districts and neighborhoods inside the built-up area, whereas outside the built-up area cycle routes concern the connections between centers, villages, towns and cities.

4.5 Road Sections

In the Netherlands, there is now general agreement on dividing the road network into three categories for motorized traffic, namely:

1. Distributor Roads: These are designed to ensure a continuous, uninterrupted flow of traffic at a relatively high speed. This means that the road has separate directions of traffic flow, an uncrossable carriageway, and a relatively homogenous group of users. Cyclists are not permitted on distributor roads; instead they cross them by means of overpasses or tunnels.

2. District Access Roads: These roads are used for flow and exchange. However, these functions are separated spatially: the flow takes place on the road section, the exchange on the intersections. On road sections, as much as possible is done to meet the requirement of a distributor road: separate directions of flow, no crossing traffic and a relatively homogenous group of road users. At exchange points (intersections and crossings), speeds should be low enough to avoid serious conflicts.

3. Estate Access Roads: These roads are intended to provide access to housing estates, which means that all groups of road users must be able to use them. It must be possible to make maneuvers such as parking, getting in and out, as well as turning and crossing safely, so the speed of motorized traffic must be kept low.

These functional road categories set different requirements for the road design for bicycle traffic. The general principle is that district access roads require specific bicycle facilities whereas road sections designed to fulfill an estate access function do not normally require such facilities due to the low speed of motorized traffic. However, this general principle can be interpreted in a variety of different ways. For example, a road section that forms part of a main cycle route should offer more cycling quality and comfort than a road section that is used only by a few cyclists. Similarly, there are situations where a wider profile is better than a narrow one.

Therefore, designers always have to determine the best solution for bicycle traffic in a given situation, taking into account the actual conditions. In other words, for each road section designers have to ask themselves what traffic facilities are required to guarantee cyclists a safe and pleasant situation. Table 3 shows an initial guideline for making choices for each road section based on three basic premises: (1) the most preferable situation for cyclists is key; (2) for a bicycle friendly infrastructure, the entire traffic situation is important and not only the specific bicycle facility; and (3) there is often more than one possible solution and the boundary between possible solutions is not always fixed.

4.5.1 Solitary Track

Solitary tracks follow their own route and are solely intended for cyclists or in some cases for cyclists and moped riders. These are connections through a park, a short cut between districts, or a connection through the country side. Solitary tracks are not related to an adjacent carriageway (as separated tracks are), and more specifically at least 10 meters away from a carriageway[7]. In theory, solitary bicycle facilities are intended for traffic moving in two directions, thereby setting the width at 1.50 meters for cyclists' only tracks with local traffic intensity and at least 2.00 meters if mopeds use the tracks as well. Additionally, the center of the track should be marked to make it clear that oncoming traffic can be expected.

4.5.2 Combined Traffic

An estate access road, typically a traditional residential street, has a speed limit of 30 km/h. In the case of quiet, normal bicycle use and intensities of motorized traffic up to 5,000 pcu/day then no special bicycle facilities are necessary. In the case of combined traffic, parking is an aspect that requires special attention. Parked vehicles not only hinder cyclists, but also form a source of danger due to opening doors and evasive maneuvers. It is found that an occasional parked car is not a problem, but if more than approximately 20% of the length of the road is used for parking, it is advisable to build a parking lane. This restores straight riding for the cyclist. To further ensure the safety of cyclists, it is advisable to build a critical reaction strip on the parking lane.

4.5.3 Cycle Street

The cycle street is a functional concept: an estate access road that forms part of a main cycle route, but where motorized traffic does occur to a limited extent and as subordinate traffic. A cycle street can be laid out in a variety of ways and it is recommended to minimize nuisance caused by parked vehicles, use a closed surface paving (asphalt preferred), and provide a form of guidance in situations where choices have to be made. The cycle streets' safety and attractiveness can only be matched by a solitary or separate cycle track; however, the cycle street has a number of advantages in comparison:

- Less use of space: the cycle street is open to motorized traffic but requires less space than a solitary cycle track or separate track next to the main carriage way. This also makes the cycle street more cost-effective.

- Improve accessibility: Unlike full closure of a street or rout to motorized traffic, cycle streets allow access to motorized traffic.

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[7] Case law shows that in legal terms, a cycle track is not part of a carriageway if it is situated more than 10 meters away.

- Better social safety: a route through a residential district with a combined use of bicycle and car provides more social safety than a solitary cycle track or separate cycle track next to the road.

An important condition for designating a road section as a cycle street is that the bicycle traffic really has to dominate the streetscape, at least doubling the motorists on a road section. However, if this requirement is not met while policy calls for additional quality for cyclists, the road authorities may try to reduce the intensity of motorized traffic. Nevertheless, a large number of cyclists have to be present. In fact, to qualify as a cycle street, the street must carry at least 1,000 cyclists a day. Studies have shown that on a main cycle route with a car intensity level of up to 500 pcu/day, the superiority of bicycle traffic can easily be achieved without modifications to the profile. As of yet though, there is no definite answer as to how much motorized traffic on a cycle street is acceptable. For example, in Germany, the maximum for cycle streets is set at 3,000 pcu/day, while in the Netherlands it is either 1,000 or 2,000 pcu/day.

4.5.4 Cycle Lanes

Cycle lanes are possible on district access roads with relatively low bicycle use and on sections of estate access roads with a high intensity of motorized traffic. A cycle lane is characterized by: (1) sufficient width; (2) red color; and (2) the bicycle symbol. For safety reasons, it is advisable to build cycle lanes with a minimum width of 1.50 and a maximum width of 2.50. Additionally, cycle lanes are not recommended in combination with parking bays, because opening car doors is a source of danger; however, if parking is absolutely necessary, than a critical reaction strip of at least 0.50 meters wide is strongly recommended. In this case, designers should check whether a cycle track would not be a better solution. For example, a width of 1.50 meters for the cycle lane, 0.10 meters of markings, and 0.50 meters of critical reaction strip also provides room for a cycle track with a width of 1.80 meters with 0.30 meters of partition verge.

4.5.5 Suggestion Lanes

Since cycle lanes make parking and stopping of motor vehicles impossible, suggestion lanes can be used as alternatives. Suggestion lanes can be regarded as a fully fledged bicycle facility and, consequently, have the properties of a cycle lane or may be regarded as less giving way to motor vehicle parking. Some people believe that suggestion lanes should be red and white to provide maximum comfort and safety to cyclists, although others believe there should be a distinction between the cycle land and suggestion lane to avoid confusion among road users. The latter is more effective for road safety, and for this reason the suggestion lane should not be colored red. Instead suggestions lanes should have no red color, a width between 1.50 meters and 2.00 meters, and preferably in combination with a parking ban.

4.5.6 Cycle Tracks

On sections of district access roads, cycle tracks are the safest solution, preferable to the cycle lane. This is because cyclists are separated from motorized traffic, making the risk of conflict minimal. The design of the cycle track depends on the function (design and speed) and the use (width). A disadvantage of cycle tracks is that cyclists are outside of the direct field vision of the motorists and this disadvantage grows as the distance between the cycle track and carriageway increases. On the road, this is not a problem because cyclists and cars are separated; however, a problem may arise at intersections. Since motorists do not have to allow for cyclists on road sections, there is a danger that they will not do so at intersections either. Solutions to this problem are discussed later in Section 1.6 regarding intersections.
In principle, cycle tracks next to carriage ways are designed for one-way traffic. At intersections, two-way bicycle traffic can lead to traffic movements in unexpected directions, which may impact safety. However, there may be good reasons to have two-way cycle track, for example if:

- A two-way traffic cycle track shortens the route for cyclists and/or forms a logical short cut in the route;
- A two-way traffic cycle track prevents crossing movements; and/or
- There is not enough room for a cycle track on both sides of the road.

A condition for a two-way cycle track is that sufficient attention must be paid to its design, particularly at intersections, where the cycle crossing should be slightly elevated. Additionally, if the cycle track has the right of way, then the pavement, signposting, and markings should support it. This reduces the chance of road users failing to notice cyclists coming from unexpected directions. An option diagram regarding these road sections is provided in Annex 3.

4.6 Intersections

The main requirements of directness, safety, and comfort are significant at the intersection level. Cohesion is part of safety and therefore is not dealt with separately. Additionally, attractiveness plays a lesser role with regard to intersections.

4.6.1 Directness

The same distinction between directness in time and distance as made above with the network can be made here with regard to intersection.

Directness in Time

Directness at the intersection level is related to design speed. Directness in time is an important consideration for intersections in routes that are used by large numbers of cyclists. Directness can be achieved, where possible, by giving cycle traffic the right of way through the intersection. Where this is not possible, the risk of waiting can be minimized by installing traffic lights with remote detection on the cycle directions. For intersection in general, and especially for intersections that form part of a main cycle route, the chance that the cyclist has to stop should be minimized.

Directness in Distance

Directness in distance is important at the intersection level because, wherever possible, cyclists should be able to follow the most direct route. Directness in distance is threatened at crossings controlled by traffic lights where traffic movements through intersections must occur in several stages. Additionally, cycle tracks that are bent outward, for example, negatively impact directness in distance.

4.6.2 Safety

Safety requirements should have priority in the design of cycle facilities at intersections. First, conflicts with oncoming traffic should be prevented. It is important that road users can recognize conflicting traffic flows and conflict points. Similarly, cyclist should be in the motorists' field of vision so that the motorists can react to their presence. Conflicts with intersecting and crossing traffic should also be minimized. If the traffic flows take place in the same level, all traffic participants must be able to observe the intersection in good time (driving visibility) and crossing traffic must have a good view of the traffic flow to be crossed (approach visibility). Crossing conflicts can be converted into passing conflicts (which are generally less dangerous) by converting an intersection into a roundabout.

Furthermore, because many crossing conflicts are possible at an intersection it is recommended that the speed difference between the various types of traffic is minimized. This should be based on the speed of the cyclists, which would be 20 to 30 km/h. A smooth and even road surface is also necessary to enhance the safety for cyclists, as uneven road surfaces with holes and bumps can lead to falls, rain puddles can form on road surfaces that are not smooth, and when they freeze cyclists can be forced off the road. Additionally, using a limited number of types of intersections can contribute to the recognizability of road categories for road users, making them even better aware of their expected behavior. Therefore, uniformity in design, right of way rules, signposts, and marking results in an intersection that is comprehensible to the road user.

4.6.3 Comfort

In terms of comfort, intersections should meet the following requirements: ensure a smooth road surface; maximize the ability of proceeding unhindered; minimize traffic nuisance; and minimize weather nuisance. To ensure a smooth road surface the pavement of intersections should be even, especially for junctions between main and side roads. Being able to proceed unhindered involves avoiding delays at intersections. Thus, waiting times should be minimized. Nuisance from other traffic should also be minimized for cyclists. In busy situations with substantial fume and noise emissions, a separate route should be sought.
Lastly, minimizing nuisance from wind and rain should be a point of attention, although this is very difficult to achieve at intersections. It may be possible to use vegetation to minimize nuisance from wind without compromising safety. The main requirement of “attractiveness’ is less relevant at the intersection level. However, intersections should still meet the requirements of social safety. This means that they are well lit, there is supervision from the surrounding area, the surroundings are visible, and the public space is well maintained.

4.6.4 Options for bicycle – friendly provisions

A minimum waiting time at stops is essential for a bicycle-friendly atmosphere, and policy development has the most significant impact on the options for facilitating bicycle traffic. More concretely, the formulation of clear basic policy principles can be a significant improvement for bicycle traffic, especially with regard to traffic light provisions. For example, a basic principle that can be applied could be that main cycle routes have the right of way at intersections in the built-up area. Another option is to indicate maximum values for waiting times at stops or cycle time. These types of principles can be recorded in administrative regulations to ensure that traffic engineers have very clear specifications to follow.

The design manual provides many measures for improving the situation for cyclists at intersections. Most of these pertain to traffic lights and shortening waiting times, however, there are other facilities for cycle traffic, which are even safer than the traffic light. These include roundabouts and grade-separated facilities, including bridges and tunnels. Roundabouts have numerous advantages, including avoiding encounters between motor vehicles driving in opposite directions, simplifying conflict situations, and ensuring low speeds at conflict points. On roundabouts it is recommended that cyclists on separate paths have right of way.

Grade-separated facilities are advisable or necessary when other intersection solutions cannot meet the design relation to directness and safety. The two alternatives are a bridge or tunnel, which may have potential advantages or disadvantages for height, social safety, spatial fit, comfort and cost depending on the location and exact design. Additionally, a bridge or tunnel almost always involves a height difference that must be bridged while cycling. Cycle lifts or escalators/stairs can be used for large height differences. While grade-separated solutions are advisable there may not be enough space or financing for their construction, in which case a safe crossing can only be realized if the speed differences are reduced or if the volume and direction differences are separated in time using traffic lights. However, if traffic lights are necessary any one or a combination of the measures may be utilized. A list of the various measures is provided in Annex 4.

4.7 Design, Maintenance, and Furnishings

4.7.1 Road surfacing and paving

With regard to road surfacing and paving, the following requirements apply: evenness of the paving surface, skid resistance, and drainage. First, the evenness of the paving determines the vibrations experienced by the cyclists while riding and, accordingly, forms an important condition for comfortable cycling. To a large extent, evenness also determines the resistance that cyclists experience and, consequently their energy consumption. Skid resistance of the paving is determined by the texture, which is important for cycling comfort and energy loss and also safety. Careful consideration must also be given to proper drainage as it is very uncomfortable to have to cycle through big puddles. Puddles are also dangerous because cyclists are unable to see how deep the puddle is or whether there are any potholes or ruts on the road surface, which can cause evasive maneuvers or falls.

Designers can choose from different types of paving; however, research has shown that cyclists prefer the following paving types successively: asphalt, concrete, tile paving, and paviours. Asphalt and concrete offer the greatest evenness, least resistance, and, consequently, the most comfort. Using color is something a designer can do to make cycle tracks and lanes clear to the road users. For example, red is now the national standard for cycle tracks and cycle lanes in the Netherlands, although there is no statutory basis for this. It is believed that by using the red color, cycle provision become more recognizable and visible resulting in a favorable effect for cyclists comfort (ease of use) and traffic safety. The use of colors can also support the continuity of the route.

4.7.2 Green and verges

Generally, green areas are intended to strengthen landscape characteristics and the overall quality of an area. For cyclists, it is important to enhance the cycling experience and residential quality, provide protection by reducing wind nuisance, reduce glare from oncoming cars, and provide visual protections from car traffic. While green areas offer these benefits to cyclists, they also can have some negative effects in certain situations. Green areas may impede visibility or provide somewhere to hide for people with bad intentions. Despite these disadvantages, there are alternatives, such as low-level shrubs, ground-cover, and solitary trees. Verges alongside cycle tracks may not cause any hindrance, therefore, an obstacle-free area of at least 1.00 meters is recommended.

4.7.3 Lighting and signposting

Lighting serves many functions including increasing traffic safety, improving traffic flow, increasing (cycling) comfort, improving social safety, and making the area visible. Lighting should always be provided for on main cycle routes and the basic network. Standard street lighting will typically suffice for the basic network. Separate cycle tracks that are situated no further than 2 meters from the main carriageway can be lit by the lampposts on the main carriageway, provided that these are positioned on the partition verge. For cycle tracks further away or where lampposts are not positioned on the partition verge, dedicated lighting may be necessary for the cycle track.

The most important function of signposting is to help cyclists who are unfamiliar with an area find their destination. A subordinate function is to help cyclists who are familiar with the local area understand the cohesion of the through route network. It is recommended to have a dedicated system of bicycle signs that links up with the cycle route network. Plans for signposting should include the following:

- Identify important departure and destination locations
- Locate signs at decision points
- In the event of different routes, opt for the most direct route
- In larger cities, indicate the center as well
- Number routes (optional)
- Locate a map on the edge of a built-up area
- Locate street signs on street corners and at intersections.

Signs should include the next destination(s), which outside the built-up area would be relevant cities, towns, villages, and residential centers and inside the built-up area would be major facilities and places of interest for cyclists, such as recreation areas and tourist attractions, as well as the corresponding distance.

4.8 Bicycle Parking

Cyclists not only need good and safe cycle routes, they also need facilities to park their bicycles safely, easily and tidily. Good parking facilities is a requirement for mobility policy, as the fear of theft leads to reduced use of bicycles. The process of developing effective parking policies is comprised of the following five steps:

(1) Bicycle parking is placed on the agenda;
(2) Support and policy integration;
(3) Policy aims;
(4) Analysis and solutions; and
(5) From solutions to policy.

To analyze the number of bicycle parking facilities required, locations must be considered. Locations can be classified in a variety of ways, including:

- Solitary functions versus interrelated functions/areas;
- Homes (points of departure) versus companies/government agencies (destinations) versus transfer points (intermediate destinations)
- Employees/residents versus visitors; or
- Existing construction versus new construction.

For example, in the Netherlands, if these classifications are related to each other, there are five relevant categories for which bicycle parking policy can be developed:

(1) City center areas/station areas;
(2) Older residential areas;
(3) New Housing;
(4) Companies and Institutions;
(5) Public transport stops

The desired capacities of bicycle parking facilities are not static numbers of parked bicycles per location because they change regularly and substantially. Therefore, frequent monitoring is important to determine the correct capacity. Regarding city centers, the type of bicycle storage facility can encourage or discourage cyclists. For example, the introduction of free, supervised storage is very effective in stimulating the use of bicycles and reducing bicycle theft. Related measures can enhance use as well, such as: situating the storage facility directly on access cycle routes; situating the storage facility in or right on the edge of a core sopping area; situating the storage facility no more than 30 meters from a busy area (if the storage facility has to be built in quieter street); and ensuring a good visual relationship between the core shopping area and a good, attractive walking route.

Bicycle parking solutions in older residential areas often include the construction of neighborhood storage facilities and/or the installation of collective bicycle lockers. For new housing, until recently, sufficient space for storing bicycles in private storerooms in new housing was guaranteed by legislation in the Netherlands[8]. The lack of any stipulation about private storerooms in dwellings is to be regretted, especially in larger cities where fear of bicycle theft strongly inhibits bicycle ownership and hence bicycle use. Municipalities cannot compel developers to include storerooms in dwellings absent any agreement[9]; however, municipal authorities can try to create communal neighborhood storage in the public space. A municipality's option for bicycle storage may include rack systems for the front wheel, front fork, frame, or handlebars, a suspension system for handlebars or wheels, or a system to lean the frame against. Beyond these parking systems, municipalities may also consider other storage facilities, such as individual bicycle lockers, collective bicycle lockers, supervised storage, or unmanned storage facilities.

When analyzing the bicycle parking situation and developing bicycle parking policy for new business accommodations, the Buildings Decree still serves as the point of departure for both employee and visitor bicycle parking. The 2003 Buildings Decree stipulates that new structures contain a storage room for bicycles, which can be indoor, semi-protected like a carport, or an outdoor space designated as a storage space for bicycles. The requirements for the type of bicycle parking required vary depending on the type of building as well as its function. For example, a small company may be able to make do with an unsupervised, highly visible parking facility; however lockable storage is certainly required for larger companies. According to the manual, the Buildings Decree standards are too low to cover

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[8] The Buildings Decree (article 2.50, section 2) specified that every dwelling must have a lockable storage room, the surface area of which comprises at least 6.5% of the usable surface area of the dwelling, subject to a minimum of 3.5 square meters. The minimum width was 1.5 meters and the minimum height 2.1 meters. According to these regulations, a 100 square meter dwelling should have a storeroom of, for example, 2.50x2.60 meters (=6.5 square meters). Assuming the average dwelling occupation, each occupant can keep one cycle in storage. Since 2003, the Buildings Decree has not contained any stipulation about private storerooms in dwellings. The Buildings Decree cannot be revoked by municipal building regulations, and a municipal authority can now only set requirements for storage when they are directly involved in the development of new construction locations and conclude private law agreements with market parties in this regard.

[9] Since 2003, the Buildings Decree has not contained any stipulation about private storerooms in dwellings. The Buildings Decree cannot be revoked by municipal building regulations, and a municipal authority can now only set requirements for storage when they are directly involved in the development of new construction locations and conclude private law agreements with market parties in this regard.

both employees and visitors, and therefore, it is recommended that extra capacity standards for bicycle parking facilities for visitors is agreed in proper consultation and, if possible, in formal agreements.

In addition to capacity, it is equally important to create good facilities and to provide them at the right locations. For instance, solitary facilities should be a maximum walking distance of 50 meters for the largest facilities. Beyond business, bicycle parking at public transport stops is essential. The analysis for existing situations begins with counting the number of bicycles parked. The number of bicycles parked at the stop at approximately 11 a.m. on a weekday when the weather is good can be used as the basis for determining capacity. On the other hand, bicycle parking at new stops is difficult to predict, and accordingly, calls for a flexible approach. Lastly, facilities should be installed as close to the stop as possible, at a maximum distance of 30 meters.

Chapter Five: The Dutch Approach

5.1 Urban Policies

The Netherlands is a "decentralized unitary state" with a three-tier system of government: the national government; 12 provinces; and just over 500 municipalities. The administrative system is based on a constitution and implementing acts (van der Valk 2002). Generally, the National government makes broad plans and policy guidelines wherein the provincial government makes more specific plans for its geographic area within the framework set forth by the National government, and the municipalities then make detailed plans for its boundaries following the higher tiers (Nijland 2008). Additionally, there are many instances where it is better to look at the regional scale, and accordingly, regional plans and policies are developed. Moreover, the different tiers of policies exist for both spatial and transportation planning (Nijland 2008).

With regard to spatial planning, the compact cities concept has been at the heart of the national, provincial, regional, and municipal urban policies since 1985 (van der Valk 2002). The essential component is to intensify the land use within existing settlements. The compact cities and restrictive building policies have had a positive impact on transportation choices by preferring proximity to accessibility, thereby assisting the Netherlands in maintaining high densities (van der Valk 2002). On the municipal level, cities are obligated to make a land use plan for land outside the built-up area of the municipality (Needham 2007). They are not required to make that plan for the built-up areas, but if they do not, then they have fewer powers to control building permits. Therefore, since municipalities want full control, they have made land use plans which cover almost all of the built-up area of the Netherlands[10] (Needham 2007).

In practice, municipalities acquire the flexibility they want by making "postage stamp plans". What this means is that the municipality has made a land use plan in the past, but someone wants to build something which would not be allowed by that plan, so a new plan is made just for that one development project, and it replaces the existing plan for that small area. Thus, municipalities end up with hundreds of land use plans to give legal significance to various development projects. For example, the municipality of Nijmegen with 160,000 inhabitants has 840 valid land use plans (Needham 2007). Furthermore, for bicycle and pedestrian infrastructure, the general location and form are set forth in land use plans just as a building would be specified. Therefore, for purposes of this research, it was not feasible to review the municipal land use plans.

[10] Nothing is regulated about the size of the area which a land use plan must cover (Needham 2007).

Nevertheless, the concepts learned are still relevant and contribute to the positive impact on promoting pedestrian and bicycle transit (Nijland 2008). For example, if cities want to realize specific pedestrian and bicycle infrastructure, then it can be designated in a land use plan, and then the developer, whether it is the government or a private developer, must comply with its regulated form. This is an important tool for municipalities to develop a cycling network and designate particular routes, because if these items are not designated, then a developer has no obligation to build them. The city of Houten provides a good example of a city that used its land use plans to give cycling a prominent position. When the city decided to build a new residential area it used spatial plans to set forth an extensive, high-quality cycle network for the area that the private housing developers were then legally bound to implement according to the plan[11] (Nijland 2008).

The compact cities concept also provides many useful lessons. In terms of influencing the modal split for shopping trips, the compact cities policy and retail policy, which restricted the establishment of out-of-town shopping malls, have had a considerable influence on travel by foot and by bicycle (Schwanen, et al. 2004). In fact, in all residential environments, over a quarter of the population uses the bicycle to shop. Additionally, research has shown that many spatial policies in the Netherlands, including redeveloping brownfield sites, urban renewal, and upgrading the inner-city housing stock have contributed to a modal split for commuting in which walking, cycling, and the use of public transport predominate (Schwanen, et al. 2004). Indeed, these policies are assisting the Netherlands in maintaining high densities[12]. On the other hand, the concept of multiple land use is a relatively new spatial concept for the Netherlands (van der Valk 2002). Multiple land use was not identified as a land use strategy, nonetheless mandate, by any of the policy-makers I interviewed. To the contrary, where multiple land use does exist, it is typically not due to a specific planning measure, but rather, coincidence (Spape 2008). Thus, given the practical environment of land use planning on the municipal level, the data I was able to collect is more heavily weighted in transportation systems.

Regarding urban design, a "reverse design" approach is advocated in the Netherlands (Bach 2006). The procedure for reverse design is as follows:

> 1. *Locate* meaningful activities and daily amenities, such as schools, greens, shopping centers and homes for the elderly, park entrances and starting points for walking routes.
>
> 2. *Lay out* routes for pedestrians, cyclists and the elderly to run from address clusters (neighborhoods) to destinations for people using vulnerable modes of transport.

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[11] See also Section 5.6 Delft.

[12] A more specific example of these concepts in practice is provided in Section 5.5 Groningen.

3. *Designate* the zones and areas, location, configuration and size of residential areas and public gathering spaces, such as 30-kph zones, pedestrian precincts, and station forecourts.

4. *Position* “people pumps” such as public transport stops, interchanges and rail and metro stations, and the pedestrian entrances to public buildings and parking garages.

5. *Develop* lines and networks for public transport.

6. *Evaluate* whether your objectives have been achieved.

7. *Narrow and tailor* the associated routes for motor vehicle access by designing a suitable mesh size with appropriate street sections.

This design method makes it possible to make full use of the local significance of places, gives preferential treatment to vulnerable road users, and instills unique places with greater meaning. The approach results in shorter trips and more trips made on foot, bicycle, and public transport. Therefore, the reverse design approach is also promoted as an instrument for reducing the environmental impact of mobility (Bach 2006).

One city in the Netherlands that was built according to this design method is Houten (Netherlands Ministry of Transport 1995). In 1979, Houten was designated as a new town with a plan to build an extra 6,000 homes. The development plan was based on the “ring and loop” system, with a ring road surrounding an area three kilometers across, with a total length of 8.6 kilometers. The area consists of sixteen residential zones with local shops. Car access from one zone to another is possible only via the ring road while cycle ways give access to all parts of the town (Netherlands Ministry of Transport 1995). By utilizing this urban design tool, the city of Houten has given priority to cyclists and pedestrians, and consequently, car use is not dominant inside the built up area. The city of Groningen is an example of a city that was redesigned using the reverse design approach [13](Borgman 2008).

[13] *See* Section 5.5.

5.2 Pedestrian Mobility

While almost every Dutch city has a car-free city center or at minimum pedestrian streets, nearly every policy-maker I interviewed stated that the Netherlands is not a pedestrian country and to that end has no policies which promote walking. Although there are no specific pedestrian policies or promotional activities, the ability to walk from point A to point B is given much consideration. As such, pedestrians are always considered in the development or redevelopment of an area and facilities, such as sidewalks, are automatically provided. In fact, it was identified as a basic human right to be able to travel via a walkway to a destination (Tillie 2008). One city that is taking a second look at pedestrians and their place in the urban environment is Rotterdam. Section 4.4 provides more detail on these initiatives. However, beyond this section, most of the data collected relates to cycling and not walking due to the fact that cities are much more involved in the promotion of cycling.

5.3 Bicycle Mobility

Despite the increasing distances covered by the Dutch, the bicycle is still used for almost a quarter of all journeys, and for distances up to 7.5 kilometers it is the most popular means of transport (Netherlands Ministry of Transport 2007). Most people in the Netherlands do own cars, and do not make absolute choices between using the car or bicycle, but rather, tend to alternate in their respective use. As shown in Table 4.1, from a European perspective, the Netherlands has the highest level of bicycle use. There are cities within the countries listed that have a higher level of bicycle use then the national figures. Also reflected in Table 5.1 is that the Dutch own more bicycles per person than the other European countries (Netherlands Ministry of Transport 2007).

The Netherlands is the only European country with more bicycles than people. On average, the Dutch own 1.11 bicycles per person. The number of bicycles sold in the Netherlands is also high: 1.2 million in 2005 for 16 million residents. In absolute terms, however, more bicycles are sold in European countries with higher populations (4.9 million bicycles in Germany/82 million inhabitants; 3.2 million bicycles in France/60 million inhabitants; and 2.5 million bicycles in Great Britain/60 million inhabitants). This demand for bicycles has led to the creation of numerous businesses to serve this demand. In the Netherlands, there are many bicycle dealers, shops that specialize in the sale of bicycles and bicycle accessories, as well as maintenance and repair facilities (Netherlands Ministry of Transport 2007).

Table 5.1 European Bicycle Share in all Journeys

Country	Bicycle Share (all journeys)	Number of Bicycles/Inhabitant
The Netherlands	27%	1.11
Denmark	19%	0.83
Germany	10%	0.77
Austria	9%	0.40
Switzerland	9%	No data
Belgium	8%	0.50
Sweden	7%	0.67
Italy	5%	0.45
France	5%	0.34
Ireland	3%	No data
Czech Republic	3%	No data
Great Britain	2%	No data

(Source: Netherlands Ministry of Transport 2007)

The Netherlands Ministry of Transport has identified many important factors for the high levels of cycling in the Netherlands. These include geographic and spatial factors, including compact cities which make trips more easily covered by bicycle in terms of their distance. Historical-cultural factors have also been identified, such that nearly every child received his or her first bicycle around their fourth birthday and learns to use it. Notably, bicycle policy has been identified as a key contributor to the high cycling levels. In fact, nearly 73% of the variance in bicycle use among municipalities is explained by integral traffic policy (2007).

There are also many influential actors that promote bicycle use among individuals and municipalities. For example, the Fietsersbond (Dutch Cycling Union) carries out a benchmarking “Fietsbalans” (Bicycle Balance) project which reveals a clear link between bicycle use in a municipality and the quality of the infrastructure (Netherlands Ministry of Transport 2007). In the summer of 1999, a long-term benchmarking project began and ran or three years (Borgman 2008; Borgman 2003). The primary objective of the project was to stimulate local authorities to adopt even better cycling policies. The aim of benchmarking is to learn from others by comparing the performance of cities and looking for best practices (Borgman 2008; Borgman 2003).

The secondary objective of the project was to enhance the position and strength of the local Cyclists' Union branches. Since most decisions that influence cycling conditions are made on a local level, the National Fietsersbond believed that it was important for local councils and civil servants to recognize the Fietsersbond local branches as knowledgeable and influential partners that represent cyclists' interests. The aim of the Bicycle Balance was also to establish a cooperative environment in which discussions could be based on facts rather than emotions. The Bicycle Balance used the five main criteria established by CROW (directness, comfort, safety, cohesion, and attractiveness) as its primary assessment criteria. To this, however, it added five more criteria: competitiveness compared to car; bicycle use; urban density; cyclists' satisfaction; and cycling policy on paper (Borgman 2008; Borgman 2003).

By 2002, the Bicycle Balance had been executed in 115 towns in the Netherlands, which includes all Dutch towns with a population of more than 100,000 inhabitants and covers nearly 50% of all Dutch cyclists. The results showed a strong correlation between a well executed coherent cycling policy and actual bicycle-use. For each town, a comprehensive report is written, which is the put on the agenda of the council committee for transport and traffic, accompanied by a list of priorities for actions and activities the council should decide on to improve conditions. The local and regional media are then invited to a presentation to the council. Media attention has been an important component of the Bicycle Balance; however, the Fietsersbond also used the collected data to declare a city as "Cycle-City"[14]. The cycle-city elections have generated communication about the good practices that can be found in the nominated towns and the publicity has given the Fietsersbond more clout. Overall, the Bicycle Balance has proven successful in achieving its objectives and has conducted a second Bicycle Balance, the results of which will be posted in October, 2008 (Borgman 2008; Borgman 2003).

Although bicycle planning is primarily a municipal function, the National government hosts several noteworthy programs and initiatives to stimulate bicycle use. One project aims at increasing bicycle use among commuters by offering them "cycling points". Every employee using his or her bicycle to come to work gets rewarded by adding another point to the bicycle point's card, which can then be redeemed for a variety of items (ELTIS 2006). Additionally, the Dutch Railways is investing in theft-proof, user-friendly bicycle storage facilities at railway stations and bus stops. The Netherlands believes these facilities stimulate the purchase of better bicycles, bicycle use as well as the combined use of the bicycle and train or bus, and is a helpful measure against bicycle theft (ELTIS 2003).

Perhaps the most notorious initiative of the National government is the OV-fiets (Public Transport Bicycle). In 2002, the OV-fiets started as a publicly subsidized project aimed at making the bicycle part of the public transport system (Buehrmann n.d.; Bakker 2008). To date, it has been established as a permanent service and is available at over 120 rail stations.

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[14] Groningen was chosen as "Cycle – City 2002"

The OV-fiets provides fast and easy access to rental bikes, which can be used as extensions of the rail trip. Users must register with OV-fiets, and then they receive an OV-fiets card, which allows them to check out the bicycles from a computerized system at the stations (Buehrmann n.d.; Bakker 2008). The user fee is €2.85 per 20 hours, with a maximum rental period of 60 hours (Bakker 2008). Thus, the bicycle can be used one way, for example to work, where it can be parked and locked for the day, and the user can take a return trip to the rail station. The Netherlands has had great success with this system, with nearly 400,000 rentals, and is already making a profit (Bakker 2008).

Nonetheless, the major bicycle initiatives occur within the municipalities. Accordingly, the three case studies of Rotterdam, Groningen, and Delft, will provide insight into how bicycle use is promoted on the municipal level. The section on Rotterdam is longer than the other two case studies for a few reasons. First, Rotterdam is more comparable with U.S. cities because it was rebuilt for the automobile, but is now transitioning itself to be more pedestrian and bicycle friendly. From this, many valuable lessons can be learned. Also, as stated above, Rotterdam is the one city that is taking a significant initiative with regard to pedestrians. Lastly, due to the size of the city and the municipal department, I was able to conduct more interviews and collect more information.

5.4 Rotterdam

The city of Rotterdam has approximately 600,000 inhabitants and the region is home to approximately 1,100,000. Within the city, there are 11 sub-municipalities. Rotterdam is often described as the "economic, social, and cultural center of the Rijnmond region", the "industrial heart of the Netherlands", and with the world's busiest port as the "gateway to Europe" (Buningh and Smidt n.d.) With regard to land-use/spatial planning and urban design, the main policy in the city is the Spatial Development Strategy 2030, under which several different plans and projects fall. This is explained further in section 4.3.1. Regarding transportation, the major policies are a Regional Traffic and infrastructure Plan (2007 – 2011), a Municipal Traffic and Infrastructure Plan (2003 – 2020), and the Rotterdam Bicycle Action Plan (2007 – 2010). Section 4.3.2 explains these policies in more detail.

5.4.1. Spatial Development Strategy 2030

Rotterdam commissioned famous Danish architect Jan Gehl and his firm to examine the public realm of Rotterdam and make suggestion on how to improve conditions for pedestrians, people staying in public spaces, and the legibility for cyclists (Jenke 2008; Guit 2008). Their recommendations were incorporated into a city vision for public space in downtown Rotterdam, which is part of a larger Spatial Development Strategy. The Spatial Development Strategy is a large plan for the city of Rotterdam under which are several smaller projects and plans, including the "Linked City: vision for public space in downtown Rotterdam" and the "Destination Downtown!" plans. The mission of the Spatial

Development Strategy is based on two keystones: (1) Strong economy: more employment opportunities; and (2) Attractive residential city: balanced composition of the population. The underlying policies and plans are in accordance with these two objectives (Jenke 2008; Guit 2008).

The work of Gehl began with a study of the urban quality of Rotterdam (City of Rotterdam 2007). This study was based on the themes expressed in Figure 5.1. Gehl's review of the urban quality of Rotterdam made it clear that the existing public space in Rotterdam was insufficient for a vital, attractive downtown. This is true both for its image and management. The main problem lies with the monofunctionality of the downtown, concerning place and time. During the day, people come to the city center to work and shop, but at night these areas remain unused as relatively few people live there. The city agreed with Gehl's observation and the need for a change (City of Rotterdam 2007).

The outcome of the research did not suggest that Rotterdam must entirely start over again, but rather, that it should make better use of its existing attractions. Only 25% of the public space in Rotterdam is in the form of squares and open space, whereas the remaining portion exists of streets and water. Therefore, the city decided to prioritize investments for those existing squares and open spaces, which could be enhanced. It was also noted that car traffic was given the largest amount of space, whereas the quality and attractiveness of space for pedestrians and cyclists was moderate. This, as well as environmental considerations, has led the city to start creating plans and projects which give more priority to slow traffic (City of Rotterdam 2007).

Figure 5.1: Key Urban Quality Criteria

PROTECTION	**Against Vehicular Traffic** - Traffic Accidents - Pollution, fumes, noise - Visibility	**Against Crime & Violence** - Well lit - Allow for passive surveillance - Overlap functions in space & time	**Against Unpleasant Sensory Experiences** - Wind/Draft; Rain/Snow; Cold/Heat - Pollution - Dust, Glare, Noise
INVITATIONS	**Walking** - Room for walking - Accessibility to key areas - Interesting facades - No obstacles - Quality surfaces	**Standing and Staying** - Attractive and functional edges - Defined spots for staying - Objects to lean against or stand next to	**Sitting** - Defined zones for sitting - Maximize advantages – pleasant views, people watching - Good mix of public and café seating - Resting opportunities
	Visual Contact - Coherent way-finding - Unhindered views - Interesting views - Lighting (when dark)	**Play, Recreation, and Interaction** - Allow for physical activity, play, interaction, and entertainment - Temporary activities (markets, festivals, exhibitions, etc.) - Optional activities (resting, meeting, social interaction) - Create opportunities for people to interact in the public realm	**Day, Evening, and Night Activity** - Variety of functions throughout day - Light in windows (residences) - Mixed-use - Lighting in human scale
	Audio and Visual Contact - Low Ambient Noise Level - Public seating arrangements conducive to communicating		**Varying Seasonal Activity** - Seasonal activities (skating, Christmas markets) - Extra protection from climate - Lighting
DELIGHT	**Dimensioned at Human Scale** - Dimensioning of buildings and spaces in observance of the important human dimensions related to senses, movements, size and behavior.	**Positive Aspects of Climate** - Dimensioning of buildings and spaces in observance of the important human dimensions related to senses, movements, size and behavior.	**Aesthetic and Sensory** - Quality design, fine detailing, robust materials - Views/vistas - Rich sensory experiences

(Source: Gehl Architects 2007)

Shifting priority from cars to cyclists and pedestrians is also important for connectivity. There are five major points of activities in Rotterdam – culture centers, supplies, stations, parks, and squares – which should be connected. In fact, the functionality of the city center is dependent on good pedestrian and bicycle connection between these five main cores of activity. The streets that connect these areas are viewed as the "life veins" of the city. They are essential as this is where city residents stroll, shop, commute, jog, bicycle, sit on a terrace, etc. From these observations, a core vision for the public space of downtown Rotterdam was planned to become a linked city. The vision aims at making good streets as a result of which an attractive network of public spaces arises: a network which links important building and other locations with each other, a network which is includes residential areas, and network which itself is an attractive space for public events, meetings, and serving different urban cultures (City of Rotterdam 2007).

Rotterdam's urban street network has three layers: (center) boulevards, city streets, and streets on the neighborhood level. For the center boulevards, it was deemed necessary to invest in more and better pedestrian crossings, broad sidewalks, continuing tree structures, high quality concrete, and street furniture. To improve the attractiveness and quality of city streets, numerous interventions were needed, including more continuity in the design of the street profile, reduction of carriageways, attractive entrances to the public spaces, alternative paths, good pedestrian crossings, and a continuing tree structure. Slow traffic should also be given priority. Overall, giving priority to slow traffic will have a positive impact on the quality of the center boulevards and city streets (City of Rotterdam 2007).

There are three main strategies which will help enhance the public space and urban street network in Rotterdam. First, the city is investing in a "Park and Walk" system, wherein a ring of garages will be placed around the center which connects to both walking routes and the public transport network. Second, is a "Traffic Winding-Off" system, which cuts off through movement of motorized traffic in the city and provides connections only for slow traffic and public transport on city streets. Lastly, the city is going to make improvements in the spatial quality and attractiveness of the public transport stations. In the same vein, the city is going to invest more in public transport concerning water (City of Rotterdam 2007.)

The Park and Walk system is designed to discourage automobile traffic inside the city center and encourage pedestrians and cyclists (City of Rotterdam 2008; Guit 2008). Initially, when one drives into Rotterdam, there is an opportunity to park for free at a Park and Ride on the edge of the city. The Park and Rides are combined with either a metro or tram. If you drive further into the city it is more difficult because there is less parking, which is more expensive, but there is another opportunity to park at the Park and Walks. The Park and Walks are planned in several areas, so that no matter what direction one drives from, a Park and Walk is available and the main destinations are reachable within 10 minutes walking from each parking garage. Moreover, all parking in the city will be transformed into either a Park and Walk or Park and Ride so there will no longer be visitor parking at any buildings.

Additionally, parking places on the street inside the city will be removed to make more room for public space, pedestrians, and cyclists (City of Rotterdam 2008; Guit 2008).

The Traffic Winding-Off system was developed after studies of the pedestrians in the city center were made by Gehl. He counted pedestrians and cars on a Saturday between the hours of 10.00 and 18.00. At that moment, pedestrians already dominated the city center. For example, in one area there were 40,670 pedestrians versus 14,980 cars. Therefore, it was determined that the pedestrians needed more and better space and that there was too much room for the car, and that one way of achieving this is to cut-off through traffic in the city center. For instance, although the measure has not been approved by the Mayor yet, the city would like to disconnect one of the major boulevards through the city (Coolsingle) for motorized traffic but not for pedestrians or bikes. Other initiatives that support this strategy include the following:

- Better pedestrian crossings;
- More green time to pedestrians than cars at traffic lights;
- Good pedestrian routes and areas (including more space, priority, landscaping, and amenities, such as lighting, street furniture, waste baskets);
- Connectivity between the main entrances of public transport and Park and Walk facilities;
- Change street profile to reduce lanes of the carriageway, give more space to pedestrians, reduce speed, and add more shops, cafes, and restaurants[15];

One difficulty the city is facing with these ambitions is that businesses believe they will lose customers if people cannot drive to and/or park in front of the business. However, the city believes that pedestrian connections between stores will actually be more profitable for businesses because people walk between, and consequently, to more stores. Additionally, where there is a good, attractive public space, more people will want to walk around. There should also be good connections between different areas, because that will encourage people to walk to more places. Similarly, inhabitants should be able to comfortably and safely walk to shops and restaurants in their neighborhood (Guit 2008).

The city also has the ambition to densify the city center (Jenke 2008; Guit 2008). For example, the area of Lijnbaan is a shopping district, which is busy during the day, but completely empty at night because there are few residential areas nearby. Thus, the city wants to add more housing in the city center to attract more residents to this area. It is also

[15] The city would like to narrow Coolsingle, a main boulevard through the city from 4 lanes to two lanes and provide more space for pedestrians. This plan will go for approval in the next few months.

believed that this will make it attractive for business, particularly restaurants, to come to this area, because they can have business at night in addition to the day time. The goal of more people living in the city center is good for the economy and improving the attractiveness of the city center (Jenke 2008; Guit 2008).

The third strategy is to make improvements in the spatial quality and attractiveness of the public transport stations (Guit 2008). To achieve this, the city intends to improve the entrances to the public transport station, making them more attractive and safe. Likewise, the signage at the metro stations will be changed. It is now a yellow "M", which is regarded as very unattractive. The areas surrounding public transport stations will also be improved by being connected to the pedestrian areas and overall being more safely and easily accessible (Guit 2008).

It is believed that the introduction of a strong green structure will improve the social climate of Rotterdam (City of Rotterdam 2007). The center can be enriched by adding green courts at residential and employment areas. A spatial design with boulevards and city streets passing through a range of trees is highly desirable. For water management, vegetation roofs will be used. Overall, these contributions have multiple effects on the city, including providing extra outdoor space, an attractive city, and a better environment (City of Rotterdam 2007).

5.4.2. Rotterdam Bicycle Action Plan 2007 – 2010

Bicycle use is relatively low in Rotterdam in comparison with other Dutch cities, comprising approximately 22% of the modal split (City of Rotterdam 2007). Bicycle ownership is also approximately 10% lower than the national figure. Potential causes include the fact that young people, elderly, and immigrants cycle less frequently in Rotterdam than the average figures. Additionally, good public transport, including buses, trams, and a metro, are available in Rotterdam. It is believed that a high quality bicycle network and good bicycle parking facilities as well as the encouragement of bicycle use for short distances in combination with public transport can greatly increase bicycle use in Rotterdam (City of Rotterdam 2007). These elements are discussed further below.

Government Support

Rotterdam really did not begin stimulating bicycles as an alternative to car use until the 1990's. At this time, the municipal authorities began designing bicycle friendly infrastructure (Buningh and Smidt n.d.). Before then, however, Rotterdam was focused on accessibility by car. On May 10, 1940, Rotterdam was heavily bombed during World War II. When Rotterdam was rebuilt, it was rebuilt for the automobile with wider streets and generally wider areas and more space for cars (Ligtermoet 2008). Initially, Rotterdam thought it could distinguish itself from Amsterdam by being a more car-friendly city. However, now, for numerous reasons, including the economy, environment, health, and livability, the city has begun to redesign itself from car-friendly to more of a bicycle and pedestrian friendly city (Jenke 2008).

To promote cycling in Rotterdam, the city developed an action plan “Rotterdam on Bike!” for the period 2007 – 2010 (City of Rotterdam 2007; van der Woude 2008). Rotterdam believes bike–use stimulation is important to keep the city accessible, vital, and attractive for inhabitants as well as visitors. Rotterdam also thinks it is important because there is an increasing role for the bicycle with respect to air-pollution and health. Cycling also fosters social participation for foreigners. Moreover, cycling has relatively low investment costs, approximately € 500,000 - € 1,000,000 per kilometer. The objectives of the action plan are to promote the use of the bicycle for trips to the city center and central station and in cooperation with the projects “Integration of cycling and Public Transport” and “Extension of bike parking sheds” to improve routes, circulation, the network, and education. The strategy to increase bicycle use for trips to the city center and central station is to improve the door-to-door cycling chain by focusing on the bicycle network and bicycle parking (City of Rotterdam 2007; van der Woude 2008).

Investment

For the execution of the Rotterdam Bicycle Action Plan, the municipality has reserved €12 million (van der Woude 2008). This means that approximately €5 is spent on cycling measures per inhabitant each year under the plan. This amount covers many aspects of cycling infrastructure, services, and amenities. The majority of the money is allocated to parking facilities and the upgrading of the 20 km of cycling paths. At least half of the funding for the upgrading of the 20 km is financed by the Regional Authority. The remaining amount is financed by the municipality; however, some of the financing comes directly from the province. Furthermore, the Regional Authority has the ability to receive grants from the provincial and national government (van der Woude 2008).

Within the framework of the bicycle in the chain project initiated by Rotterdam (further described below), the city has agreed to finance 100% of the parking facilities near public transport stops (City of Rotterdam 2007; van der Woude 2008). This is notable because it is typically up to the private public transport company, for example RET, to finance parking facilities near its stops. However, the city believes that investing in high quality bicycle parking facilities near public transport stations will encourage both cycling and the use of public transport. This project is done primarily under the bicycle in the chain project, but also incorporates the city’s ambition for more Park and Ride facilities. Additionally, the city will analyze whether it is desirable to add more options to rent bicycles at these locations (City of Rotterdam 2007; van der Woude 2008).

Within the city's annual budget, the city can pay for approximately 35 new bicycle drums that are requested for residential areas (van der Woude 2008). However, the demand for bicycle drums per year is approximately 170. Thus the city has learned that it cannot keep up with the demand for these drums. Additionally, the procedure for reviewing applications and submitting claims is timely and costly. Therefore, the city has had to allocate a relatively large amount of money towards the approval process of applications, while the implementation is lagging (van der Woude 2008).

Infrastructure/Accessibility

The targets set to achieve this are to bring 20 kilometers of 11 main urban cycle routes up to quality and constructing a route along the river Rotte which serves both a connecting and recreational function (City of Rotterdam 2007; van der Woude 2008). The upgrading of 20 kilometers on 11 main cycle routes is to be done in cooperation with other urban projects. This ambition is labeled "making work with work", which means that any time an existing infrastructure improvement project is undergone, cycling infrastructure along the site will be added or improved. The improvement project could include street work, sewer work, or the like. The idea is that because work is already being done in the area, they are simply adding a bicycle project to the existing construction project (City of Rotterdam 2007; van der Woude 2008).

The ambition for bringing the network design up to quality is to achieve the five major requirements for a network as set forth by CROW. The main requirement of cohesion can be realized by connecting living areas with main regional centers and public transport stations, including the train, metro, and tram. The ambition of directness will be achieved by avoiding detours and following direct lines in the landscape. To achieve comfort the network is designed for a quick and comfortable traffic flow for cyclists with a design speed of 25 km/h. To ensure safety the cyclists and other road users should be protected. Red asphalt, signposting, and illumination will be utilized to enhance comfort, safety, and attractiveness. Additionally, at intersections bicycle routes will have the right of way and there will be multiple green traffic lights to improve the directness, comfort, and safety of cyclists. To further fulfill the five major requirements, the optimal dimensions for bicycle lanes/tracks will be utilized where possible (City of Rotterdam 2007; van der Woude 2008).

To make cycling in the city more attractive and more competitive with the car, the city is committed to improving the flow of 17 urban bicycle routes. The traffic light regulations regarding these routes will be examined to see how it is possible to give more priority to the bicycle. A number of measures are considered and will be implemented where applicable. In other words, not all measures are applicable to every location and instead fitting in these measures is a tailor-made job. These measures include bicycle traffic light modification, distance detection, bicycle priority versus the car, and other safety measures. These measures are summarized in Table 5.2. Rotterdam notes that to achieve its goals cycling must be attractive, and therefore the design for bicycle must be part of a well thought urban design, meaning the quality is demand oriented from the point of view of cyclists (City of Rotterdam 2007; van der Woude 2008).

Table 5.2: Measures to Improve Flow

Description	Implementation
Institution traffic lights	At traffic lights where the wait time is longer than 90 seconds, an analysis will be conducted to determine if the waiting time can be shortened by either extending the green time for cyclist or two green lights per cycle.
(Distances) Detection	Use detectors to react to approaching cyclists.
Under Lights	On main routes use reflection strips.
Right-refusing car traffic versus two directions bicycle path	Never have green light the same for car and bike where there is a two direction bicycle path.
Right – refusing movement versus one direction bicycle path	Can have green light the same for the car and bike where there is a one direction bicycle path.
Stopper Line	The bicycle stop strip should be located 1 meter before the road. The strip should be a reflection strip.
OFOS	If bicycle movement is mixed with car traffic, at intersections, the cyclists can be first (at the front).
Dead Angle Mirror	At intersections where there have been accidents between cyclists and motor vehicles with motor vehicles turning right, dead angle mirrors will be installed.

(Source: City of Rotterdam 2007; van der Woude 2008)

The combination of the bicycle and public transport is a fast and attractive way to travel. On average, as many as 30% of train travelers get to the station by bicycle (City of Rotterdam 2007). However, only about 10% of travelers use a bicycle from the train station to their destination point. The position of the bicycle in the transport chain was reinforced in 2003 with the introduction of OV-Fiets. As previously stated, OV-Fiets are a rental bicycle which can be rented at train and underground railway stations for € 2.85 per day. OV-Fiets can be reserved in advance by means of Internet, whereupon season ticket holders can rapidly rent a bicycle. OV-Fiets has proved to be a success in the Netherlands, which now has over 125 locations. In the Rotterdam region, there are 11 OV-Fiets rental locations. However, the municipality is investing in the extension of the OV-Fiets to Park and Ride locations as well as guarded bicycle parking facilities in the city center (City of Rotterdam 2007).

To further increase bicycle use, one project “bicycle in the chain” aims at increasing the possibility for bicycle parking at public transportation points (City of Rotterdam 2007; van der Woude 2008). These parking facilities would effectively function as a Park and Ride so that both public transport and cycling are encouraged by making bicycle parking close, safe, and convenient. Another aspect that impacts bicycle use is the risk of theft. Guarded parking facilities can contribute to a reduction in stolen bikes, and accordingly, Rotterdam has plans to develop more of these facilities. Additionally, more guarded parking that is free is thought to stimulate bicycle use and decrease automobile use which in turn improves air quality and improves individual health. To test this, the city will engage in a pilot project for free guarded bicycle parking to monitor the impact on bicycles and automobiles (City of Rotterdam 2007; van der Woude 2008).

Another project aimed at preventing bicycle theft is an action plan with the police department called “Fietsridder” (City of Rotterdam 2007). Under this plan, the locations of reported bicycle theft are analyzed. The locations with a high number of bicycle thefts are considered hotspots for which the public is then notified. Additionally, more safety information will be provided to the public, such as the best way to lock the bike, what locks are the safest, where the safest parking is located in the city, and where the guarded facilities are located. This plan is intended to lead to a 10% reduction in bicycle theft (City of Rotterdam 2007).

Moreover, for residential areas, Rotterdam has been trying to come up with solutions in response to the National governments repeal of the Building Decree, which required bicycle parking facilities to be built in new homes (City of Rotterdam 2007). Initially, Rotterdam requested the minister to reconsider this decision. The minister’s response was that it should be left up to the market. However, as of 2005, 50% of new homes were built without any bicycle parking facilities. The municipality is now in the process of drafting its own regulation that would make building bicycle parking facilities in new homes compulsory (City of Rotterdam 2007).

One alternative to bicycle parking facilities inside homes is bicycle drums placed outside the home (van der Woude 2008). Rotterdam has a system where residents can apply for a bicycle drum in their neighborhood. The bicycle drums fit approximately 5 bicycles, so the application can be made by one family or a group of residents. These bicycle drums are subsidized by the city, so no personal investments are needed. However, as noted above, the budget provides for approximately 35 drums per year, but the demand for these is approximately 170 drums per year. Additionally, the approval process is complex and lengthy, taking approximately 6 month, and the implementation of these facilities can take up to 4 years. The alternative to the bicycle drums are “staples”, which can be requested by the sub-municipalities who can more readily get funding from the municipality and/or region (van der Woude 2008).

Traffic

Traffic safety is major concern in Rotterdam. Particular attention is paid to locations where cyclists and cars interact. The city looks at two forces to safety: objective and subjective. On the objective side, safety analyses are continually performed and locations that have reoccurring accidents are deemed "Black Spots" for which funding is available from the Province to improve safety at that location. The subjective side involves whether people feel safe or not on their bicycle. Particular attention is paid to this issue because it determines bicycle use; if people feel safe when they cycle, then they are more likely to use the bicycle (van der Woude 2008).

In Rotterdam, children receive road safety lessons in primary school and must pass a bicycle examination (City of Rotterdam 2007). Rotterdam is very active in the field of road safety lessons and supports projects which provide practical lessons on movement skills and road safety to students at every grade level in primary school. Additionally, actions to bring attention to the health and mobility of young people are undertaken. For example, "The Traffic Snake Project" motivates children to go by foot or by bicycle to school. In 2006, 50 primary schools took part in the project (City of Rotterdam 2007).

Marketing

The municipality is engaging in communication regarding the urban bicycle network to inform the public about the construction and improvements of the bicycle route (City of Rotterdam 2007; van der Woude 2008). The core message in the communication is that bicycles are healthy, clean, and rapid, and that is why Rotterdam is working to achieve a high-quality urban bicycle network. Bicycle use cannot be only stimulated by the construction of good bicycle infrastructure, but also by softer measures which aim at specific target groups. Emphasis is placed on immigrants, young people, and employees. First, bicycle possession and bicycle use is much lower for immigrants than the native population. One reason for this is because many immigrants do not know how to cycle. Accordingly, Rotterdam organizes bicycle lessons for immigrants (City of Rotterdam 2007; van der Woude 2008).

Young people are also an important group of bicycle users. Extra attention is paid to young people because if from a young age people did not experience the pleasure and freedom of the bicycle, then it is more difficult to motivate them for that purpose later. An additional reason to stimulate bicycle use among young people is because now children move less and the bicycle is the most simple and effective resource for daily movement to stimulate and reduce children with weight problems. Furthermore, children who are enthusiastic about the bicycle can persuade their parents to take to the bike. Schools also try to encourage children to come to school by bike. This is thought to have a cyclical effect on cycling, such that if more children are cycling to school, then less people will be driving, which in turn influences the safety of cycling, thereby encouraging more people to cycle (City of Rotterdam 2007; van der Woude 2008).

Incentives

Employees are the third group where bicycle use can be stimulated (City of Rotterdam 2007). For the use of alternative transport – such as the bicycle – the government enables employers by means of a bicycle plan to stimulate its employees to commute by bike. The bicycle plan is fiscally pleasant for employees as it allows employees to use their gross salary to purchase a bicycle. Alternatively, employees can renounce up to 5 days of holiday, spread over the course of up to two years to contribute €750 towards the purchase of a bicycle. The transport coordination center also offers services to businesses for transport management. One of these services is to aid in the development and implementation of a bicycle plan (City of Rotterdam 2007).

Disincentives

There are no specific disincentives for motorized traffic provided for in the Rotterdam Bicycle Action Plan. Most of the disincentives for motorized traffic come under the Spatial Development Strategy discussed above.

Integration

The Rotterdam Bicycle Action Plan 2007 – 2010 (Municipal Bicycle Plan) is a follow-up to a prior bicycle policy (van der Woude 2008). The Municipal Bicycle Plan falls under a broader Municipal Traffic and Infrastructure Plan for 2003 – 2020 (Municipal Traffic and Infrastructure Plan) and is an elaboration of the ideas set forth in the Traffic and Infrastructure Plan. The Municipal Bicycle Plan is also an elaboration of the specific bicycle policy that is mentioned in the Regional Authority of Rotterdam's "Agenda of Implementation Traffic and Infrastructure 2007 – 2011" (Regional Traffic and Infrastructure Plan). The Regional Traffic and Infrastructure Plan provides support for the Municipal Bicycle Plan by setting forth a bicycle network. If the municipality wants to upgrade the routes along the networks in the regional plan, then they can get funding from the Regional Authority (van der Woude 2008).

Safety has also been identified as an integral issue. It is dealt with in nearly every municipal policy and is a national, provincial, regional, and local concern. There is also integration among departments within the municipality. For example, when a road is redeveloped the transportation department works in cooperation with the city building department to determine how to facilitate different road users. At this time as well, road safety is a primary consideration (van der Woude 2008).

5.5 Groningen

Groningen has approximately 181,000 inhabitants, with students comprising about 25% of that figure (Valkema 2008). Regionally, nearly 500,000 people are economically dependent on Groningen. The city of Groningen is believed to have one of the highest levels of bicycle use in Europe. This achievement has been made through an integrated approach to town planning and traffic policy. The two main contributors include spatial plans that favor the compactness of the city and a strong and consistent bicycle policy (Valkema 2008). Accordingly, these two approaches will be discussed below.

5.5.1 Compact City

One of the biggest contributors to the high cycling levels in Groningen is its commitment to maintain a compact city (SMILE n.d.). The compact city approach aims at keeping the distances to as many destinations as possible short in order to limit the number of necessary traffic movements. The city has worked towards ensuring that points of attraction, specifically residential areas and employment centers, can be located in bikable distances (SMILE n.d.). Groningen has been successful in this effort. In fact, 80% of the inhabitants live within 3 kilometers of the city center, and 90% of the jobs are located within this distance (Valkema 2008).

The main spatial planning instrument Groningen used to achieve its ambitions was a municipal structure plan, which is one of the main planning instruments of local authorities in the Netherlands (Martens & Griethuysen 2002). The structure plan outlines future developments and serves as a guideline for all spatial planning for the municipality. Groningen has grown, and prior to 1987, emphasis was put on expansion and growth of the town, however, the structure plan approved in 1987 shifted the focus from quantity to quality. The two main objects formulated were: (1) the central position of Groningen in the economy and culture should be strengthened; and (2) the quality of life in the city should be enhanced. In conjunction with transport policy, the plain included the following aims:

- Reduce the need for journeys be car;
- Concentrate institutions and employment-intensive development near the station;
- Locate new housing areas close to the inner city;
- Prevent further suburbanization; and
- Enhance the position of the city center as the main center for the whole of the northern Netherlands.

The basic principles have remained, although some amendments have been made with regard to car traffic, including parking. First, the city wanted the road network to be used more efficiently by concentrating traffic on the main network, and giving priority to essential traffic such as freight traffic and business trips while trying to get commuters to shift their travel mode from the car towards public transport or bicycle. The prevention of suburbanization was enhanced by using zoning instruments to limit parking possibility for long-term parking, improve public transport and bicycle facilities, concentrate employment centers near main public transport nodes, and limit the supply of building areas outside the urban area. Following, a structure concept was drawn, which outlined the major spatial and functional developments within the urban area, focusing on the city center itself, and designating five intensification zones based on proximity and accessibility to the city. These intensification zones are also located near public transport junctions and cycle routes. The elaboration of the structure plan takes form in separate transportation policies, including a traffic report, bicycle plan, and parking plan (Martens & Griethuysen 2002). These will be discussed below.

5.5.2 Cycling Policy (Step Up! Bicycle Measures 2006 – 2010)[16]

In 2002, the Dutch cyclists' union proclaimed Groningen "Cycling City of the Year". Groningen has topped the cycling ratings for Dutch cities for many years. In fact, for nearly 20 years, the citizens of Groningen have been making approximately 40% of their trips by bicycle (Fietsberaad 2006). The most recent figures place the modal split in the city at 59% for bicycle, 37% by car, and 4% by public transportation (Valkema 2008). It is necessary to understand how the city has achieved such high level of bicycle use, and the elements listed below provide that explanation.

Government Support

Support for cycling in Groningen began in 1972. At that time the city had a left-wing city council who envisioned the city center as a living room. The major aims to achieve this vision included an integral approach to town planning and mobility and to stimulate living in the city center. Since that time, the city has continued to pursue a policy of integrated town and traffic planning (Valkema 2008). This pursuit has included the promotion of bicycles and local public transport as well as the reduction of motor vehicle traffic. The first major instrument that was utilized was the compact city approach mentioned above. Additionally,

[16] While Groningen does have a cycling policy, the most current being the "Step Up! Bicycle Measures 2006 – 2010", its cycling policy is much different than other municipalities. The municipality of Groningen's policy is directed at the broad spectrum of cycling and is integral with the traffic and spatial policies for the city (Fietsberaad 2006). Therefore, while this section does focus mostly on the past and present cycling policies, the broader elements and influences are included as well.

the city started giving priority to building special facilities for environmentally friendly transport alternatives, mainly bicycle and public transport (EAUE n.d.).

Political choices and effort on the part of the civil service have been identified by many as a strong source of Groningen's success as a cycling city (Fietsberaad 2006). As stated by mobility expert Ineke Spape, it has been the "guts" of city officials, which have allowed it to become a world renowned city. Groningen's innovative measures, most of which are discussed below, have not always been welcomed by residents and/or business owners. For example, businesses have opposed restrictive car use policies for fear of losing business. However, the city, compromising on some issues[17], had the gumption to pursue its ambitions, and to that it owes much of its success (Spape 2008).

Investment

Beginning in 1976, the traffic circulation plan in Groningen began devoting a lot of attention to bicycle traffic, including spending 2.7 million Euros on bicycle facilities (Valkema 2008). This attention continued throughout the next couple of decades. The 2000 bicycle policy demonstrated that the city had invested nearly 23 million Euros in bicycle facilities during the period between 1989 and 2000. This included investments in cycle paths and bridges as well as asphalt surfaces. Additionally, under the 2000 bicycle policy itself, the municipality devoted another 4 million Euros for the years up to and including 2002 and another 5.5 million Euros for the period between 2003 and 2006 (Fietsberaad 2006). Under the newest bicycle policy, the city has decided to spend 6 million Euros for the years 2007 to 2010, with approximately 3 million spent in 2007 and 2008, and the remaining 3 million to be spent in 2009 and 2010. This means approximately €8 is spent on cycling measures per inhabitant each year under the plan (Valkema 2008).

Infrastructure/Accessibility

The city of Groningen has a long tradition of bicycle policy, and in the last few decades the municipal bicycle policy has focused on creating a good bicycle infrastructure. To that end, Groningen has developed an extensive cycling network. The laying of cycle paths and lanes has been a central issue, supported by the Bicycle Traffic 2000 policy. Now, the city has approximately 200 kilometers of cycle lanes, with some routes hosting over 10,000 cyclists a day. Beyond cycle paths and lanes, the bicycle policy supports other special facilities for cyclists, including guarded parking facilities, cycle bridges, cycle tunnels, and bicycle-friendly traffic lights (Valkema 2008).

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[17] The municipality initiated a project in close cooperation with local businesses and several market parties to find a solution for better accessibility of the city center for transport services while enhancing the quality of life and environment in the city center. The resulting measures included an enlargement of the pedestrian area and a time-window for distribution in the car-free areas between 5-11 a.m. and 6-8 p.m.

Beyond the specific bicycle policies is Groningen’s traffic policy, with one of the main objectives being the promotion of bicycle use. Despite the fact that the city is growing in size and that distances to the suburbs are increasing, the city is still striving to have bicycles account for sixty percent of all travel within the city. One way in which Groningen is trying to achieve this is to minimize cyclists waiting times at traffic lights. Consequently, several types of measures have been taken to reduce delays for cyclists at traffic lights with the following objectives in mind:

- Ensuring a safe flow of bicycle traffic;
- Reducing delays;
- Being able to cross roads conveniently and safely; and
- Creating dedicated cycle routes without traffic lights wherever possible.

In practice, at locations where the green sequence for cyclists is too short, it will be extended. The city wants to enable cyclists to have sufficient green time to cross without having to wait for a second green sequence. Additionally, cyclists turning right will be able to ignore the traffic lights, meaning that they are allowed to turn right on red instead of waiting unnecessarily. Cyclists will also get simultaneous green lights at the majority of crossroads, which enable them to turn left in one go instead of two. Further, at crossroads that are relatively quiet, the green frequency for cyclists may be increased to two times during a traffic-light cycle (Valkema 2008).

The city is also attempting to remove traffic lights wherever possible and replace the intersections with roundabouts where bicycles have priority (Fietsberaad 2006; Valkema 2008). The roundabouts enhance the directness and safety for cyclists. Over the last few years, Groningen has done this in over seven locations. Now, the city center is accessible from various residential quarters without cyclists having to take even one traffic-light crossing. Priority to bicycles is also seen in the city center where cyclists and pedestrians take first priority (Fietsberaad 2006; Valkema 2008).

Parking is also an important component of the bicycle climate and bicycle use in Groningen (Valkema 2008). Groningen also has numerous guarded and unguarded parking facilities that help promote bicycle use. In the city center there are four guarded bicycle shelters, and there are also 15 guarded bicycle shelters at schools. In further promotion of bicycle use, the four guarded shelters in the city center are now free. Parking a bike in a guarded facility reduces the chance of bike theft. Consequently, citizens naturally feel inclined to use the bike more often to visit the city center and show a greater readiness to purchase a high-quality bike. This also helps to prevent people from parking their bikes at random in the streets (Valkema 2008).

At the railway station there is one guarded bicycle shelter, which holds 2,700 racks and one unguarded shelter which holds 4,200 racks (Valkema 2008). The unguarded shelter is a recent project - City Balcony - which is a response to large amounts of bicycles being parked near the railway station. City Balcony is a large covered space located below the square in front of the Groningen railway station where bicycles can be stored at two levels. The parking area opened in the fall of 2007 and was finalized in January, 2007. The City Balcony offer free storage for up to 4,200 bicycles, is located a short distance from the train platform, and was designed to be an accessible space where cyclists feel safe to store their bikes. While the parking area is technically unguarded there are always some security personnel in the vicinity, due to its proximity to the rail station. The City Balcony has proved to be a huge success, and the number of bicycle thefts in the area dropped from 6 to 1 (Valkema 2008).

Other parking initiatives of the city include adding more bicycle parking facilities near bus stops and the red carpet (explained below). In the city center there are several problematic locations when it comes to bike parking. Despite placing extra racks, parking demand remains high. The city acknowledges that strict enforcement is an option, but believes that penalizing cyclists is counter-productive. To discourage bike parking at problematic spots, a number of experiments were carried out in 2007. One successful experiment, involved laying red carpets near shop entrances. The idea was that cyclist could park alongside the carpet, but not on it, thus ensuring access to shops. Another way to give the streets a more regulated appearance is the use of peak racks, which are placed in the city only during busy hours and removed afterwards (Valkema 2008).

The city has also devoted a lot of attention to constructing tunnels and bridges to make destinations as easily accessibility and direct as possible. This type of infrastructure also gives priority to the bicycle over the car. For instance, there is a new tunnel that was constructed solely for cyclists to pass under a railway line. Similarly, the city built a special cycle bridge that is high enough that it does not have to open should a ship pass through. The bridge is built next to a car bridge, which does have to open for water traffic; however, cyclists and pedestrians can cross the cycle bridge unhindered at any time (Valkema 2008).

Traffic

Similar to Rotterdam, the city center of Groningen was heavily damaged during the Second World War, and it was rebuilt to accommodate motorized traffic, including wide arterial roads that passed through the city. In the 1960's car traffic boomed, and car ownership in Groningen was higher than the national average. In 1969, the municipality drafted a traffic circulation plan, which provided for a ring road to encircle the city center and a transformation of the inner city. This plan was recorded into a policy document which re-allotted the public space in the city center to pedestrian and cyclists instead of car traffic. The policy document set forth that Zuiderdeip, an arterial road cutting through the city, would be transformed to accommodate bus lanes, city center stops for district buses, and the construction of segregated, uninterrupted cycle paths, rather than the car (Fietsberaad 2006).

For the purpose of barring through car traffic from the city center, the inner city was split up into four traffic sectors. Going straight from one sector to another became impossible by car. Instead, cars have to leave one sector and go onto the ring road in order to travel to another sector. However, bicycles can pass through any of the sectors. This traffic system, although initially severely contested, has proven to be a huge success in limiting car traffic in the city center and for stimulating bicycle use (Fietsberaad 2006; Valkema 2008). This has promoted the bike because it is always faster to go by bicycle in the city than by car. In fact, the average distance traveled within 10 minutes is only 1.6 kilometers via car; however, it is 2.4 kilometers via bicycle (Valkema 2008).

Traffic safety is a priority for the City of Groningen. In the last 10 years, the city has seen a decline in overall traffic casualties, and has been able to keep the number of bicycle casualties under 110/year for the last five years. The promotion of traffic safety has been primarily in the form of traffic safety education and lessons. There are also traffic analyses performed where accidents have occurred to see what possible measure can be implemented to make the location safer. One new project has been targeted at making routes from home to school as safe as possible for children (Valkema 2008).

Marketing

The city has not engaged in any specific marketing events. This fall will be the first time that the city will engage in specific campaigns because for the first time funds have been earmarked for this purpose. However, the city has yet to decide in what type of specific marketing events it will engage (Valkema 2008).

Incentives

The major incentives to go by bicycle include the high quality infrastructure and priority that bicycles receive throughout the city. The intricate network of cycle routes also supports traveling by bike. Additionally, the largest incentive is that traveling by bike is always faster than traveling by car in the city (Valkema 2008).

Disincentives

The disincentives for motorized traffic include the restrictive through traffic in the city center (discussed above) as well as car free-zone in the core. The city also has a car parking policy that acts as a disincentive. The city has a car park distribution ring. Starting in the city center, there is parking, but it is only available for short-term parking and it is very expensive. The second ring is around the city center, where the cars can park for a longer period of time and it is slightly cheaper. The third and final ring is a Park and Ride. The Park and Ride facilities have a bus service. The city is researching whether it is feasible to use these as a park and bike facility as well, by providing a bike rental service at the location or facilitating personal bicycles (Valkema 2008).

Integration

Groningen's success in its bicycle climate and bicycle use has been attributed to how its broad cycling policy is firmly embedded in the cities overall transport and traffic policy. Similarly, the spatial policy which is oriented towards maintaining a compact city has also maintained the locations of activity in a bikable distance for residents. In addition to the strong integration of policies in Groningen, there is a strong integration among civil servants. Where city center policy and traffic policy have involved intense political struggles, the cycling policy has always held a council-wide basis in the city. The Groningen civil service, despite political turnover, has worked hard to retain continuity in the preparation and implementation of bicycle-related policies and measures (Fietsberaad 2006).

5.6 Delft

Delft is located 14 kilometers north of Rotterdam and 9 kilometers south of The Hague (EAUE n.d.; Polman 2008). Delft has a population of approximately 95,000 inhabitants. The city has served as a model for transport planning for the last three decades. While Delft does have a historic city center and a compact building style, the first national Traffic and Transport Structure Scheme and the subsequent municipal bicycle policies were identified as the main contributors of Delft's success in the promotion of bicycle transportation within the city (EAUE n.d.; Polman 2008). These policies will be discussed below.

5.6.1 Traffic and Transport Structure Scheme

One of the major aims of traffic planning in the Netherlands has been directed towards the restriction of the use of cars (EAUE n.d.). To support this aim, in the late 1970's, the first national Traffic and Transport Structure Scheme gave priority to the encouragement of bicycle use and the improvement of traffic safety by providing better facilities for cyclists. Within this policy strategy, the municipality of Delft was selected as a model city for pro-bicycle traffic planning. Between 1979 and 1985 the first cycling plan, the Delft bicycle plan, was put into practice. The initial major efforts of realizing this plan focused on the construction of facilities that were needed to complete a city-wide cycling network (EAUE n.d.).

The network plan included a diversity of measures regarding urban infrastructure as well as traffic regulations. The main characteristic of the Delft bicycle network plan is its hierarchy; it is made up of three networks at three different spatial levels – the city level, district level, and sub-district level (EAUE n.d.). Each of these levels has its own functional and design characteristics, as described below in Table 5.3.

The second Traffic and Transport Structure Scheme also encourages cycling by trying to strike a balance between individual freedom, accessibility, and environment. It has been concluded that the only way to reach this goal is to control the use of the car by allowing the bicycle to represent a reasonable alternative. The following two ambitions are desired:

1. For short distances (up to 7.5 kilometers), a shift from using cars to using bicycles should take place with a considerable increase in the number of kilometers covered by non-motorized transport;

2. A shift from using cars to public transport should take place, with the expectation that twice as many passengers' kilometers will be covered by public transport in 2010 (EAUE n.d).

Table 5.3 Hierarchy of Cycle Network

Network Level	Function and Design Characteristics
City	▪ Grid of cycle paths situated approximately 500 meters apart ▪ Paths running directly through the city and connected with regional bicycle path system ▪ Network designed for the purpose of linking intensive flow of cyclists with important urban activity centers (schools, university, railway and bus station, office and industrial area, and sport and recreation areas) ▪ Physical barriers (canals, railways, etc.) require expensive infrastructure measures to avoid detours
District	▪ Two major functions: connect various facilities within districts (schools, shops, etc.) and collected and distribute traffic to and from the city level network ▪ Links are spaced 200 – 300 meters apart ▪ Bicycle flows are less dense than at city level because the district level is mainly used for short trips ▪ The facilities required at this level are relatively simple: separated bicycle lanes and small bridges
Sub-District	▪ Provides connections between housing areas and local amenities ▪ Typically utilized for short trip purposes ▪ Often used by children ▪ Finely-meshed system with links at 100 meter intervals ▪ Simple structure and provisions which can also be used by pedestrians

(Source: EAUE n.d.)

Concerning the use of bicycles, the national plan's primary goal is to encourage cycling. It aims for a 30% portion of city-wide transportation to be achieved through cycling by 2010. This should be reached by using a combination of measures that favor cycling, such as: the provision of new cycle routes, facilities at railway stations, principal bus and tram stops, and various other aims to make cycling both safer and more pleasant. The project recognized that the implementation of a high-quality infrastructure and bicycle network are the most promising way to get people on their bikes. However, the project is also conscious of the subject feelings of safety of the potential users, which impact their attitudes for cycling. Within this framework, the Delft planning approach pays tribute to different user demands (EAUE n.d.).

5.6.2 Delft Bicycle Action Plan II (2005 – 2010)

As stated above, Delft was one of the first cities in the Netherlands to implement a systematic network of bicycle paths. The National government was the catalyst to this main effort. However, since the 1970's, the city of Delft has continued to develop its network. The city has continued to develop bicycle plans to support the network and accomplish a variety of measures related thereto. As a consequence, the bicycle accounts for approximately 40% of trips within Delft (Sammer & van Goeverden 2003). The city's contribution toward bicycle transportation within the city is discussed in more detail below.

Government Support

In the 1970s the primary focus in Delft was on building a bicycle network (Polman 2008). After the initial contribution from the National government, Delft continued to develop an integrated bicycle policy. In 1999, the city of Delft made a new bicycle policy, "Bicycle Action Plan I". This plan was in place from 1999 – 2004, and focused primarily on the completion and improvement of the bicycle network and the improvement of bicycle parking facilities. To complete and improve the bicycle network the city gave priority to filling in missing links, laying red asphalt, placing route signs, and giving cyclists priority at traffic lights. For the improvement of parking facilities, the city placed more bicycle drums, parking racks, and guarded parking facilities throughout the city (Polman 2008).

To date, most of the projects from the first bicycle plan have been carried out, however a second bicycle action plan has been approved, which offers the possibility of continuing and extending the ambitions of the first bicycle action plan (BAP I) (City of Delft 2005). "Bicycle Action Plan II" (BAP II), aims at the implementation period of 2005 – 2010. The major objective of the BAP II is to stimulate bicycle use and make it a serious alternative to the car. To assist in the achievement of these objectives, the city has set the following targets: (1) increase the percentage of bicycle transportation in the city by 5%; (2) have a larger growth of bicycle traffic, rather than car traffic, to the inner city; (3) improve bicycle satisfaction; and (4) start cycling at a younger age and keep cycling at an older age (City of Delft 2005). The city intends to achieve these targets with the methods described below.

Investment

Under Bicycle Action Plan I, € 2,900,000 was allocated for the years 2000 – 2005 (Polman 2008). BAP II budgets €3,100,000 for the years 2005 – 2010. However, in addition to this amount, the city has also directed from 5 million Euros to 6 million Euros for major bicycle projects, which includes bicycle tunnels and bicycle bridges. This results in approximately €1,000,000 to €1,500,000 per year for the Delft to realize its initiatives under BAP II. This means that approximately €11 to €16 is spent on cycling measures per inhabitant each year under the plan. This amount does not include any funding needed for maintenance or communication (Polman 2008).

Infrastructure/Accessibility

To fully understand what measures were needed concerning the infrastructure and accessibility given to cyclists, Delft paid particular attention to the appraisals of its bicycle supplies and cities that had been performed (City of Delft 2005; Polman 2008). The bicycle supplies and policy of the city of Delft had been assessed by the Fietsersbond (Dutch Cycling Union) in 2001 and BYPAD (Bicycle Policy Audit) in 2004. Accordingly, the city had two objective assessments performed, which allowed it see where attention needed to be paid. The city took both of these assessments quite seriously, and their observations were the impetus for most of the measures set forth in BAP II. The city hopes to achieve a high status in the next Bicycle Balance assessment that will be performed by the Fietsersbond[18] (City of Delft 2005; Polman 2008).

To improve its bicycle climate in accord with the observations set forth by Fietsersbond and BYPAD as well as the cities own observations, the city has engaged in numerous efforts to improve the bicycle infrastructure and promote the accessibility for cyclists in the city. The cities goal is to have uniform and high-quality bicycle supplies, fulfilling the CROW requirements (cohesion, directness, attractiveness, safety, and comfort) as well as the additional Fietsersbond criteria (competitiveness, bicycle use, cyclist satisfaction, and policy on paper). The city is trying to have cycle tracks wherever possible, which are the safest solution because cyclists are separated from motorized traffic. The city has been building new cycle tracks and converting cycle lanes into cycle tracks. To date, the city has 25 kilometers of cycle tracks. However, where it is not possible to have a cycle track, typically due to lack of space, a cycle lane is the next best alternative[19] (City of Delft 2005; Polman 2008).

[18] The results of the Bicycle Balance will be released in October, 2008.

[19] Depending on the intensity of bicycle and car traffic, a bicycle street may be a better alternative (Polman 2008).

The city also wants to have comfortable and recognizable material on bicycle infrastructure, including having all bicycle tracks in asphalt, and all bicycle lanes in red asphalt. The city is also utilizing a new type of bicycle infrastructure – the bicycle street. To date, the city has three bicycle streets. On these streets, the bicycles have priority, and although cars can ride on them, they are treated as “guest” on the road. The city is also engaging in studies for the feasibility of having more bicycle streets. In some instances, it may be possible to convert roads with a mixed profile into bicycle streets (City of Delft 2005; Polman 2008).

Good signposting has also been identified as a necessary measure. An inventory of bicycle routes will be taken, and where there is a need for signposting, such destinations will receive attention. Good signposting is thought to enhance the overall mobility and accessibility of cyclists. Additionally, the city is giving attention to locations where there may be missing links. The city believes that missing links lead to problems with the directness and consistency in the network. In other words, a cyclist should not have to deviate too quickly from its continuing direction. Moreover, shortening the distance by the realization of an extra link can promote bicycle use (City of Delft 2005; Polman 2008).

To further enhance accessibility and safety for cyclists, the city has engaged in the construction of bridges and tunnels for cyclists. Some of these are combined with car traffic; however, there are tunnels and bridges that are reserved solely for cyclists and pedestrians. The city is also assessing more areas to see where a bridge or tunnel could create a more comfortable experience for cycling. The flow and comfort of cycling can also be enhanced by traffic light modifications. The city is taking numerous measures which reduce the wait time for cyclists at traffic lights, including the following:

- Achieving a maximum 90 second wait time for cyclists at traffic lights;
- Improving safety for cyclists outside the bicycle lanes;
- Improving the traffic light signals for cyclists (especially those located at “bike level”, approximately 1.5 meters high);
- Synchronizing bicycle traffic lights with each other;
- Allowing cyclist to be in the front at intersections where bicycle movement is mixed with car traffic
- Using “green waves” for bicycle traffic where traffic lights are close to each other (at a constant speed, the cyclists can ride without stopping)
- Improving safety at intersections
- Giving priority to cyclists and public transport with respect to other users
- Constructing more crossing points for cyclists along roads (to increase the possibility for cyclists to cross streets at more than one location)
- Using distance-detection for bicycle traffic lights (City of Delft 2005; Polman 2008).

The city of Delft also realizes that good bicycle parking is necessary both at the origin (house) and the destination (shopping centers, offices, school, etc.) (City of Delft 2005).

Good bicycle parking is necessary as it increasing the number of bicycle owners as well as users. Additionally, good parking that reduces the change of theft of vandalism also impacts the choice to have and use a bicycle. To realize good bicycle parking at origins, the city is making an extension of bicycle drums in residential districts. This means that if there is no good safe bicycle parking possibility and sufficient space, then the municipality will subsidize a bicycle drum. To realize good parking in destination areas, the city is extending the bicycle parking facilities at primary schools and placing new parking infrastructure throughout the city (City of Delft 2005).

Traffic

Regarding traffic safety, the city is reviewing intersections that have had more than 4 accidents in 5 years. Where such an intersection exits, measures that remediate the specific accident cause will be put in place. Beyond the "objective" unsafe locations that come from accident statistics, the city is also paying attention to "subjective" safety considerations, focusing on locations that give unpleasant feelings to cyclists. The focus is on children, their parents, and the elderly. The municipality is also paying extra attention to the road safety around schools (City of Delft 2005).

The city of Delft wants to improve traffic safety in school areas, nurseries and school routes because a lot of parents feel the traffic situation is unsafe around schools, and consequently, chooses to take their children to school by car. The city wants to break the vicious circle of increased car use that makes streets unsafe for children to walk and cycle, encouraging their parents to bring them to school by car. In 2007, in order to break this circle, the city implemented seven measures at several schools, after school care facilities, and neighborhoods (ELTIS 2007). These measures are provided in Table 5.4

Table 5.4 Safety for Children in Delft

Measure	Goal
1. Working together on safe school areas	The main goal of this measure is to make the school area safer for children by involving all parties involved. Every school engages themselves to implement a package of measures aimed to increase the number of cycling and walking trips to schools.
2. From the back seat onto the bicycle	The main goal of this measure is to encourage children to cycle independently to after school care facilities.
3. KINDlint	This measure is a public space instrument; a route where it is safe and fun for children to walk and cycle independently. Literally translated this is a child ribbon and can be seen as a ribbon of child friendly environment throughout the city.
4. Website	This measure aims at developing a website providing information on all traffic safety measures for children in Delft.
5. Bicycle Racks	This measure wants to make an inventory of all bicycle racks in all Delft primary schools.
6. Practical traffic education	This measure wants to support schools in providing for traffic education during and outside school hours.
7. Traffic parents	This measure aims at training one or two "traffic parents" at every school that meet regularly and are supported by "Safe Traffic in the Netherlands"

(Source: ELTIS 2007)

Marketing

The city's main marketing initiatives are in the form of education and communication (City of Delft 2005; Polman 2008). In 2004, the city made a bicycle page on the municipality's website wherein anyone could become informed about current and upcoming bicycle projects, bicycle routes, bicycle rentals, and bicycle parking. The city is also publishing information about bicycles for both residents and tourists. Finally, the city is engaging in several education projects to stimulate children to use the bike. These projects include practical road safety lessons and "action days" to travel to school by foot or bike (City of Delft 2005; Polman 2008).

Incentives

The major incentives to travel by bicycle in Delft include the following:

- Bicycle use has increasingly become a viable option for the inhabitants;
- Environmentally compatible means of travel have been integrated into the overall town planning;
- Infrastructure improvements systematically contribute to the positive image of cycling; and
- Cycling comfort and safety standards are continually being improved (EAUE n.d.).

Disincentives

The disincentives for motorized traffic include increased waiting times at intersections, giving priority to cyclists. Cyclists are given more direct routes where possible, including tunnels and bridges made only for cycling. The city center's car-free zone is also expanding (City of Delft 2005; Polman 2008).

Integration

First, the BAP II is a continuation and extension of the BAP I (City of Delft 2005). Additionally, the BAP II incorporates the pursuit of the Local Movement and Transport Plan (LVVP), which is an accessible and livable city. To this end, both plans seek to limit the increase of commuter traffic and make the bicycle a serious alternative to the car. Moreover, the city set forth its intentions for the cycle network so that it can be supported and realized through spatial planning obligations. The missing links which have been specified under the framework of the LVVP and BAPII will be realized because as such they are reserved in spatial as well as other municipal plans (City of Delft 2005).

5.7 Conclusion

Table 5.5 Matrix of Policy Instruments

City	HARD INSTRUMENTS				SOFT INSTRUMENTS			
	Investment	Government Support	Infrastructure/ Accessibility	Traffic	Marketing	Incentives	Disincentives	Integration
ROTTERDAM	€ 12 Million (2007 – 2010) (€5/inhabitant/ year)	1990's "Making work w/ work"	Bicycle in the Chain Interconnected Network Parking Facilities Ambitions for high quality infrastructure (CROW) Traffic light modification	Traffic Education Objective & Subjective Traffic Safety	3 Target Groups Communication	Bike and Ride National	Expensive Parking Limited Parking New initiatives to be adopted (e.g., Coolsingle)	Regional Traffic and Infrastructure Plan (2007-2011) Municipal Traffic and Infrastructure (2003 – 2020) Bicycle Action Plan Spatial Development Strategy 2030 (& related projects)
GRONINGEN	€ 6 Million (2007 – 2010) (€8/inhabitant/ year)	1972 (Political Priority)	200 km of Cycle Lanes Traffic Light Modification Bicycle Shelters Bike Bridges and Tunnels High Quality infrastructure	Round – About; Traffic Education Traffic Safety	Beginning	Travel time High quality bicycle network and facilities	Car cannot drive through IC Restrictive Parking Policy Car free CC	Municipal Transport & Traffic Policy Bicycle Policy (2006 – 2010) Structure Plan (Compact City)
DELFT	€ 9 Million (2005 – 2010) (€11 – 16/inhabitant/ year)	Late 1970's Model City	25 km Bicycle Tracks Bike Bridges and Tunnels High Quality infrastructure Parking Facilities Traffic Light Modification	Traffic Education Safety for Children	Communication Website Publications and Brochures	High quality bicycle network and facilities	Car free IC Priority to Cyclists Longer Routes	Bicycle Action Plan I (1999 – 2004) Bicycle Action Plan II (2005 – 2010) Local Movement and Transport Plan

Chapter Six: Sustainable Community Development Code

The Design Manual for Bicycle Traffic as well as the Case Studies provided many relevant examples for the Sustainable Community Development Code (SCDC). The SCDC is set up so that for each topic, in this case Pedestrian and Bicycle Mobility Systems, an introduction is provided, implications of not addressing the issue are presented, and goals for community health and safety are stated. Then the framework is structured by policy provisions, which can be an approach to removing obstacles, suggesting incentives that might be created or focusing on enacting standards that might be adopted to ensure progress in a particular area. For each case, levels of effort are assigned to the innovative approaches. Based on the organization of the code the application of the collected data is set forth in Sections 6.1 and 6.2.

6.1 Pedestrian and Bicycle Mobility Systems

Introduction

A. Pedestrian Mobility:

With regard to pedestrian mobility, much can be learned from European cities. European cities have made conscious land use decisions to keep civic and municipal functions in the center, create highly attractive environments, and provide housing within and in close proximity to such areas (Beatley 2000). Additionally, many European cities have been pedestrianizing parts of their city centers, which has contributed to the attractiveness of the areas, making them places where people want to visit, shop, and live. Cities have achieved these areas by gradually taking space away from cars and parking and returning it to the pedestrian. Pedestrian areas have a significant impact on the public life in these cities. This is also clear from the American cities that have pedestrianized urban spaces. The success of pedestrian areas is demonstrated by the cities that have created pedestrian areas, such as Boulder (Colorado), Portland (Oregon), and Minneapolis (Minnesota), where Americans are attracted to visit, shop, live, and work (Bealtey 2000).

B. Bicycle Mobility:

The European approach to bicycle mobility demonstrates the importance of the bicycle as a part of the transportation system. For example, in the Netherlands, the bicycle is used for almost a quarter of all journeys. For distances up to 7.5 kilometers it is the most popular means of transport. In fact, in 2005, 35% of all trips up to 7.5 kilometers were made by bicycle. Notably, bicycle use is dependent on the distance covered. Approximately 70% of all journeys in the Netherlands are shorter than 7.5 kilometers. Nevertheless, the strong position of the bicycle over short distances (35%) extends into the total modality split with the bicycle being used for 27% of all trips (Ministry of Transport, Public Works and Water Management Directorate-General for Passenger Transport 2007).

In the United States, approximately 63% of trips take place within a “bikable distance” (5 miles from origin to destination) (LEED ND Core Committee 2006). Yet, the bicycle is used for approximately 1% of all trips (Pucher 2008). However, some cities have demonstrated that the bicycle does have a place in the traffic system. For example, in Boulder, Colorado, the bicycle accounted for 21% of commute trips and 14% of all trips (League of American Bicyclists 2005). Davis, California, is also notable as 17% of all trips in the city are made by bicycle (League of American Bicyclists 2005). In larger cities the bicycle has a place in commuter travel, being used for 5% of such trips in Portland, Oregon; 2% in San Francisco, California; and 1% in Chicago, Illinois (City of Seattle 2008).

Bicycle-friendly infrastructure is a prerequisite to the bicycle becoming and retaining a full status position in a traffic system. High quality cycling infrastructure leads to a higher proportion of bicycles in the modal split. High quality cycling infrastructure starts with an integral design at the network, connection, and facility level. First, at the network level, integral design starts in the spatial planning phase because the ability to make short journeys is vital for the bicycle to be used as a means of transport. Therefore, points of departure and destination (home, work, school, shopping, etc.) should be located in close proximity and new residential areas should not be built more than two miles from a town or city center. At the connection level, choosing to cycle over another means of transport is a valid option when conflicts with fast moving traffic are minimized. To avoid conflicts, traffic types should be separated, the speed of motorized traffic should be reduced, and the amount of motorized traffic on major cycle routes should be reduced. Finally, the quality of facilities offered to cyclists should be assessed with the same criteria as the quality offered to other road users. In this regard, integral thinking means that traffic is viewed from how different road users, including bicyclists, actually behave.

High quality infrastructure also requires five key factors in the development of a cycle network: cohesion, directness, safety, comfort, and attractiveness. Cohesion means that connections have to link up from a cyclist’s point of departure to their destination. The two major components of directness at the network level are directness in terms of distance and directness in terms of time. Directness in terms of distance is the extent to which a network provides the opportunity to cycle between a departure point to a destination point via the most direct route possible, whereas directness in terms of time concerns connections that optimize traffic flow. At the network level, there are many measures that can be implemented to enhance safety, including avoiding conflicts with crossing traffic, separating vehicle types, reducing speed at points of conflict, ensuring recognizable road categories, and ensuring uniform traffic situations. Cyclists must also be able to comfortably use the connections, meaning that encounters between bicycles and cars are minimized and attraction points are clearly signposted so that cyclists can easily find their destinations. Attractiveness is also an important consideration and should be enhanced through running connections through built-up areas in varied surroundings with well-maintained public space, having connections well-lit, and locating connections where social safety is not imperiled. (*See* Annex 2 for a summary of the main requirements for a cycle network).

The main requirements of directness, safety, and comfort are also significant at the intersection level. Directness at the intersection level can be achieved, where possible, by giving cycle traffic the right of way through the intersection and allowing cyclists to follow the most direct route. Safety requirements should have priority in the design of cycle facilities at intersections. At intersections, conflicts should be prevented and the speed difference between the various types of traffic should be minimized. In terms of comfort, intersections should ensure a smooth road surface, maximize the ability of proceeding unhindered, minimize traffic nuisance, and minimize weather nuisance. To achieve the requirements of directness, safety, and comfort, there are many bicycle-friendly provisions that may be implemented. First, a minimum waiting time at stops is essential and traffic light modifications as well as giving right of way to cyclists at intersections are two tools that can be utilized. Other measures for improving the situation for cyclists at intersections include roundabouts and grade-separated facilities.

The facilities for cyclists on road sections should be based on what function the road is to serve for both bicycle and other traffic. The combination of functions results in the right basic form, within which the actual appropriate layout is determined. Three factors play a role in the process: the intensity of the bicycle traffic; the speed of the motorized traffic; and the intensity of the motorized traffic. Based on these measurements, a variety of bicycle-friendly infrastructure can be implemented. The most common facilities are cycle lanes, suggestions lanes, and cycle tracks. Cycle tracks are the safest solution because cyclists are separated from motorized traffic. (*See* Annex 3 for an option diagram for road sections inside the built-up area).

Additionally, the design, maintenance, and furnishings of the cycling facilities are also important. With regard to road surfacing and paving, the evenness of the paving surface, skid resistance, and drainage must be considered. For paving, asphalt is recommended as it offers the greatest evenness and least resistance. Green areas also enhance the cycling experience as they provide protection by reducing wind nuisance, reduce glare from oncoming cars, and provide visual protections from car traffic. Verges along cycle tracks are also recommended. Further, lighting should always be provided for on the cycling network. Lighting serves many functions, such as increasing traffic safety, improving traffic flow, increasing cycling comfort, improving social safety, and making the area visible. Finally, it is recommended to have a dedicated system of bicycle signs that links up with the cycle network.

Cyclists not only need good and safe cycle routes, they also need facilities to park their bicycle safely, easily, and tidily. Good parking facilities is a requirement for a mobility policy, as the fear of theft leads to reduced use of bicycles. To analyze the number and type of bicycle parking facilities required, locations must be considered. For example, points of departure (homes), destination points (companies and institutions as well as service and retail centers), and transfer points (public transport stops) have different parking needs. Regarding city centers, the type of bicycle storage facility can encourage or discourage cyclists. For example, the introduction of free, supervised storage is very effective in stimulating the use of bicycles and reducing theft (CROW 2007).

Implications of Not Addressing the Issue

An investment in cycling offers numerous public and private benefits, including the following:

- The bicycle improves accessibility and prevents traffic congestion;
- The bicycle helps prevent air pollution caused by traffic, and the consequences thereof for the environment and public health;
- The bicycle provides exercise and therefore has a major effect on the prevention of a number of illnesses;
- The bicycle is cheap to buy, maintain, and use;
- The bicycle does not provide noise nuisance;
- The bicycle improves the quality of life in cities;
- The bicycle contributes to employment and stimulates new businesses;
- The bicycle provides mobility and reduces travel time and costs; and
- The construction and maintenance of cycle paths and the construction of bicycle parking facilities costs much less than roads and parking facilities for cars.

A question that cities must answer when considering a specific cycling policy, is the extent to which it can contribute to the city's economy and its residents' quality of life. Cycling policy is known to make an important contribution to the accessibility and quality of life in a city and therefore also contributes significantly to the urban economy. In many American cities, increasing car use has had a negative effect on the accessibility and appeal of city centers. However, it has been found that cycling can improve the quality of life of city centers and therefore attract more activities, a result of which is consumers spending more money in city centers. Furthermore, the bicycle can contribute to a good climate for new businesses and also attract new employment (Interface for Cycling Expertise 2000).

Similarly, when proposals to pedestrianize city districts or specific streets are made, they are invariably met with hostility and opposition from shop owners who fear losing business. Yet, experience shows that these fears are unfounded and that business activity and profits often increase when car traffic is restricted. Additionally, most city residents prefer pedestrian areas over cars and traffic. An incremental process of pushing back cars and reclaiming streets and squares for pedestrians is the key to success for inner city transformations. In this way, people have time to change their patterns of driving and parking (Beatley 2000).

Goals for Community Health and Safety

Designs offering quality to pedestrians should be the be-all and end-all in spatial planning as each journey begins and ends on foot (Bach 2006). Thus, everyone is a pedestrian at some time. Pedestrians are vulnerable, and therefore walking distances, walking environment, and public safety must be carefully considered. A reverse design sequence, which begins with the desired patterns of the slow modes of transport, is an efficient and cost-effective instrument to take into account the interests of pedestrians, particularly the most vulnerable – the elderly and children. Additionally, attractive axes, squares, and frontages extend the length people are willing to walk (Bach 2006).

Distances are also a crucial consideration for the promotion of bicycle use (Interface for Cycling Expertise 2000). When designing new construction or reconstructing an area, it is important to build in high densities so that destinations are nearby for as many residents as possible. Keeping distances between activities short increases the opportunity to travel by bike. Besides making cities more compact, mixed-use development and the decentralization of facilities, such as a shop on every corner also promotes the use of the bicycle. Nevertheless, it is only possible to take advantage of cycling when the right provisions have been made. The provisions for high quality bicycle infrastructure described above are essential for the promotion of bicycle use (Interface for Cycling Expertise 2000).

Additionally, a cycling policy that is part of a fully integral traffic and transport policy is necessary in order for the bicycle to compete with other means of transport on different types of journeys. Despite the construction of bicycle facilities that have made the bicycle a fast, safe, comfortable, and attractive means of transport; the bicycle will be left behind if other means of transport are faster and/or more comfortable. Therefore, measures aimed at motorized traffic must also be utilized. Measures that can make it more advantageous to travel by bicycle than by car include traffic calming, parking policies, and the creation of car free zones. There are also several financial instruments that give cycling a head start, such as road pricing, high rules prices, or a road tax (Interface for Cycling Expertise 2000).

Furthermore, in order to create a bicycle culture certain barriers may need to be overcome. Barriers include people's perception that cycling is only for the poor, unsuitable for women, or a matter of status. These perceptions can be changed through information (preferably visual) about countries or cities where these barriers do not exist (Netherlands, Denmark, Germany, Italy, etc.). Education is also an important tool. The inclusion of lessons about bicycles in school curriculum is a good way of teaching children about cycling at an early age (Interface for Cycling Expertise 2000).

Involving cyclists in the policy development may be an important tool in order to meet the local needs of existing cyclists. To attract new cyclists, cities can engage in a variety of marketing campaigns or offer incentives to those who travel by bike. For example, cities can support programs such as credit and saving schemes when buying a bicycle with the assistance of employers, bicycle rental, education, parking facilities, and promotional campaigns such as a "bicycle day". The promotion of cycling can be from a variety of perspectives as well, such as mobility, accessibility, quality of life, the environment, or health. To that end, a cycling policy should be based on these needs (Interface for Cycling Expertise 2000).

6.2 Framework

Pedestrian Systems

The transferable measures include removing obstacles to achieving the overall goal of pedestrian mobility. Existing regulations that if eliminated or significantly amended could assist in achieving this goal. For pedestrian systems, these range from allowing more activities in public space in order to foster a more pedestrian-friendly environment, to allowing a variety of functions both in space and in time to promote livability and multi-purpose trips, and go as far as reducing lanes on carriageways and reducing the speed of motorized traffic to enhance safety and create a more pedestrian and bicycle friendly-environment. This range is based on the level of effort needed to achieve these obstacles. Allowing more activities in public space is relatively easy to achieve from a political, planning, and economic perspective, and therefore is placed at the Bronze level. Allowing a variety of functions in time and space is at the Silver level because it requires more substantial changes. Introducing measures to inhibit motorized traffic is at the Gold level because is the highest possible level of achievement toward achieving pedestrian and bicycle mobility systems. The new initiatives that are being taken on by the City of Rotterdam provide good examples of standards that can be enacted to transfer space from cars to pedestrians.

Bicycle Systems

Regarding bicycle systems, there are also many regulations that could be eliminated or amended to foster bicycle use. These would include spatial considerations such as allowing mixed-use development as well as transportation considerations like allowing cycle infrastructure to be added or improved anytime an existing infrastructure project is undergone. However, the highest possible level of achievement would entail items such as restricting new residential development more than two miles from a town or city center; shifting priority from cars to cyclists and pedestrians on streets in the urban core; limiting the possibility for long-term parking in the city center, and barring car traffic through the city center while allowing bicycle traffic. Regulatory incentives that could be administered include promoting the “bicycle in the chain” to encourage the use of the bike in combination with public transport, which in some circumstances could require substantial changes to a regulatory code. A high level of achievement would be the introduction of the Public Transport Bicycle[20], like the OV-Fiets in the Netherlands. Nevertheless, the largest contribution for the SCDC is regarding the standards that can be enacted regarding bicycle systems. See the following pages for the SCDC section on Pedestrian and Bicycle Mobility Systems with the applicable policy provisions from the Netherlands.

[20] Public Bicycles are innovative schemes of rental or free bicycles in urban areas that can be seen as part of the public transport system. Public Transport Bicycles offer a range of potential benefits including promoting urban cycling and increasing its modal share; providing fast, convenient, and flexible inner urban transport; encouraging intermodality; allowing efficient use of inner urban space; increasing sustainable non-polluting mobility choices; improving traffic safety; strengthening local identity; and offering positive health effects (Buehrmann n.d.).

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Pedestrian & Bicycle Mobility Systems

KEY STATISTICS:

- In the United States, approximately 63% of trips take place within a "bikable distance" (5 miles from origin to destination).
- The bicycle is used for approximately 1% of all trips in the United States.
- More than a quarter of trips are "walkable" (27% of trips take place within one mile and 14% take place within a half mile of home).
- Walking is used for less than 10% of all trips in the United States.
- More than 90% of trips take place by automobile.

Pedestrian Systems

		ACHIEVEMENT LEVELS (NOTE: HIGHER LEVELS GENERALLY INCORPORATE ACTIONS OF LOWER LEVELS)				
		Bronze (Good)	**Silver (Better)**	**Gold (Best)**	**References/Commentary**	**Code Examples/Citations**
	Remove Obstacles	▪ Allow visual contact (coherent way-finding, unhindered views, interesting views, lighting (when dark)). ▪ Allow for physical activity, play, interaction, and entertainment. ▪ Allow for temporary activities (markets, festivals, exhibitions, etc.). ▪ Allow for optional activities (resting, meeting, and social interaction). ▪ Allow seasonal activities (skating, Christmas markets, etc.)	▪ Allow for a variety of functions throughout the day, evening, and night. ▪ Allow for a good mix of public and café seating. ▪ Allow for mixed-use development.	▪ Shift priority from cars to cyclists and pedestrians on streets in the urban core. ▪ Dimensioning of buildings and spaces in observance of the important human dimensions related to sense, movements, size and behavior. ▪ Reduce lanes on carriageways. ▪ Reduce speed of motorized traffic.		▪ Public Spaces – Public Life (Rotterdam 2007) ▪ City of Rotterdam: "Linked City: Vision for Public Space in Downtown Rotterdam" (2007)
	Create Incentives	▪ Provide objects to lean against or stand next to. ▪ Create opportunities for people to interact in the public realm.	▪ Maximize advantages (pleasant views, people watching). ▪ Provide resting opportunities. ▪ Emphasize positive aspects of climate (sun/shade; warmth/coolness; breeze/ventilation). ▪ Create alternative pedestrian paths. ▪ Create attractive entrances to public spaces.	▪ Enhance aesthetic quality with good design/detailing; views/vistas; and trees, plants, and water. ▪ Provide street furniture.		▪ Public Spaces – Public Life (Rotterdam 2007) ▪ City of Rotterdam: "Linked City: Vision for Public Space in Downtown Rotterdam" (2007)

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Pedestrian & Bicycle Mobility Systems

Pedestrian Systems

		Bronze (Good)	Silver (Better)	Gold (Best)	References/Commentary	Code Examples/Citations
	Enact Standards	▪ Provide room for walking. ▪ Provide accessibility to key areas. ▪ Provide quality surfaces. ▪ Provide interesting facades. ▪ Provide lighting. ▪ Define spots for staying. ▪ Provide possibilities for hearing and talking (low ambient noise level; public seating arrangements conducive to communicating). ▪ Provide extra protection from unpleasant climatic conditions. ▪ Provide good pedestrian crossings. ▪ Provide continuity in the design of the street profile. ▪ Provide a continuing tree structure.	▪ Protect pedestrians against vehicular traffic. ▪ Protect pedestrians against crime & violence. ▪ Protect pedestrians against unpleasant sensory experiences. ▪ Define zones for sitting.	▪ Develop an attractive network of public spaces. ▪ Create more pedestrian crossings. ▪ Make broad sidewalks. ▪ Give priority to slow traffic in city center. ▪ Invest in a “Park and Walk” System. ▪ Develop a “Traffic-Winding Off” system to cut-off through traffic in city center. ▪ Give more green time to pedestrians than cars at traffic lights. ▪ Establish Car-Free Zones.	▪ The City of Rotterdam had designed a Park and Walk system to discourage automobile traffic inside the city center and encourage pedestrians. Park and Walks are planned in several areas, so that no matter what direction one drives from, a Park and Walk system is available and the main destinations are reachable within 10 minutes walking from each parking garage. The Park and Walk system is for the inner city, whereas a Park and Ride system is provided on the edge of the city. The Park and Rides are combined with public transport. The city intends to transform every parking garage into either a Park and Walk or Park and Ride.	▪ Public Spaces – Public Life (Rotterdam 2007) ▪ City of Rotterdam: “Linked City: Vision for Public Space in Downtown Rotterdam” (2007)

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Pedestrian & Bicycle Mobility Systems						
Bicycle Systems						
		ACHIEVEMENT LEVELS (NOTE: HIGHER LEVELS GENERALLY INCORPORATE ACTIONS OF LOWER LEVELS)				
		Bronze (Good)	**Silver (Better)**	**Gold (Best)**	**References/Commentary**	**Code Examples/Citations**
	Remove Obstacles	▪ Make car parking in the city center expensive.	▪ Allow mixed-use development. ▪ Allow for cycling infrastructure to be added or improved anytime an existing infrastructure project is undergone. ▪ Allow only short-term parking in the city center.	▪ Restrict new residential development more than two miles from a town or city center. ▪ Shift priority from cars to cyclists and pedestrians on streets in the urban core. ▪ Limit the possibility for long-term car parking in the city center. ▪ Designate intensification zones based on proximity and accessibility to the city. ▪ Bar car traffic through city center while allowing bicycle traffic.	▪ For purposes of barring through car traffic in the city center, the city of Groningen split its inner city into four traffic sectors such that going straight from one sector to another became impossible by car, and instead, cars have to leave one sector and go onto a ring road in order to travel to another sector. However, bicycles can pass through any of the sectors. This traffic system, although initially severely contested, has proven to be a huge success in limiting car traffic in the city center and stimulating bicycle use as now it is always faster to travel by bicycle in the city than by car.	▪ Design Manual for Bicycle Traffic ▪ City of Rotterdam ▪ City of Groningen ▪ City of Delft
	Create Incentives	▪ Engage in communication regarding bicycle routes as well as the benefits of bicycle use.	▪ Offer commuters "cycle points" if the travel to work by bike. ▪ Promote "bicycle in the chain" to encourage use of the bike in combination with public transport.	▪ Design the most direct bicycle route possible such that using the bicycle is quicker than the car. ▪ Introduce Public Transport Bicycle. ▪ Offer local businesses a Bicycle Plan in which fiscal benefits are given to employees to purchase and use the bicycle.		▪ Design Manual for Bicycle Traffic ▪ City of Rotterdam ▪ City of Groningen ▪ City of Delft

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Pedestrian & Bicycle Mobility Systems						
Bicycle Systems						
		Bronze (Good)	**Silver (Better)**	**Gold (Best)**	**References/Commentary**	**Code Examples/Citations**
	Enact Standards	▪ Create uniform traffic guidelines ▪ Create recognizable road categories ▪ Implement a system of bicycle sign postings. ▪ Develop cycling route based on main departure points and destination areas. ▪ Utilize vegetation to minimize nuisance from wind and rain. ▪ Assign maximum waiting times at stops for cyclists. ▪ Reduce waiting times for cyclists by concurrent extension of green phase for cyclists to the detriment of motorized traffic. ▪ Use asphalt where possible for bicycle road surfacing. ▪ Provide lighting on cycle routes. ▪ Provide bicycle parking facilities based on the location. ▪ Use reflection strips on main cycle routes. ▪ Provide bicycle traffic light signals.	▪ Avoid conflicts by separating traffic types, reducing the speed of motorized traffic, and limiting the amount of motorized traffic on major cycle routes. ▪ Minimize waiting times at traffic lights by having remote detection on cycle routes. ▪ Situate bicycle storage facilities in or on the edge of a core shopping area. ▪ Situate bicycle storage facilities no more than 30 meters away from a busy area. ▪ Ensure a good visual relationship and attractive walking route between the destination point and the bicycle storage facility. ▪ Provide road safety lessons to children in primary school. ▪ Construct more crossing points for cyclists along roads to increase the possibility for cyclists to cross streets at more than one location. ▪ Give considerations to both objective and subjective safety considerations.	▪ For main cycle routes limit the number of intersections where cyclists do not have the right of way to near zero. ▪ Replace intersections with roundabouts whereupon cyclists have right of way. ▪ Design facilities for cyclists on road sections based on the function it is to serve for both bicycle and other traffic. ▪ Implement cycle tracks separated from motorized traffic wherever possible. ▪ Park and Ride access. ▪ Require direct integration into or creation of a cycling network with a mesh width of no more than 750 feet. ▪ Reduce waiting time for cyclists at traffic lights by using green light for all directions. ▪ Reducing waiting time for cyclists at traffic lights using green wave for bicycle traffic. ▪ Reduce waiting time for cyclists at traffic lights by using long-range detection/pre-request. ▪ Introduce free, supervised bicycle storage facilities. ▪ Establish car-free zones.		▪ Design Manual for Bicycle Traffic ▪ City of Rotterdam ▪ City of Groningen ▪ City of Delft

Chapter Seven: Conclusions and Recommendations

7.1 Conclusions

Bicycle Mobility

The first major conclusion that can be reached from this research is that urban policies do have a significant impact on the promotion of bicycle transit in the Netherlands. There are five fundamental issues regarding bicycle mobility: (1) spatial policies; (2) high quality infrastructure; (3) disincentives for motorized traffic; (4) integral and reciprocal policies; and (5) traffic safety. First, spatial policies which promote the compact city concept, limit sprawl, and maintain bikable distances between departure and destination points create the opportunity for cycling to be a feasible mode of transit. This can be seen from Groningen and Delft, which have pursued strict spatial planning to attempt to limit the distances residents have to travel. Both of these cities have very high cycling rates. Additionally, most residents in these two cities chose the bicycle over the car.

However, it appears that the issue runs much deeper than proximity. Beyond proximity, spatial policies and transportation policies must support the construction and maintenance of high quality bicycle infrastructure. This means that there is a cohesive network with direct routes, providing cyclists a safe, comfortable, and attractive experience. High quality infrastructure in and of itself can promote the use of the bicycle. This can also be seen in both Delft and Groningen who have invested heavily in the creation of high quality bicycle infrastructure. The investment of these two cities goes beyond creating a cycling network, but also investing in bicycle bridges and tunnels to give cyclists priority.

Moreover, all three cities - Rotterdam, Groningen, and Delft – have bicycle policies which realize the importance of high quality bicycle infrastructure and stress it as an objective therein. To achieve this objective, the cities intend to fulfill the CROW requirements wherever possible. Each city has also taken on significant measures with respect to traffic light modifications. The measures undertaken by the cities, such as the simultaneous green in Groningen, remote detection in Delft, and limiting the wait time and/or extending the green time for cyclists in Rotterdam enhance the directness, safety, comfort and attractiveness that cyclists experience. These types of measures can stimulate bicycle use.

Even with high quality infrastructure, it is evident that more is needed. In other words, people will still opt for the car over the bicycle unless traveling by bike is advantageous over driving the car. Much can be done to achieve this goal. One opportunity is to direct car traffic in such a way that traveling by bike is faster than by car. An additional opportunity is to make it expensive to drive the car. Furthermore, parking policies as well as driving restrictions in downtown areas can impact the choice to travel by car.

Rotterdam, Groningen, and Delft demonstrate the importance of implementing disincentives for motorized traffic. First, Rotterdam, a car-friendly city, has relatively low bicycle use and is now taking on numerous projects, the end result of which will be deterring automobiles. Additionally, Groningen pursued a very ambitious traffic plan which limited through traffic in its inner city, requiring cars to leave the inner city and travel via a ring road to get to another section of the city. Finally, Delft also has pursued a restrictive car policy as it keeps expanding its car free city center. What is also important is that these initiatives have been undertaken despite opposition from business owners and residents.

Notably, none of these restrictive policies appear in the cities' bicycle policy, but rather are supported through other spatial and transportation plans. This point, as well as other research that has been done in this area, suggests that integral and reciprocal policies are also a factor of success for the high levels of bicycle use in the Netherlands. In fact, all three cities have mutually-reinforcing policies. For example, in Rotterdam the bicycle policy is supported by both a municipal and regional traffic and transportation plan as well as the cities new spatial development strategy. Likewise, Groningen's cycling policy is embedded in the cities transport and traffic policy and its spatial policy maintains the locations of activity in bikable distance for residents. The Delft bicycle policy also receives reciprocity from its overall transportation plan which aims at an accessible and livable city.

Traffic safety is also an important element for each of the cities studied. All three cities strongly support traffic education in primary schools with regard to the bicycle. In addition, the cities review bicycle routes to schools to ensure that the maximum safety is provided. Extra attention is paid to young people because it is believed that if people experience cycling from a young age, then they will be more apt to cycle in the future. Both Rotterdam and Delft look at the objective side of safety: traffic statistics, as well as the subjective side of whether people feel safe or not on the bicycle. The overall belief is cyclical in that if people feel safe, then more people will cycle, and the people cycling as opposed to driving, contributes to a safer environment.

Particularly interesting is that marketing has relatively no place in the overall promotion of bicycle use in the Netherlands. In fact, Groningen, does not engage in any marketing whatsoever. Rotterdam and Delft do some marketing, mainly targeted at young people. Likewise, there are few overt incentives to ride the bicycle beyond the high quality infrastructure provided and the fact that is may be faster to travel by bicycle than by car, as in Groningen. However, on a national level, there are tax incentives to purchase and use a bicycle.

In sum, with regard to bicycles, the cities studies revealed that the promotion of bicycle use requires political support and continuous attention. This not only means specific bicycle policy, but that the bicycle is applicable and supported by all policies. The bicycle should also be regarded as a main transport mode, being taken into account along with motorized transport and public transport.

Pedestrian Mobility

Regarding pedestrian mobility, the research revealed that there are no specific pedestrian policies, with the exception of the new initiatives in Rotterdam. This reveals two relevant considerations. First, while there are no specific pedestrian policies, facilities for pedestrians are always considered and provided as a matter of right. Thus, there are significant pedestrian facilities ranging from sidewalks, to pedestrianized streets, to car-free city centers. On the other hand, bicycles, cars, and/or public transport rank highest on the agenda, and pedestrians typically come last.

Nevertheless, in Groningen and Delft, this did not reveal any problems as the facilities provided (sidewalks and car-free zones) contribute to a pedestrian-friendly environment. However, the Rotterdam case reveals many important initiatives a city can take on to give more space to pedestrians. For instance, prohibiting on street parking and giving that space to pedestrians is a relatively simple but significant measure. The efforts to create Park and Walk facilities as well as a complete network of public spaces will also contribute significantly to the pedestrian environment and urban quality of Rotterdam. The Rotterdam case demonstrates the type of initiatives a city can take on to transform from car-friendly to people friendly. Similarly, Groningen also provides an important example of a city once built for the automobile transformed to serve pedestrians and cyclists.

These lessons are invaluable for improving bicycle and pedestrian infrastructure in the United States. While the above measures are prerequisites, more will likely be needed. For instance, with regard to marketing, due to the fact that there is not an existing cycling culture, more marketing will likely be needed to promote bicycle use. However, this research as well as other studies done in the field reveal that policy is the biggest impetus for bicycle use as opposed to topography, culture, and weather. Cities in the United States have demonstrated that there is a demand for the bicycle as those who have invested therein have higher levels of bicycle use. Likewise, the cities that have pedestrianized their urban spaces are the areas where people are attracted to visit, shop, live and work. The measures applied to the Sustainable Community Development Code demonstrate that there is much that can be done in this field.

7.2 Recommendations

The Netherlands presents an interesting case for pedestrian systems. In the Netherlands, there are no specific policies to promote walking per se. However, the ability to leave your home and walk to a destination is regarded as a basic right. The promotion of walkable spaces is key to promoting a healthy living environment and also supports the mobility of persons who cannot use other modes of transport. The ability to walk should be regarded as a basic right in the United States. The provisions for sidewalks and pedestrian facilities are relatively inexpensive, use little space, and are low maintenance. The inclusion of these facilities should be obligatory.

The Design Manual for Bicycle Traffic developed by CROW provides numerous guidelines, that if applied, can assist in making the bicycle a full fledge participant in an overall traffic and transport system. In the context of the Netherlands, these guidelines demonstrate that if good functional policy guidelines are available, then they will be used and it is not even necessary to make them compulsory. The lesson for the United States is that a uniform, functional, and knowledgeable set of policy guidelines like the one provided in the CROW manual can be the starting point for changing legislation in this field. A small project which incorporates the necessary measures for bicycle traffic can be initiated. If it is successful it can be applied be applied in other communities and in this way standards can be developed that promote the bicycle as a main mode of transport. The other benefit to creating a set of regulatory standards is that uniformity in these systems creates a seamless system for users, meaning that if the system is easily recognizable, then it is more comfortable to use, and thus will gain more participants and in addition increase safety as users will know how to behave.

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INDIVIDUALS INTERVIEWED

N. Abrahamse, Consultant, MuConsult

M. Bakker, Advisor, Senternovem

F. Borgman, President, Fietsersbond

D. Drenth, Professor of Urban and Regional Planning (retired), Nijmegen School of Management

M. Guit, Urban Planner, City of Rotterdam

E. Heinen, Department of Urban and Regional Development, OTB Research Institute, Delft University of Technology

S. Jenke, Urban Planner, City of Rotterdam

J. Maijers, Bicycle Coordinator, City of Rotterdam

H. Nijland, Senior Researcher, Netherlands Environmental Assessment Agency

D. Polman, Policy-Maker, City of Delft

I. Spape, Consultant, SOAB

H. Talens, Project Manager, CROW

N. Tillie, Landscape Architect, City of Rotterdam

J. Valkema, Traffic Engineer, City of Groningen

M. van der Woude, Urban Traffic Planner, City of Rotterdam

Annex 1: Interview Topics

Agency Organization

A. Official position

B. Departments

C. Type of work

D. Hierarchy

Urban Policies:

A. Spatial Policies: (distances and spatial distribution)

- Spatial policy re municipality/region/province/national (extent of authority)
- Zoning regulations; building codes; density of development; location of stores, jobs and schools in walking or biking distance
- Binding
- On paper/on practice

B. Urban Design Measures:

- Street layout; connectivity of streets, sidewalks, and bicycle paths; green space; other aesthetics of built environment

C. Transportation Systems:

- Bicycle Policy
    - Time Period
    - Follow-up/New
    - Objective
    - Target
    - Legal or regulatory requirements
    - Integration
    - Policy-making process
    - Agency involvement (relevant nat'l/regional/local authorities for transportation, education, health, environment, energy, NGO's, cyclists, the public etc.)

  - Authorization/Approval Process
  - Support or Resistance
  - Implementation
  - Challenges
  - Revisit/Update
  - Evaluation and Monitoring
- Recent projects
- Future projects

Infrastructure: (Bicycle)

- Frequency and location of bicycle routes/lanes/paths
- Network design
  - Factors for consideration
- Distance determination
  - Departure and destination points
- Travel time
  - Stops
  - Hindrances
  - Waiting times
  - Detours
- Intersection modifications
- Design criteria: width; color; materials
- Route Guidance/Traffic signs
- Bicycle Traffic Signals
- Urban design amenities (street lighting, landscaping, building access)
- CROW guidelines
- Support of cycling network
  - Policy
  - Traffic Codes
  - Laws
- Responsibility
  - Government
  - Private Developer

- Frequency and location of bicycle parking
    - Types of parking facilities
    - Free or pay
- Maintenance

<u>Dutch Organizations</u>

- Fietsersbond
- CROW
- Consultancy Firms
- Higher level of gov't – regional, provincial, national

<u>Investment</u>

- Budget for cycling measures
- Financial support from other levels of gov't (regional, provincial, national)
- Sources of funding

<u>Safety:</u>

- Measures re the promotion of safety of bicycles
- Traffic calming measures
- Separated bicycle infrastructure
- Intersection modification
- Education

<u>Pedestrians</u>:

- POD development
- Agency/department involvement
- Specific Policy
- Legal requirement/plan oriented

Incentives/Disincentives:

- Promotion or marketing schemes re bike use
- Incentives provided to individuals or businesses
- Disincentives for motorized traffic
    - Discourage (actively)
    - Parking
    - Speed

Opportunities and Challenges:

- Factors of success
- Barriers/challenges
    - Past
    - Present
    - Future
- Transferable instruments
- Requirements (for development of cycling network/culture)
    - Recommendations

Annex 2: Summary of Main Requirement for a Cycle Network

MAIN REQUIREMENT	IMPORTANT ASPECTS	EXPLANATION
Cohesion	• Network Completeness (inside built-up area) • Route Completeness (outside built-up area) • Match with need to travel	The mesh width of the network is no more than approximately 250 meters Centers and important amenities are interconnected At least about 70% of all bicycle journeys are made via the cycle network
Directness	• Directness in terms of distance • Directness in terms of time	Minimization of the number of intersections where cyclists have no right-of-way Minimize the stopping frequency
Safety	• Avoid conflicts with crossing traffic • Separated vehicle types • Reduce speed at conflict points • Recognizable road categories • Uniform traffic situations	Summed up for all intersections, the number of crossing movements made by cyclists times the intensity of the passing flow of motorized traffic, weighed according to speed is minimized Summed up for all road sections, the density of motorized traffic times the density of bicycle traffic times the speed difference squared times the length of the road section is minimized In the case of major speed differences, cyclists are separated from motorized vehicles Where the cycle network crosses networks carrying other vehicle types, speed differenced between both are reduced Every amenity should be recognizable as such to all road users Cycle amenities and intersection solutions are related to functions of tracks and roads for bicycle and motorized traffic. Solutions that are characteristic of a certain type of road should not be used on other types of roads.
Comfort	• Prevent Traffic Nuisance • Ease of Finding Destination • Comprehensibility	Encounters between bicycle s and cars are minimized Towns, cities, villages, districts and amenities that attract the public are signposted The network makes the best possible use of spatial and landscape features so users can form a mental map.
Attractiveness	• Social Safety	Networks, and particularly the main routes with them, meet the requirements of social safety. At network level, this means that busy routes are plotted in areas where there is sufficient social control in the community.

Annex 3: Option Diagram for Road Section inside the Built-Up Area

<table>
<tr><th colspan="5"></th><th colspan="3">CYCLE NETWORK CATEGORY</th></tr>
<tr><th>Road Category</th><th colspan="2">Max. Speed of Motorized Traffic</th><th>Motorized Traffic Intensity</th><th>Base network</th><th>Cycle Network</th><th>Main Cycle Route</th></tr>
<tr><td></td><td colspan="2">N/A</td><td>0</td><td colspan="3">Solitary Track</td></tr>
<tr><td rowspan="3">Estate Access Road</td><td colspan="2" rowspan="3">Walking Pace or 30 km/h</td><td>1 – 2.500</td><td colspan="2" rowspan="2">Combined Traffic</td><td rowspan="3">Cycle Street or Cycle Lane (with right of way)</td></tr>
<tr><td>2.000 – 5.000</td></tr>
<tr><td>> 4.000</td><td colspan="2">Cycle Lane or Cycle Track</td></tr>
<tr><td rowspan="3">District Access Road</td><td rowspan="2">50 km/h</td><td>2x1 Lanes</td><td rowspan="3">Irrelevant</td><td>Cycle Lane or Cycle Track</td><td colspan="2">Cycle Track or Parallel Road</td></tr>
<tr><td>2x2 Lanes</td><td colspan="3">Cycle Track or Parallel Road</td></tr>
<tr><td colspan="2">70 km/h</td><td colspan="3">Cycle Track, Moped/Cycle Track, or Parallel Road</td></tr>
</table>

Annex 4: Traffic Light Provisions

Description	Implementation
Reduce the waiting time for cyclists using short cycle time	Maximum cycle wait time is 90 seconds)
Reduce waiting time for cyclists by concurrent extension of public transport priority	When public transport is registered (non-conflicting) parallel cycle directions are also registered, so that they are given a green light simultaneously
Reduce waiting time for cyclists by increasing motorized traffic flow capacity	Despite extra lanes, keeping intersection as compact as possible
Reduce waiting time for cyclists by concurrent extension of green phase for cycle directions along with other directions	By concurrent extension of the green phase with non-conflicting motor vehicle directions, cyclists are offered more green light time
Reduce waiting time for cyclists by favorable phase sequence for cyclists turning left	By considering all traffic flow that are turning left as a single combined direction within the control (instead of as one direction straight ahead and one direction left-turn) cyclists turning left can continue without stopping
Reduce waiting time for cyclist using cycle crossings in two directions	If a cycle crossing is permitted in two directions this can limit the waiting time for cyclists turning left
Reduce waiting time for cyclists using green wave for bicycle traffic	By taking into account the average cycle speed and linking the traffic provisions, the through cycle flow (straight-ahead, right turn or left turn) can ride on without stopping
Reduce waiting time for cyclist using long-range detection/pre-request	By suing detection a good distance (40 – 50 meters) before the stop line, traffic control can react to approaching cyclists more effective
Reduce waiting time for cyclists by using green light for all directions	By giving all cycling directions a simultaneous green lights each cycle gets two green lights (especially favorable for cyclists turning left)
Reduce waiting time for cyclist by favorable hold for cyclists	Type 1: Hold green light on cycle track: control is motor-vehicle dependent if there is no flow of other traffic, the main directions for bicycle traffic are given the green light; unless other traffic is reported the bicycle light remains green; effective detection of motorized traffic is required so that vehicle scan continue without stopping if there are no cyclists. Type 2: Hold green light on carriageway for motorized traffic; control is bicycle-dependent (long-rage detection of bicycle is required) if there is no flow of bicycle traffic the motor vehicle direction is given the green light; effective detection of bicycle traffic is required so that cyclists can continue without stopping if there are no motor vehicles. Type 3: Hold red-light: direct influence; control is motor-vehicle and cycle-dependent.
Countdown signal	The countdown signal gives cyclists an indication of the remaining waiting time)
Blind spot mirror below traffic light	Installing a (curved) mirror below the green light improves the view from a cab of cyclists standing next to and in front of a vehicle)