Cyclism & Sustainable Urban Design Strategies to Increase Bicycle Ridership
Research Paper for Sustainable Urbanism – ARCH 507
Prof: Nico Larco, Associate Professor of Architecture
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Abstract

Cyclism as an ideology should be taken into serious consideration by every resident of Earth. Questioning current beliefs concerning urban planning will help educate human kind and biofuel the Sustainable Revolution. This research paper provides reasoning for why bicycles should be treated as the new means of primary transportation. On average bikes are two times more efficient than other primary means of travel, compared to bus, car, and walking. Bikes require substantially less space than the Single Occupancy Vehicle, or SOV (which this report will generally use as an opposing factor). The primary issue for increasing ridership is that a large percentage of the human population may be interested in biking, but concerned due to safety. Rightly so. In the United States riding a bike in the urban setting in not yet supported by current social culture. This social culture may only be altered by educating people, providing the infrastructure for bikes, and encouraging ridership as a primary goal aimed at a sustainable future. Some successful ways of increasing safe riding in the urban setting are repainting the streets for bike lanes, permanent infrastructure improvements, or implementing the most revolutionary urban retrofit the Multimodal Tri-Split (MTS). The MTS involves cutting dedicated motor vehicle streets to 1/3 existing conditions, and converting the other 2/3 into dedicated cycle and transit routes. This may only happen in conjunction with another currently socially unacceptable idea, urban densification. Altering cultural believes about SOVs will be a major hurtle. This research will be intended to convert all non-followers of the bi-cycled machine to *Cyclism*.

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Research

Cyclism, the act of riding a bicycle, is a new ideology. New, relative to human kind. Bicycles were invented in the 19th century[2], and have since continued to be a functional means of transportation. The bicycle has been cited as being the most efficient means of human transportation. In the rising Sustainability Revolution bikes have become even more popular as a cost effective, healthy, and socially acceptable way to travel. However, even though it has gained popularity, many types of potential cyclists are deterred by the dangers associated with taking to the streets with nothing but a helmet for protection. Once the information in this research paper has been discussed, it should become clear that increasing safety for ridership in urban environments should be a high priority for city planners. The focus of this research is to support increased ridership among urban dwellers, encourage reduced dependence on the motor vehicle as the primary means of transportation, and that the best way to support this culture shift is by generating compact development while implementing the Multimodal Tri-Split (MTS).

There are many benefits to riding a bicycle. Just like all things, there tends to be new levels of benefits and detriments depending on the intensity that they are practiced. Riding a bike is a healthy choice that can be functional, recreational, family friendly, fun, and serious. On the other hand, biking in a city may be dangerous. Failure to see cyclist and texting while driving can be significant dangers, for example. The National Safety Council determined that 26% of vehicle collisions in America were associated with texting (NSC, 2014). Other unexpected accidents that do not include a car may also deter a new rider, such as catching a tire in the railroad track of a street car. These are all dangers that can put a cyclist in the hospital, or worse. During the research for this Cyclism proposal, the author was hit by a car while riding on a completely normal route in

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[2] As recorded in the Oxford English Dictionary under "bike, n.2."

the streets of Portland (*Figure 6*); luckily there was no permanent physical damage. These things seem scary to a hesitant rider, a parent with children, and the general population. However, many of these dangers may be mitigated with sustainable urban planning. Part one of this research will show the sustainable and healthy reasons why choosing to bike is good, while proposing some means for creating positive cultural change. Part two will separate the population into four types of rider, and offer suggestions for how to get the 60% more willing. And part three will discuss urban planning and design strategies that have worked around the world, with some original proposals by the author. The basic point of this research will be to clearly state, to planners, designer, and citizens, that the best way to increase safe cyclism is to separate the bike from the motor vehicle. Existing conditions must be critically evaluated – even the ones that seem mundane. A new form of urban organization must come to the surface.

Part 1) Education: The Benefits of Cyclism and why it is Sustainable

Sustainable decisions pervade every aspect of human life in the 21st century (Popular Science, 2013). From BYOC (bringing your own cup) for coffee, to cities actively providing resources and information for recycling. And then there are the social pressures of simply turning off the lights when they are not in use. Additionally, with increased technology and measurement methods, the public has become more aware and educated about current pollution in major cities (see *Figure 1* and *Figure 2* in the Appendix). Climate change, as a result of human activity, has major influences on daily choices, whether or not the consumer is aware of the little leafy green label at the bottom of a cereal box, for example. So how is cyclism a sustainable choice? In what way are bicycles healthy for humans, and in what way may they affect the urban fabric?

Transportation vehicles are composed of materials such as petroleum (for plastics and rubber), various alloys and mechanical parts that move together. Some even incorporate animal skin – leather. Others use petroleum - an efficient and powerful, but polluting, energy source. Each of these materials require resources, refineries, and processes where raw materials are removed from the earth. This process can be very intensive, causing added pollution and chemical waste to our currently choking ecosystem. Comparing the weight assemblage of materials and parts of transportation vehicles, the bike is an optimal choice (*Figure 3*). What makes the bicycle *the* optimal choice however is its combined efficiency. Bikes have been cited as being the most energy efficient means of transportation ever created, with an efficiency between 89% and 99% depending on the user, gear, lubrication, quality of materials, and other factors. With almost the same effort as walking, a person may increase their speed of travel by four times, and their relative distance of travel to several miles, within the same amount of time. All by using the same intake of food nutrition that would normally be consumed anyway (Wilson D. G., 2004).

None of this should be shocking. Bikes are smaller than motorized vehicles, lighter, and only run on human power. *Vehicles* in this research proposal, will be used in reference to the type of travel, whether it be a bus, truck, car, motorcycle, bicycle, or the pedestrian (feet/wheelchair). It should be obvious that bikes consume far less raw resources than cars, and may help curb the graph in *Figure 2*. A wonderful image has been replicated around the internet that compares the amount of passengers in single-occupancy vehicles (SOVs) versus those same passengers outside of their car. *Figure 4* is the author's own illustrative interpretation that compares four means of travel. The image shows one bus on the left, which may carry 48 passengers (packed uncomfortably). Using the capacity of the bus as a base, all four vehicle modes were compared against each other. The most significant observation that may be made in *Figure 4* is that 48 SOVs require a significantly higher amount of area compared to the other vehicle modes. While calculating the ratios, each vehicle was measured in terms of its individual unit area, and its air buffer space (comfort zone). Realistically, pedestrians would not normally stand compressed against each other as they may standing in a crowded bus, so the pedestrian was given an area of 50 square feet buffer, for example. Surprisingly, the bus received the best ratio in terms of transportation type area usage efficiency. It should be made clear however, that this delineation does not take other critical factors into account such as turn radii, buffers from higher speeds, or actual usage patterns, but merely looked at a single instance. Anecdotally, the cars packed close together in *Figure 4* closely resemble reality during traffic jams on inner-city streets and even high-speed freeways. For about 50 million car owners in the U.S., this scene is not hard to visualize since it is a weekly occurrence (Langer, 2005).

SOVs are down-right space hogs. They occupy a larger amount of space, which adds to demands for more infrastructure, wider roads, and more space to park them. Planners and the urban dweller should consider the implications of using a car for personal individual use, as well as making accommodations for them in a city.

Education of a topic is the primary means for making a positive culture shift, as suggested by Nico Larco (Larco, 2014), Associate Professor of Architecture at the University of Oregon. Educating the public, and professionals is not an easy task however. It requires successful pamphlet design, appropriate email advertising, social networking, and a lot of capital investment in something that may not come with a direct return. Because of these reasons, and more, educating a culture on cyclism can be a monumental task. This is why leaders must rise up and take the charge to make change. But the best way to do this is with solid numbers, great success stories, and honest research. Even if that research does not work out as hoped every time, communicating the results is always the best decision. The best course of action then, is to question assumptions. *Figure 5* shows a graph that compares the efficiency values between a bus with 48 passengers, a car, bike, and pedestrian. This graph is one example of how powerful education can be in helping to communicate the reasons for choosing one vehicle over another. Leaders must step forward, take a risk, and provide solid ground to stand on that questions convention.

Figure 5-A is a spread sheet calculation, while *Figure 5-B* is its respective graph showing on average the bicycle is two times more efficient than all three other forms of travel. The red bar

indicates one travel trip (point A to B). The blue bars indicates the same calculation, but for the respective maximum vehicle usage - once their fuel/calories are expended. 'Efficiency' was a ratio output calculated by comparing each vehicle's energy usage, weight with passengers, passenger capacity, and average mile usage. In order to compare human energy and motor vehicle energy, gasoline was converted into a calorie value (ConvertUnits.com, 2014). Note that the car used in the graph was a highly efficient Toyota, Corolla, which is light weight and has high miles-per-gallon output at 32mph. This graph is significant, because it directly compares each travel mode against each other. This is a good example of how to encourage a culture change. When setting out to crunch the numbers, at first the end result may not be obvious. The author believed that the order of efficiency would start with the bus as the highest performer, then the car, followed by the pedestrian and then the bike as lowest. The results turned out to be a great representation of what value may come from questioning expectations, then communicating the results. Similar positive, unknown, or possible negative results may come from other scientific research that could help positively change the minds of an entire culture. The important education take away here is to question expected results, and that the bike is more efficient.

These results may help provide the educational opportunity to also show important facts. Specifically the goal is to educate the general public to comfortably densify into urban centers – centralization. It is clear that the SOV, and cars in general, use more space for the simple fact that the scale of a car is large. Cars requires structures, doorways, and lanes that are much larger than what a human or bike must fit through. Required safety provisions associated with car travel also increase these dimensions and demand for the infrastructure to support them. Reduced scale forms of travel means that developers may build closer to urban centers. Reduction of parking lots means more space devoted to fun and functional human endeavors. A return to less cars means a decrease in polluted air, quieter urban street environments, and more wholesome neighborhoods. The most impressive advantage of diminished motor vehicle usage is the preservation of the natural environment (*Figure 7*).

Although all of this sounds wonderful, there are many reasons why cyclism has not caught on the same as vehicular travel. In Portland, OR between 2005 and 2013, SOVs maintained a strong 69% average commuter use (Office of the City Auditor, 2013). Although during the economic downturn after 2008 there was a slight noticeable shift in vehicle use (*Figure 8*). Although this is not proven, there may be a correlation between economy and vehicle use. Notice on the chart that after 2008, use of transit and bicycles increased, while SOVs declined. Once the economy began taking a better turn, use of SOVs returned to the previous state. This may indicate that the general U.S. population is already aware of the economic advantage associated with bike and transit use, or that they were forced to stop using a car.

Education is the single most powerful strategy that humans possess in generating positive change. Observing, predicting, testing, interpreting, and communicating honestly is how everyone will discover all of the unmentioned sustainable reasons to become a cyclist. There are still hurtles for the individual to overcome however.

Part 2) Types of Cyclist: The 60%

In 2006, Roger Geller, and a group of other serious individuals, took the lead to determine types of cyclist in Portland (Geller, 2006). It should be made clear that Geller stated in his report that the data for which his information was based was not completely scientific research, and likely had flaws. This should not reduce the value of the report, as it brings up critical issues that may help planners make more informed decisions. The report was intended to communicate the potential percentage of population that may be willing to convert to cyclism. Geller's report broke down the population into four types of cyclist (*Figure 9*).

- <1% - Strong & Fearless
- 7% - Enthused & Confident
- 60% - Interested but Concerned
- 30% - No Way No How

There is a certain badge of honor that the Strong & Fearless may possess. Geller mentions that this type of rider may be defined as one of those crazy individuals who braves the treacherous West Burnside Road up into Hillside of Portland (*Figure 10*). A pleasant spring day drive through lush forested hills – a dangerous high speed and narrow corridor during a typical dark and rainy evening. Although bicycles are efficient, as mentioned earlier, the highest consistent speed that one may maintain uphill could be between 10 to 15 mph. Compare that to a motorist likely speeding at 50mph, and those daring individuals likely have more brushes with death than the overgrown shrubs that block the bike lanes.

Enthused & Confident is exactly what it sounds like. Even if these meager seven percent get hit by a car (yours truly), or fall during their ride, they are still likely to continue riding. They are comfortable riding just about anywhere and are likely to sell their personal vehicle in exchange for their two-wheeled mechanical companion. As planners, there are few provisions that must be made for these individuals, since they will ride anyway.

Then there are the *Interested but Concerned* taking the majority of 60%. Followed by the *No Way No How* at a reasonable 30%. The folks that planners and society should be most interested in are the *Interested but Concerned* (IbC). These folks include some kids, adults, and some elderly. These folks tend to be those who may or may not already be riding to work on a regular basis. Those who do not already may want to ride, but cannot get over the dangers associated with hitting the streets, or cars hitting bikes. The 60% likely already own bikes too, but stash them in the garage, right next the fishing poles and skis. They end up choosing to drive instead of ride, because there is a significant feeling of comfort, security, and convenience that come along in the driver's seat. Due to this perceived convenience over time streets have grown to be unsupportive of bikers as well, which has caused most of the concern.

Designers should focus on the IbC, because they are the folks who need support. These people must be reassured, and educated on the benefits that support a more sustainable compact urban form. Additionally, informing the IbC of subjective benefits can generate a positive outcome. As mentioned earlier, folks need to see incentives that directly affect them. This is not because they are selfish or needy though, it is simply that each individual has a busy schedule and wishes to feel good about their decisions. Which may be exactly the root of the challenge in this process of a culture change. The individual must consciously decide for themselves whether it is the right thing to do. Forcing people to change will not positively reinforce their attitude. Taking this into consideration, planners and designers may have little influence over the individual. What they can do is critically evaluate existing conditions, then ask 'what if?'

Part 3) Planning: How to Encourage Ridership

There are many aspects to riding a bike that must be discovered subjectively. Starting out as a new cyclist, one may not understand the minutia, or even think about what strange lessons await them. For example, a new cyclist may fail to consider that bikes, while they love to be ridden, also love to eat pant legs and shoe laces. This one may be learned early on as a child, but into adulthood this kind of small detail may be easily overlooked. This and many more problems are impossible to comprehend when an IbC citizen hops onto a bike for the first time. This is where urban planners may not have much influence. This type of educational opportunity must be taken up by leaders in the community, bike shop owners, and experienced cyclists. The web is a great place to find quick and easy tips for first-timers (Yeager, 2014).

But wait! Can planners do something about first time riders? Of course! Here is how: design better access routes for the new cyclists. The unfortunate hazard associated with getting onto a bike for the first time is that the 'newbie' is often tossed directly into traffic. This is analogous to a bird being pushed out of the nest in order to learn to fly. The cyclist may fly, or like the bird, hit the ground, a car, a bus, other cyclists, etc. Planning has the opportunity to set up design strategies that allow for a new rider to experience flying for the first time.

Urban planners have a tremendous influence over the form of city layout. It will not be long before every city starts making significant improvements to existing streets that encourage the IbC to start riding. Many new publications have been released recently on complete street design guides that show clearly how to provide accommodations for safer cyclable streets. The best is the *Urban Street Design Guide* (NACTO, 2013). No doubt, the brightly-colored green book is perfect for designers – the text impaired. Impaired by text because sometimes words just do not convey as much meaning as a single well-drawn image or photo. This book lays out many ways to create all levels of minor to intensive street renovation, and it does so with concise, easy-to-understand, imagery (and some text too).

The problem with this type of transformation – to transportation planning - is that the changes will take a long time to accomplish. In Portland, over the past decade, provisions in the code have made the current bike infrastructure a more comfortable place to ride. Those changes came to fruition by taking steps toward those goals. They had to occur incrementally over a long period of time due to budgetary constraints, willingness of the public and developers (Larco, 2014). For example, adding one bike lane to one side of one street in any city, even Portland, requires a monumental amount of administrative decision-making and design. These changes cannot occur over night as planners already know – so they are not who must be educated on this process. It is the public, who want bike lanes now, but are not willing to wait, who need convincing. They must be shown the goods, such as statistics, figures, and case studies from other successful places to see the benefits. Planners have control over this. By setting up a study to perform on their own city, generating values to interpret, and using that data to evaluate the existing condition, positive changes can be accommodated for.

Starting small, as suggested by NACTO, there are minor alterations to existing urban form that can start setting up the framework to support substantial change later. Two spectacular examples of small change now are 1) Paint / Interim Design (NACTO, 2013, p. 6), and 2) Street Seats (PBoT, 2013) (see *Figure 11*). There have been small interventions around the world where the municipality or small initiative groups proposed painting the streets or setting out furniture and planters temporarily to test their success. The painting example in *Figure 11* by NACTO does require planning and traffic considerations. However the cost is minimal while the results are substantial. As long as the density allows for such changes, these inexpensive solutions may be the catalyst that helps continue sparking further permanent changes to make biking more comfortable for everyone.

Street Seats are less about biking, and more about social space in the urban setting. This type of small-scale intervention may be extrapolated in other ways that do support increased ridership. It is the innovative thinking that must be drawn out from this precedent and applied in other ways. In particular, the Street Seat proposed that one parking space is less valuable than all of the potential people who will choose to sit there. Consider that one parking space may allow for a two-hour paid time. The cost and allowed time may range widely, but for this example let us say that parking space costs $3 for two hours. During a regular 6am to 6pm day, that parking space may be used at exactly two-hour increments, resulting in about $18 city profit. If that parking space is converted into a place to sit, eat, talk, drink coffee, or socialize, then its potential value is surely greater. This is a valuable example, because the similar rough logic may also be applied to biking. For example, if one lane of car parking was removed for a safer segment of bike turning lane, then not only does the space provide a higher level of safety for pedestrians, but it opens up accessibility to passing cyclists. Additionally noisy car traffic may be exchanged for the silent whirring of cyclists. Consider too that a cyclist has the ability to stop almost immediately in front of a shop in the city, lock their bike, then go inside for lunch, to buy some shoes, or meet a friend or client for business.

This latter point is much more challenging for an individual in a car who will need to search for a parking space. It was left intentionally general by using loose logic. This was for the fact that completely removing parking is not an option. As respectful designers and citizens, it is important to factor in more than just the dollars, but to consider as many humanizing qualities as possible. One point that must be remembered, and has not been mentioned till now, is to always consider those who cannot bike at all. Folks who requires a wheelchair, or other mobility assistance may require the use of a car. Provisions should always be made for these individuals.

This next proposal for increasing bicycle ridership in the urban setting is for new town development, or existing city urbanization. NACTO, again, is a superior guide for this as well. One point that is often hard to communicate to resistant community members and business owners has to do with what happens when less provisions are made for cars. There is typical confusion associated with reduction of vehicle traffic and increased public space provisions. It is logical to assume that by removing parking, for example, business will decline, or a street will become "dead." It makes sense that fewer places for people to park their car will equate to fewer patrons – simple logic. This is a potentially false assumption however, and one of those moments when questioning traditional logic can provide significant positive culture changes. One leader recently stepped up, with good data and research that went against traditional planning assumptions describing that with every 1000 square feet of office space, 1-3 parking spaces must be provided

(Shoup, 2005). Shoup pointed out that this planning provision had no basis founded in logic, the rule simply existed. He challenged it, and now as a result, developers have been able to devote less attention to parking, more attention to amenities, and compact design development.

Ready to question traditional logic some more? Okay, here we go! With good design, comes great amenities, lively spaces, and wholesome communities. Likewise, with compact design, comes bikeable neighborhoods, and neighbors to bike in them. Consider the distance suburban homes are from town centers (*Figure 12*). A lower percentage of residents are close to the center (because there is less area near the center), while the majority of them are far away. This means that walking, biking, and transit are out of the question due to shear distance. Transit service coverage area is tremendous, which means non-profitable routes. Spacing residents far apart leaves no room for anything except the car. Consider too, that arterial roads, are highly traveled by people in cars. These highly active arterial roads and peripheral streets translate into similar activity in compact urban settings – this is why: Take a look at *Figure 7* again for a moment. Consider the left image (suburbia) and how many people frequent the 12 possible street segments. If those same residents chose to move to a compact urban environment (city) depicted to the right, then all nine of them will frequent two possible street segments. This is significant information for business owners. The reason is that in the suburbia example, if a business owner set up shop on one of those blocks, then they might capture 0.75 patrons. If the owner moved to a corner, perhaps they would increase patronage to 0.81 people. If the same business owner set up on the ground level in the city then the chance receiving patronage is 4.5. If they set up on the corner, they would likely capture all nine residents. Whoa - Chaching! Logically too, the business owner would be charged a value premium for the respective spaces. However, with more frequent patronage, it becomes more feasible to maintain a business.

In the suburban setting, biking is almost impossible other than for recreation. However, when the same amount of tenants and residents are moved to a compact neighborhood setting, the amount of available amenities within a short distance increase substantially. With closer amenities (jobs, retail, etc) streets designed to support bicycles become feasible since everything is within a few mile radius. Questioning conventional thought helps urban bike planning. This is because when cities investigate existing conditions, solutions to problems are much easier to resolve. Planning to densify, not only creates sustainable neighborhoods, but biking becomes viable as a primary means of transport. Consider the flip-side too. If in the future, bicycle riding is taken up to 69% of urban dwellers, and traffic jams of bikes result, then what? Bike traffic jams would likely be just as aggravating as are car jams. To counter this though – and somewhat anecdotal – have you seen how sexy a cyclist is? One thing SOVs do very well, is provide a steel exoskeleton between users. In this technological revolution, and with increasing lack of direct human interface, people must take more opportunities to experience each other. So now think again about what it would be like to get stuck in bike traffic, next to a trim, healthy, confident rider like yourself. With a more compact urban form, suggesting to a nearby fit rider to stop for a health smoothie may be less than a blocks ride ahead.

The final proposition that this research will present, to increase ridership from an urban planning approach, requires planning on a massive urban scale. The Multimodal Tri-Split (MTS), *Figure 14-A*. In a recent design project, the Lloyd District of Portland, OR was approached with urban design strategies to improve the existing fabric. The Lloyd District is littered with vast expanses of parking lots, little public space, and parking garages. Some high-rises poke the sky, but mostly low-rise single tenant buildings fill the landscape with inefficient use. Currently the Lloyd District is fortunate to be located between residential and Downtown Portland, which gives it some vitality. If this was not the case however, it would not be the same. The MTS proposition is intended to cut down the existing streets for cars to 1/3 current conditions. *Figure 14-B* delineates three new street types. One of them may appear to be very normal, which is the VP Route – practically a typical street. However the VP route incorporates parallel parking on only one side with a bulb-out, and street furniture on the other (to provide a level of safety for pedestrians). The TBP Route is primarily transit only. Then the CP Route is made to be a safe expanse of pedestrian and bike right-of-ways. This proposition may seem to be at first a wild idea.

Consider *Figure 15*, which depicts each new MTS street type separately. Also take note of the typical grid block pattern. In many cities around the world, this plan would be more difficult to organize, since some urban forms are not rectilinear. The typical Portland block size is 200 foot square, as shown in the MTS plan. This block size is unusually small, as many worldly cities actually have larger blocks. For example, in Manhattan the standard block size is 260 by 900 feet (Google, Inc., 2014). This reduction of car dedicated roads on the existing Portland grid would not be a significant detraction from the norm. However the distinction is that every other street becomes a cycle and pedestrian dedicated path, with transit dedicated lines within the average walkable distance of ¼ mile. This new street design would support the safe streets that *Interested but Concerned* (IbC) bicycle riders desire.

The MTS street conversion would only be possible however with a more dense urban fabric plan. The qualities IbC riders would find in this new plan, would be primarily in the separated street use. Parents would feel comfortable with their children riding next to them without the fear of a car driving three feet away. New cyclists would not need to battle traffic during their first rendezvous with a car failing to use their blinker. Texting auto drivers would injure less cyclists. The din of noise from constant car travel would be reduced. Less intensely-used infrastructure maintenance on the CP Routes would mean more capital municipality investment in other important aspects of the community, such as education, planning, and design. Best of all, imagine the massive leap for mankind toward a sustainable urban future where bicycle ridership is up at 69% or higher.

Conclusions

The ultimate collective goal of planners, designers, citizens, and every human, should be sustainable compact urban dwelling. Questioning convention and educating people will be the keys that unlock potential in the minds of every person to put their hands on the handlebars for the first time. Readers should even question the propositions made in this research paper, for the goal of making the world a better place. Raising bicycle ridership in the urban setting will bring humans leaps and bounds closer to a sustainable future. Although maintaining a network of motor vehicle access will always be important, reducing dependence on the SOV alone will reduce carbon emissions substantially. The only way to make this vision work will be to encourage communities to grow closer together into compact forms that support the Multimodal Tri-Split (MTS). These compact forms provide all the amenities that people desire, close by, at biking distance. The increase of bicycle ridership will raise municipal investment capability in human capital – an important humanizing strategy – simply through shear reduced mass and intense use of infrastructure. All of this will be possible when each person converts to *Cyclism*.

Appendix

Figure 1. (Bobak, 2005)
On the left, Beijing in 2005 after two days of rain. Right, smog on a normal sunny day.

Figure 2. (Boden & Andres, 2008)

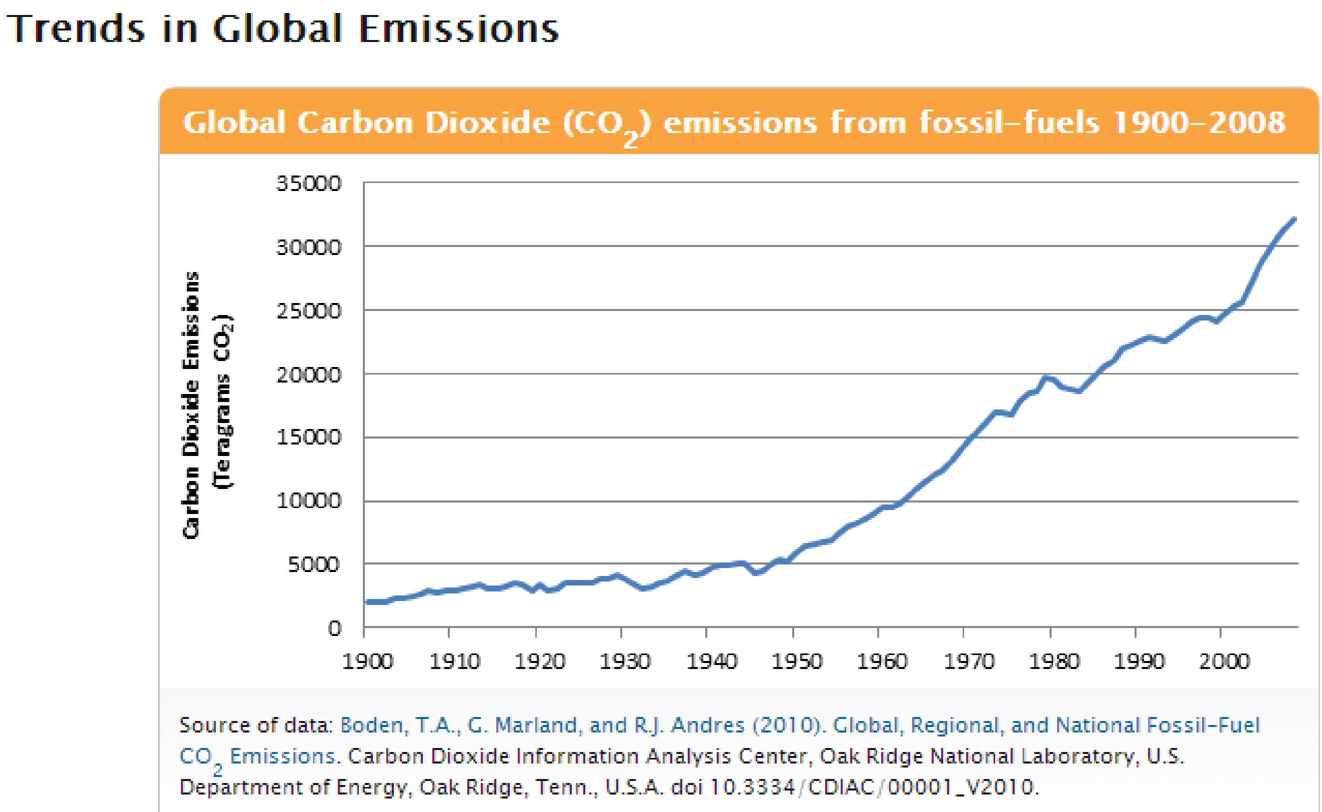


Figure 3.
Data collected from Toyota and Trimet, and by weighing the author's bicycle and skateboard.

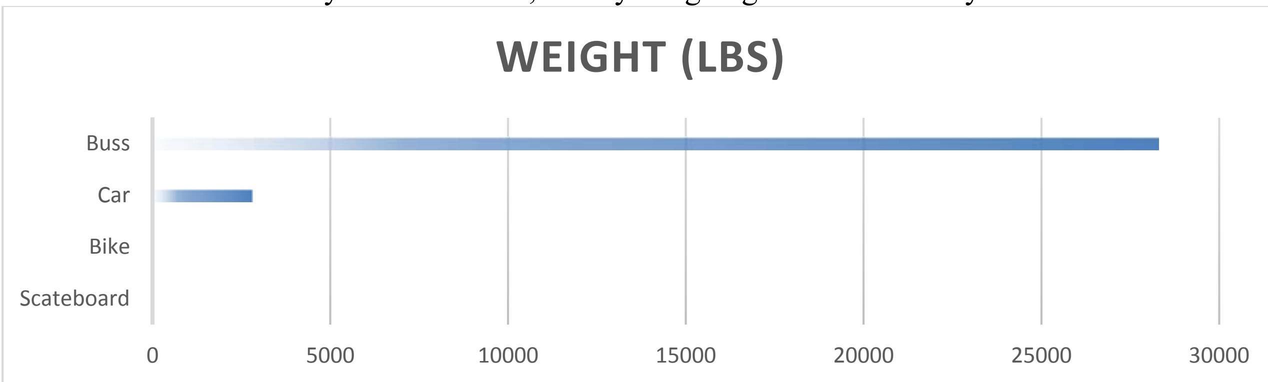


Figure 4.
Vehicle Mode Comparison for 48 People (higher value means poor performance)

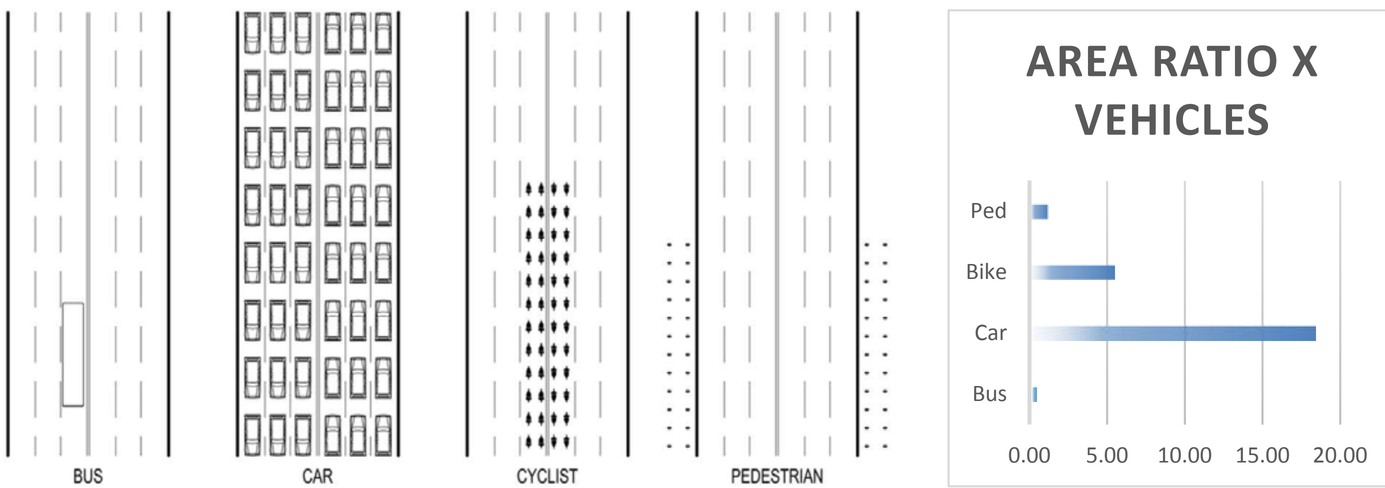


Figure 5-A.
Vehicle Mode Travel Efficiency Comparison (higher values are more efficient)

Vehicle Efficiency Comparison - One Trip					
	Bus	Car	Bike	Ped	Comments
Weight Lbs	28,300	2,750	28	170	Weight of vehicle
Pessengers	48	1	1	1	Typical passenger usage
Lbs w/ 48 People	36,460	140,160	9,504	8,160	Weight of Vehicles for 48 people
Fuel capacity (gal)	100	13	0.063	0.063	Vehicle gasoline carrying capacity
Calories	3,177,596	413,087	2,000	2,000	1 gallon = 31,775.96 calories
Cal x 48	3,177,596	19,828,197	96,000	96,000	Calories for 48 people
Lbs/Cal ratio (1)	0.008906105	0.006657186	0.014	0.085	Ratio of weight per calories for each vehicle
Lbs/Cal ratio (48)	0.011474084	0.007068721	0.099	0.085	Ratio of weight per calories for 48 vehicles
	One Trip BMT	One Trip VMT	One trip Daily BMT	One trip PMT	
Avg Travel Distance (mi)	12	12	5	1	Typical travel distance per vehicle type for a typical one-way trip.
Travel Efficiency Value	0.138	0.085	0.495	0.085	Efficiency value for each type of vehicle and its corresponding typical travel distance. A higher value is better.

Figure 5-B.

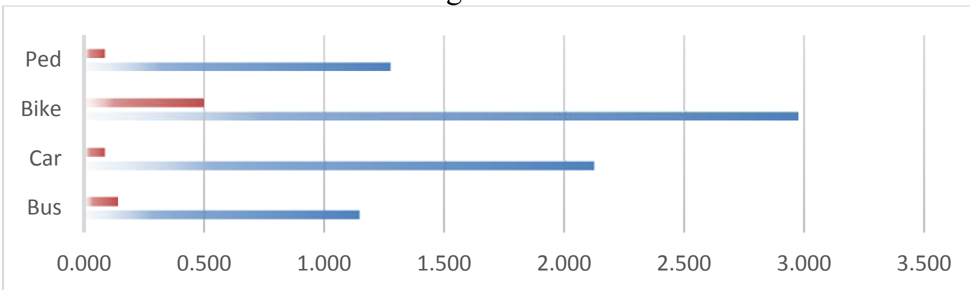


Figure 6.
The author's recent experience with a car and bike love triangle (Wilson R. H., 1987-2014)

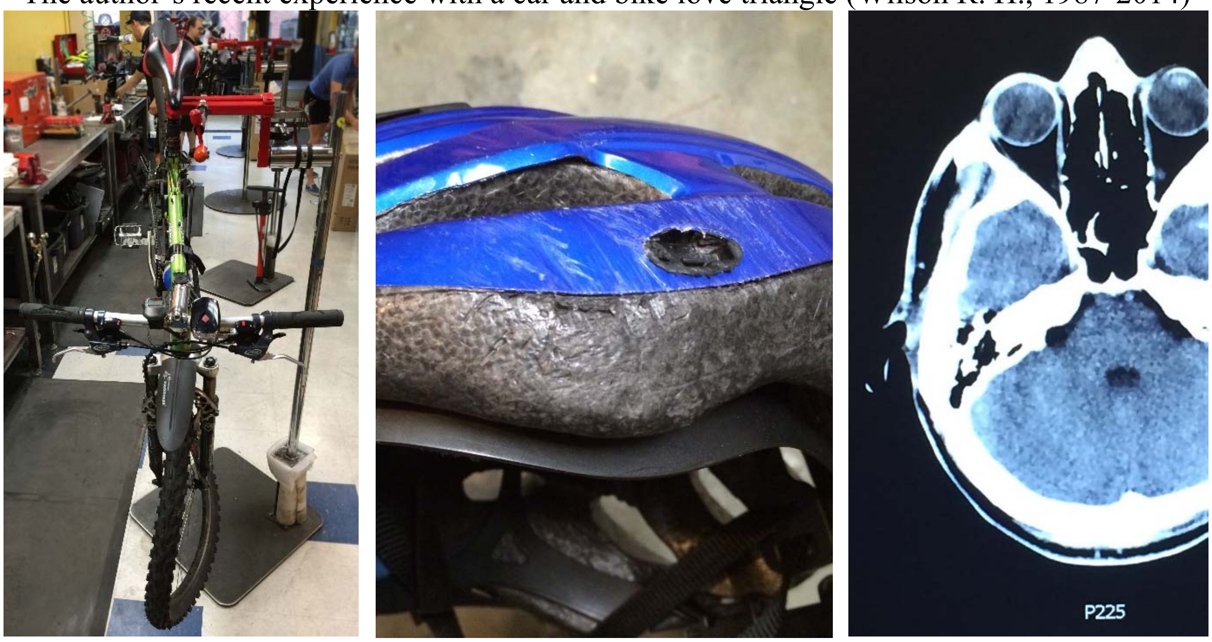


Figure 7.
The obvious value of living together (Wilson R. H., 1987-2014).

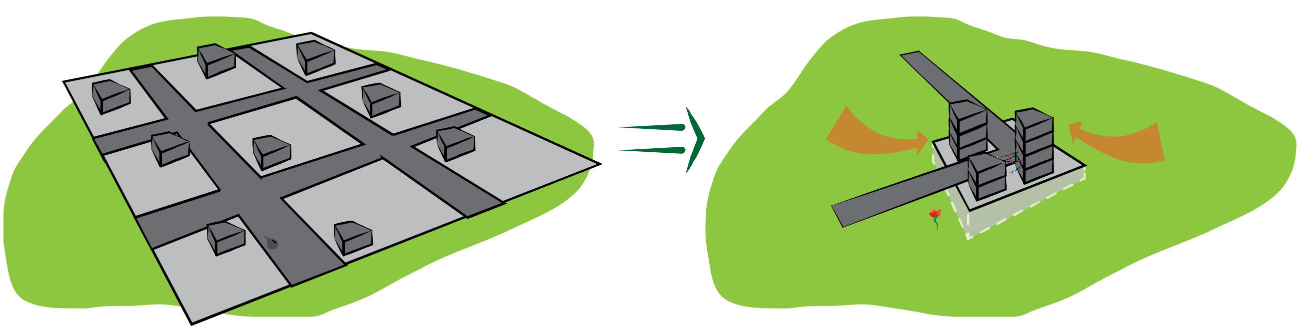


Figure 8.
Travel Type Usage in Portand, OR 2005-2013 (Office of the City Auditor, 2013)
Graphics (Wilson R. H., 1987-2014)

Primary Transportation Data - City of Portland Auditor

	SOV	Carpool	Transit	Walk	Bike	Other
2005	71%	8%	10%	3%	4%	4%
2006	72%	8%	8%	3%	5%	4%
2007	70%	7%	10%	4%	6%	3%
2008	65%	8%	11%	4%	8%	4%
2009	68%	7%	10%	5%	7%	3%
2010	66%	14%	6%	7%	4%	3%
2011	67%	13%	7%	7%	5%	1%
2012	68%	12%	6%	7%	4%	3%
2013	70%	11%	5%	7%	4%	3%
Average	69%	10%	8%	5%	5%	3%

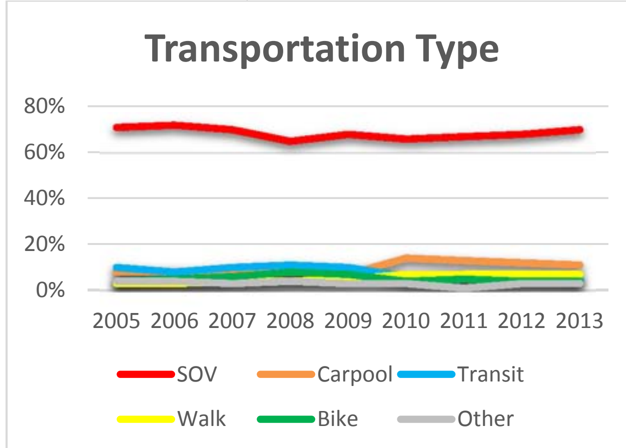


Figure 9.
Four Types of Cyclist in Portland (Geller, 2006)

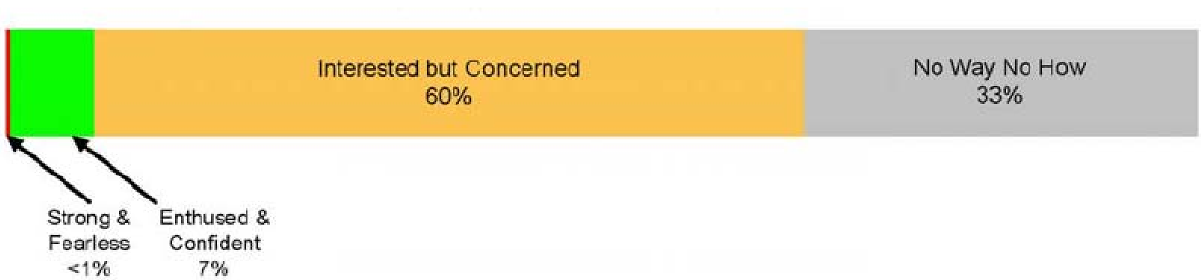


Figure 10.
W Burnside Rd, Portland, OR (Google, Inc., 2014)

Figure 11.
Interim Redesign (NACTO, 2013, p. 10 & 11) & Street Seats (PBoT, 2013)

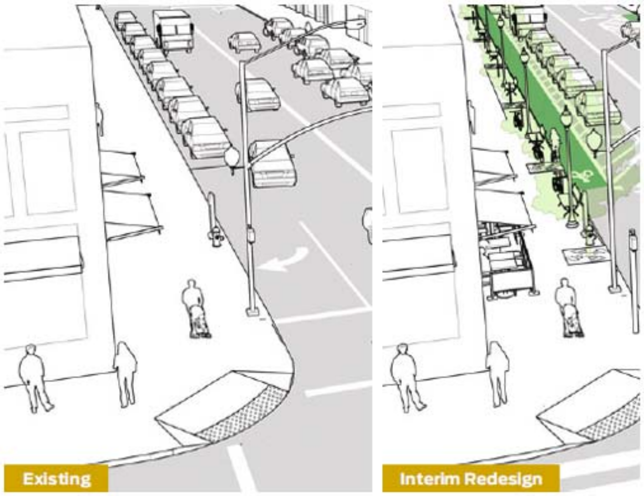


Figure 12.
Suburbia to Town Center (Wilson R. H., 1987-2014)

Figure 13.
Rendering of the Lloyd District Plan, Portland, OR (Wilson R. H., 1987-2014)

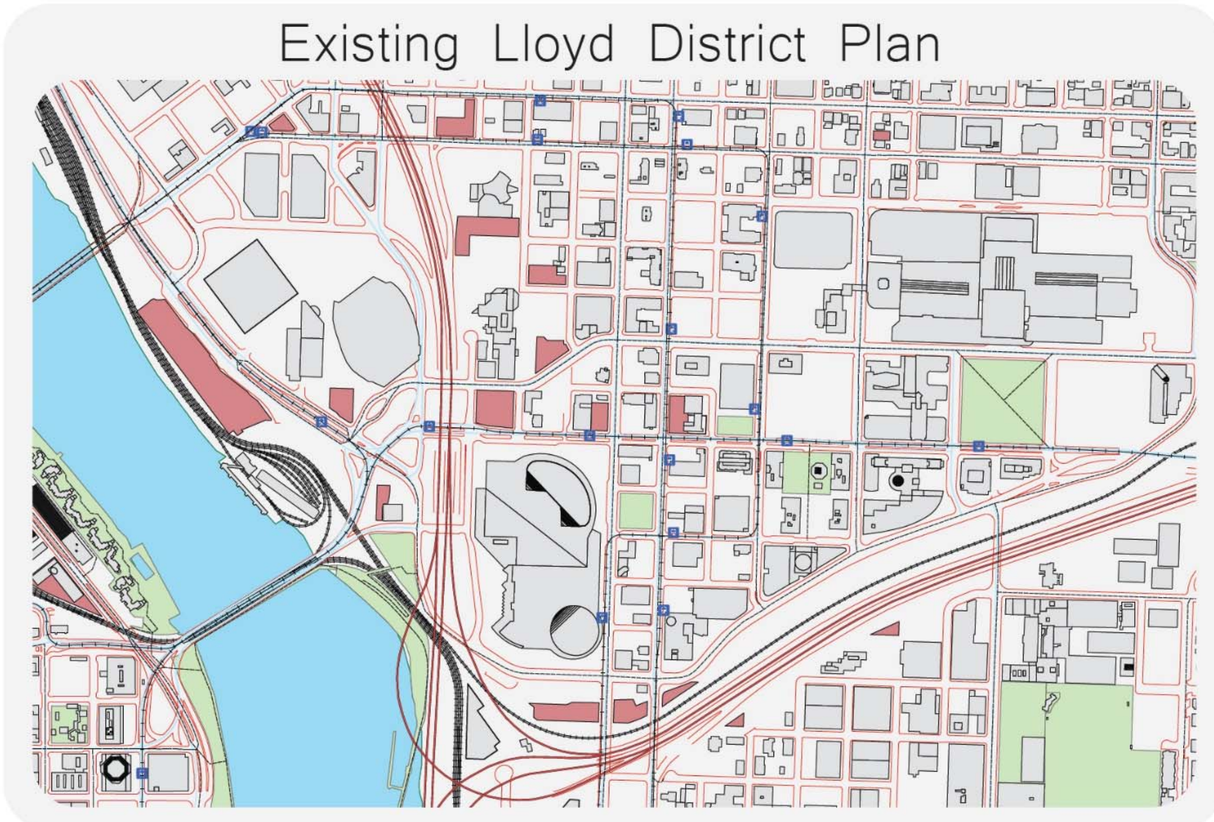


Figure 14-A.
Multimodal Tri-Split (MTS) (Wilson R. H., 1987-2014)

Figure 14-B.
Proposed TBP, CP, and VP MTS Routes (Wilson R. H., 1987-2014)

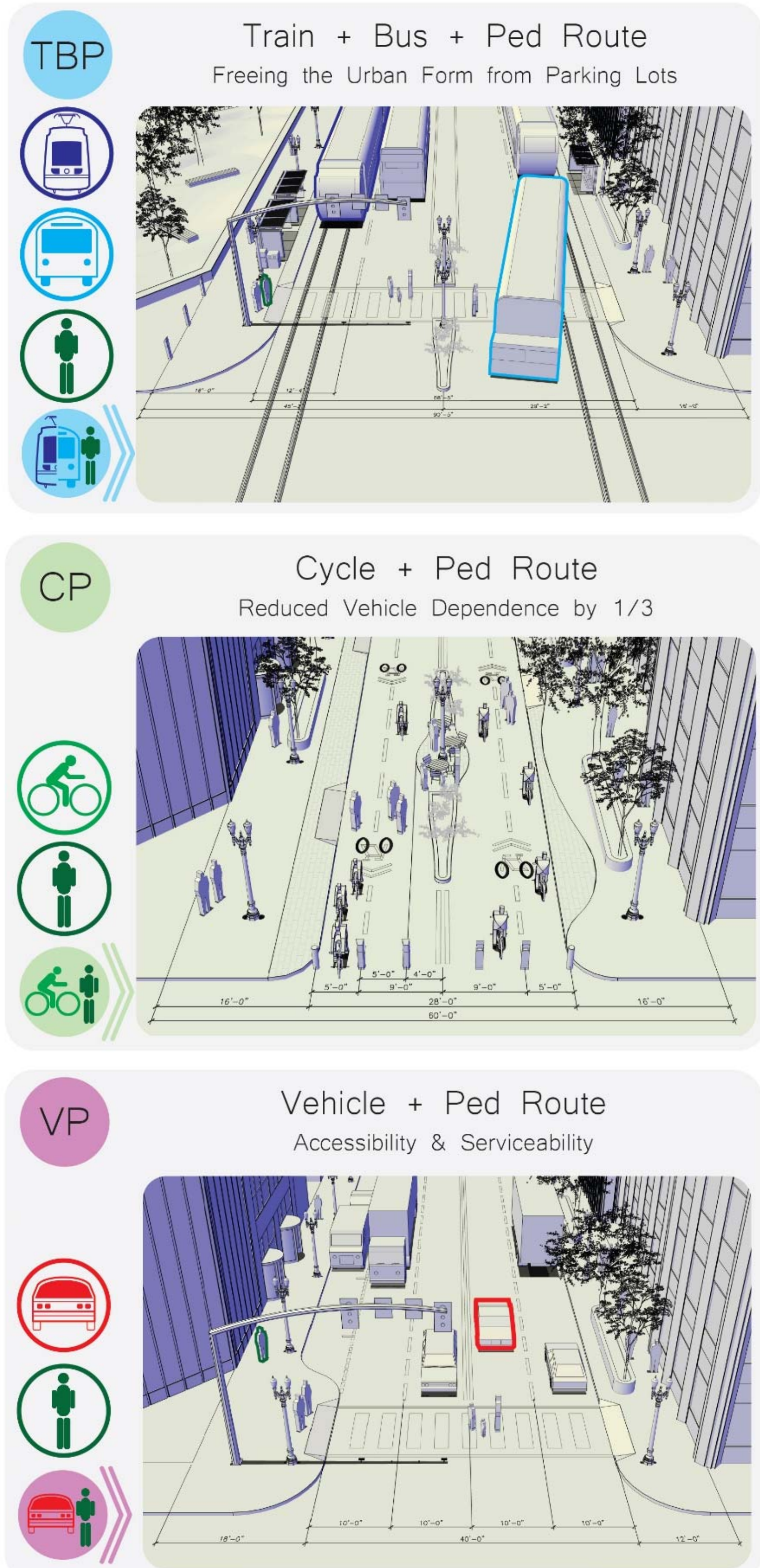
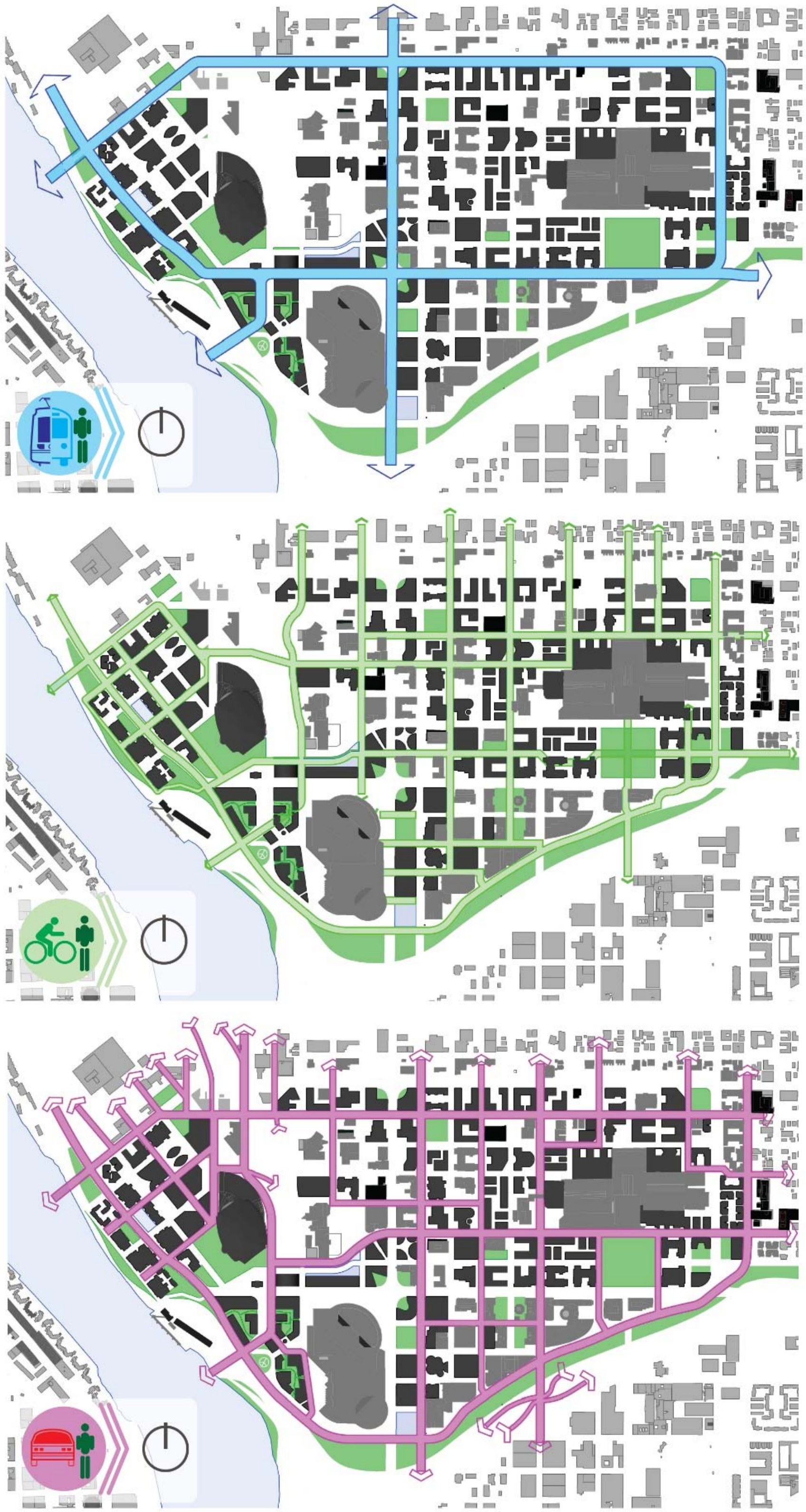


Figure 15.
Organization of the Three MTS Routes (Wilson R. H., 1987-2014)



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