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# Boston Cycles

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The views expressed in this paper are solely those of the author.



# Introduction

Cities are often looked critically in terms of their suitability for human living, most commonly referred to as livability. The livability of a city can be determined by a number of factors, such as accessibility, affordability, safety, publicly accessible green space, and employment potential. Each year cities experience an influx in population growth as college graduates search for a new place to live and work. As this wave of young people enters the city they are looking for two things: employment and accessibility. A city is then, by consequence, measured on its ability to efficiently transport a large number of people from one location to another. Accessibility to transit is key to this younger, less financially established generation in terms of their perception of the livability of a given city. As this circulation of people plays a critical role in the fundamental aspects of a city dweller's day, it is important that cities have efficient and effective public transit systems. It is in conjunction with this ability to move the masses that cycling comes into play. As a vehicle for transporting a large quantity of individuals from point A to point B at a low cost, cycling has the potential for increasing the quality of life for those living within a city. Both cycling and public transit can further a city's livability in terms of how accessible that city is to the average inhabitant. By increasing the number of bikeable miles within a city, the city's livability also increases.

At the turn of the century and in the first decades of the twentieth century, the rapid dissemination of the motor vehicle not only changed socio-economic factors within the United States but also changed the environment and the landscape indefinitely. Henry Ford brought the American people not only a quality product, but efficient assembly methods, affordability, and consumer desire, the combination of which has been a driving force in consumer motor vehicle markets for nearly a century. Today, "the United States is the most extravagantly motorized nation in the history of the world" [1] and as consequence, this automobile-centric culture, has brought urban sprawl, severe traffic congestion, and pollution to American cities.

Traffic congestion is a problem that the majority of the world's most populous cities are currently facing, and is in no way unique to North America. Specifically, this issue can be found plaguing many of Asia's most populous cities. Western Europe on the other hand, by and large, has tackled the problem of vehicle congestion better than most. As will be discussed at length in the following chapters, European cities such as Copenhagen, Denmark have not only made their public transportation more efficient and appealing but have also created a bicycle friendly environment for commuters. While cities like Copenhagen are thought to be exceptional and unlikely to be replicated, especially in North America, the time has come when a change is no longer wanted but is now urgently needed.

As private automobile ownership has steadily increased since the 1950s, congestion in the United States has also risen. Traffic congestion costs the American economy, "\$115 billion every year in wasted time and fuel – or \$808 per person, a figure that has increased by 50 percent in the last decade" [2]. As populations within cities increase, the more important it becomes to promote a city's livability. People must be able to access stores, work places, and parks without having to continually be concerned with personal safety. Mass freeways and crowded boulevards infested with tired drivers and desperate taxis make for treacherous living conditions for those on foot, on bike, and in neighboring vehicles. A decrease in vehicular use within cities not only decreases noise and air pollution but also promotes a healthier, less stressful lifestyle. The time has come for local and national governments to invest less in infrastructure catering to the automobile and invest more in public transit. Changes needed to accommodate infrastructure to better promote cycling for smaller trips within cities as well as walkability is comparatively small to the infrastructure needed for automobiles. The goal should not be to eradicate vehicles from American cities but to decrease their use for extraneous trips that can easily be accomplished daily on foot or by bike. The changes are small, but the implications that accompany them are enormous.

This project will analyze the successful design of three cities that have successfully implemented a safe transit system for cyclists: Copenhagen, Denmark, Amsterdam, Netherlands, and Portland, Oregon. As will be shown, the changes made to these cities has increased walkability and livability. This project will also analyze the unsuccessful attempt of creating a cyclist friendly city in New York City and why the city's efforts have largely failed. The project will conclude with a study of Boston, Massachusetts and a proposal for a redesign of its street system with infrastructure for bicycle commuting, making it a more sustainable and livable city to reside in. Applications of successful design elements derived from a bicycle and pedestrian transit analysis of four cities: Copenhagen, Amsterdam, Portland and New York City, will allow Boston to become a more sustainable, healthy, and livable city.

# Copenhagen

## History

Since the late 1800s the bicycle has been a **symbol of freedom** for Danish citizens, allowing men and women to escape from inner city housing and into the clean air of the countryside [3].

In the 1960s, however, a rise in the standard of living made car ownership available to more and more families. Danes embraced the new development of the automobile as a sign that the economy was finally on the mend after the Great Depression of the 1930s and the turmoil of WWII in the 1940s. During the 1960s, many of the public spaces and pedestrian-only streets, now prized by Copenhagen residents, were riddled with heavy traffic and air pollution [4]. During the 1960s there was even talk of creating policies that would get rid of bikes within the city, due to the many accidents that had been sustained as cars began to invade the city. Due to protests and upheaval from Copenhagen residents, the plan to abolish bicycles from the city was soon abandoned, and “the city made the Strøget **car-free** in 1962” [5]. Today the Strøget is Europe’s longest uninterrupted pedestrian street and the heart of retail and small business operations in Copenhagen.

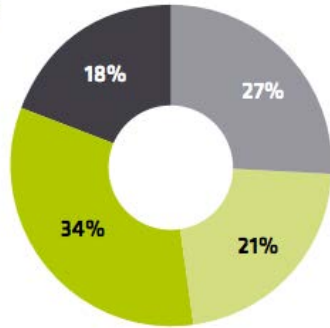
In the years following the Strøget transformation, more streets were deemed car-free and public squares were added to the city’s fabric by setting aside spaces within the city for pedestrian use only. Another major contributor to the development of pedestrian and bike infrastructure within the city was the OPEC embargo of the 1970s, which greatly impacted energy-poor Denmark particularly. The impact in Denmark was so great that the Copenhagen government had to enforce car-free Sunday’s during which the use of vehicles was prohibited [6]. Today, as a result and thanks to crucial policies enforced by the Danish government, a 25-square acre swath of downtown Copenhagen is **closed to motor vehicles**.



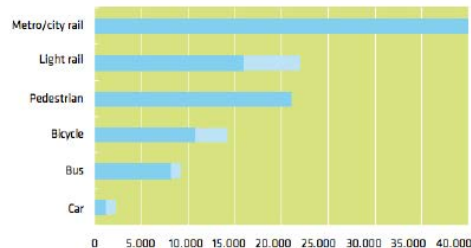


## TRANSPORTMODES FOR ALL TRIPS IN THE CITY OF COPENHAGEN

● Walking  
● Cycling  
● Public Transport  
● Car



SOURCE: DTU Transport



### CAPACITY OF VARIOUS TRANSPORT SYSTEMS

The city's infrastructure is congested and in general there is a struggle for urban space. That is why it is important to make the best use of the space.

The green means of transport take less space per person and thus they ensure better use of the scarce urban space. The figure shows how many persons one track of each transport mode can carry per hour. E.g. the same space can carry 7-10 times as many cyclists as cars.

# Copenhagen

One of the key things to keep in mind when looking at Copenhagen is that while it is considered to be the most cyclist friendly city in the world, its inhabitants do not consider themselves cyclists. People are often seen riding their bikes to work in their work clothes, men in polished shoes and women often in heels [7]. In Copenhagen, the **bicycle is the average person's mode of transportation** for all ages and classes alike. In fact, the popularity of cycling in Copenhagen can be quantified in the number of bicycles that are within the city

The **number of bicycles** in Copenhagen greatly outnumbers its inhabitants, "at the last tally, central Copenhagen counted **560,000 bikes, but only 519,000 people**" [8]. As the ridership percentage has increased every year, today 55 percent of residents get to work or school by bike in the central core of Copenhagen, and 37 percent from the greater Copenhagen area [9]. Astoundingly, "More people commute by bicycle in greater Copenhagen, population 1.8 million, than cycle to work in the entire United States, population 310 million"[10]. Copenhagen is singularly unique in its approach to **cycle track** systems, but luckily the rest of the world seems to be catching on.

There are three main reasons why cycling as a means of transit has been so successful in Denmark, and specifically Copenhagen: **cultural identity, local and national policy, and design.** The bicycle has long been a symbol of Danish life and a source of pride for its people. High taxation of gas, vehicle registration, and vehicle ownership have made it increasingly more expensive to own a car, while large government subsidies and investment in public transit systems have increased the quality of life for citizens to enjoy and utilize the city to the fullest extent. Careful attention to urban planning supplemented by annual surveys and circulation studies have encouraged some of the most innovative design solutions from world-class architects and planners.

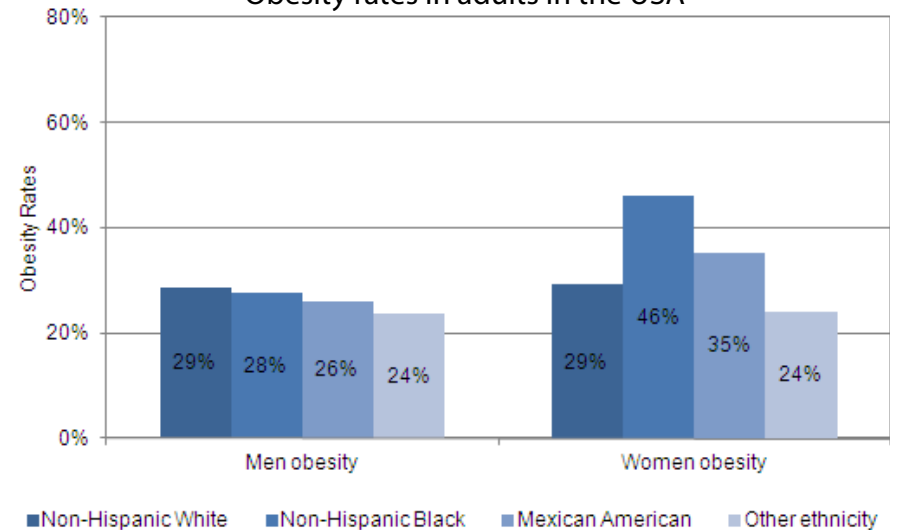
# Copenhagen

## Cultural Identity

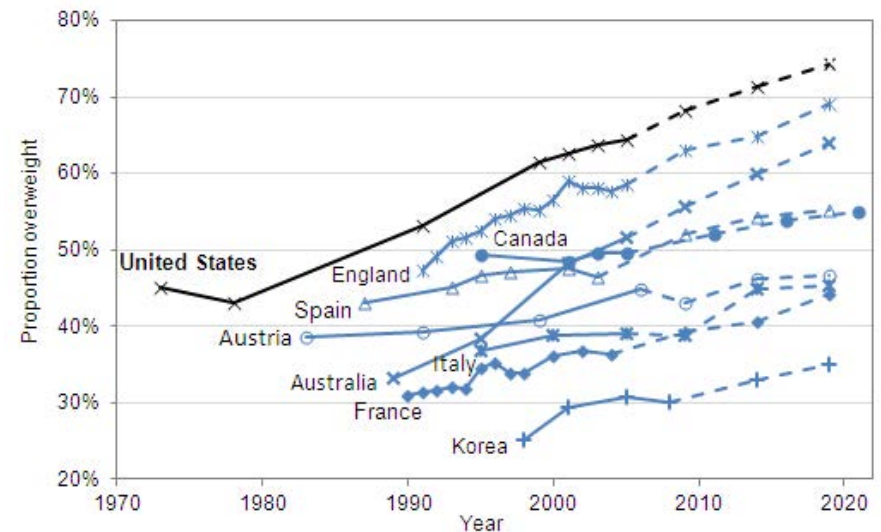
It is essential for a project to have a broad base of support and for the community to remain open to new ideas and initiatives and not oppose change. Bicycles have been a **part of Danish tradition** for well over a century, a utilized tool of everyday life in and outside of cities. Just as Americans instinctually use vehicles to get to a destination, Danes hop onto their bikes and head off. Danes, despite increased cost, are able to, "afford cars, but they choose bikes – **simple, economical, nonpolluting machines** that show no status and help keep people fit." The bike, more importantly, has become a **symbol of health** within the Danish culture.

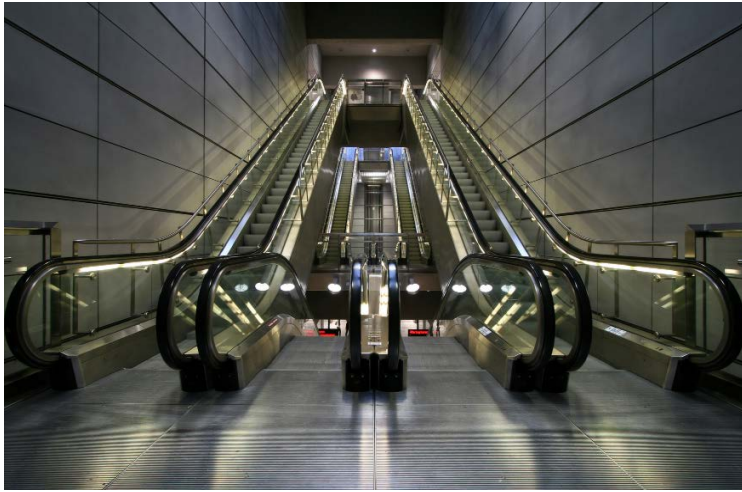
Ranked top three, the Netherlands, Denmark, and Germany have the largest distribution of bike share programs in Europe. As obesity has become a growing concern among many populations, including the United States, "it is not lost on observers that those three countries have among the **lowest obesity rates** in Europe [11]". The percentage of persons afflicted with obesity in Denmark is presently **one third of the number of citizens living with obesity in the United States**. This statistic indicates another possible correlation with the number of people who forgo commuting by car for commuting by bike on a daily basis. According to the city of Copenhagen, **26 percent of Copenhageners cycle because it is good for their overall health**, while an additional 12 percent cycle daily because, "it's a good way to start the day [12]". While cycling in Denmark was not made popular due solely to its health benefits, this appealing byproduct has increased cycling popularity throughout the country in the last decade.

Obesity rates in adults in the USA



Past and projected overweight rates





Copenhagen Metro



# Copenhagen

## *Local and National Policy*

The city of Copenhagen was able to facilitate an **increase in ridership** among cyclists within the city through several different policies and taxes. In Denmark there is a **180 percent tax on cars**, part of a series of taxes put into place to discourage people from driving and allowing the government to invest that money into less environmentally destructive modes of mass transport [13]. Investment not only in infrastructure for bicycles, but also in public transport including the Copenhagen metro system and regional train routes, have successfully **raised the bar for public transport**. The city's successes are highlighted in the fact that the system was deemed "The World's Best Metro" in 2008 [14].

In accidents, the presumption of **guilt is always on the driver**, who is considered to be the operator of a potentially lethal piece of heavy machinery [15]. Not only are **drivers taught** to check their side mirrors before taking any turn for oncoming cyclists, they are also taught to open car doors with their opposite hand, forcing them to turn their head and look behind them less they open their door on an unsuspecting cyclist [16].

Should it snow in winter, city policy mandates that snow be removed from the cycle tracks **before** it is cleared from the car lanes – with the exception of car lanes on the four largest roads, which are cleared at the same time as the cycle tracks [17].



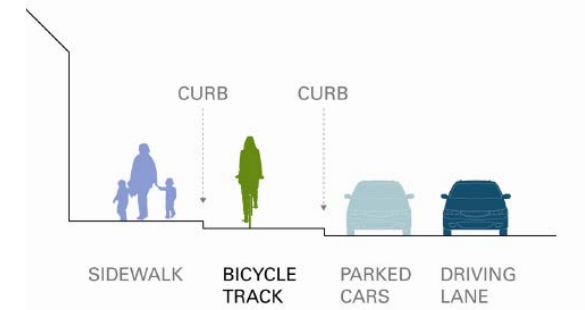
# Copenhagen

## Design

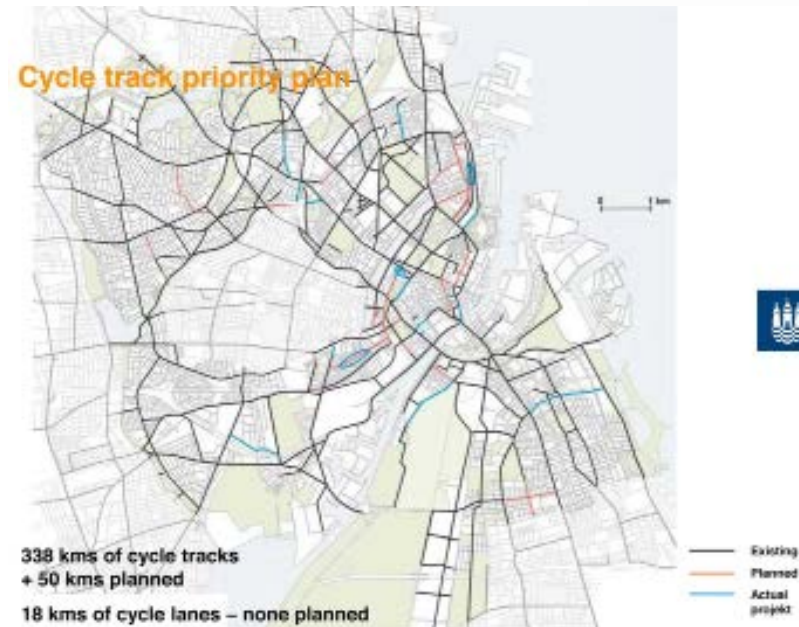
Public transit, highways, streets, and sidewalks make up the arterial system of a city, allowing people to **flow and circulate** from one destination to another. While public transit might bring a commuter from one stop to another stop there is the problem of **“first, last and toughest mile”** [18] of the route. This mile is the “extra time and hassle commuters face when they’re going from home to a transit station then from the station at the other end of the trip to a final destination [19].” The car’s unequalled convenience of delivering a person from point A to point B is juxtaposed with this inconvenient last mile dilemma that comes with traveling by public transit.

As bikes are able to deliver most effectively the first and last mile of a trip, the city of Copenhagen has designed its bike lanes and cycle tracks in a way that they provide the most direct route of transit. By centrally locating cycle tracks and connecting them directly to metro stops throughout the city, **cycle tracks have become the most direct route for travel**. Uniquely, “bike paths follow the most direct possible routes to downtown, while drivers are forced to detour along one-way streets” [20]. Prioritizing bike routes in Copenhagen has made cycling to and from a destination, “the preferred means of transport because it’s the quickest and easiest way to get around town” [21].

Countries such as Denmark and the Netherlands have adopted the use of “cycle tracks” – raised, designated bike lanes that run alongside traffic lanes. **Sidewalks, bike lanes, and vehicle lanes are positioned at different elevations**, which leaves each type of traveler feeling safe and secure. Another attempt to make cyclists, and their routes, more visible to drivers at these points of intersection, are **bold blue stripes** indicating paths to be traveled on by cyclists. There are also **separate traffic lights** strictly for cyclists, indicating when it is safe to cross an intersection, much like a signal at an American crosswalk.



Raised Cycle Track



Raised Cycle Track



# Amsterdam

## History

The bicycle was widely popular in the Netherlands, among all classes and ages, proceeding World War II. As the **average means of transport**, the bicycle was an essential tool to everyday life. During World War II and the German occupation, many of the country's bicycles were rounded up by the Nazi's and dismantled and stripped for their rubber and metal components [22]. Instead of reclaiming the healthy bicycle culture that existed before the war, in the years succeeding World War II, Dutch planners thought that accommodating the car would be the sole future of the traffic system, leaving the bicycle to take the back burner for the next decade.

By the early seventies, however, "**protests about car-centric policies** had become a regular feature in Amsterdam, Utrecht and other cities" [23]. Several events that took place in the early 1970s contributed to the revitalization of bicycle culture in the Netherlands. The Arab oil embargo in 1973 greatly impacted the growing car culture in the Netherlands, which was heavily reliant on foreign oil imports. The Dutch quickly imposed **car-free Sundays** to save on suddenly scarce oil" [24]. The oil embargo allowed the Dutch population to reconnect with its rich bicycle culture, and decreased its future oil vulnerability by slowly implementing **policy change in favor of the bicycle**.

Through the implementation of a new series of policies and demonstration projects, and with the help of pressure from the newly formed Dutch Bicyclists Union, the **national government reoriented its philosophy** [25]. This resulted in the encouragement of shorter trips within urban areas to be made by transit, bicycling, and walking.



# Amsterdam

The bicycle, a **decentralized method of transportation** that has become increasingly popular among the Dutch, holds a position of power within the imposed traffic system in the Netherlands. Unlike in the United States, “the most vulnerable road users – cyclists and pedestrians – are treated as the exalted kings of the Dutch road hierarchy” [26]. By **prioritizing the most vulnerable road users** over drivers, Dutch municipalities have empowered cyclists and pedestrians to make more varied and frequent trips on a daily basis. One crucial aspect of cycling in the Netherlands is the large percentage of people making trips via bike each day. A **critical mass of cyclists is needed** before vehicle drivers realize that they have to share the road [27].

Massive changes made to the traffic system in the 1990s and early 2000s, allowed the Netherlands to “**cut total traffic fatalities roughly in half** to 791 (per year) in 2007” [28]. Comparatively speaking the Netherlands boasts, “just under five deaths per hundred thousand people ... about a third of the US rate” [29]. The discrepancy between the motor vehicle fatality rates of each country accounts for several factors that are at play: education, political support and policy, and infrastructure. By “accepting the cyclist as a **normal traffic participant with equal rights** in the ‘50s and ‘60s,” [30] the Netherlands has successfully incorporated bike culture both socially and politically.

Perhaps one of the most crucial factors that allows Dutch society to cycle safely is the level of connectivity between cyclists and drivers. Most **motor vehicle drivers also cycle**, allowing them to predict typical behavior when encountering a cyclist on the road. Another important factor is the **integration of cycling lessons into the Dutch school curriculum**, teaching children and young adults how to properly share the roads and cycle lanes with other vehicles and cyclists alike [31]. A lack of proper bicycle and traffic law education for American cyclists is directly linked to an increased number of bicycle related fatalities [32]. As driver’s education is mandated in most states, it would make sense to **incorporate bicycle education into the required curriculum** in America as the number of cyclists increases each year.







# Amsterdam

## Design

Traffic experts in the Netherlands today frequently implement design concepts found in a report produced by CROW in 1993. CROW, an independent research organization focusing specifically in the field of infrastructure, public space, and traffic and transportation, published a design manual on cycling recommendations, the latest version of which was revised in 2006 [33]. This design manual introduced **five main requirements for bicycle-friendly infrastructure**, which can be seen in the infrastructure built and utilized throughout the city today. The main requirements include: **safety, direct routes, comfortable surfaces, attractive environments, and cohesion of routes**. Within these development guidelines, the improvement of traffic safety is the first of the five main requirements. One requirement is to create **direct short and rapid routes** from origin to destination to allow for efficient travel routes. Another is to **build comfortable surfaces** to ride on with generous space and little hindrance from other traffic participants. It is also important to **establish an attractive and socially safe environment** for cyclists, **free from air and noise pollution**, and **cohesion of logical routes** throughout cities and the countryside [34]. These requirements are applied to the entire network of bicycle routes as well as the facilities and intersections that are present in the overall infrastructure. Abiding by guidelines such as these, have made the cycling experience in Amsterdam unique and **completely user friendly**, as it is a system that incorporates multiple considerations.

The expansion of cycle tracks in the Netherlands may seem revolutionary and unattainable for some countries, but the Dutch too have bicycle lanes mixed in with motor vehicle traffic. Part of the roadway is **reserved for cyclists** and is clearly marked with red paint and bicycle symbols [35]. Perhaps the most important aspect of these lanes however, is that the **lanes hold legal status**. Vehicles may not stop or park within these marked lanes [36]. There are strict fines that come with the violation of these lanes and are heavily monitored by local police. Legal status is paramount to the success and safety of these cycle routes, and the **strict enforcement of the laws** that govern the roads in the Netherlands.



# Amsterdam

As the **popularity of cycling has increased** in the Netherlands over the last several decades, so has the number of bikes. Currently the number of bikes outnumbers the number of inhabitants that live in Amsterdam, which has become rising issue as a result of limited parking and bicycle storage infrastructure. Where are all the bikes stored when they are not being used, and where can they be stored safely? As the fear of theft and vandalism leads to a decrease in bicycle use, **good parking facilities are needed** to accommodate commuters throughout the city. Again referring to the guidelines published by CROW in 2001, it is essential for new residential and commercial projects to incorporate bicycle storage into their plans. Infrastructure built solely to house bicycles, and prevent bicycle pile-ups outside of main destinations like the central train station has been crucial to the **safety and prevention of stolen bikes**. Just like cars, there must be a safe, easily accessible and organized storage area for bikes or a decrease in use is inevitable [37].

The arguments for cycling as a primary means of transportation are overwhelming as it is a **sustainable option**, promotes a **healthy life style**, and produces **zero emissions**. Air pollution as well as noise pollution from bicycles is non-existent, and bicycles are both cheap to purchase and provide infrastructure for. Bicycles take up little space and are traffic efficient, enhancing urban traffic circulation and **providing more livability** to residential areas [38]. Most bicycle commuters in the Netherlands choose to bike because it is **the most convenient option** for them to get from one location to another. Like any other rational beings, the Dutch choose to cycle not necessarily because it is good for the environment or their health, but because it gets them where they need to be the fastest. The infrastructure and policy implemented in the Netherlands lends itself to the Dutch population, making cycling a **rational choice for commuting**. If similar infrastructure were to be implemented in the United States a paradigm shift would likely occur, changing our concept of travel completely.



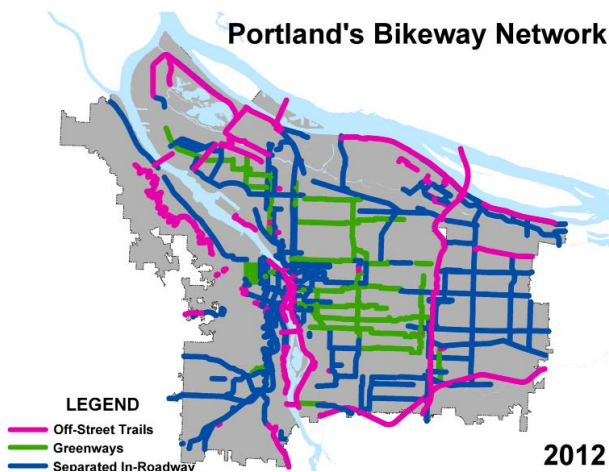
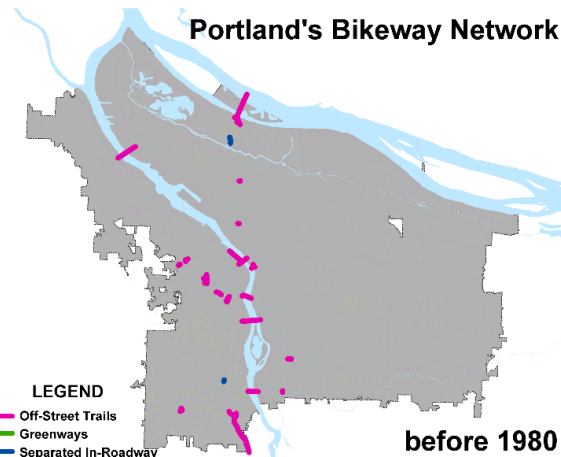


# Portland

## History and Culture

The city's unofficial mantra, "keep Portland weird" may be an anomaly in America, but one that is slowly being emulated by other cities across the nation. Over the last two decades, Portland has successfully transformed its public transportation infrastructure, making extensive changes to its light rail and streetcar systems as well as implementing a bikeway network. As cities around the country are rushing to imitate Portland's light rail system, its bicycle network is also attracting attention [39]. The bikeway network that has been **incorporated into the city's infrastructure** has been an inexpensive investment for the city, amounting to roughly less than \$100 million between 1993 and 2008 [40]. When compared to the \$143 million project estimated to rebuild, "just one of the city's freeway interchanges" [41] an entire bikeway network for 60 percent of the cost seems like a bargain. While Portland may not be Amsterdam, signs of change in the city are impossible to ignore. Cycling plays a **huge role in the subculture of Portland**. The 2007 United States Census' annual American Community Survey found that nearly **five percent of the city's commuters travel by bike** [42]. This estimate might seem low when compared with statistics collected from the Netherlands and Denmark, but for American cities, this number **signifies a paradigm shift** among commuters.

Before the city made its adaptations over the last several decades, city planners had the privilege of working with an already well laid out grid system of roads and streets, a good foundation or "**good bones**" as some might say. The city expanded around a pre-WWII transit network. The city was developed along arterials lined with small businesses, and the houses and apartments in the city's center and innermost suburbs were built within walking distance of streetcar lines [43]. Original districts were **designed around frequent transit service**, and reviving these older neighborhoods to their former transit glory was an ideal choice for the city. Portland's prized Pearl District was an area to be avoided less than two decades ago and is now a thriving business district, thanks in large part the streetcar trams that glide between the buildings. The new Portland streetcar system began running in 2001 and since then, \$3.5 billion in new development has been invested within a two-block radius of its route [44]. **Utilizing existing systems** and exploiting the city's "good bones" is a lesson that can be applied to other American cities with enough determination, foresight and local support.





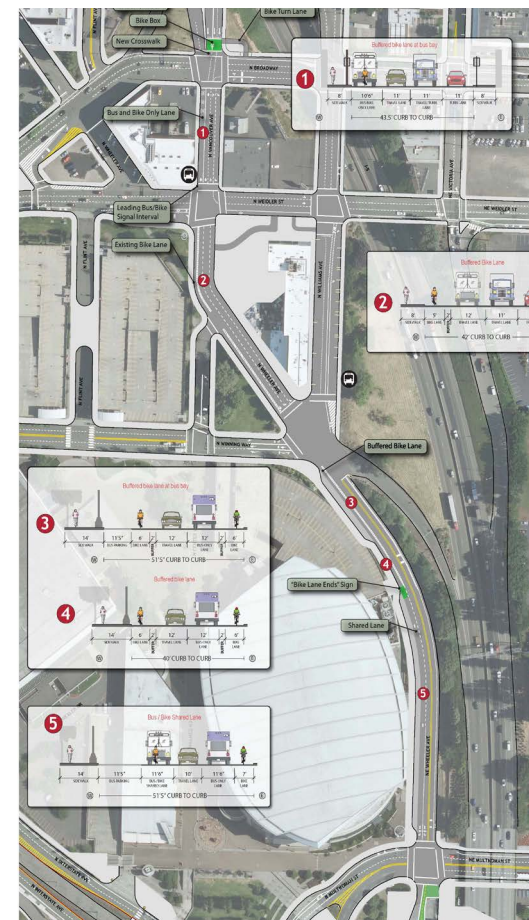
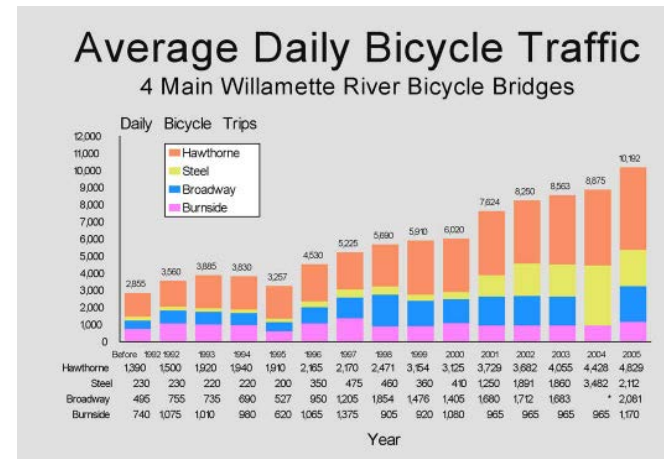
# Portland

Portland, through **changes in policy enforcement**, regulations, and infrastructure, was able to accommodate and encourage the city to cycle. In just over a decade Portland was able to triple the mileage of its bikeways and renovate most of the bridges over the Willamette River. The river runs east of the compact, thriving downtown area, allowing for a more extensive and safe path for cyclists to travel in order to reach the city center [45]. The city is covered with directional signs and pavement markers for riders and downtown signal lights are set at speeds between 12 and 18mph, which are slow enough for cyclists to keep up with traffic flow.

Long before Portland's bicycle movement began the state of Oregon adopted a law that required at least one percent of funding given to roads be spent on accommodating cyclists and pedestrians [46]. This bill is still in use today and is known as the **"Bicycle Bill"**. Though this may not seem like much, it has in fact remained one of the most powerful tools to be utilized by bike activists in Oregon. The money from the Bicycle Bill helped fund several projects as well as aid in the creation of a rudimentary system of bikeways in various parts of the state [47].

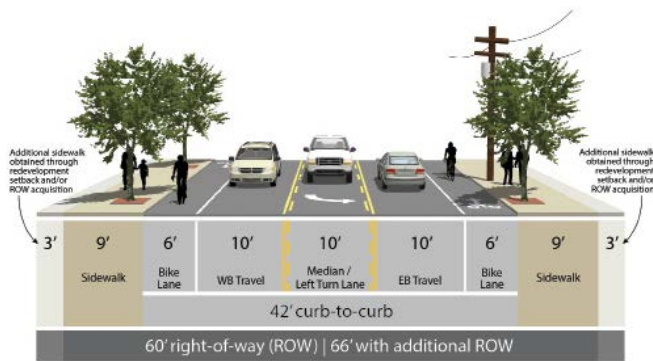
In 1975, the State legislature passed a land-use program requiring each city to draw an **urban growth boundary** around its fringe and direct new development inside of it [48]. Political leadership at the time **fervently embraced the policy**, pushing, "for a compact city that would maintain a strong, lively downtown and close-in middle-class neighborhoods" [49]. The urban growth boundary has enforced a restriction on the amount of development spread outside the city, forcing development to remain within the city's boundary.

Another upsurge began in the early 1990s with the establishment of the **"Bicycle Transportation Alliance"**, which emerged as local activists began to gather and discuss the city's bicycle related shortcomings. United States Congressman and former Portland Transportation Commissioner, **Earl Blumenauer**, was a strong bike advocate and was largely responsible for the push to draw up a **complete bicycle track master plan** for the city and stick to it [50]. **Mia Birk**, Blumenauer's chief engineer and advisor on the project, found ways not only to make notable changes in the infrastructure but also to change the culture of the city and ultimately **mainstream biking** as a form of transportation [51]. Finally in 1996, Birk was able to grow the bike network enough for the city to **adopt a master plan**, calling for a 630-mile system.





# Portland



The shift in attitude toward bike culture in Portland rapidly aided in the development of new infrastructure for cyclists and diminished support for vehicles. Four-lane streets with excess capacity were **downsized** to two lanes, one in each direction, with a turn lane in the middle to free up space for cyclists to share the road. These changes, "freed up room for bike lanes, slowed speeders and prevented congestion by giving motorists a save haven for left turns" [52]. **Blue painted lanes** signal to drivers to surrender the right of way when crossing over a bike lane, giving cyclists a non-physical barrier from motorists. The creation of quick thoroughfares called **bike boulevards** facilitate expedient travel for cyclists, and ultimately inconvenience vehicle traffic. In 1990, the city launched a large scale **traffic-calming project**, "that funneled traffic to two major commercial streets – Hawthorne and Division – and away from nearby residential streets" [53]. The creation of these commercial streets, inconvenient for vehicles and **quick thoroughfares for bikes**, not only positively affected the economic well being of the local businesses and restaurants, but also made the quiet neighboring streets highly sought after.

Economically speaking, cycling is the most cost **effective** and efficient way for the city to transport large quantities of people, even beating out ever-popular light rail systems. As a cheap investment to begin with, **bicycles are not demanding of the system**, leaving little to no wear on the pavement. Bicycles are favorable when compared with the many external negatives of transit systems, such as air pollution and traffic congestion. Transit buses pound and wear away pavement, destroying the roads for others and are in constant need of repair. Inefficient automobiles that move very few people relative to their mass, as well as high capacity transit systems, take a major investment of energy and materials and construction cost [54].

When gas prices began to spike in 2005, more and more city residents began using bicycles for shorter trips around the city. Cycling has, in large part, **attracted waves of younger generations** to the city and has also brought many lucrative events to the area such as "Bike Summer" [55] that also helped foster a sense of community among the city's riders. Bicycle related businesses began to crop up at the end of the 1990s and in a study conducted by the city in 2006 found that bicycle-related businesses were **generating \$63 million a year** [56].



# New York City

## History

In terms of cycling transit, New York City is an example of a city with **mixed successes and failures**. Despite the efforts made by New York City and Manhattan specifically, the development of cycling infrastructure has led to comparatively disappointing results. An increase in demand for designated bicycle lanes has spurred more development than has been seen in the past, but **without effective implementation** of safety regulations and cycling education for pedestrians, cyclists, and drivers, the city's progress has slowed. While marginal success such as the West Side Greenway has given activists reason to remain hopeful, in a city like New York, one success is not sufficient enough to spur change. It is going to take more than small initiatives and good faith efforts to change a metropolis heavily routed in the automotive industry.

A city long developed or "doomed" by one of its master planners, Robert Moses, **New York City was designed for cars** and cars alone. Responsible for the construction of the central arteries that traverse and segment the city, private automobiles were given free reign and flooded the city. The increased flow of automobiles in New York City, even to this day, has yet to subside. City trolley tracks were ripped up to improve traffic flow and vast low-density suburbs were developed, making mass transit less effective for the average city dweller. Though New York has arguably one of the best public transit systems in the country, its maximum capacities are stretched everyday while expansion of the system has remained relatively stagnant. The better half of the twentieth century was dedicated to **building more bridges and highways** with public funds to alleviate vehicle congestion within the city, but what it created, however, was **more congestion**. Communities fell victim to concrete wastelands and people were forced out of their homes and neighborhoods in order to build more highways. Vehicle **traffic is still a major concern within the city** and is the reason why many have, once again, turned to mass public transit to get them from point A to point B.





# New York City

One hopeful indicator, however, is a noticeable **shift in investment** as we enter the twenty-first century; public funds are once again being invested in public transit projects. While Manhattan may not be able to call itself a success, it is certainly making strong efforts in the right direction. As New York faces a **population increase of one million over the next twenty years**, congestion and efficiency have become the city's top priority. Currently roughly **95 percent of commuters get to Manhattan's business district by transit, bicycle, or on foot** and **45 percent of New Yorkers do not even own cars** [57]. The New York City Department of Transportation has created nearly **200 miles of bike lanes** over the last three years [58]. Despite these small changes there has been no major infrastructural change in an attempt to restrict the traffic flow into the city.

Roughly **750,000 vehicles enter the central business district of Manhattan each day**, thanks in large part to Robert Moses who ensured that almost every major highway in the area led to Manhattan [59]. Interestingly enough, about a fifth of the daily traffic is comprised of people who are simply just passing through. A large portion of the remaining drivers come from areas in Queens, Brooklyn, and Long Island that are poorly serviced by public transit. While many people think that the solution to inner city congestion is to build more infrastructure to accommodate and alleviate traffic, the opposite is true. **The more space you provide for vehicle traffic the more vehicles the space attracts.**

Janette Sadik-Khan, the commissioner of New York City's Department of Transportation from 2007-2013, pushed for **tolls** on all East River bridges under policy maker David Dinkins, but the policy was immediately side-lined [60]. Sadik-Khan again worked hard, under Mayor Bloomberg, to introduce a **charge for vehicles entering Manhattan**. Initially the New York City Council passed the legislation, but it was later defeated by the state legislature in Albany. Without an initiative to significantly reduce the amount of vehicle traffic within the city there will be little chance for alternative transportation and infrastructure to grow.







# New York City

In May 2013, Manhattan was introduced to a new citywide campaign called “Citi Bike.” The New York City Department of Transportation (DOT) first proposed the project in 2009, laying out a strategic plan to accelerate the **goal of doubling bicycle commuting** in a three-year period [61]. The DOT recognized that in New York City nearly **10% of auto trips are under a half-mile, 22% are less than one mile and 56% are less than three miles**, all distances that can easily be traversed by bicycle. The bike share program showed promising potential during the first week of operation, which saw over **65,000 rides with users accumulating over 200,000 miles** [62]. Despite the initial success and the current ongoing use of the program, there have been many problems that citizens of New York have not been able to look past.

Problems that have cropped up with the bike share system have been relatively small, and with further investment should not obstruct the system from progressing. Some objections that have surfaced have been conduct oriented – disdain for cyclists who do not obey by the rules of the road. Others complain that the **bikes are too heavy** and strain the lower back as one rides throughout the city, causing injury and tardiness to work. City sanitation workers have been inconvenienced, having to throw heavy trash bags up and over the bikes in order for service vehicles to receive them. Frequent users of the program often consist of tourists, who are either **inexperienced** or naturally out of place in the new environment [63]. The **volume** of the program is another problem as the number of Citi Bikes on the streets is so vast that the program’s employees are simply unable to keep up with reports of damaged bikes and broken gates [64]. Portland, Oregon based Alta Bike Share is the company responsible for the Citi Bike operations in New York, a small company that is struggling to keep up with the growing demands of the popular program. As **North America’s largest bike share system**, the Citi Bike system has seen more than **7 million trips and has roughly 100,000 annual subscribers** [65]. The small company has been unable to find a solution to the uneven flow of bikes that occurs between stations – an issue that requires the bikes to be redistributed manually, which quickly adds up in cost. The small, but far from fatal flaws with the system can easily be fixed with up-front investments that can be found through **expanded sponsorship**. If the problem cannot be easily resolved, however, New York City should seek a replacement for Alta.

## History

Founded in 1630 by Puritan colonists from England, the city of Boston has played a crucial role in American history. The city was **developed through an expansion of small immigrant neighborhoods**, which created winding streets and seemingly disjointed neighborhoods. This segmentation is an element of the city that can be cumbersome to navigate and headache-inducing to those who prefer the orderliness of a grid system. Though the city is not as easy to navigate as other cities, such as New York City, there are many parts of the city that exhibit intentional design and a great deal of care. Boston's Emerald Necklace, a six-mile stretch of green parkland, designed by Frederick Law Olmsted, is a shining example of city planning within Boston [66]. During the first half of the twentieth century, Boston saw enormous growth in public works projects including parks, hospitals, and roadways under the several mayoral terms of James Curley, which on more than one occasion brought the city to near bankruptcy [67]. Perhaps one of the most **defining moments for city planning in Boston**, however, was the construction of the **Central Artery** in 1959. The construction of the Central Artery and related projects has dramatically impacted the dynamic of the city and the livability of its residents.

The Central Artery was an **elevated six-lane highway** built to accommodate traffic flow in, out, and throughout the city, running through the center of downtown Boston. When the Central Artery opened in 1959, the expressway was able to **accommodate nearly 75,000 vehicles each day** [68]. By the early 1990s, however, the expressway was carrying upwards of **200,000 vehicles each day**, making it one of the most congested highways in the United States [69]. Stop and go traffic was estimated to be non-stop for more than 10 hours each day, **putting annual costs to motorists in wasted time and fuel at an estimated \$500 million annually** [70]. As the Central Artery ran straight through downtown Boston, it posed a **physical barrier** separating Boston's North End and Waterfront neighborhoods from downtown, restricting the economic viability of each area [71]. Concerned that congestion would only increase at the turn of the twenty-first century, the Massachusetts Turnpike Authority sought to find an **alternative solution** to the increasingly encumbered Central Artery.







## oston cycles

As city and state officials pursued sets of transportation policies that had extraordinarily high costs, the inception of what was later to be named the “Big Dig” was born in the 1980s [72]. The project itself was of a scale that had never been attempted before and remains the most expensive urban highway project in the history of the United States at a **cost of \$15 billion** [73]. There were two major components of the project that were central to facilitating a long-term solution in the new design to replace the Central Artery. The first step was to **replace the six-lane elevated highway with an eight-to-ten-lane underground expressway** directly beneath the existing infrastructure of the Central Artery. Upon the completion of underground highway, the old elevated artery would be demolished and the space would be reclaimed by the city as open space or used for modest development. The other central component of the “Big Dig” was to **extend the reach of the Massachusetts Turnpike (I-90)** to run through a tunnel beneath South Boston and Boston Harbor to Logan Airport. The end product has resulted in **decreased traffic congestion during peak hours** and a **12% reduction in citywide carbon monoxide levels** [74]. The “Big Dig” allowed for the **creation of over 45 parks and public plazas** throughout the city, as well as major shoreline restoration to the Charles River Basin [75]. A new tree-lined boulevard in Boston’s downtown corridor was also created, allowing access to the Greenway through several miles of new and refurbished sidewalks.

Critically analyzing the project, however, it is hard to ignore the overall cost of the project and the potential for that money to have been spent elsewhere. Other **alternative means of transportation** could have benefitted from a fraction of the money spent on the project, instead of a project geared toward privatized modes of transit. The highly popular subway systems in Boston are often both **underfunded and over-capacity** on a regular basis, serving the largest number of people for their main mode of transit. While the “Big Dig” diminished the problem of vehicle congestion within Boston, it **failed to discourage citizens from using privately owned vehicles** as a main means of transport. Overall, the United States’ most expensive urban highway project, seems like it could have had a little more “bang for its buck” had alternative means of transit been considered in the process.



## Design

Former Mayor of Boston, Thomas Menino, left a sizable **bicycle-centric legacy** behind him when he launched the “**Boston Bikes**” campaign in 2007. The program initiated a number of projects that started rapidly incorporating bicycles into the regular hustle and flow of the city’s streets. Not only has the program expanded the number of bikeable miles within the city, installed over **2,500 bicycle parking spaces** throughout the city over the last 5 years, but has also created an award that is given to businesses that encourage their employees to commute by bike [76]. Boston currently boasts a **bicycle network of 65 miles**, which lies mostly on the periphery of downtown Boston and neighboring boroughs [77]. “Boston Bikes,” a program overseen by the Boston Department of Transportation has set in motion a plan to **add 75 additional miles** to the existing network over the next five years and to have a total of 356 miles traversing the city in 30 years.

The proposed network of **bikeable miles** includes two distinct types: “primary routes” and “secondary routes” [78]. The **primary routes** have the ability to connect neighborhood centers, transit hubs, major employment centers, and institutional destinations together. These routes would traverse the farthest distance and have the capacity to carry the highest volumes of bicyclists [79]. The **secondary routes** would provide branching pathways from primary routes, bringing cyclists into neighborhoods and would provide access to local businesses. The secondary routes are key to the success of the program as it will take care of the “**first, last and toughest mile**” problem addressed earlier in this paper. The secondary routes will give cyclists direct access to schools, neighborhood stores as well as access to primary routes [80].

With the establishment of more direct and protected routes, Boston will surely see a **drastic increase in their citizen ridership** and hopefully an equally impressive decrease in carbon emissions. For the successful creation of a bikeable environment within an urban setting, planners will need to **pay attention to the smaller details** such as traffic lights, just as much as the large scale details such as network expansion. The incorporation of small scale and large-scale design will help the city of Boston become the most bikeable city in America.



## *Proposal: Lane Selection*

Safety is the crucial element that makes the construction of a cycling network a successful and viable transportation option, without which the project is a failure. There are several different types of bike lanes, of which **“conventional bike lanes”** are the most common in urban areas. Conventional bike lanes are designated traveling lanes that have **no physical barrier** separating cyclists from motorists [81]. Conventional lanes usually run in the same direction of traffic, placed in between parking spaces and the right-most lane of vehicle traffic.

Safety is increased with the construction of **“buffered bike lanes”** – conventional bike lanes paired with a designated **buffer space or physical barrier** that provide the cyclist more protection from vehicle traffic. Ideally, Boston would implement as many buffered lanes as possible, boosting the confidence riders have in the safety of each commute, while conventional lanes would be sufficient in areas that cannot accommodate buffered lanes.

To take bicycle infrastructure a step further, **“cycle tracks”** are safer than conventional or buffered bike lanes, but cost more in terms of construction and road space from vehicles. Cycle tracks are **physically separated from motor traffic and are distinct from sidewalks**. Cycle tracks are intended for the exclusive use of bicycles and are not vulnerable to traffic, pedestrians, and parked vehicles. Raised cycle tracks would provide the greatest distinction from vehicle traffic and would be a huge addition to the cycling infrastructure currently in Boston. Cycle tracks placed in highly congested areas throughout the city would **ease traffic flow and decrease overall congestion**. The physical separation from traffic, for both cyclists and drivers has the potential to make cycling a more appealing commute.



Conventional bike lane



Buffered bike lane



Raised Cycle Track





## *Proposal: Intersections*

Cyclists and pedestrians are **most vulnerable** to vehicle traffic when crossing intersections, so it is important for all road users to obey traffic laws and for intersections to be properly designed and well signed. Heightening the level of visibility between cyclists and drivers at intersections has the potential to diminish the number of accidents that occur when crossing.

Placing designated areas known as **“bike boxes”** – a painted waiting area at the head of traffic lanes – provides bicyclists with a safe and visible way to get ahead of traffic when the traffic light is red and all road users are at a stop [82].

Another important indicator to include at all major intersections that involves both bicycle and vehicle traffic is **cross markings that extend through the intersection**, connecting one side to another via a visible lane. Bicyclists are guided by these markings on a direct path through the intersection, and provides a clear distinction between intersecting paths [83].

**Median refuge islands** are also valuable protected spaces that help facilitate bicycle and pedestrian crossings. The median allows bicycles and pedestrians to **navigate only one direction of traffic at a time**. If the median is located in the middle of an intersection, however, depending on the orientation, it will obstruct the direct crossing of two parallel lanes, forcing only right turns. When placed at the head of a lane to restrict traffic flow, the median provides a perfect space for pedestrians and cyclists to cross safely [84].





### *Proposed: Signals*

Bicycle signals work effectively as traffic signals, taking authority away from the cyclists and ensuring that all people sharing the road are abiding by the same rules and regulations without taking matters into their own hands. Bicycle signals are the **most effective signal** to use at vehicle and bicycle intersections, usually located above walk signals for pedestrians. The bicycle signal is an electrically powered traffic control device that is **used to improve identified safety areas** of concern or operational problems involving bicycles at vehicle and pedestrians crossings [85]. Bicycle signals are imperative to the success of implementing bicycle lanes throughout the city as it ensures safety for all traffic participants at the most vulnerable part of their journey.

### *Proposed: Signing and Marking*

**Colored pavement** within bicycle lanes is essential for **increasing street presence** of bicycles when sharing lanes with vehicles and highlights predictable conflict areas on the road. The colored lanes not only help indicate to cyclists the limitations of their own route but also signal to drivers boundaries that should not be crossed unless absolutely necessary and with caution [86]. Shared bike lane markings reinforce the legitimacy of bicycle traffic on the street, and indicate the shared nature of the lane between bicycles and vehicles. **Way-finding signage** is also important to the success of urban bike routes, as they direct cyclists on the right path to their desired destination. A **comprehensive and uniform sign system** guides bicyclists along preferred bicycle routes to their ultimate destination in a safe manner using direct and efficient routes. Both signage and road marking are essential to directing cyclists where to go, and how to use the road in the safest way possible.



### *Safety: Bicycle Boulevards*

Most urban streets in the United States prioritize vehicles over any other road user, a design flaw that has left other travelers vulnerable and inconvenienced. Bicycle boulevards are streets with **low motorized traffic volumes** and speeds and are designed to **give cyclists priority over vehicle traffic**. Signs, pavement markings, and speed management are elements that are integrated in order to diminish and discourage motorized trips. Bicycle boulevards can also be improved through the **incorporation of vegetation** in its design; garden planters or trees enhance the physical environment of the street. Bicycle boulevards help maintain quieter streets that benefit residents and improve safety for road users and pedestrians alike.





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