A Cycling Network for the Cities of Boston and Cambridge

by

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ABSTRACT:

In recent years, many cities have been looking for alternative urban transportation tools due to the high cost of energy and the global climate change. As one of the clean transportation types, cycling has become gradually noticed by many American cities. The cities of Boston and Cambridge have been promoting cycling for years and have started to lay more emphasis on it recently. This paper will propose a possible cycling network for the two cities to illustrate in general how to design a cycling network within an already built city.

Firstly, the thesis briefly goes over the history of cycling, addressing the unpopular role of utilitarian cycling in American cities. Secondly, the thesis will review previous cycling planning theories and discuss different models of bicycle planning. In this part, it will also take the city of Davis, California as a case study, discussing the planning strategy of how to implement cycling in American cities. Thirdly, the thesis proposes a cycling network at three different scales: the urban scale, the community scale and the street scale. Conclusions of the design proposals and future suggestions are included in the last chapter.

Thesis Supervisor: William J. Mitchell

Title: Professor of Architecture and Media Arts and Sciences

ACKNOWLEDGEMENTS:

I guess most of urban design proposals and researches will more or less change during their developing process and this thesis is the same. It is challenging as well as frustrating when these changes happen, and I was so fortunate that I always had friends who helped me at these time. This thesis could not be finished without the help of the following people:

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And my parents.

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Chapter 1. Introduction

1.1. The starting questions

In August 2007, when I came to study at MIT, the first thing I did after settling down on the campus was to buy a bicycle. For me cycling is an important transportation mode since in China, I cycled almost every day not only when I was in school, but also when I started working. However, I encountered several surprises after I bought my bicycle here: the first one was the high price of a bicycle (often as high as two or three hundred USD) in contrast to the low price of a car; the second one was that a large portion of cyclists in the street were cycling for exercise at a high speed with their professional cycling suites. One year later I found cycling was so inconvenience here and finally dropped my bicycle down at my apartment building and never used it. I was shocked by these observations and experiences and began to think what makes a cyclist stop using his bicycle. Obviously, many reasons can explain my experiences, such as the car-dominated social culture in the U.S., the product designs discouraging utilitarian cycling, and the transportation policies prioritizing vehicular traffic. At the same time, I also noticed that both cities of Boston and Cambridge have promoted cycling for many years. It seems that the most concentrated cycling population in Boston is the university students. However this population has never gone beyond the campuses. As an architect and an urban designer, I wonder what spatial elements have hampered people from cycling, and whether physical planning and designing could play an active role in encouraging cycling in American cities, while the cultural change of a society is always much slower than physical changes.

1.2. Why cycling?

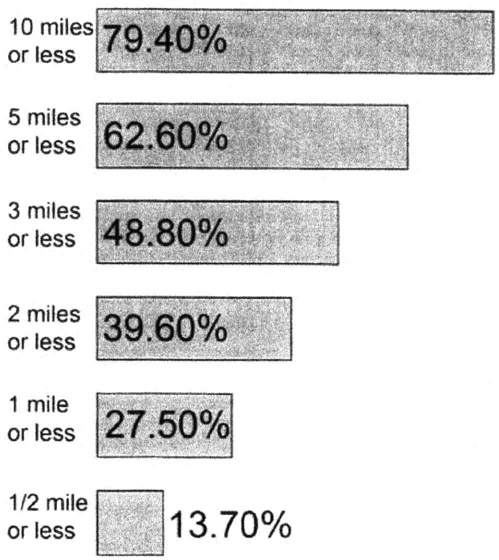

Figure 1 Daily trip distances in the U.S.

A large portion of our daily trips can be made by bicycles. As is shown in Figure 1, 39.60% of our daily trips are within 2 miles or less and 48.80% are within 3 miles. If we consider that the normal cycling speed is 10 miles per hour, these distances mean 12 minutes and 18 minutes cycling travels respectively. Traveling by bicycle, for these trips is not only feasible, but also pollution-free and only costing human power. Moreover, due to the larger traveling distance, cycling can also bring more people to public transit stations, which do not support door-to-door travel.

In the city of Boston, the daily trips made by bicycle are about 38,000, of which only 20% are trips to work[1], compared to Amsterdam where 60% of total trips are utilitarian[2]. Moreover, the existing cycling network is mostly for recreational purposes not only because they pass through the parks, but also they seldom connect people's homes with their working places. As a result,

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[1] Boston (Mass.), and Boston Metropolitan Planning Organization. 2002. Boston *transportation fact book and neighborhood profiles.* Boston: Boston Transportation Dept. Pp12.

[2] Wray, J. Harry. 2008. Pedal *power: the quiet rise of the bicycle in American public life*. Boulder, Colo: Paradigm Publishers. Pp45

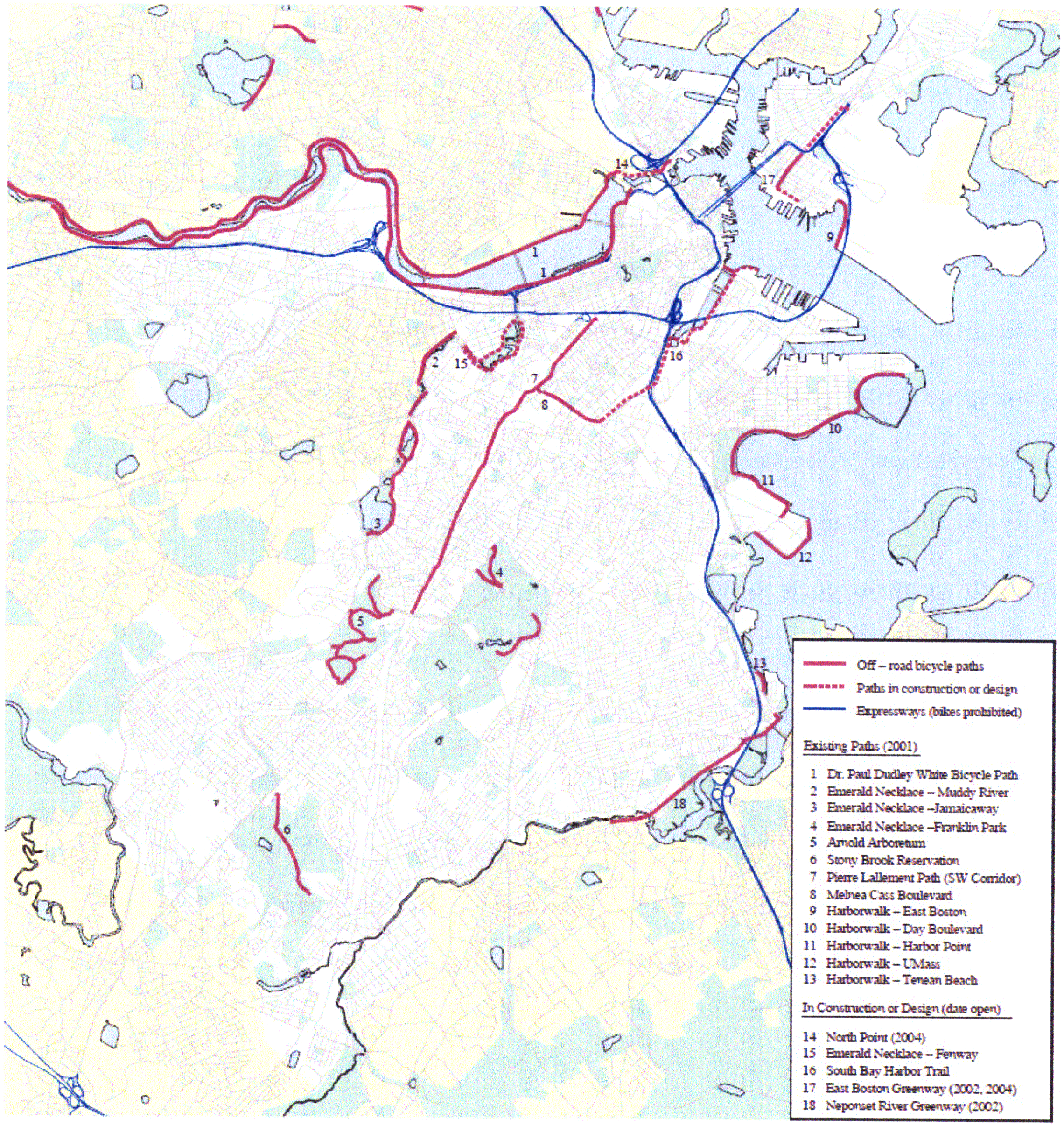


Figure 2 Bicycle paths in Boston.

people have to drive even though their working places are within a cycling-feasible distance. The more people drive, the less cycling-friendly streets become, which results in less people riding bicycles. In this way, the relationship between cars and bicycles becomes a vicious circle.

Apart from its energy-efficient and environmental reasons, cycling has another cultural merit. Modern cities have been long criticized for the isolation between people and the lack of street life. People driving in the street are encapsulated in cars. They are protected from the weather changes, but are isolated from nature as well as other people. Cars driving at high speed in the street have also segregated public spaces and have made it dangerous for pedestrians to cross streets. In contrast, through cycling, people are more exposed to nature the daily street life.

1.3. A brief history of utilitarian cycling in the U.S.

There are two kinds of cycling in general: recreational cycling and utilitarian cycling. Recreational cycling means people cycle for recreational purposes, such as racing or exercising. Utilitarian cycling means people cycle for daily trips, such as to work or to school. This subject of this thesis will focus on utilitarian cycling. Although cycling has a long history in the U.S, utilitarian cycling has never become a major transportation mode in American cities.

John Forester states that “in the United States, the motoring transition occurred so early and so rapidly that the United States never had a time when cycling and motoring coexisted.[1]” In the article *Missing Link: The Case for Bicycle Transportation in the United States in the Early 20th Century,* Paul Rubenson argues that in the early 20th century, practical cycling (utilitarian cycling) “could have provided the same benefits to Americans that they did to cyclists around the world[2]”. He sees the major barrier that prevented people from cycling in early 20th century was the technical characteristics of early American bicycles. In other words, bicycles was designed and produced as recreational and exercising machines instead of transportation tools. He states that many perceived barriers, such as long distance, climate, poor roads, and transportation alternatives, are not the main causes of the low use of cycling.

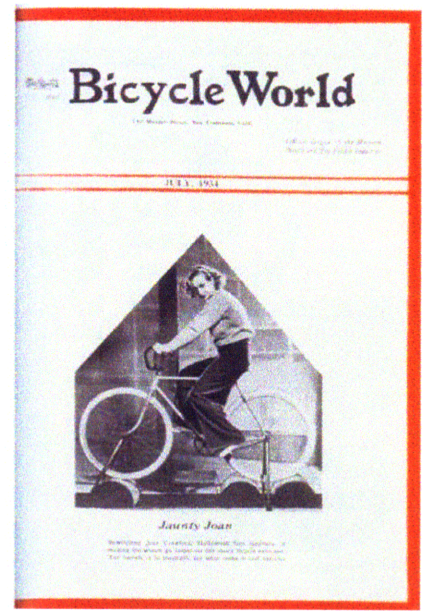


Figure 3 1930s bicycle magazine cover showing the design of a bicycle

During the first half of 20th century, cycling as an urban transportation tool had almost disappeared in American cities. The two world wars temporarily raised the cycling population in the U.S. On one hand, some troops began to use bicycles; on the other hand, due to the

[1] Forester, John, and John Forester. 1994. *Bicycle transportation: a handbook for cycling transportation engineers.* Cambridge, Mass: MIT Press. Pp16.

[2] International Cycle History Conference, and Andrew Ritchie. 2006. *Cycle history 16: proceedings of the 16th International Cycling History Conference, University of California, September 2005*. San Francisco, Calif: Van der Plas. Pp73.

Figure 4 Contemporary utilitarian bicycles in Europe with racks on their backs

shortage of gasoline in domestic market, people also started to use bicycles instead of cars. The 1950s is a key period in transportation development history in the U.S. It is the time when the automobiles industry boomed and cars became so affordable that "one could walk into an auto dealership and drive out with the car of one's own choice.[1]" The flourish of auto industry was followed by the emergence of cities that were designed exclusively for automobiles. People lived outside of the city and only came in to work. The distance between many home-working trips was so long that it was impossible to travel through bicycles. This shift also changed the way of how people travel: "The urban American of the 1940s had had at least four transportation choices: driving; walking; or rapid transit; and bicycling. But now the suburbanite had only two choices, and at first he recognized only one.[2]" Driving soon became a burden for the families living in the suburbs. A parent had to drive his/her kid to school before he/her drive him/herself to work. At the same time, due to the lack of communications after school, kids began to be fond of bicycles. A large portion of bicycles were produced as recreational tools during this period. However, as soon as the kid became legal to drive, their parents would purchase a car for him/her for school. Cycling to school for the adolescents became an almost

[1] Forester, John, and John Forester. 1994. *Bicycle transportation: a handbook for cycling transportation engineers.* Cambridge, Mass: MIT Press., pp 18

[2] Forester, John, and John Forester. 1994. *Bicycle transportation: a handbook for cycling transportation engineers.* Cambridge, Mass: MIT Press., pp 18

shameful thing at school. Perhaps the following quotation can illustrate the transition of this period:

"For the great majority in my generation, this is the extent of their bicycle stories: interesting toys that opened up new possibilities but that in adolescence were left rusting in garages and basements across the land. This was true for me until I was thirty, when for some reason I was attracted by the possibilities the bike offered for recreation and exercise. "

-- J. Harry Wray, *Pedal Power: the Quiet Rise of the Bicycle in American Public Life*

The bicycle sales boom at mid 1970s was caused partially by children bicycle sales, and partially by the prompting of oil prices due to the oil crisis. Bicycle sales even exceeded car sales during 1980s for the first time in the U.S. However, the role of cycling was still mostly recreational. This situation continued during the 1990s. In the book *The Bicycle and city traffic: principles and practice*, Andrew Clarke, the author of the chapter *The United States of America*, contributes the following reasons to the unpopularity of cycling during 1990s: (1) Predominance of the car. (2) Flight to the suburbs. (3) Highway design. (4) Mistakes of the 1970s. (5) Defensive cyclists. (6) Limited statistical information.

At the beginning of the 20th century, as the awareness of energy consumption and environmental protection arose, cycling was promoted as a clean and sustainable transportation tool at many places in the country. Cycling advocates, cycling clubs and organizations started to fight against the car culture. However, there is a distinction between cycling for the sake of protecting the environment and cycling for the sake of convenience. The latter, of course, can attract more people but will not become true unless the physical environment and policies prioritize cycling.

1.4. The goal of the thesis

Transportation networks substantially influence urban forms. The medieval European cities are designed for pedestrians and carts drawn by horses; the popularization of automobiles in 1950s in the U.S. which created the sprawl of low density suburbs. In these two cases, urban forms are passively designed to accommodate transportation types. Can urban design inversely affect the transit mode that people take? The design proposal in this thesis is going to borrow ideas from previous theories and case studies, and applies them into the cities of Boston and Cambridge. The goal of the thesis is to propose a comfortable and safe utilitarian cycling network in Boston and Cambridge.

Chapter 2. Theories and Case Studies

2.1. Creating Bicycle Transportation Networks: A Guidebook

Creating Bicycle Transportation Networks: A Guidebook is a research project developed at The Landscape Studies Center of The Department of Landscape Architecture at the University of Minnesota in 1996. It focuses on the spatial designing and planning of a cycling network at different urban scales. It introduces a planning model for cycling planning in cities, suburbs and small towns. The primary tool it uses is called "bicycle friendly zones," which are "areas of the city that are blanketed with a complete set of bicycle facilities." A bicycle friendly zone consists of different components at different scales, including bicycle expressways, bicycle boulevards, bicycle byways, and bicycle access facilities.

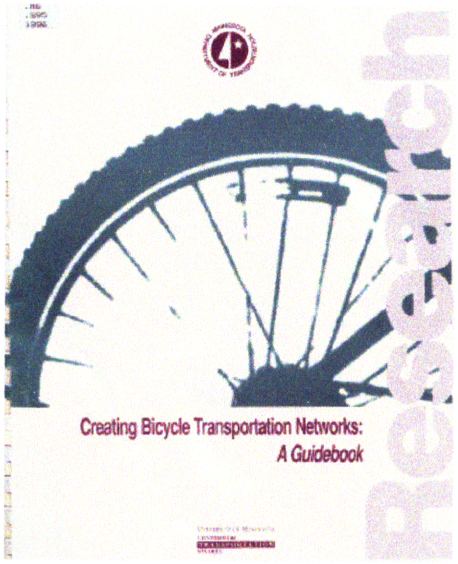


Figure 5 The cover of *Creating Bicycle Transportation Networks: A Guidebook*

The book defines the characteristics and responsibilities of each facility type, develops ideal designs for them, and creates guidelines. Following this, the authors also suggest that a bicycle friendly zone should have the following features:

(1) Selected bicycle friendly zones should be high profile areas in the community. This is aiming to create sufficient travel demand from/to these zones by strategically selecting their location. The authors suggest that it is better to implement a single successful zone than to spread out over the city. Moreover, it should also be a "focal points" of the community, which receives attention to the media.

(2) A bicycle friendly zone should have a mixed land use pattern. Residential, retail, commercial and employment in these areas should be located close to each other (two miles as suggested in the book), in order to ensure that cycling is feasible. The authors suggest as alternatives areas consisting of high residential/employment use, or residential/retail use, or transit/employment use could also be seen as acceptable choices.

(3) Bicycle friendly zones should be integrated with the city. In order to bring people into these zones, bicycle or intermodal "feeder routes" must be provided. These routes consist of the basic cycling facilities and public transit. By building high quality feeder routes, these zones can easily get cyclists familiar with the cycling environment; by providing secure and safe bicycle parking at major transit stations, they can also enlarge the cycling population.

Realizing that a comprehensive cycling network cannot be established all at once, the authors also present strategic phasing recommendations. The initial phases of implementation include bicycle infrastructure, transit infrastructure, reduced automobile infrastructure, and signage. After initial phases are established, refining phases could be implemented through improvement of bicycle infrastructures, bicycle facilities, access to all destinations, and networks of feeder routes.

There are several advantages of this book. Firstly, the main contribution of this book is that it provides a feasible framework for a cycling network at an urban scale. More importantly, it uses spatial planning and designing as a major tool to control and intervene during the cycling planning process. It shows a set of tools that urban planners/designers can use. The concept, selection and implementation of bicycle friendly zones will play an important role in later designs. Secondly, although it includes road section and intersection designs, it goes beyond engineering details, and discusses more general issues and strategic actions. Many of them have been neglected by urban designers and planners at the initial phase of community planning. Some problems, such as single use planning, are very difficult to remedy once the plan is launched. By considering these issues upfront, designers and planners can greatly reduce the difficulties of traffic engineers. Lastly, most of the diagrams the authors use in the book are drawn based on a typical American city fabric. This makes the model introduced easier to implement in another American city. Table 1 categorized in three different scales the main physical and non-physical interventions introduced in this book.

However, the book only suggests general principles for cycling networks. Not enough details are presented. As cities vary in different ways, even though they are all in the U.S., each city has to be considered specifically. Moreover, a cycling transportation environment must be examined in great detail in order to make sure the traffic routes are coherent. Another disadvantage of this book is that it puts most emphasis on discussing singular bicycle friendly zones and how to bring people into these zones. Little attention is paid on connections between these zones, which are equally important. By connecting them, the city can not only move people among these zones (due to being high profile places), but also cover the city with a coherent, constituent cycling network.

Table 1: Creating Bicycle Transportation Networks: A Guidebook

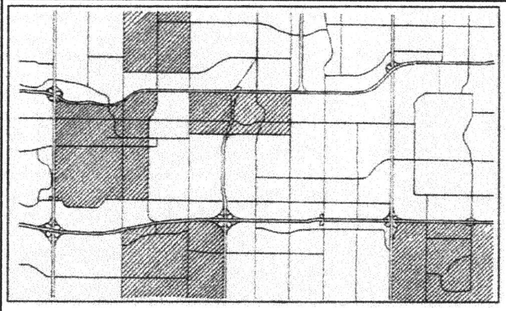
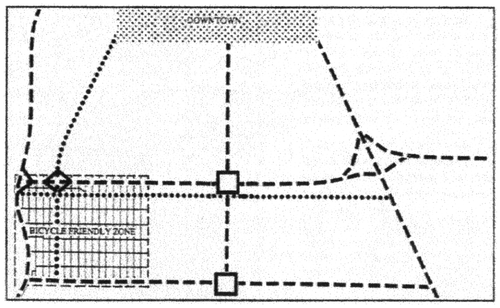
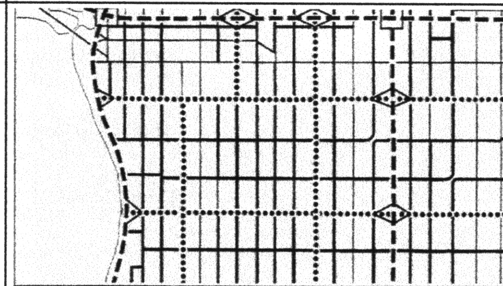
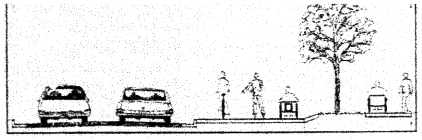
	Network Scale	Community Scale
Physical Interventions	  Bicycle friendly zones are selected and connected through bicycle expressways or bicycle boulevards.	 At a community scale, bicycle expressways, boulevards, and byways are layed out at different hierachies to cover the whole area.
Policy Interventions	1. Involve cycling planning at early stages. 2. Promote land use planning. 3. Promote transit nodes which have mixed uses. 4. Phased implementation. 5. Gather feedbacks from implementations. 6. Route finding system.	

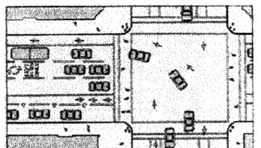
Table 1 (Continued) : Creating Bicycle Transportation Networks: A Guidebook

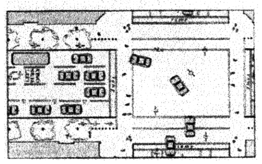
Street Scale

Seperations
Bicycle lanes are seperated from both car lanes and pedestrian walk ways.

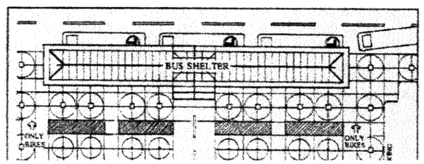


Intersections
At intersections, bicycles are priori-tized through wider bicycle lanes, which are seperated from car lanes. At the same time, car traffic are slowed down through building extra ramps at the crossing.

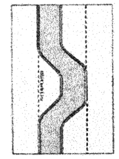


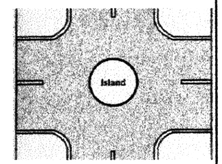


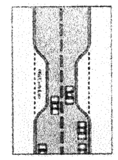
Bicycle parking lots
Specific parking lots are provided at mass transit stations, such as bus stops.

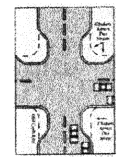


Traffic calming techniques
Meandering streets, chokers, and roundabouts are used to calm down car traffic, in order to provide safer cycling environment.

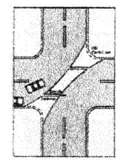








Cul-de-sacs
Cul-de-sacs are used to prevent cars running through, when bicycles and pedestrians can go through.



2.2. Bicycle Transportation: A Handbook for Cycling Transportation Engineers

In contrast with the previous book, *Bicycle Transportation: a Handbook for Cycling Transportation Engineers* starts with the psychological assumptions of cycling. Based on these assumptions, the author shows two general views towards cycling: the so-called "cycling-inferiority" view, which is dominant in current cycling engineering, and the vehicular cycling view, which he insists is a more scientific and safer model.

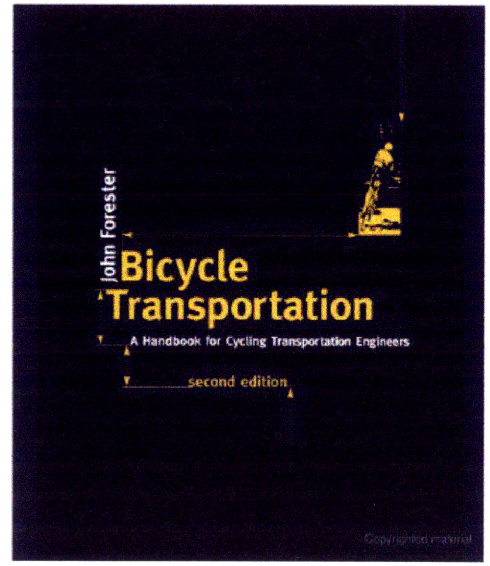


Figure 6 The cover of *Bicycle Transportation: A Handbook for Cycling Transportation Engineers*

"Cycling-inferiority" is a term to describe the conception that bicycles are more vulnerable when they are on the roads with cars. The author attributes many current cycling facility designs and phenomena to the cycling-inferiority mentality. Such phenomena include separate bike lanes, high bike/car or bike/pedestrian collision rates, previous government actions that tried to protect cyclists, and so on. Vehicular cycling, as the opposite opinion, states that cyclists should act the same way that car drivers do on the road. The author sees the two ideas as basically conflicting and thus their respective planning policies and guidelines are completely incompatible with each other. Cycling planning can only adopt one of them.

The first half of the book tries to clarify the distinctions between these two opinions. The author discusses their psychological reasons, uses traffic data, and observes vehicle operation at micro scale, aiming to prove that the vehicular cycling model is safer and more scientific. Based on this idea, the second half proposes a set of future planning guidelines for vehicular cycling. Two conclusions are made at the end of the book. The first one is, "cyclists are most successful when they act like drivers of vehicles and society so treats them." The second one is that cycling-inferiority is a psychological phobia that prevents people from being exposed to vehicular traffic.

The book lays particular emphasis on the controversies over bike lanes. The author argues that bicycle lanes, especially raised bike lanes, cause more accidents. Moreover, he states that bicycle lanes are restricting elements for cyclists and their aim is to get bicycles away from roads and keep drivers driving safely.

The first advantage of the vehicular-cycling theory is that it offers a new perspective to see current cycling transportation. In contrast with *Creating Bicycle Transportation Networks: A Guidebook*, this book starts from a cyclist's point of view, uses engineering data, and makes suggestions about existing planning program. It focuses on the safety of individual cyclists more than the top-down planning. Secondly, it looks at more aspects other than physical planning and designing. It examines policies, traffic laws, traffic engineering, and cycling equipment. These aspects are indispensible in cycling planning. Thirdly, the car-bicycle operation mechanism used in this book can be a way to examine whether an existing cycling design is safe for cyclists.

However, there are also many disadvantages of this book. Firstly, there are few existing successful examples of the vehicular-cycling system that happens in American cities. Even though the author can prove it in theory or through historic data, it is still dangerous to say this system will fit American cities. Secondly, many problems that the author attributes the cycling-inferiority view could be solved by improving the coherency of the cycling environment or enforcing regulations for car drivers and cyclists. These are not problems that generated by the cycling-inferiority view, but by the poor urban design and transportation engineering. Thirdly, although the author advocates the vehicular-cycling view all through the book, he seldom raises any practical planning methods towards it. It seems that the author wants to improve the cycling conditions through educating people the right way of cycling. The "effective cycling" program is such an educational program that the author promoted. However, it is criticized because only a small portion of cyclists are willing to spend time on extra cycling trainings.

Vehicular-cycling system needs a consensus between the cyclists and car drivers. If only one side of them accepts this theory, it is always not enough, and sometimes dangerous. For example, in the current driving culture of American cities, even if a cyclist tries to act like a driver on the road, it might be very dangerous for him because few car drivers have this expectation that a cyclist will ride, wait, and turn on the same lane with them.

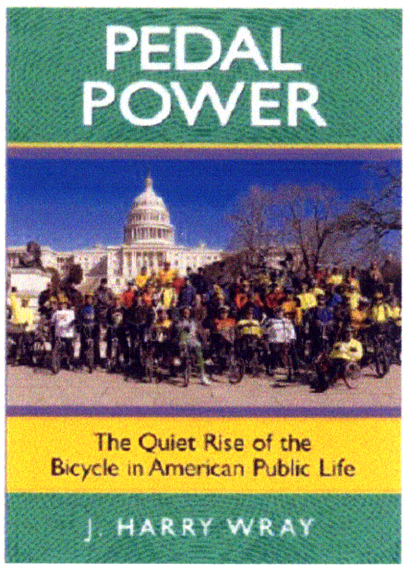


Figure 7 The cover of *Pedal Power: The Quiet Rise of the Bicycle in American Public Life*

2.3. Pedal Power: The Quiet Rise of the Bicycle in American Public Life

In the book *Power: The Quiet Rise of the Bicycle in American Public Life,* J. Harry Wray links cycling with politics. As a political scientist, he agrees with Harold Lasswell's definition about politics: "the authoritative allocation of values for society". Thus he regards the task of political scientists is to study and describe the "struggle" of people over these values. He concerns about the political culture that makes a certain society value on one thing more than another. Policies and actions are representing the value system of the society.

Based on these notions, he sees the cycling facilities, such as bicycle lanes and parking spaces, can represent a government's value system to cycling, and these value system are closely related to its social cultures. In the book the author compares the physical and political cycling environment between Amsterdam and American cities. In the case of Amsterdam the author experienced the popularity of cycling in this city. Apart from the flat terrain, and its weather, the author emphasizes the important role of the Protestant Calvinism and making decisions based on consensus (known as the "polder model") form the value system of Dutch cycling politics. In contrast to this, he suggests that individualism and materialism are the two main struts which have deep historical roots in American culture. They shaped the social value system towards different transportation modes, and resulted in prioritizing vehicular traffic instead of cycling. This auto-centric culture of America has also shaped the way how people see the world by isolating people from the surroundings, which reinforced individualism and materialism.

However, the author also suggests that cultures may change over time and cycling can be a potential tool for this. Cycling, being an easy way to move, are closely engaged with exterior activities. It is not only a transportation mode, but also changes the way how people perceive the world and may fundamentally change the society's value system.

The author put cycling in a larger political background in America. The book shows the cultural reasons why cycling is not popular in American cities and help to understand the social context of cycling. The author also points out that it is possible role of cycling in changing the social value system.

2.4. Case study: the city of Davis, California

Recognized as "America's Best Cycling City" (City of Davis Comprehensive Bicycle Plan), the city of Davis has long been promoting cycling since 1960s. It installed the first bike lane system, and implemented the first bicycle signal head system in America. Today, "approximately 17 percent of all journey-to-work trips are made by bicycle. For most cities, 2% - 3% is considered significant.[1]" The reasons why Davis has achieves this result are multiple.

"A number of factors appear to contribute in enabling the cycle to play this major transportation role. Among these are mild climate, level terrain and wide streets. Presence of the University of California campus assures a high percentage of the population will be comprised of young adults

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[1] City of Davis Public Works Department and City of Davis Bicycle Advisory Commission. 2006. *City of Davis Comprehensive Bicycle Plan*.

and the dispersed layout of the campus itself encourages use of the cycle. Also important is the fact that Davis heretofore has been a closed defined and relatively self-sustained community. All activity centers in the city are within easy cycling range of the most remote households and with relatively little external travel, the bicycle is a viable form for almost all trips. "

This paragraph cited from "Bicycle Circulation and Safety Study" in 1972 shows some of the natural reasons why Davis has become the "America's Best Cycling City". The dominant role of the university, mild climate and flat land in the city consist of the key factors that make sure Davis could facilitate cycling. However, as is stated the same article, "... the most significant element has been the attitude of Davis residents and city officials and the provisions they have made to ensure that cycles are not crowded off city streets by growing automobile traffic." By looking at Davis's 2006 Comprehensive Bicycle Plan, the following features can be observed:

Firstly, the University of California in Davis (UCD) has played a key role in the bicycle planning. UCD contributed in the following ways to the popularity of cycling in Davis: (a) large student population provides sufficient and young users of bicycles. The total population of UCD used to be 50% of total population of Davis over the last twenty years, and still consisted of a large portion after residents from San Francisco or Sacramento came in; (b) the adjacency between the university and the city makes the travel distance within a cycling radius. Thus both the students/staff in the university who go to the city or those living off campus who go to school will feel comfortable for cycling; (c) the university also put effort by banning "almost all motor vehicle use from its central core roadways that were formerly open to motor traffic from off-campus." By doing this, the campus not only provided a smooth environment for cycling inside the campus, but also greatly encouraged people to come to the university by cycling.

Secondly, the systematic planning of bike lanes and its combination with bike paths across the city makes the plan create a coherent network for cycling. For the core of urban area, every two or three blocks there's a planned bike lane; and for the outside neighborhoods where there are larger blocks, there are bike lanes on every street.

Thirdly, the combination of bike paths and bike lanes gives cycling much more accessibility than cars. In the neighborhoods around the central urban area, automobiles are only allowed on the periphery of the blocks and the dead-end streets, no trespassing is allowed for cars. On the contrary, bicycles are not only allowed on the major streets, but also allowed to go across these blocks by bike paths. These bike paths are the extension of the dead-end streets, but designated to cycling. The transportation network here forms a hierarchy, where cars take the larger grid, and bicycles penetrates a much denser grid. As for the university, bicycles are more heavily used. As its core area banned automobiles, either bike lanes or bike paths (especially the latter) are highly used. These paths or lanes are connected to the urban bicycle network.

Fourthly, the city implemented special designs to deal with high speed car traffic. One example is using roundabouts to slow down car traffic at local streets. The other example, which is more significant, is to build many bicycle bridges or under-crossings to make sure the cycling environment is not disturbed by inter-state highway or local high speed roads. There are in total twenty existing bike bridges or under-crossings, and another five in the future plan.

Although the Davis has many successful experiences in promoting cycling, it does not mean "Davis model" can be applied in every American city. The self-sustained feature and the size of the city have contributed much in the success of its cycling network. When we want to improve the cycling work in a larger area, strategies on a larger scale have to be considered. Table 2 categorized the main physical and non-physical interventions in the *City of Davis Comprehensive Bicycle Plan (2006).* By comparing it with Table 1, we can see that although they use similar design techniques at the community scale and street scale, Davis' cycling network is much simpler at the urban scale.

Table 2: City of Davis Comprehensive Bicycle Plan, 2006

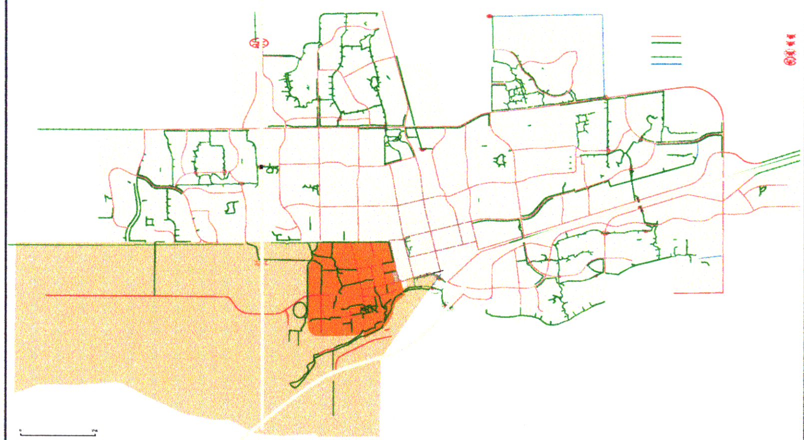
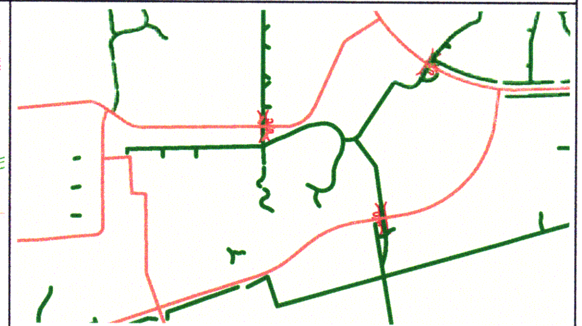
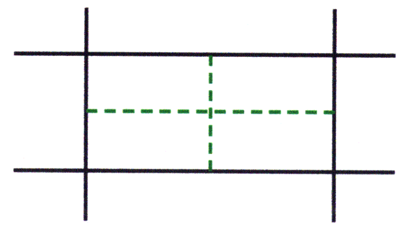
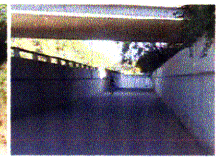
	Network Scale	Community Scale
Physical Interventions	 The overall network has two features: first, it has an (almost) evenly distributed bike way network throughout of the city; second, the contribution of UCD.	  For each block defined by car drive ways, cars are not allowed to drive through a block. However, bicycles can run through on bike paths/ways, forming another layer of transportation.
Policy Interventions		

Table 2 (Continued) : City of Davis Comprehensive Bicycle Plan, 2006 (Continued)

Street Scale

Undercrossing
They are used when a bicycle path meets high speed roads, such as the inter-state highway.

Chokers
Chokers are used to slow down car traffics in order to provide safety to bicycles.

Overcrossing
They are used when a bicycle path meets high speed roads, such as the inter-state highway. In the pictures on the right the bike path overcrosses a railway.


Lane seperators
For bikelanes next to high speed car traffic, seperators are used to ensure safety.


Parking lots
There are sufficient bicycle parking lots at not only each popular destination, but also the outskirts of the city.


Bike paths
Bike paths are exclusively designed for cycling. Sometimes shading are cast by trees besides them, providing more comfort for cyclists.


Bollard
Bollards are used mostly to diverge automobiles in inner city in order to create a safe route for cyclists.


Traffic lights for bicycles
Traffic lights for bicycles are used at intersections where there are high speed car traffic. These lights can turn green by either Push buttons or pressure sensors on the gournd.

Chapter 3.Proposals

Figure 8 Universities in Boston and Cambridge.

The proposal includes three steps at three different scales: the urban scale, the community scale, and the street scale. Each of them will address one or several specific problem, and designs at these different scales consist of the overall cycling network. At the urban scale, the proposal aims at the cities of Boston and Cambridge. At the community scale, the proposal concentrates on the network design between Harvard and MIT campuses. At the street scale, the proposal picks two specific sites and uses two different strategies to solve the problems. The following part of this chapter is going to describe designs at these three scales respectively.

3.1. The urban scale

The urban scale design is going to look at the city as a whole and proposes strategic locations for possible bicycle friendly zones. The book *Creating Bicycle Transportation Networks: A Guidebook* has the following criteria for choosing these zones:

"Communities should select high profile areas for their first bicycle friendly zones. The area should be patronized by large numbers of people on a daily basis. It should already be one of the major focal points in the community. Ideally, the area should already be a focus of community and media attention. It should be an area that is patronized by people who have the inclination and the opportunity to travel by bicycle, given an attractive, safe and accommodating

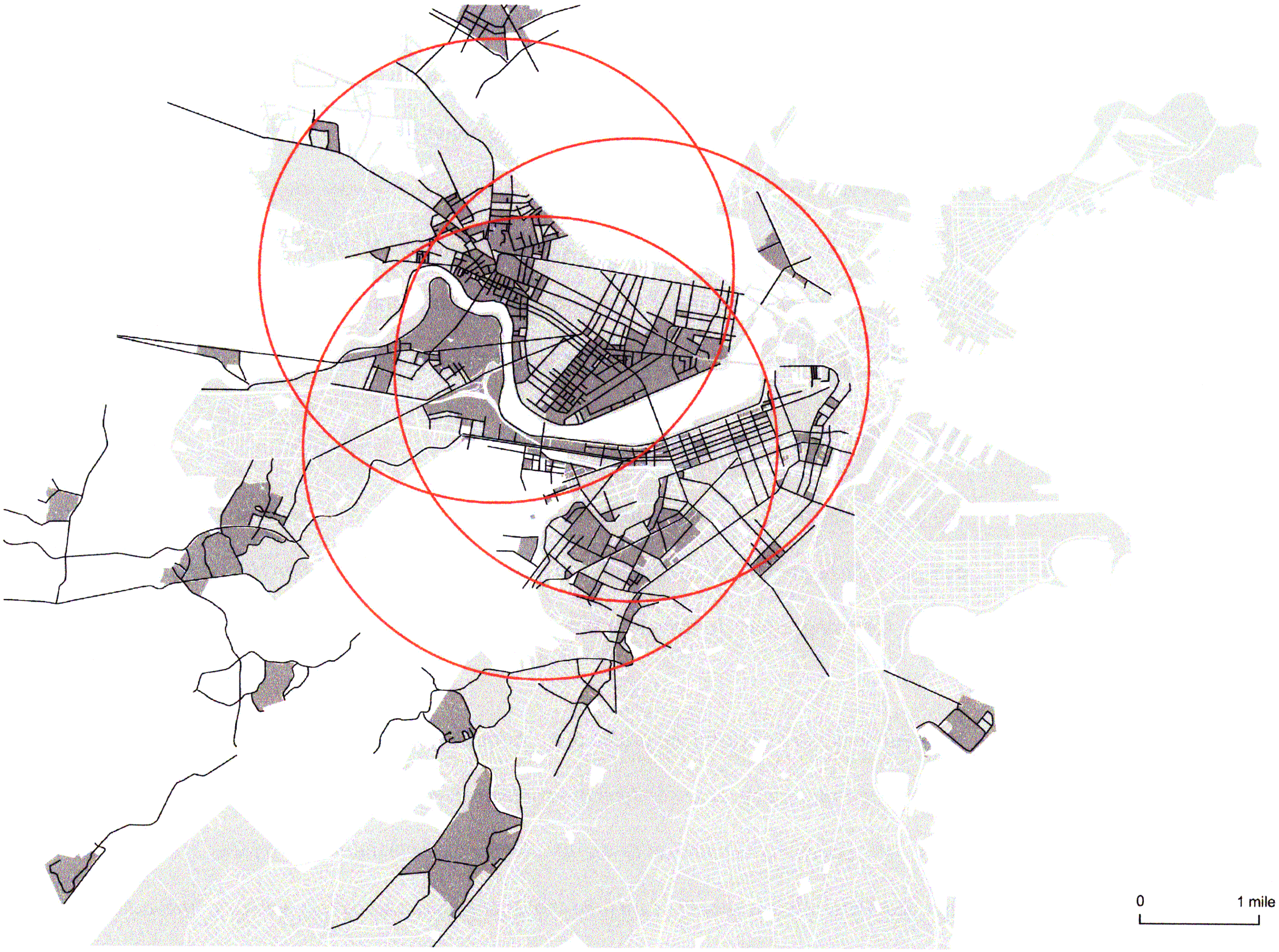


Figure 9 Streets that directly connected to the campuses and the 2-mile radius.

infrastructure. The area should be heavily patronized by large numbers of people who reside within 3.2 km (2mi) from the bicycle friendly zone. The area should also be patronized by others who typically travel 8 km (5 mi) to the zone. The area should also already be well served by existing transit facilities and should have good candidate roadways that can be used as bicycle and intermodal feeder routes."

Under these criteria, universities in Boston and Cambridge could be very good candidates for bicycle friendly zones because of the following reasons:

Firstly, most universities have a well established bicycle user groups. They include students, professors, and other facility staffs. Most of the students live close to the campus within 2 miles, which is considered to be the appropriate cycling distance. Even though professors live further, a large portion of them still lives in a distance that could be reached by cycling.

Secondly, universities have better bicycle facilities for cyclists. Figure 10 shows the entire current bicycle parking racks of MIT campus. The total number of the available bicycle racks is about 2,500. The height of the red bars in the map shows the number of bicycle racks.

Figure 10 Bicycle parking capacities and locations on MIT campus.

Clearly, campuses have much more advantages in bicycle facilities in terms of both density and quality.

Thirdly, the universities in Boston and Cambridge occupy a large portion of land in the urban area. By changing cycling conditions in these universities, a large part of the urban area will be improved for cycling. Moreover, universities are more dependent from the city, and its land uses are less complex compared to normal urban area. Thus, these reasons make universities easier to implement cycling friendly policies than other places.

Fourthly, universities are both extensive travel origins and destinations. Universities are not only study and teaching places for students and professors, but also popular spaces for visitors and local residents. They have more open spaces and public facilities, which make them attractive urban places. Specifically for Boston, as it is famous for its internationally known academic center, universities in this area are its focal points.

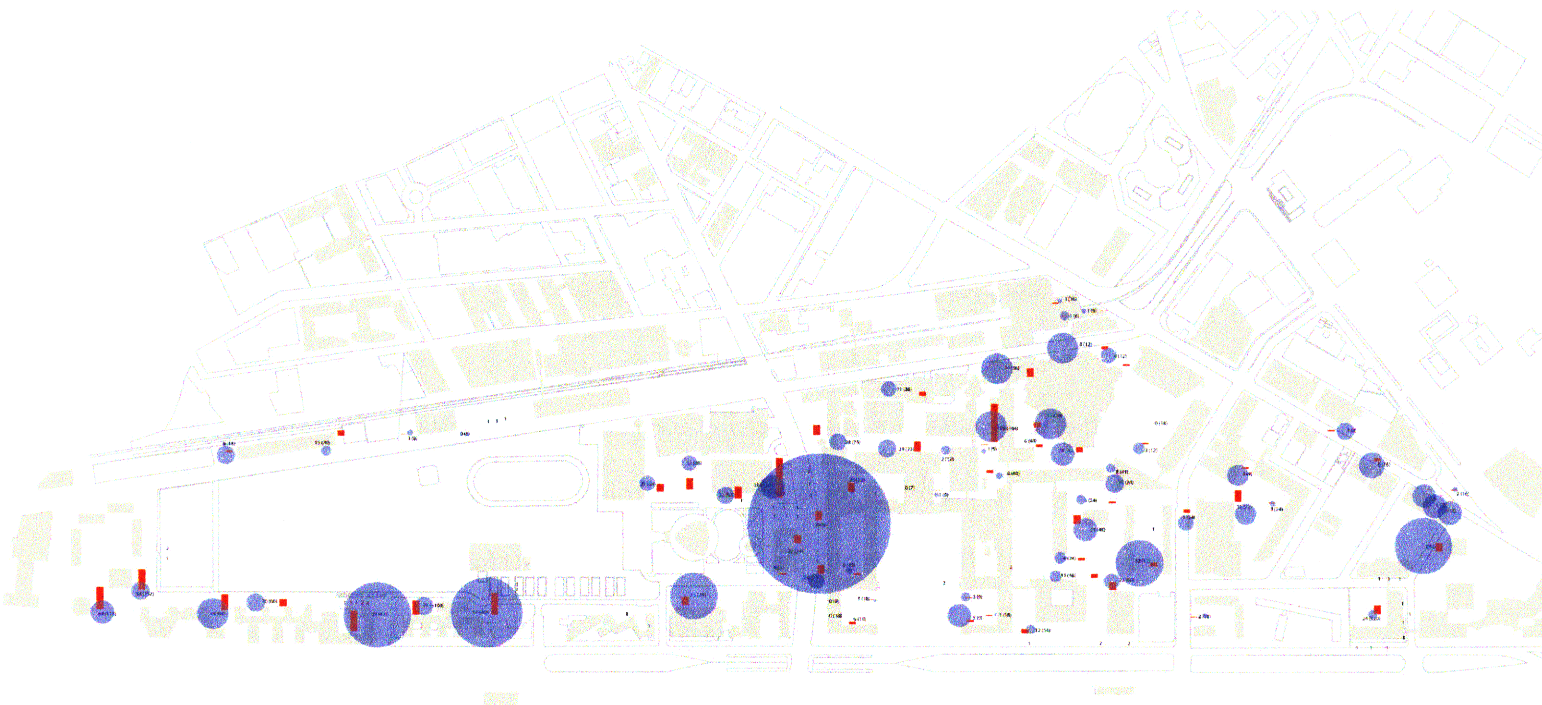


Figure 11 Bicycle parking desirability on MIT campus.

3.2. The community scale

This proposal uses the cycling network design between Harvard and MIT campuses to illustrate the design at the community scale. It consists of three parts. The first part is the investigation of current cycling condition of the existing street network. It includes both investigations within the campuses and their linking streets. The second part is a survey conducted among cyclists who live within this area. The third part is the proposal.

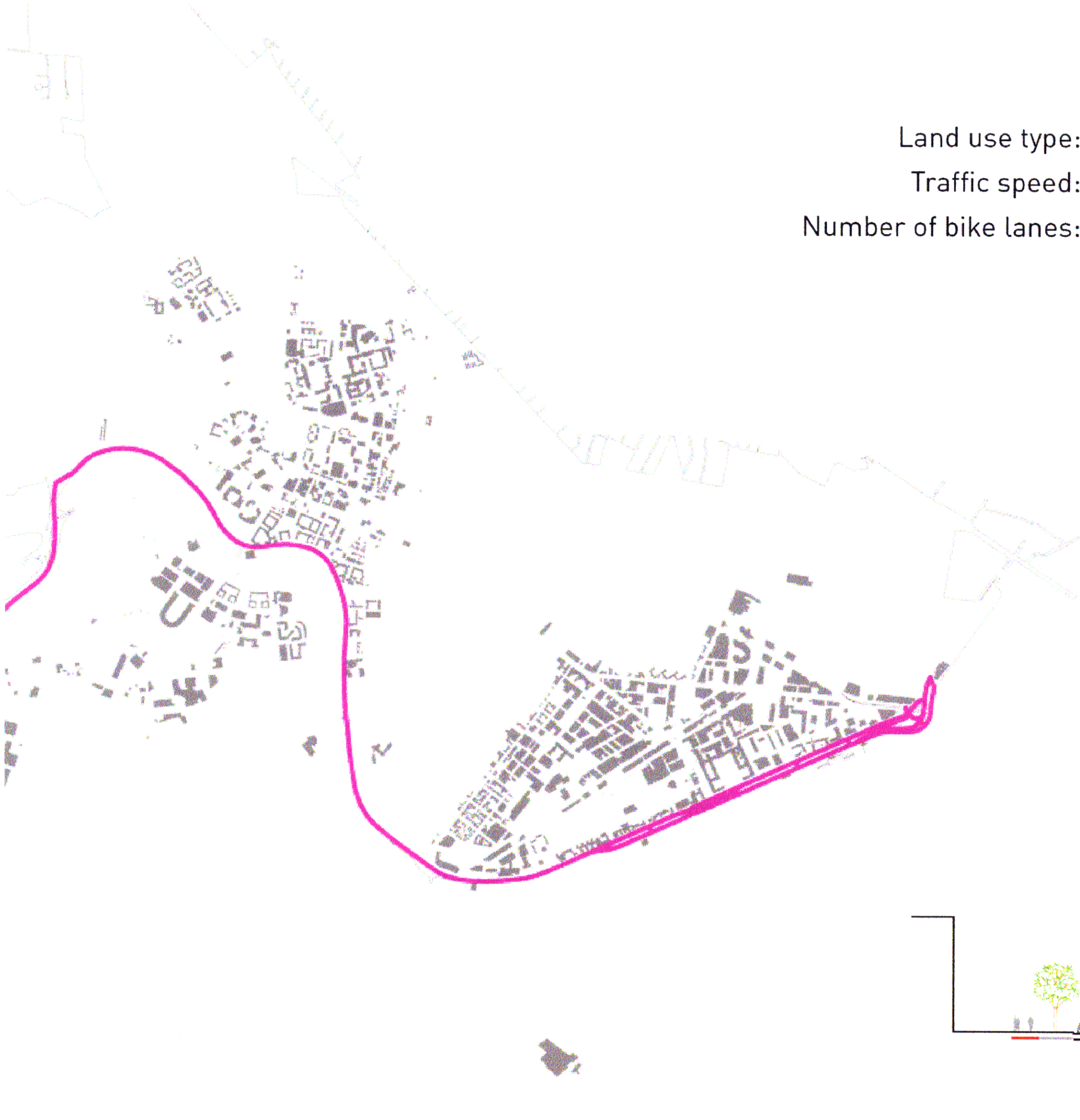
3.2.1. Campuses (MIT campus as an example)

Compared to normal residential districts, campuses in Boston and Cambridge have much better bicycle facilities. The following investigations will concentrate on the MIT campus. The number of bicycle parking spaces at MIT was as many as 2,518 at the end of 2008. They are widely spread across the campus. More than 60% of them were used during a Sunday afternoon. However, there are still many shortcomings of cycling facilities in the campus. Firstly, although there are large numbers of bicycle parking spaces, some of them are not well located. Many of the racks are seldom used, while others have much more demand. Figure 11 shows this uneven demand of bicycle parking in the campus. It implies that not only the number, but the location and the distribution of bicycle racks should be taking into account during the planning of cycling

Figure 12-15 Bicycle parking conditions on MIT campus.

facilities. Secondly, many of the parking spaces do not have good accessibility. Taking the parking spaces in front of the Student Center for example, although there are abundant bicycle parking spaces, they are located several steps above, which makes people either have to carry their bicycles up, or have to lock their bicycles to something else, such as trees. Thirdly, the cycling environment is not consistent. MIT is in the urban area, thus it has many cars go through its campus. Although It is impossible to completely ban urban vehicular traffic as UCD did in Davis, it is feasible to design a cycling coherent environment to ensure the safety of the cyclists. However, in Amherst Street, which is a main east-to-west street in the campus, it is common to see cyclists riding on the sidewalk and there are no bicycle lanes.

The general cycling conditions within the MIT campus can partially represent the conditions in other universities. Although some people argues that students will cycle no matter how the cycling environment is (due to economic reasons), the importance of these campus facilities is that they not only serve the students, but also all the people around the campuses. Improving campus facilities can definitely expand the cycling population.



Highways

Land use type:	Commercial and others
Traffic speed:	Fast
Number of bike lanes:	No

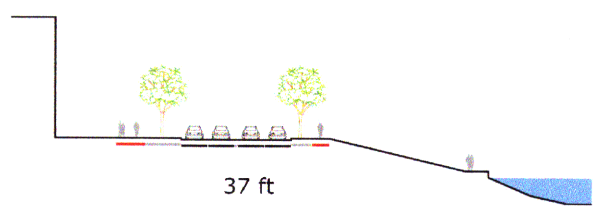


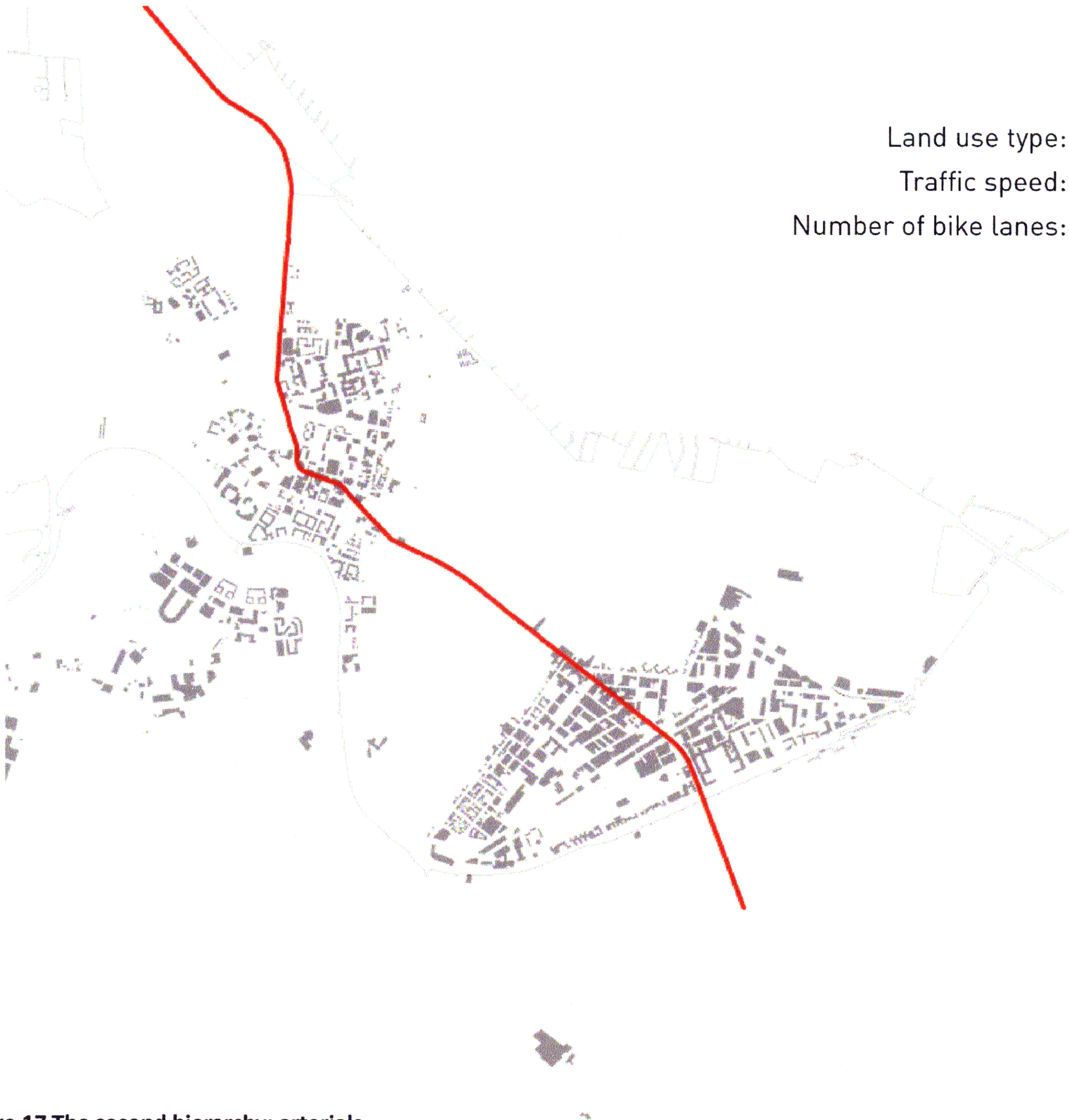
Figure 16 The first hierarchy: highways.

3.2.2. Linking Streets (between Harvard and MIT campuses)

General streets: There are generally five different typical streets/roads linking MIT and Harvard campus:

Memorial Drive is a road of the first hierarch. It goes along Charles River has the highest average automobile speed in the community. It is difficult for bicycles to go across, and dangerous for them to go along with cars on the road surface. Some intersection points, such as the intersection between Memorial Drive and the Boston University Bridge, have extremely complex traffic flows. Cyclists have to go across multiple vehicular traffic flows in order to get across the road. However, due to the riverfront views, many cyclists choose to cycle on the two sides of Memorial Drive. They mostly cycle on the sidewalk, which is dangerous for both the cyclists and the pedestrians.

The second hierarchy is the arterials. Massachusetts Avenue is one of them and acts as the spine across both Boston and Cambridge. Its width varies, but typically 60 feet. It has two driving car lanes, two parking lanes, a medium sometimes, and bicycle lanes in both directions in Cambridge. As for cycling, it is very inconsistent. In its Boston part, there's no bicycle lane on



Arterials

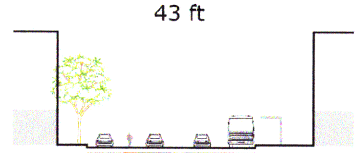
Land use type: Commercial and others

Traffic speed: Fast (over 30 mph)

Number of bike lanes: 1 or 2, but inconsistent

60 ft

43 ft



57 ft

Figure 17 The second hierarchy: arterials.

Massachusetts Avenue. There are few people cycling on it, either. In very few cases, there are several cyclists cycling between two cars which seem never expect cyclists riding beside. There are seldom any cycling facilities beside the avenue, such as parking racks. The street conditions are bad, too. Several places in the street surface beside the curb are broken which could be very dangerous for cycling. It is only near Backbay there are more people to cycle on the street, because there are more colleges in this area.

The bridge part of the avenue that connects the two cities is also unfriendly to cyclists. Although it has bicycle lanes, they are right next to the cars which run at a very high speed. The pedestrian walks are much safer because they are separated by the concrete fences and are elevated. Thus the result becomes that many cyclists ride on the pedestrian walks, knowing the bicycle lanes are dangerous. However, these bicycles then become dangerous to pedestrians. The width of the bridge is wide enough to accommodate car lanes, bicycle lanes and pedestrian walks. However, it is the design that prevents people from cycling across the river.

The Cambridge part of Massachusetts Avenue has more cycling-friendly design than that in Boston. It has bicycle lanes, more parking racks, and repair shops. However, there are still

High speed community streets

Land use type:	Commercial / residential
Traffic speed:	Fast
Number of bike lanes:	A few have one-way lane

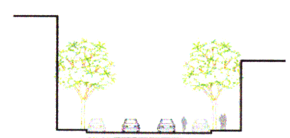


Figure 18 The third hierarchy: high speed community streets.

cycling problems. Firstly, a bicycle lanes sometimes become in-between a car driving lane and a right-turning lane. The Central Square part of the Avenue is an example. This is a very dangerous design for cyclists because when a driver wants to turn right, the car needs to go across the bicycle lane in order to merge into the right-turn lane, but the driver most of the time cannot notice bicycles from its behind. Secondly, its relationship with other streets sometimes makes it confusing and dangerous for cyclists, such as its angular intersections near Harvard Square. Thirdly, the bicycle lanes along the Avenue are inconsistent. This is most obvious when it is close to Harvard Square, where there is bicycle lane only on the right side of the Avenue (with the car lane turns into one way too). The one way bicycle lane disappears when it comes at the Harvard Square bus station, where it was replaced by the bus waiting area. After Harvard Square, there is a short distance on the Avenue with bicycle lane, but soon disappears after it passes Cambridge Common.

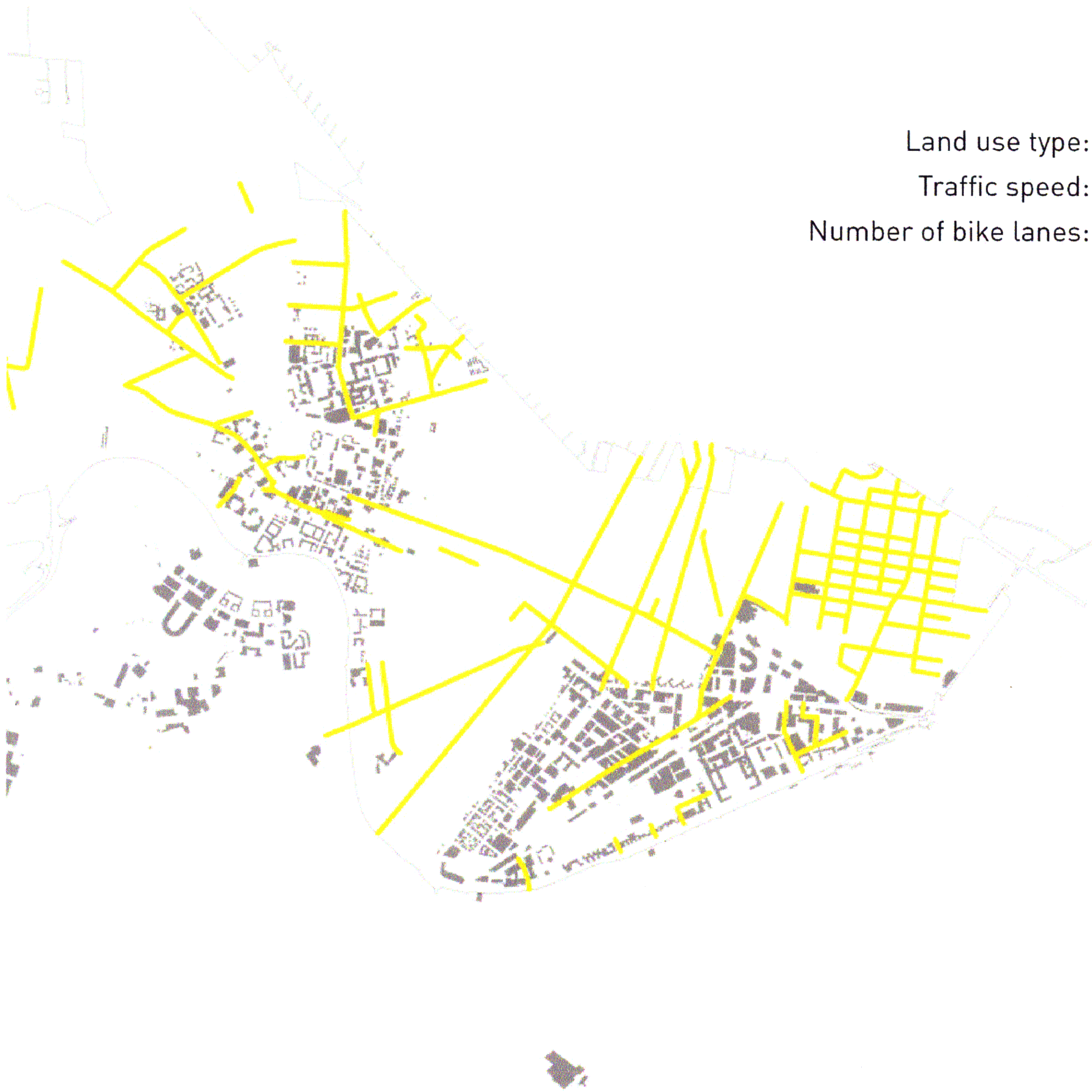
The third hierarchy is the fast speed community street. This category includes Broadway that connects MIT and Harvard campuses, Vassar Street within MIT, Cambridge Street, and so on. Most of them are over 40 feet wide. They typically have car lanes in both directions. Most of them have parallel car parking lots, while a few of them (Cambridge Street, Vassar Street, JFK

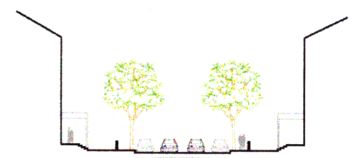
Community streets

Land use type: Residential/ commercial

Traffic speed: Medium

Number of bike lanes: Very few have one-way lane





32 ft

38 ft

Figure 19 The fourth hierarchy: community streets.

street) have bicycle lanes. They have less traffic than that on Massachusetts Avenue, but much higher than traffic on lower hierarchy streets. Cars on them have a relatively high average speed (more than 20 miles/hour estimated by eye). There are fewer buses running in them than on Massachusetts Avenue. They afford a large portion of local car traffic, thus are very busy during peak hours. Cycling in these streets is still restricted and potentially dangerous due to the high speed cars, large traffic, and parked cars.

The fourth hierarchy is the community street. It has higher penetration into the community. Most of them are flanked by either commercial or residential land uses. The typical street width is 32 feet, including two car lanes in two direction and another two parallel parking spaces. Very few of them have bicycle lanes, and they are mostly one-way. However, due to the lower car speed on them, many of these streets are popular cycling routes for local cyclists, such as Harvard Street which connects Harvard and MIT campuses.

The lowest hierarchy is the neighborhood street. They are most widely spread across the community. The typical width is about 26 feet, including one car lane and two parallel parking spaces. Most of them have residential land uses on each side, and the traffic speed in them is

Neighborhood streets

Land use type: Residential

Traffic speed: Slow

Number of bike lanes: No bike lanes

Figure 20 The fifth hierarchy: neighborhood streets.

low. Although there are no bicycle lanes, many people cycle in these streets because of the low traffic speed.

The existing cycling network in Figure 21 shows many reasons why the current network discourages cyclists. Firstly, there are very few cycling streets connecting the two campuses. Secondly, even though among these cycling streets, the cycling environment is highly inconsistent. Massachusetts Avenue has two-way bicycle lanes, but it turns to only have one-way bicycle lane when it reaches Harvard campus. Although Cambridge Street consistently has two-way bicycle lanes, it is not connecting the two campuses. In fact, not a single bicycle friendly street is connecting Harvard and MIT campuses.

3.2.3. Site survey

In order to achieve first hand materials, a cycling survey is conducted among random chosen cyclists. The purpose of this survey is to help understand the current cycling condition between MIT and Harvard campus, and prepare for the designing. The overall number of samples is 10, and most of them cycle for utilitarian purposes, such as going to school or to work. Each of them is asked to draw their favorable and unfavorable cycling routes, inconsistent cycling spots, and

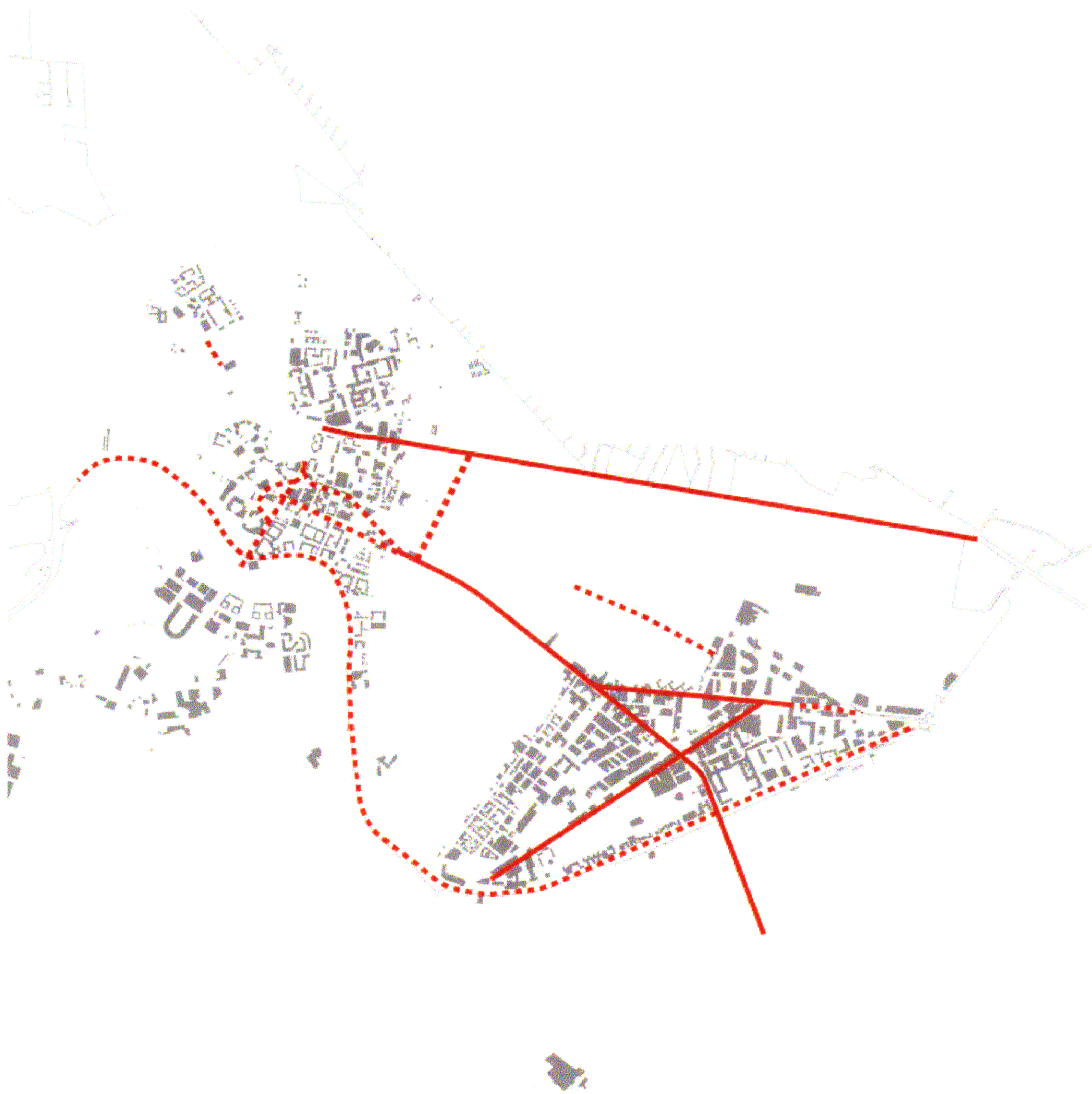


Figure 21 Existing cycling network between Harvard and MIT campuses.

other existing cycling-related issues. The first half of this section will describe three cases, and the second half will summarize the general problems.

Case one: She is an MIT student who lives in a community near Harvard campus on the east side of Massachusetts Avenue, Cambridge. In the survey she shows two cycling destinations: one is MIT campus, the other is her former working place in Somerville. For the first destination, she suggests that Massachusetts Avenue is in a bad condition for cycling. Mostly she chooses to cycle to MIT in Franklin Street and go home in Green Street. The reason why she uses different streets is because both of them are one way streets. For the second destination, she suggests that Prospect Street is not comfortable for cycling because it is a major street within the community and full of traffic and parked cars. Instead, she chooses to cycle on other streets that parallel to it, such as Inman Street and Antrim Street. She particular mentions that Cambridge Street is comfortable for cycling. For other cycling issues, she suggests that Massachusetts Avenue is in bad cycling condition due to the bus drivers and road design.

Case two: She is an MIT student who lives in a community between MIT and Harvard. She has two travelling destinations. One is MIT the other is Harvard campus. She considers most of the

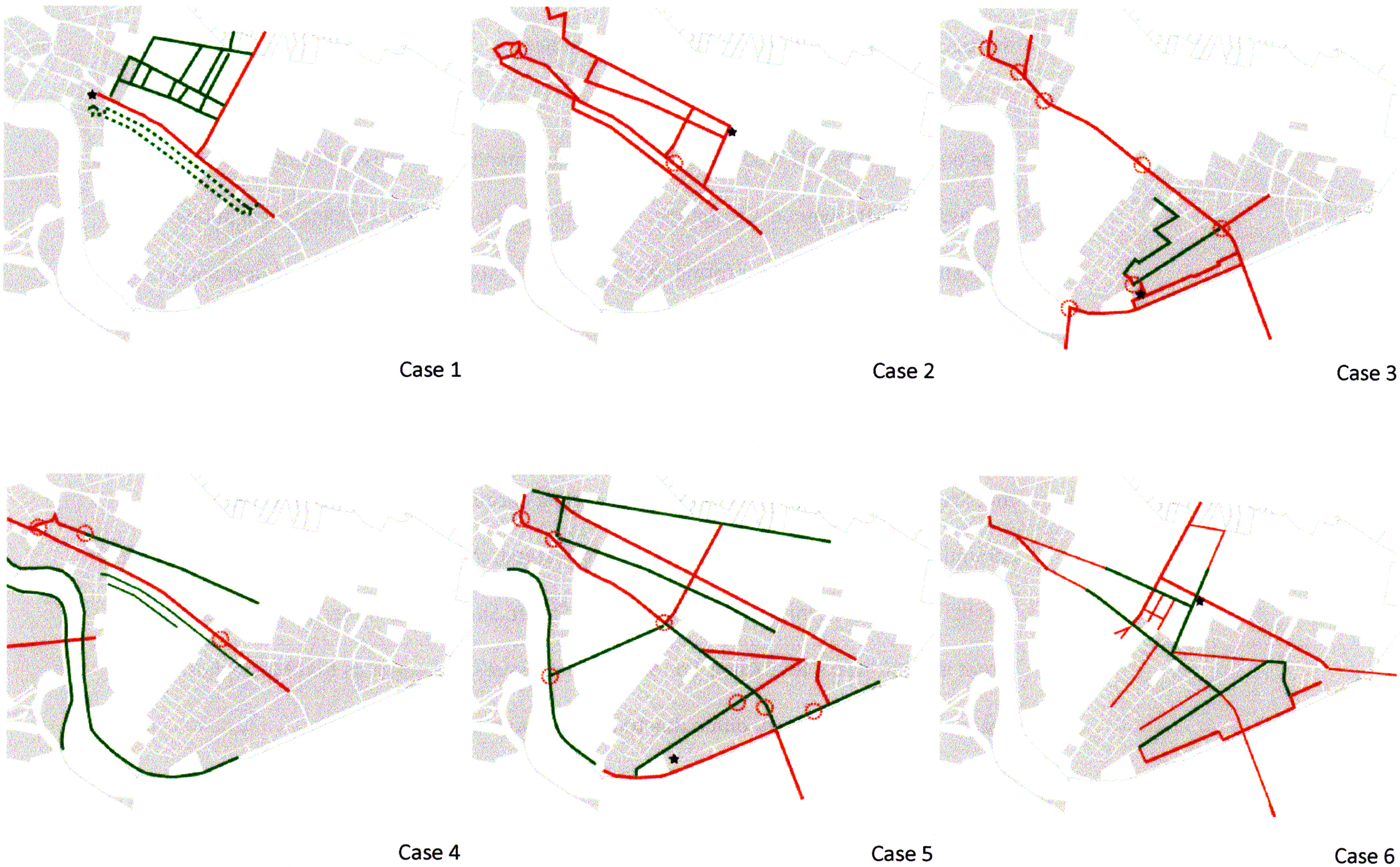


Figure 22 Cycling condition survey.

streets she cycles in are in bad cycling condition, especially Prospect Street and Massachusetts Avenue. She particular mentions that the section of Massachusetts Avenue near Harvard is bad for cycling because cycling routes are changed into one-way, together with the car traffic. As for particular spots, she mentions two. The first one is Central Square, where the cycling lanes conflict with bus traffic and taxi lanes. The second one is Harvard Square, where it lacks bicycle parking spaces and is difficult to go across the street.

Case three: She is an MIT student living in on-campus housing on the west side of the campus. He uses cycling for three destinations: central MIT for classes, Harvard for lectures, and a grocery store across the BU Bridge. For the central MIT travel, Memorial Drive only provides pedestrian walk and he sometimes cycle on it. For Amherst Street, it does not have any bicycle lanes and has combined traffic of cars, and bicycles. He also mentions that although the east part of Vassar Street is good for cycling as new cycling lanes are added, its east part is still uncomfortable. When he goes to Harvard campus, he always uses Massachusetts Avenue, which he considers a bad cycling route, especially when it is close to Harvard campus because the bicycle route changes into one-way. As for the grocery store, he has to go across the Memorial Drive and cycles along the bridge. The rotary is very dangerous for him and there are no bicycle lanes on the bridge. He identified several cycling-inconvenient spots. Three of them are on the Harvard section of Massachusetts Avenue; one is on Central Square; one is on the intersection of Vassar Street and Massachusetts Avenue; one is the intersection between Amherst Street and the railway; and the last one is the rotary on Memorial Drive.

Case four: He is a landscape architect working in Watertown. He uses a bicycle for most of his commuting trips. He also cycles between Harvard and MIT campuses for friends and shopping. He mentions that Massachusetts Avenue is his unfavorable cycling routes, although he often cycles in it. As alternatives, he chooses Harvard Street, Franklin Street and Green Street. Harvard Square and Central Square are considered to be the breaking points of his bicycle travels. He also mentions he particularly likes the experiences of cycling along the Charles River.

Although all the people in the survey live in different places, have different travel destinations, and have different occupations, the overlap of these survey maps suggests some common issues: firstly, it turns out that almost all the people in the survey dislike the cycling conditions on streets with high speed car traffic. Massachusetts Avenue is one of these examples. Its Central Square part and Harvard section are especially unfavorable to cyclists. Prospect Street as one of the most highly used street in its surrounding neighborhood, is also criticized for no cycling facilities and high car speed. Secondly, streets of lower hierarchy which are parallel to the arterials are often used as alternatives to the arterials. For example, Franklin Street and Harvard Street are very favorable routes for cyclists. Thirdly, several "breaking points" along the cycling routes have greatly increased the inconvenience for cyclists. Some of the most commonly mentioned spots in the survey include Harvard Square, Central Square, and the intersection of Vassar Street and Massachusetts Avenue. While one reason is the high capacity of vehicular traffic, another reason is that cycling is not properly considered during the design process of these spots.

3.2.4. Proposal at the community scale

The proposal at the community scale is illustrated by the cycling network design between Harvard and MIT campuses. It consists of a set of hierarchical streets and typical sections. The cycling condition on Massachusetts Avenue is improved by increasing its cycling consistency. Several community streets, such as Prospect Street and Harvard Street, are changed into bicycle boulevards which are dedicated to cycling. Besides these changes, bicycle lanes are also added in some one-way streets due to their high usage by the cyclists. These bicycle routes are also one-way, but they appear in pairs to make sure cyclists can travel in double directions.

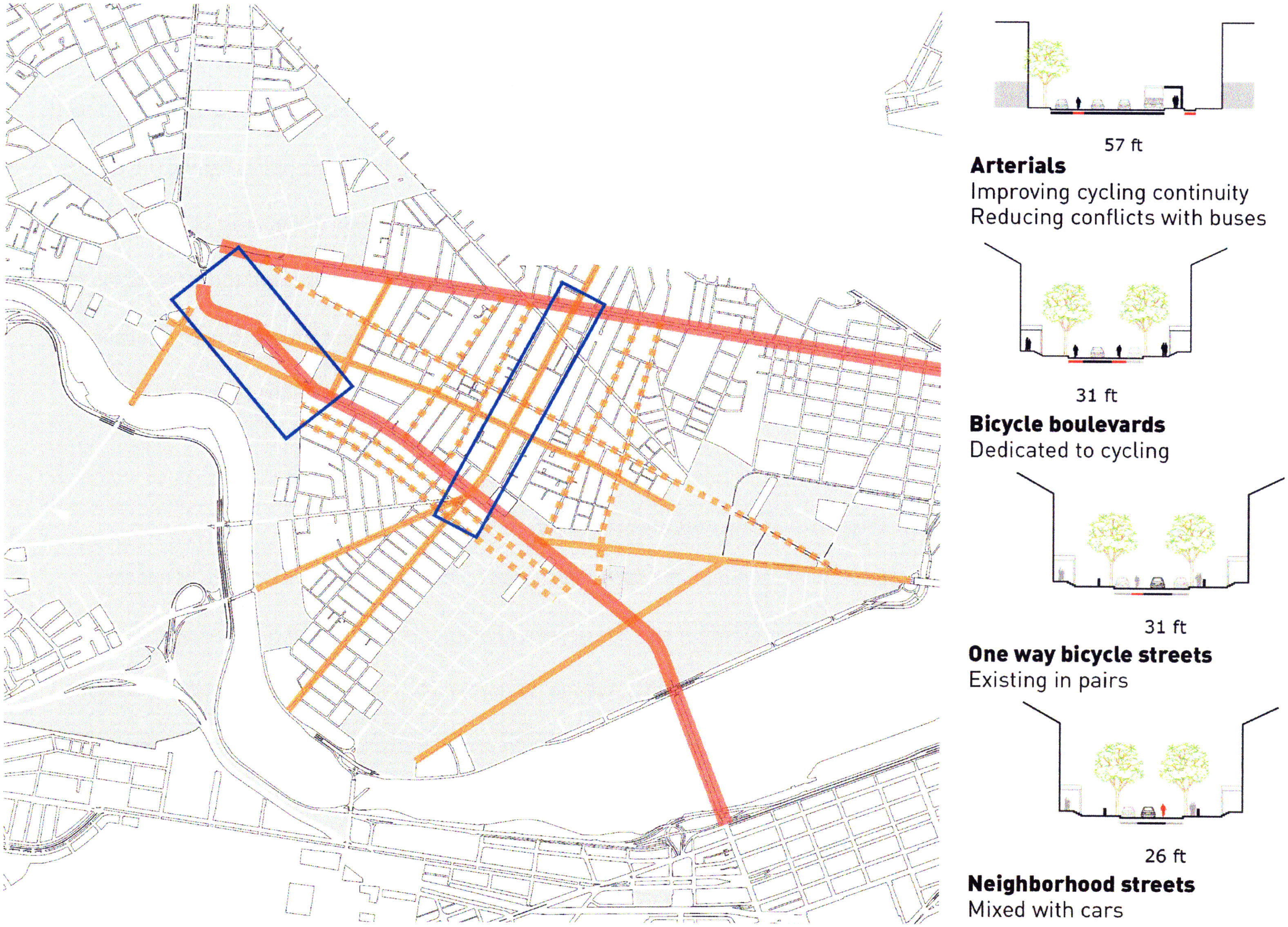


Figure 23 Proposed cycling network between Harvard and MIT campuses and its typical street sections.

3.3. The street scale

The proposal at the street scale is going to use physical design techniques to either slow down the vehicular traffic or make cycling safer. The survey in the community scale not only provided hints for the design at that scale, but also suggested several problematic spots that most discourage cycling. The following proposal is going to choose two of them, Prospect Street and Massachusetts Avenue's Harvard section to illustrate how these design techniques are utilized to encourage cycling.

3.3.1. Prospect Street

There are several reasons of choosing Prospect Street as an example. Firstly, it is a major community street which is used by many local residents. Secondly, it leads the local population to the Central T station. Thirdly, it concentrates many typical designing problems which discourage cycling. For example, both Harvard Street and Allen Street change their sections at Prospect Street. At the street scale, the following strategies are taken:

1) Changing the street sections. The inconsistency of the cycling environment brings cyclists many troubles. In the proposal, both the south and north part of Harvard Street are changed

Figure 24 Prospect Street in the proposed cycling network.

into one-way car traffic. Some parallel parking spaces are removed to make way for a two-way cycling route. Similar actions are conducted on Allen Street. The re-design of Massachusetts Avenue has to deal with the conflict between bicycles and buses. In the proposal the bicycle lane run after the bus station and thus it creates an island for bus waiting people. In this way the conflict between buses and bicycles are shifted to conflict between pedestrians and bicycles, which can reduce the number of deaths caused by of bus-bicycle collisions.

2) Changing the car accesses and exits to parking lots along Prospect Street. Many car-bicycle collisions are caused by people driving cars out of a parking lot without noticing the bicycles riding in front of them. By shifting some parking lots' accesses and exits to lower hierarchy streets, Prospect Street is friendlier for cyclists as a bicycle boulevard.

3) Traffic calming down on streets crossing Prospect Street. Chokers and roundabouts are used in order to slow down the crossing car traffic.

3.3.2. Massachusetts Avenue (Harvard section)

The Harvard section of Massachusetts Avenue has very complicated traffic flows. It has several triangles which make cycling in this area extremely dangerous. The street design of this site is

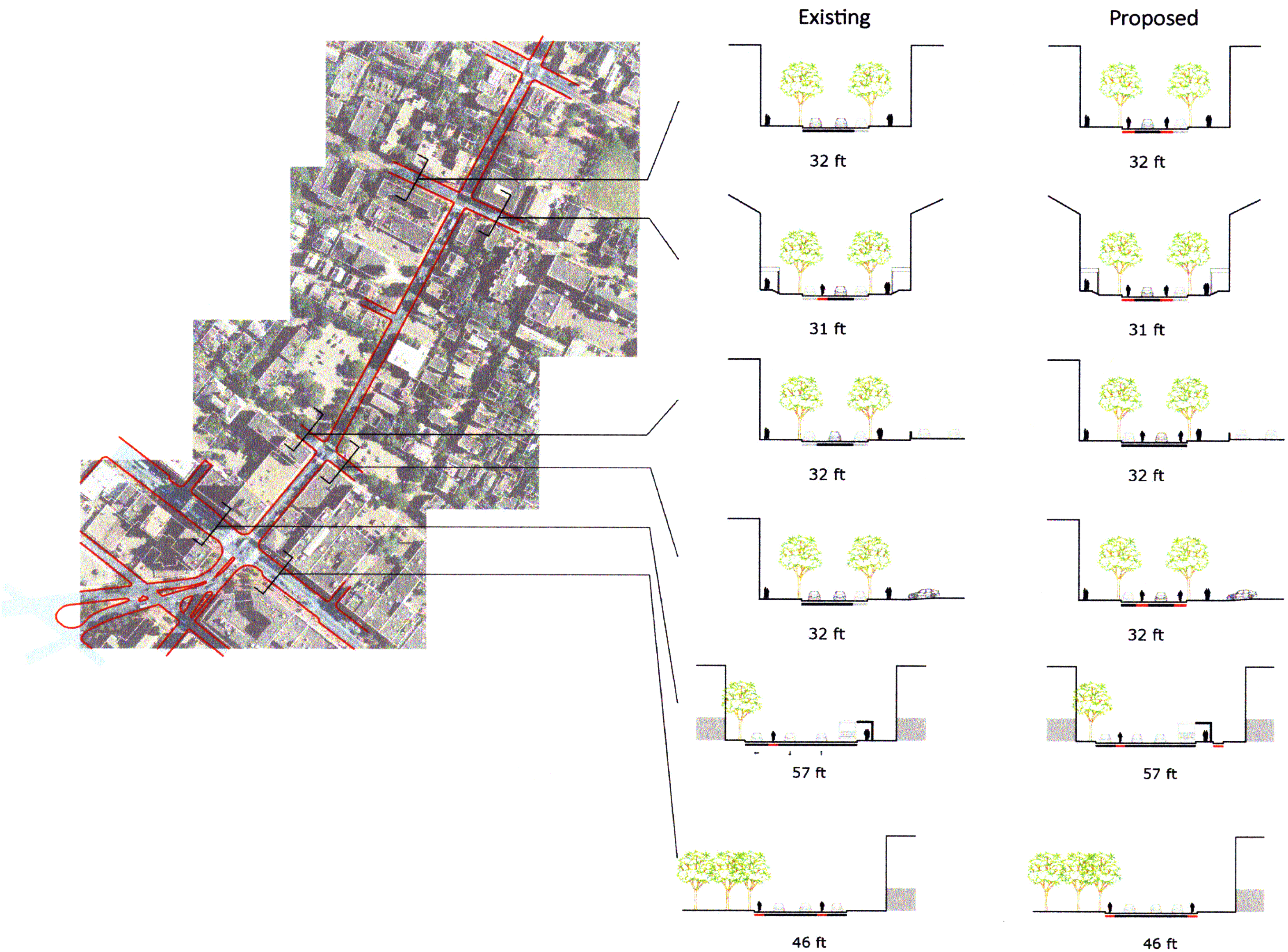


Figure 25 Existing and improved street sections for Massachusetts Avenue, Allen Street and Harvard Street.

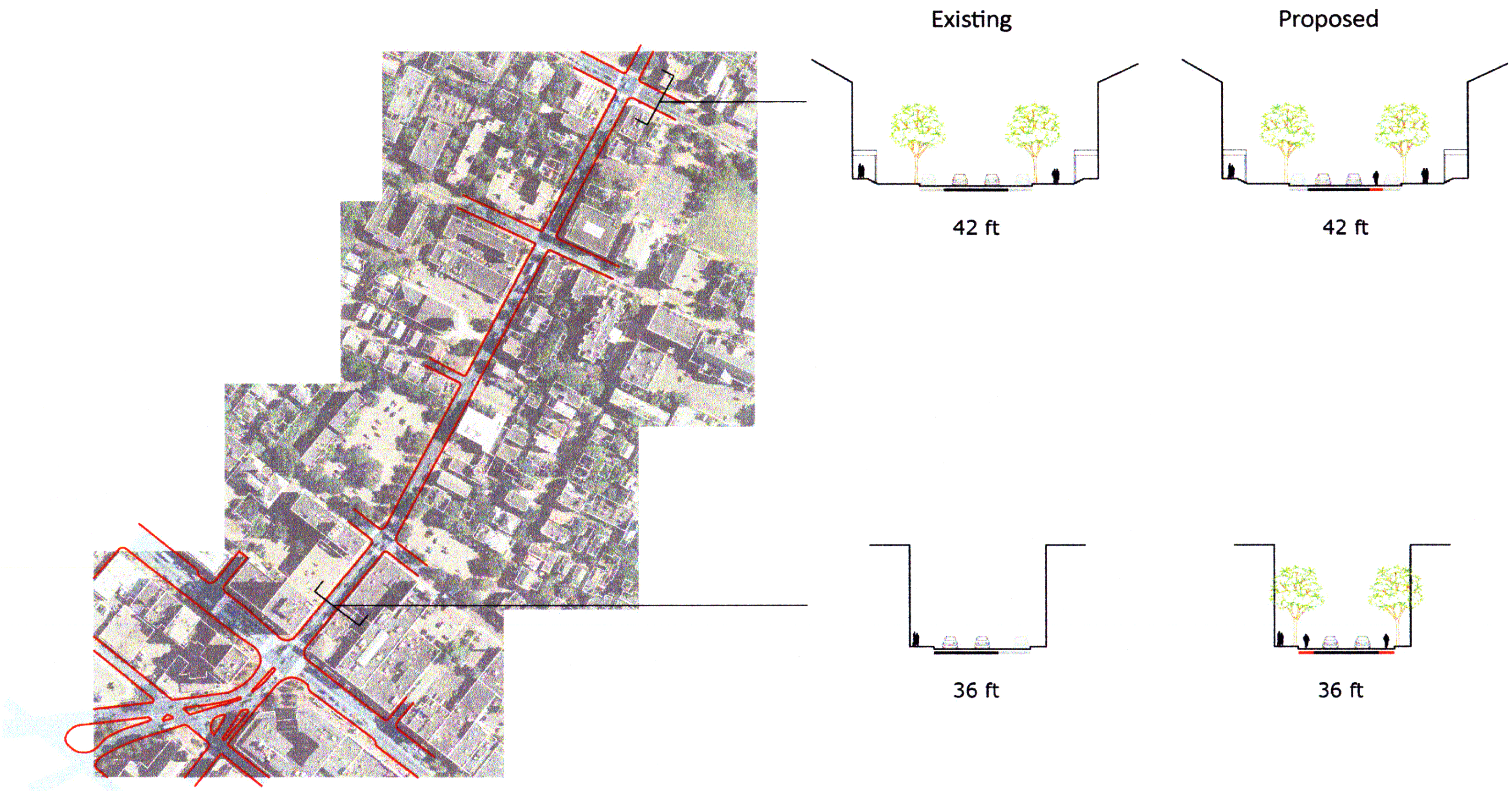


Figure 26 Existing and improved street sections for Prospect Street and Cambridge Street.

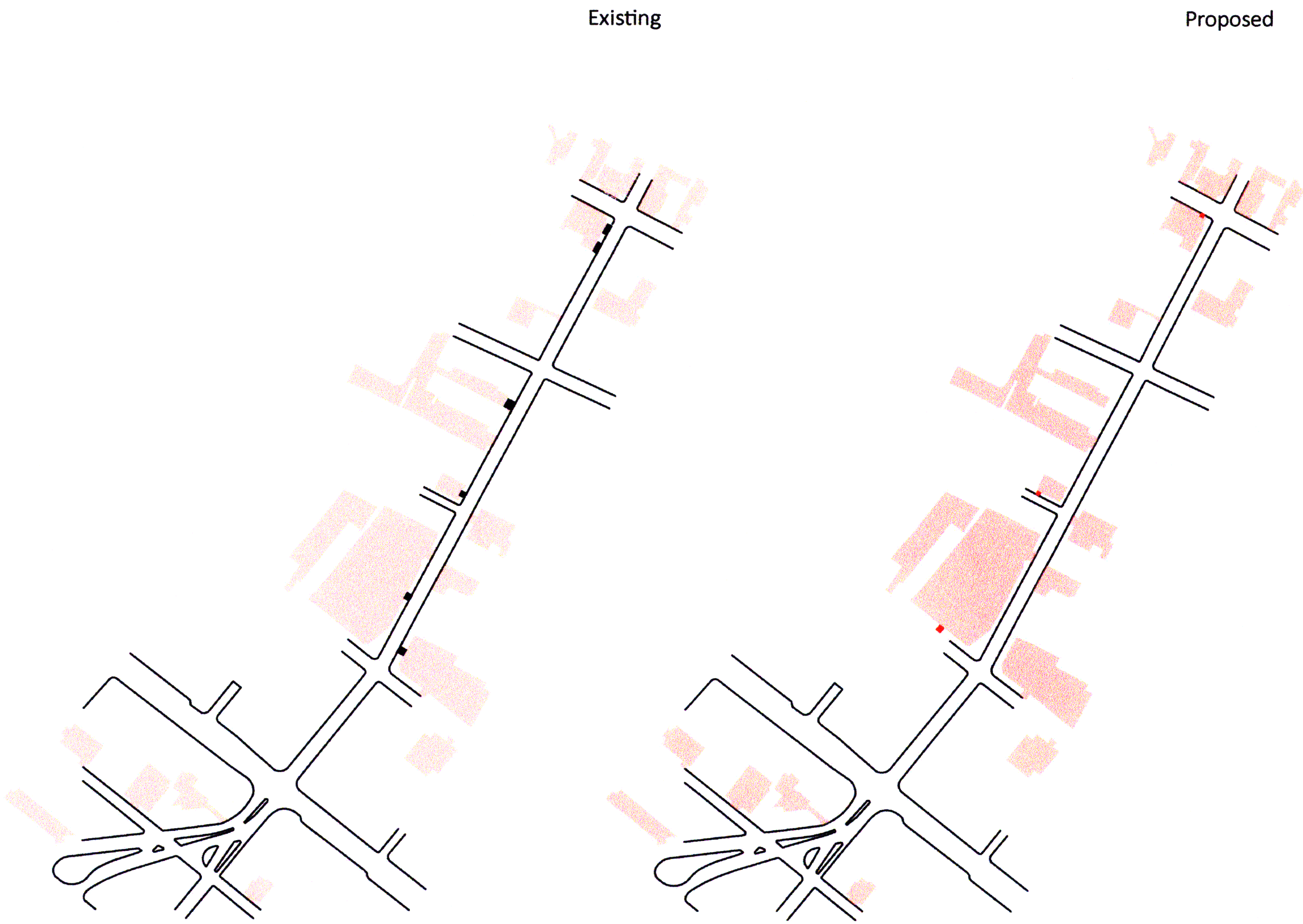


Figure 27 The changing of entrances and exits of parking lots along Prospect Street.

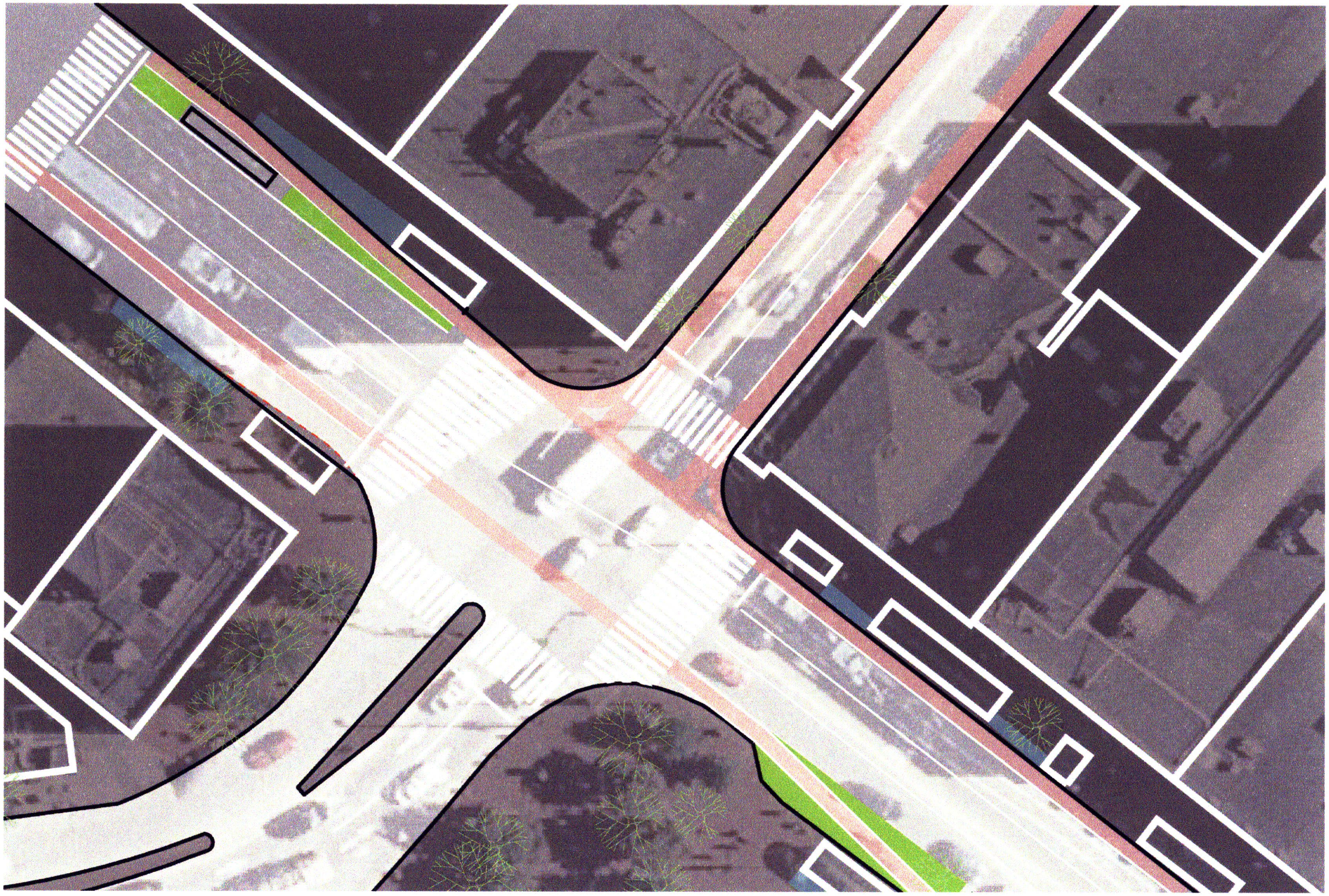


Figure 28 Intersection design for Prospect Street and Massachusetts Avenue.

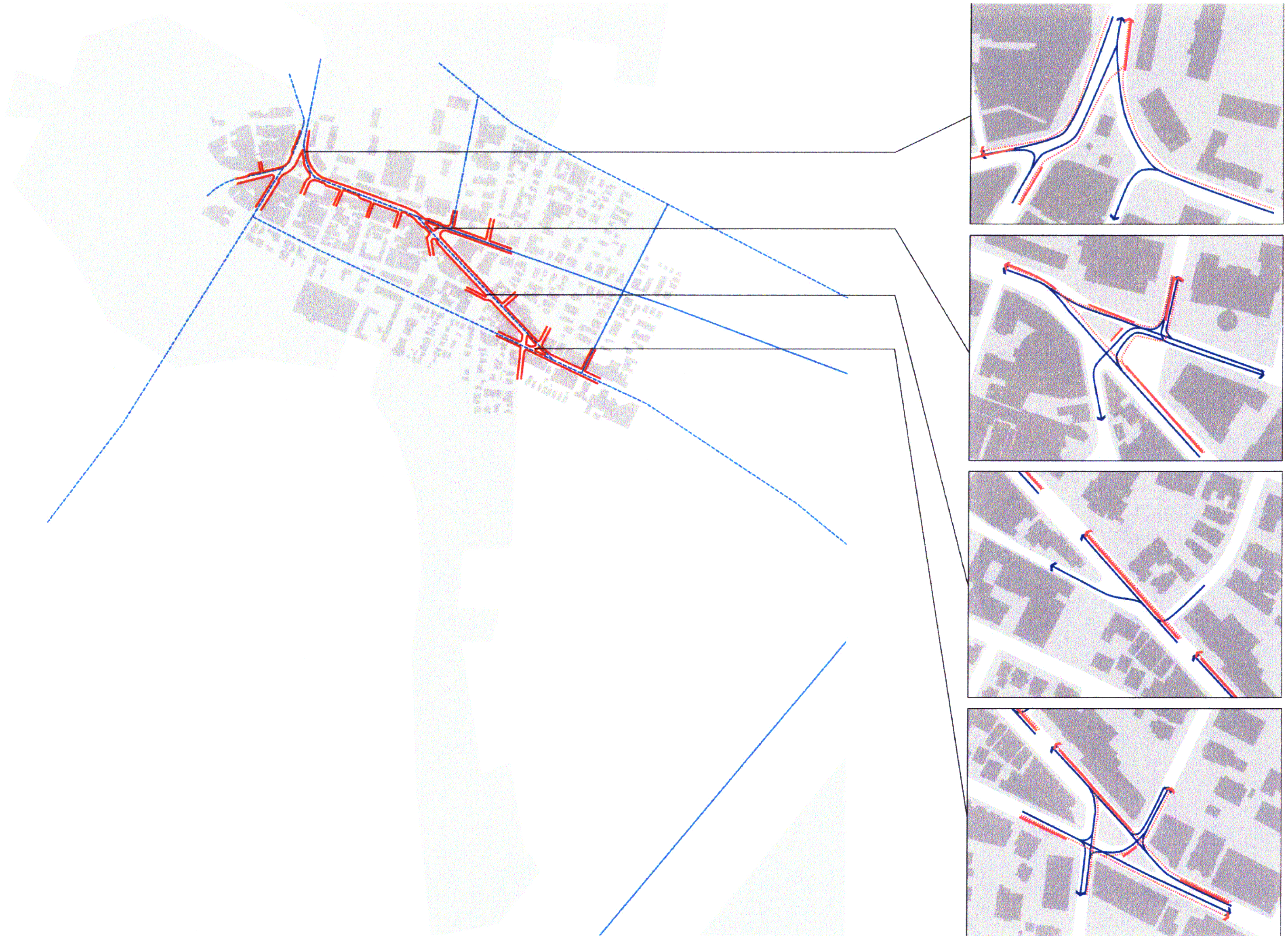


Figure 29 Massachusetts Avenue (Harvard section) in the proposed cycling network and its traffic flow analysis.

highly affected by the car-dominated culture, and with no considerations of cycling. The existing bicycle facilities are poor and not continuous. Only within this short section, Massachusetts Avenue has at least six street sections with different ways of cycling. The right side of Figure 30 shows the complexity of both vehicular and cycling traffic.

It is difficult to use the same strategies which are used in the Prospect Street site, because it is the angular street intersections that make cyclists less visible to the car drivers. Realizing this basic confliction, the proposal uses another strategy: diverging bicycle flows before they enter this bicycle unfriendly zone. Elley Street is proposed to change into a bicycle boulevard connecting Harvard Street. Parallel parking on one side is removed. In order to make cycling environment consistent, part of the curb at the intersection of Harvard Street and Massachusetts Avenue is straightened.

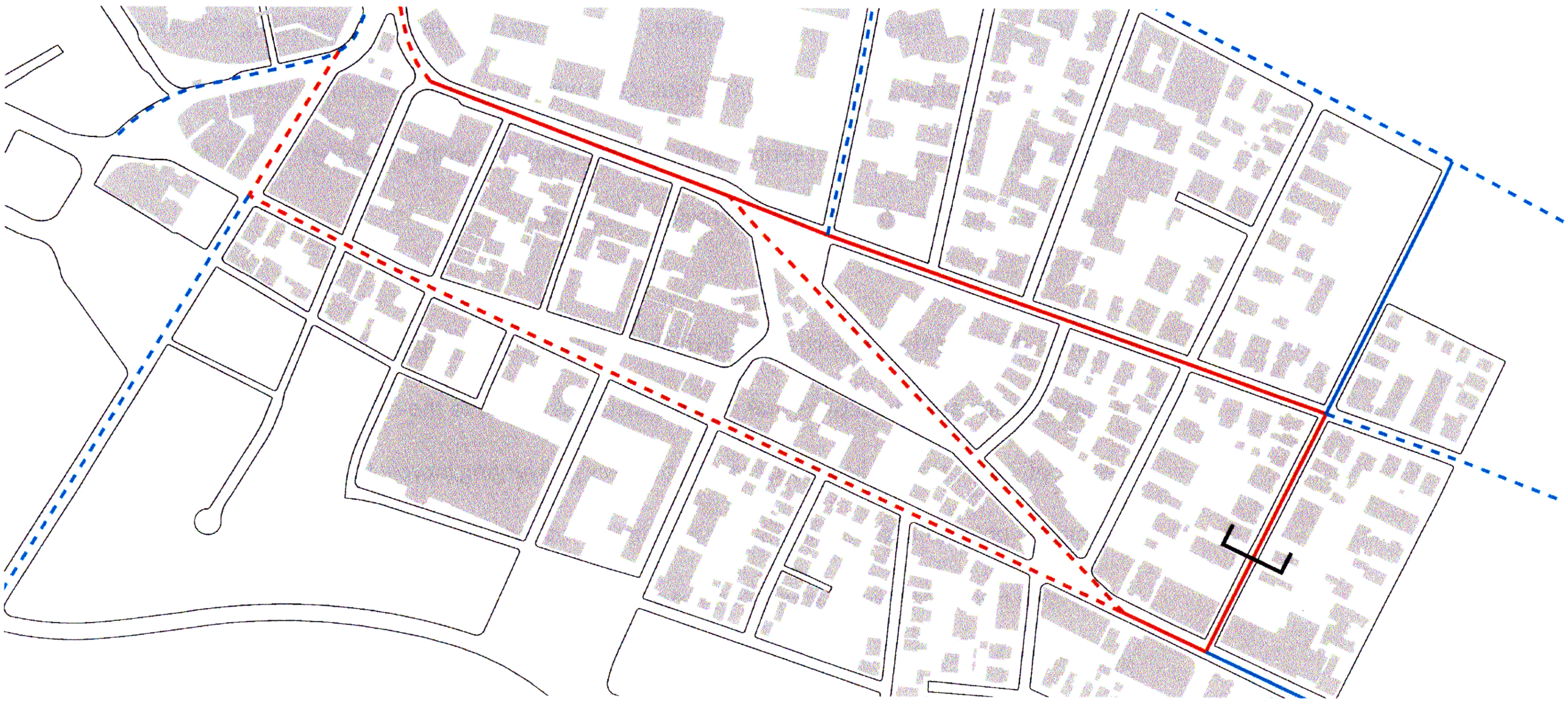


Figure 30 Bicycle traffic diverge and the proposed Elley Street.

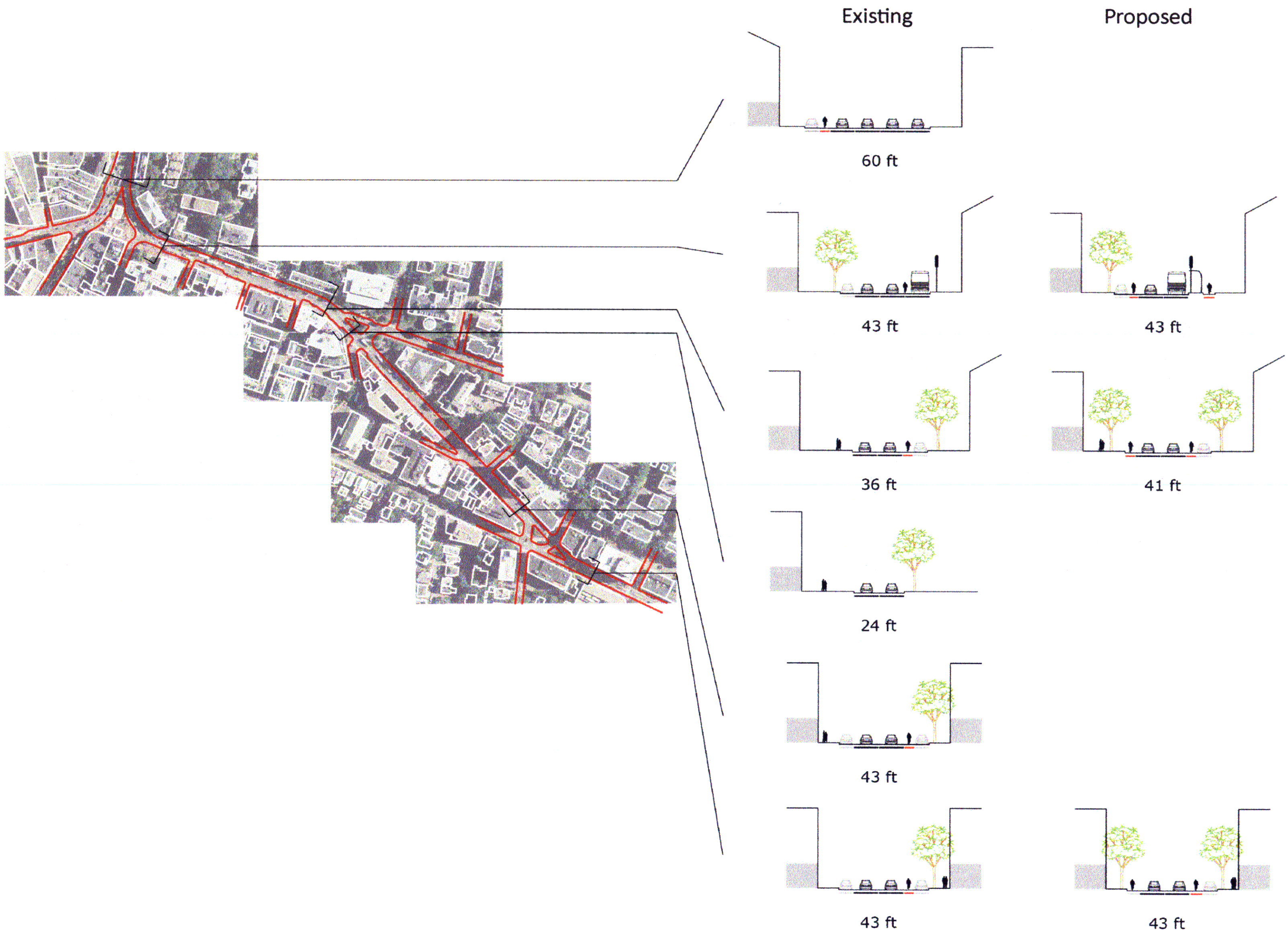


Figure 31 Existing and proposed street sections along Massachusetts Avenue.

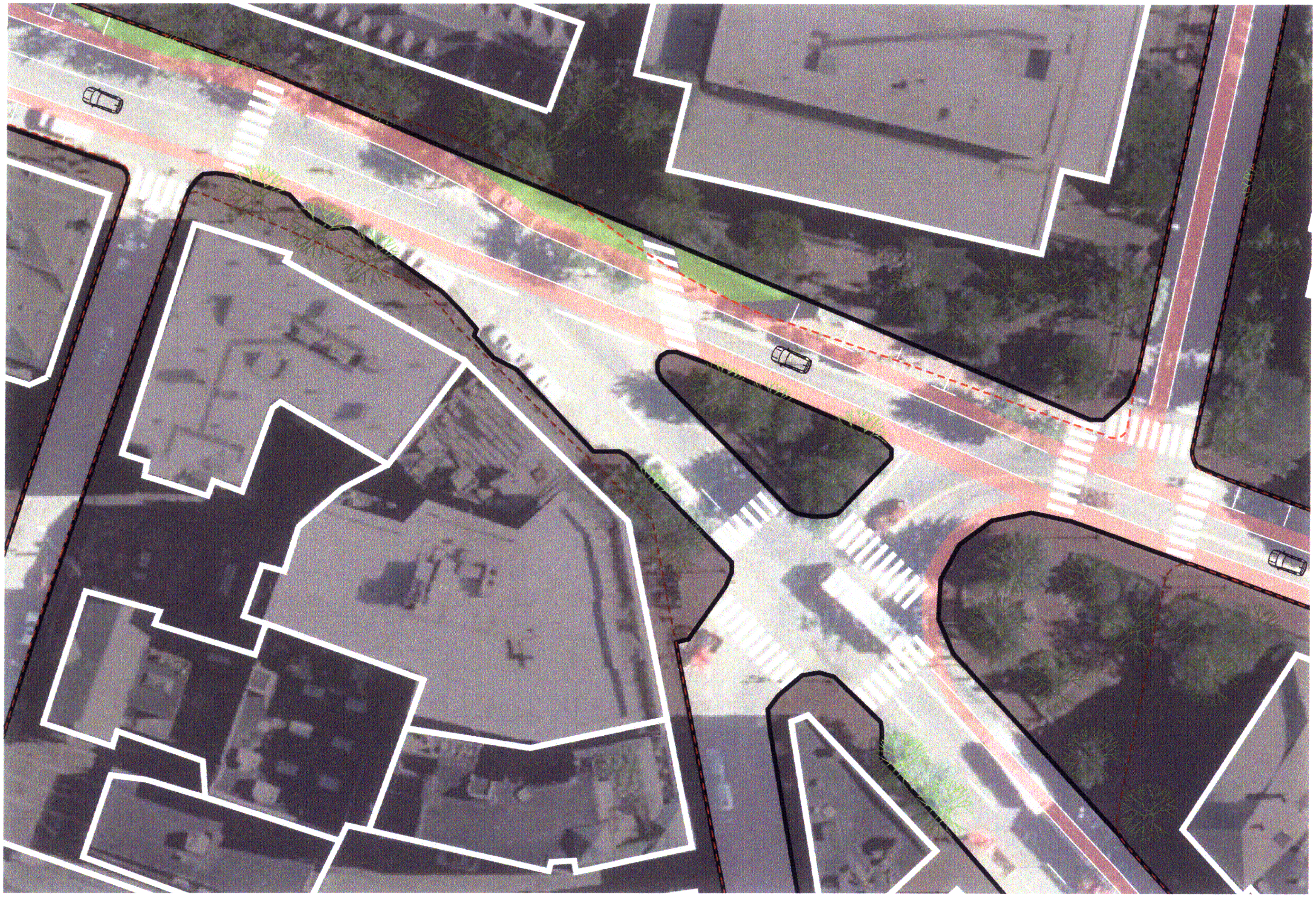


Figure 32 The connection of cycling traffic between Massachusetts Avenue and Harvard Street.

Chapter 4.Conclusions and suggestions

As is discussed at the beginning of this thesis, the urban physical form often becomes the result of its transportation modes. By reverse this process, the design proposal aims to promote particularly cycling through the physical designs at three distinct scales. During this process, urban design and planning play more active roles. The consistency at different scales is the most crucial point.

It also needs to be noticed that physical design is only one aspect to promote cycling. Much more work in traffic regulations, educations and engineering need to be done. In order to make the designs take effect, urban designers and planners need to closely collaborate with people from many fields, such as traffic engineers, communities, bicycle organizations, even bicycle manufacturers. It is also important to see the limits of physical design too.

Taking time into consideration, we can also introduce the phasing issue while carrying out these strategies or techniques. Some of them, such as changing of the curbs, can be easily implemented and achieve significant impact on vehicular traffic. They slow down the cars and make cycling much safer. Some other designs, such as the change of car lanes, have to take longer time and more financial support due to their large impacts on the overall traffic network. Such changes should be considered carefully before carrying out.

Figure 33 Electric bikes used in China

Future possibilities for urban cycling may include two directions. The first one is that innovative technologies can contribute to the evolution of cycling culture. Electric bicycles, which are powered by electricity or by both pedaling and electricity, in recent years emerged and were intensively used in developing countries. These electric bicycles use electricity to assist human power, thus could both reach longer distance and adopt larger user group (such as elder people). Moreover, they use much less parking spaces than normal cars. Although they still have many controversial issues such as battery pollutions, in the long run electric bicycles may become substitutes for cars. The charging demand may also require a completely new set of urban infrastructures.

The second direction is the new ways of managing urban cycling. The recently emerging bicycle-sharing system has been implemented in many cities and received much attention. Taking *Velib* – the public bicycle-sharing system in Paris – for example, the city provides 20, 000 rental bicycles and over 1,400 rental stations as a new urban transportation system[1]. High densities of rental stations (distance between two stations is every 300 meters) make sure people can pick up a bicycle in a nearby place, and drop it at any other stations without riding it back. The first half an hour is free of charge. By using these new ways of management, bicycle sharing not only encourages cycling, but also supports public transportations by providing them feeders.

Figure 34 Locations of rental bicycle stations in central Paris

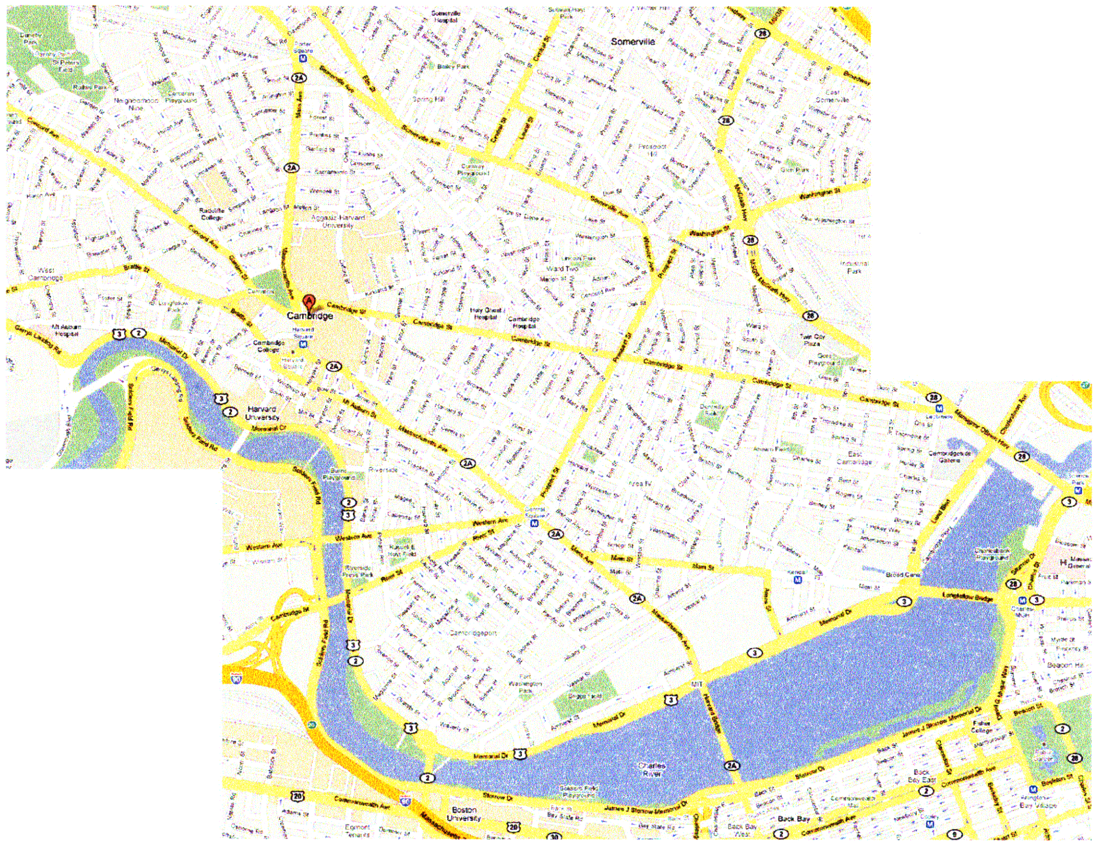
As people in the U.S. care more and more about clean transportation tools, both urban planners and designers should take these issues into consideration and be prepared to new fields of urban planning and designing.

[1] http://www.en.velib.paris.fr/

APPENDIX

CYCLING CONDITION SURVEY

Please draw on the following map:
1. Your favorate cycling routes;
2. Your unfavorable cycling routes;
3. Spots that break your cycling travel;
4. Else.



Survey image credit: Google Map

ILLUSTRATION CREDITS:

Figure 1, 5 Source: Sykes, Robert D., and Trina Wicklatz Driscoll. 1996.*Creating bicycle transportation networks: a guidebook*. St. Paul, Minn: Minnesota Dept. of Transportation, Office of Research Administration.

Figure 2 Source: Boston (Mass.), and Boston Metropolitan Planning Organization. 2002. *Boston transportation fact book and neighborhood profiles*. Boston: Boston Transportation Dept.

Figure 3-4 Source: Herlihy, David V. 2004. *Bicycle: the history*. New Haven: Yale University Press

Figure 6 Source: Forester, John, and John Forester. 1994. *Bicycle transportation: a handbook for cycling transportation engineers.* Cambridge, Mass: MIT Press.

Figure 7 Source: Wray, J. Harry. 2008. *Pedal power: the quiet rise of the bicycle in American public life*. Boulder, Colo: Paradigm Publishers.

Figure 8-9, 16-32 Source: Drawings re-drawn from Boston (MA) Boston Redevelopment Authority (BRA). *Boston, MA (Building Footprints, 2000); Boston, MA (Sidewalk Line Blocks, 2000)*; Cambridge (MA) Geographic Information System (City of Cambridge GIS). *Cambridge, MA (Major Transportation Features, 1995); Cambridge, MA (Buildings, 2006); Cambridge, MA (Road Centerlines, 2004)*. Images from *Google Map*.

Figure 10-11 Source: Redrawn from MIT Campus Map (*web.mit.edu/admissions/pdf/MIT_Campus_Map.pdf*)

Figure 12-15 Source: *Author*

Figure 33 Source: Source: *www.jixiangniao.com*

Figure 34 Source: *http://www.en.velib.paris.fr/*

Table 1 Source: Source: Sykes, Robert D., and Trina Wicklatz Driscoll. 1996.*Creating bicycle transportation networks: a guidebook*. St. Paul, Minn: Minnesota Dept. of Transportation, Office of Research Administration.

Table 2 Source: Drawings re-drawn from City of Davis Public Works Department and City of Davis Bicycle Advisory Commission. 2006. *City of Davis Comprehensive Bicycle Plan*. Images captured from video *Davis, California, A Platinum Bike City* (http://www.en.velib.paris.fr/)

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