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Bicycling Toward Sustainability: Built Environment and Policy Recommendations to Grow the Mode Share at UT Austin

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Bicycling Toward Sustainability: Built Environment and Policy Recommendations to Grow the Mode Share at UT Austin

by

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Report

Presented to the Faculty of the Graduate School
of the University of Texas at Austin
in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science in Community and Regional Planning

The University of Texas at Austin
August 2016

Bicycling Toward Sustainability: Built Environment and Policy Recommendations to Grow the Mode Share at UT Austin

by

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The University of Texas at Austin, 2016
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Despite significant progress in prioritizing sustainability goals on campus, the University of Texas at Austin is finding it increasingly difficult each semester to ensure its transportation system is efficient and thriving in a sustainable way. In light of this, I have conducted a research project that sought to evaluate the state of the bicycling community on campus and developed recommendations to benefit bicycling and sustainability. This topic is important because transportation is a significant factor in determining a community's overall sustainability. For this study, I carried out my work in three activity phases. In Phase I, I evaluated the current bicycle infrastructure, policies, and facilities on campus. Phase II involved conducting research on actual bike commuting traffic through surveys, manual bicyclist counting, pressurized tube counters, and a smart phone application in order to gain deeper understanding of usage and preferences for bicyclists on campus. Phase III entailed the analysis of Phase I and Phase II results to compose recommendations for specific actions to increase bike-commuting rates on campus through safe and efficient means. My main findings in this study are that there are many factors influencing peoples' decisions to ride bikes to campus, and for the University to significantly grow the bicycle mode share and therefore benefit sustainability, a multi-pronged "carrot and stick" approach should be leveraged and tailored specifically to the community context and the core of the campus.

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CHAPTER 1:

1.1 PROJECT INTRODUCTION:

Cities around the world are receiving much publicity as they seek to mitigate unnecessary negative environmental externalities and create communities that are more sustainable. The University of Texas at Austin is no different with its creation of the President's Sustainability Steering Committee, Campus Sustainability Policy, and the on-going efforts of the Office of Sustainability. UT Austin is seeking to be a sustainable community by designing policies that, when possible, should reduce life cycle costs, restore or maintain the functioning of natural systems, and enhance human wellbeing. The UT Austin Campus Sustainability Policy is multifaceted and details principles for a comprehensive approach to sustainability for academics, operations, campus planning, administration, outreach, and implementation.[1]

With the growing enrollment and population near the University's Central Austin campus, it is becoming increasingly difficult to ensure the transportation system is efficient and thriving in a sustainable way. This is important because transport is one of the primary factors that impacts sustainability. In light of this, sustainable transportation alternatives, like bicycling, should be prioritized due to their immense environmental, social, and economic value.

For this report, I executed a research project that evaluated the state of the bicycling community on campus and developed appropriate solutions that could be implemented to benefit bicycling and sustainability. I carried out the project in three activity phases with distinct facets and deliverables. In Phase I, I evaluated the current bicycle infrastructure, policies, and facilities on campus. Phase II involved conducting research on actual bike commuting traffic through surveys, manual bicyclist counting, pressurized tube counters, and a smart phone application in order to gain deeper understanding of usage and preferences for bicyclists on campus. Phase III entailed the analysis of Phase I and Phase II results to compose recommendations for specific actions to increase bike-commuting rates on campus through safe and efficient means.

1.2 Context

While bicycle commuting at UT Austin enjoys support from campus operations, an enthusiastic student body, and peripheral investments from the City of Austin, its efficiency and support infrastructure need to be updated to match changing campus conditions, transport patterns, and UT community member lifestyles. With the planned opening of the Dell Medical School in 2016, the University's physical footprint is also changing, as is the climate of Austin.[2]

According to the American Lung Association, UT Austin's Travis County received an ozone grade of *D* in 2014.[3] As Austin and Travis County continue to grow with more and more people moving to the Central Texas region, the increase in vehicles emitting pollution into the atmosphere will continue to strain the quality of the air we breathe. However, adopting alternative transportation options like bicycling can greatly benefit this situation. *Every 100 miles that are bicycled instead of driven displaces roughly 97 pounds of carbon dioxide*.[4] So by encouraging the replacement of car trips with bicycle trips, the University can help alleviate some of the strain on air quality in Central Texas. Moreover, the benefits associated with bicycling impact more than just the environment. Bicycling for transportation can also enhance human wellbeing by contributing to the reduction of stress[5] and to better overall health.[6, 7] Given its regional and national influence, it's important that the University lead the charge for creating a more sustainable and dynamic community.

1.3 Research Approach:

In seeking to understand the state of the community, research was first undertaken to review the literature regarding bicycling and its correlative effects on communities. A variety of types of literature were reviewed including academic journal articles, academic essays, mainstream media articles, and books relevant to sustainability and bicycle transportation planning. I also undertook assessments of campus infrastructure in person. Finally, a comprehensive evaluation was completed of University policies and documents regarding sustainability, transportation, and the built environment.

CHAPTER 2:

2.1 LITERATURE REVIEW:

As mentioned in the introduction, many communities around the world are taking initiative to envision creative and innovative ways of making communities more sustainable on a broad scale. Transportation, accounting for roughly 14% of global greenhouse gas emissions,[8] is one of the key areas on which many communities are focusing in order to realize breakthroughs. In this process, research has shown that active transportation, like bicycling, has proven to be a serious transportation mode that can serve both large and small communities with substantial sustainability benefits.[9] The majority of published research on bicycling for transport comes from academia and focuses on the actions taken that have made successful bicycling communities. John Pucher and Ralph Buehler, of Rutgers University and Virginia Tech respectively, are two of the most prolific researchers of bicycling for transportation. Jennifer Dill of Portland State University is another academic researcher that has contributed substantively to the literature of urban bicycling. This literature review explored such studies and also looked at research that focused on sustainable campus transportation.

2.1.1 University Campus Context

The concentration of the built environment is a large determinant of bicycle use, and the density and intensity of uses in a community can help make bicycling a great transportation mode simply due to geographic proximity. To their benefit, university campuses are often compact with multiple uses appropriately serving concentrated populations. When communities have such characteristics, short trips are most common and make bicycling very suitable. Because of their convenience and functionality, bicycles are an excellent mode of transportation for these types of trips.[10] Furthermore, university communities are often heavily populated with young people. This group is one of the most appropriate demographics to take advantage of bike commuting due to their general health, willingness to be active, and preference for car-free lifestyles.

Bicycling is also a low cost transport option, especially compared to driving an automobile. According to the American Automobile Association (AAA), the average annual cost of using an automobile is $8,876,[11] whereas the average annual cost of using a bicycle is $30.[12] This is obviously a substantial difference and can greatly benefit many college students that may rely on student loans and part time employment to make ends meet. College students are widely known for having relatively low incomes and with the average college graduate accruing over $35,000 in student loans,[13] the affordability of bicycling provides significant incentive for its use. At the same time, the cost savings of bicycle commuting are not exclusive to students. Faculty and staff can also certainly appreciate the economic benefits of this transportation mode.

It's important to maintain consideration for the University's academic context and its requirements as well. Studies indicate that exercise has broad positive effects on overall brain health. The benefits of exercise have been best defined for learning and memory and other things,[14] which are integral to student development and education. This is extremely valuable on a university campus like UT Austin due to the substantial demands on students' and faculty members' cognitive systems through coursework and academic research. Busy schedules often prevent people from exercising, but the benefits of exercise are easily attainable through bicycling for transportation.[15]

2.1.2 Case Study: University of California, Davis

The University of California, Davis is a particular school worth reviewing in detail. With a university bike transportation mode share of just under 50%,[16] UC Davis, in the city of Davis, CA, is the best American example at which to look for studying how to create a dynamic bicycling transportation environment. Decades ago, UC Davis sought to create a community and campus that was dependent on the bicycle rather than the automobile for transportation.

The factors that have contributed to UC Davis' bicycle environment are varied, but it started with leadership when the university's Chancellor, Emil Mrak, sought to plan for a "bicycle-riding, tree-lined campus."[17] The first campus plan detailed extensive bike paths passing through campus with ample bike parking conveniently located throughout the grounds. Still, one of the most pivotal policies came when the core campus was closed to cars in 1967. Acceptance letters to applying students stated, "Bring a bicycle to campus so you can get to classes on time."[17] Clearly, policies for bicycle prioritization were integrated directly into the university's operations. The leadership's initiative and these policies helped lay the foundation for a strong bicycle environment for decades to come.

Since these progressive and visionary policies were implemented in the 1960s, the university has also designed and implemented numerous pieces of infrastructure that have bolstered the campus community's ability and desire to travel by bike. In addition to the nation's first bicycle roundabout, UC Davis also has 15 miles of shared use (bike/pedestrian) paths, 5 miles of conventional bike lanes and 2.5 miles of bicycle boulevards.[16] Given this environment, it's easy to understand how UC Davis is one of only two universities to be awarded the platinum-level designation in the 2014 League of American Bicyclists Bicycle Friendly University rating.[18]

2.1.3 Policies for Bicycle Friendliness

As the case of Davis shows, policies are integral to benefiting bicycling in a community. They can be utilized in planning to structure transportation and travel practices by encouraging and discouraging certain modes.[19] Many people argue in favor of "carrot and stick" type policies that emulate this tactic. In the summer of 2015, the citizens of Zurich voted to allocate 120 million francs for the provision of bicycling infrastructure to create a more hospitable and enjoyable environment for bicycling.[20] In addition to this "carrot" approach, they have also taken a "stick" approach. The Swiss city has been widely publicized for its progressive transportation policies that have made riding bicycles and taking transit far easier than driving automobiles in the city. Policies have been created that are designed to deter driving and limit the number of automobiles in the city limits. They have implemented closely spaced traffic lights to create delays for drivers entering the city and have even removed infrastructure that previously was available for cars to use.[21] Many of Zurich's policies have in turn created positive change on the city's streets, and the city was even ranked the highest in a 2015 European Commission-sponsored study that looked at policies for air quality in 23 cities in the European Union.[22]

Moreover, regarding "carrot and stick" policies, a model was created and used by Rietveld and Daniel to explain how policies influence the modal choice of short distance trips. The results implied that there are essentially two ways of encouraging bicycling for transportation: 1) by making it more affordable and 2) making other modes, like the automobile, more expensive.[23] This point is significant, because many communities seem to be wary of stick policies and opt instead exclusively for politically palatable policies.[9] However, with the pro-bicycle programs and the limitation of automobiles on campus, "carrot and stick" policies are already in place on our UT Austin campus. The question simply becomes, "How can these policies be adjusted to affect more sustainable transportation choices?"

There are also more politically positive policies that are being used. Pairing bicycling with transit is one such policy. This is an aspiration of many universities and cities alike, because bicycling is an excellent solution for the first and last mile problem that many transit riders face. The reality is that there is only a limited amount of service that can be offered and it often concentrates on corridors or in dense neighborhoods. Although many live close to their campuses, people commuting to universities are not always within walking distance of these transit areas, so bicycling can be utilized to make these commute connections expediently.

Furthermore, enabling bicycling and public transit to be used in tandem will likely facilitate an increase in transit ridership *and* a greater demand for bicycling.[24]

2.1.4 Bicycle Infrastructure

Bicycle infrastructure is a necessary prerequisite to enable the bicycle to maintain and grow its full status as a transportation mode.[25] It comes in many different forms, from street paving/painting to physical barriers to end of trip facilities like bike parking; however, it must be designed intuitively and for functionality. It's important that infrastructure designs enable bicyclists to make direct, comfortable bicycle trips in attractive and safe traffic surroundings.[25] Only then is it possible for the bicycle to compete with the car and grow its mode share.

On-street bike facilities are what many people think of when considering bike infrastructure. Traditional bike lanes are some of the most common types of designs, using lane striping to delineate the exclusive space for bicyclists, recommended to be 7 ft. wide. A buffered bike lane is a type of bike lane that also uses lane striping to separate the bike lane from the traffic lane with a buffer of 3 ft.[26] These applications are mostly applied on the outside portion of two-way streets. One-way streets require a slightly different design that can be realized as a contraflow lane. Contraflow lanes are striped bike lanes designed to enable bicyclists to ride in the opposite direction of the automobile traffic flow. They convert one-way streets into two-way streets: one direction for automobiles and bikes and the other direction for bikes only.[26] These painted bike lane applications are good for streets with low traffic and low speeds.

Nevertheless, it's been found that in some of the world's great bicycling cultures, like the Netherlands, Denmark, and Germany, the most important way to make bicycling convenient and safe is to provide separated bicycling facilities on heavily travelled roads and at intersections while also utilizing design interventions for traffic calming.[27] It's reasonable to presume that this is the case in the United States as well. Therefore, many agree that streets with greater traffic flows and/or higher traffic speeds should provide more protection for bicyclists by using cycle track designs. Cycle tracks are physically separated bicycle facilities that are divided by curbs, concrete planters, bollards, or elevated grades among other items.[26] Like bike lanes, cycle tracks are recommended to be 7 feet wide.[28] This amount of space provides plenty of area for bicyclists of all levels to feel safe and allow for faster bicyclists to pass slower ones. There are also bi-directional cycle tracks permitting bicyclists to move in both directions.[26] Bi-directional cycle tracks can upgrade the environment for bicyclists but careful consideration should be taken to ensure they are applied in appropriate contexts (usually off streets). The City of Austin has even experimented with parking-protected cycle tracks which separate bike lanes from moving traffic with parked cars. Most cycle track applications are excellent for creating a safer environment for bicyclists, which then has the result of encouraging more bicycling.[29, 30]

Sharrows are simply street markings that notify drivers that bicyclists may also use the street space. Many bicyclists contend that this is an inadequate design element on most urban streets;[31] however, sharrows can be appropriate in certain contexts such as on a university campus where automobile speeds are slow.

Bicycle Boulevards are streets with low volumes of automobiles and low speeds that utilize various treatments like traffic calming and traffic reduction, signage and pavement markings, and intersection crossing designs.[32] These mechanisms allow bicyclists to travel on streets unencumbered while discouraging use by automobiles. Bicycle boulevards are not the most apparent type of bicycle infrastructure but they do a good job of prioritizing bicyclists above automobiles. Traffic calmed streets, like these, not only encourage more bicycling but they also make the streets safer.[9] The City of Portland, Oregon has seen much virtue as these designs have been implemented with gusto.

Another multimodal connection idea is the “park and bike”, which is an area that has been used in a similar way as park and ride transit lots. People can drive to these areas to park their cars and then ride a bicycle the remainder of the trip to their destinations.[33] This idea could be feasible for people commuting to universities due to the limitations on automobile use on many campuses. The only concern is that the universities would need to have land at an appropriate distance away from the core campus for such an implementation to be possible.

Intersections are important pieces of the transportation network and require further consideration to ensure safety for all users, including bicyclists. According to the CROW Design Manual for Bicycle Traffic, one of the seminal bicycle planning and design documents, over half of the serious bike and automobile crashes causing fatalities or hospitalizations occur at intersections within built-up areas, and of those, particularly at intersections with 50 km/hour speed limits.[25]

To combat these crashes, bike box design treatments are used at intersections to prioritize and clearly define space for bicyclists. Bike boxes are one of the most common intersection treatments in the U.S. and place cyclists in front of vehicles turning right to proactively avoid collisions when the light changes to green and a bicyclist is approaching the intersection on the adjacent bike lane.[34]

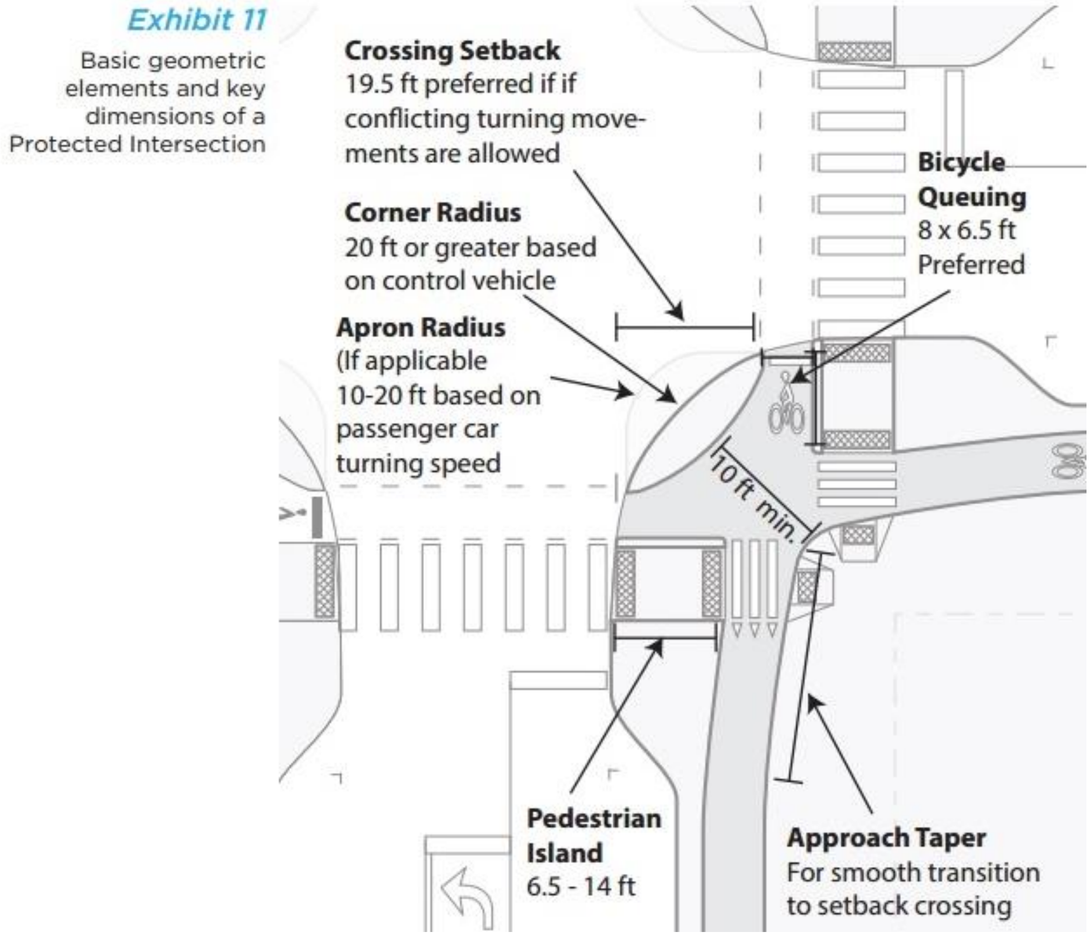
Figure 2.1: Bike Box

Sarah Mirk, 2012

Two-stage left turn boxes are similar to bike boxes but are placed at the right corner of each outside lane of an intersection. This enables bicyclists to ride through the intersection stopping at the right corner. When stopped, they are then able to reorient their direction to the left. When the light changes to green, they proceed straight in that direction. Ultimately, the two-stage left turn boxes allow bicyclists to make left turns without having to cross, unprotected, through automobile traffic. Bicyclists are required to wait at the stoplight until it changes to green, but the tradeoff of safety for time justifies the delay.

One of the most significant and arguably beneficial types of infrastructure is the protected intersection. Protected intersections are often called Dutch-style intersections given their prevalence in the Netherlands. Up to this point, there has also been a handful implemented in the U.S. as well. Directness, safety, and comfort are significant requirements of these protected intersections and great care should go into designing them with these ideas in mind.[25] Protected intersections employ elevated corner refuge islands (typically at each corner) to act as physical barriers separating bicyclists from motorists. Not only do these create barriers for comfort, they also enable a clearer interaction due to efficient geometry.

Figure 2.2: Protected Intersection



Alta Planning & Design, 2015

When these types of infrastructure designs are combined with traffic management devices, such as stoplights, roundabouts and yield signs, the potential for safe interchanges is greatly improved. There are obviously variations to consider for particular contexts but their use should always be intuitive and appropriate for a large spectrum of skill levels. They have been integrated into the developing Mueller neighborhood on Austin's east side, in addition to other cities like Boston, MA, Salt Lake City, UT, and Davis, CA.[35] This growing adoption will most likely encourage more cities to consider the idea of utilizing such designs especially in developing areas.

In an effort to ensure clarity, many cities use colored pavement when designing bicycle infrastructure. For instance, bike lanes are often colored at intersections even if they're not colored between blocks. This application doesn't physically protect cyclists from automobiles but does notify motorists that bicyclists may be moving through the area. Although seemingly insignificant to some, these colored lanes can benefit sometimes-difficult traffic sorting situations. Way finding and signage are also key pieces of infrastructure to create better environments for bicyclists. There are generally three types of signs for bicycling that are most often located at decision points: 1) confirmation signs are used to inform bicyclists and motorists that they are on a bicycle route, 2) turn signs are used to indicate where a bikeway turns from one street to another, and 3) decision signs mark the junction of two or more bikeways and may include arrows, distances, travel times, and information about destinations.[36] Understanding where they, as bicyclists, are going can contribute greatly to them feeling safer and more confident on the road. Prioritizing signage is also necessary to make sure that visitors/tourists are able to freely travel on unfamiliar roads.

2.1.5 Research Questions:

Much of the research up to this point has been focused on general policy and infrastructure considerations to increase bicycling. As my approach is rooted in increasing the sustainability of the University of Texas at Austin by growing the proportion of people commuting to and from campus on bike, this study collected data from the community to try to connect the dots on the different policies and infrastructure designs that the literature has proven to benefit usage and therefore sustainability. In addition, I am seeking to apply the ideas learned about directly to the UT Austin campus context. Therefore, my main research question is:

- What policy and built environment solutions are most appropriate for the University of Texas at Austin to adopt in order to benefit the bicycling mode share and impact the sustainability goals on campus?

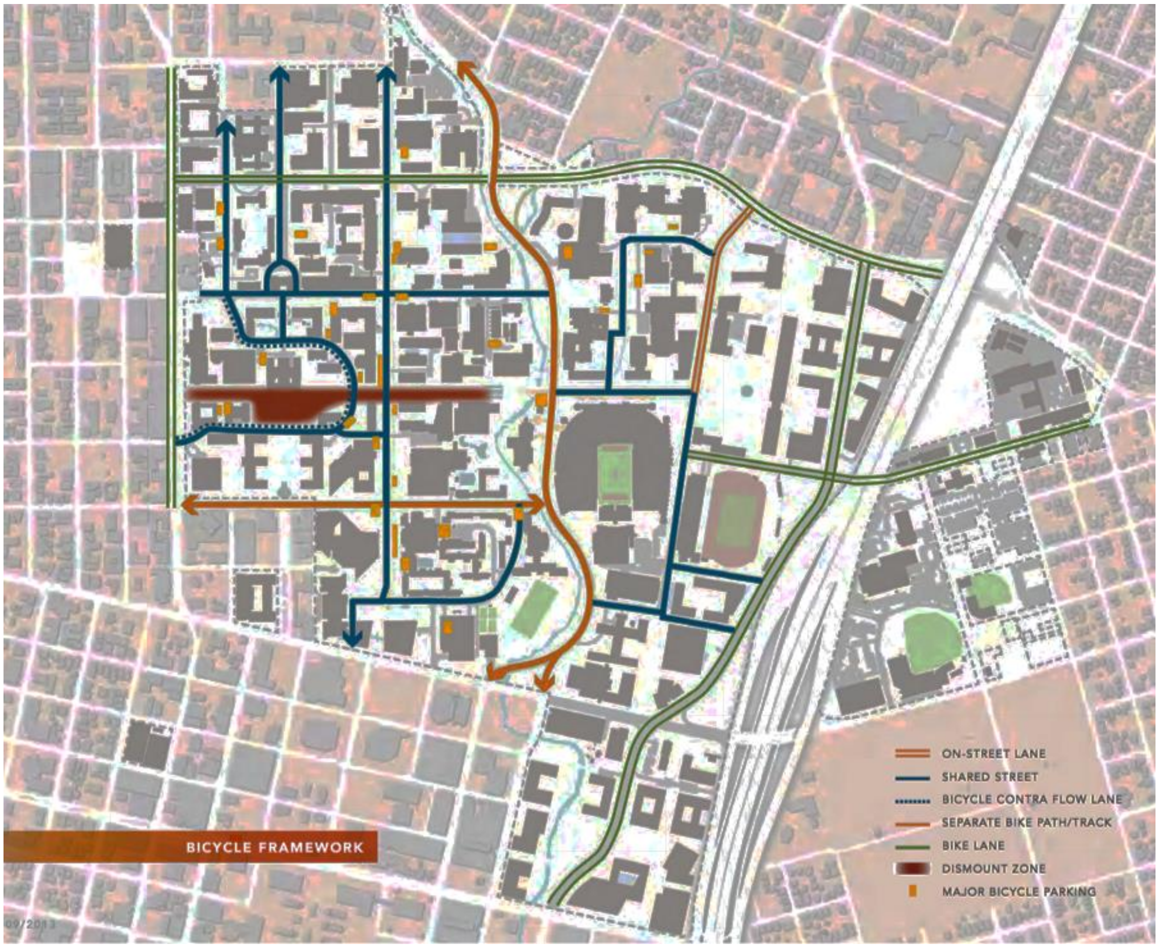
I will inform the answer to this question by also seeking answers for these questions: (a) "What are the busiest areas of campus for bicycling and what are the correlations with the built environment?", (b) "What are the most desired solutions for encouraging more bicycling at the University of Texas at Austin.", (c) "Where should limited resources be prioritized?"

CHAPTER 3:

3.1 EXISTING CONDITIONS:

The University Of Texas Board Of Regents approved the 2012 Campus Master Plan in May of 2013. This plan sets a long-term vision for how UT Austin's urban campus will be maintained and developed to meet the needs of the students, faculty, and staff. Transportation and mobility are priorities of the plan, and it recommends that bicycling be embraced and encouraged.[37] However, considering the transportation network as a whole, bicycling receives little focus and many of the plan's recommendations for bicycling have yet to be realized. Still, some breakthroughs have been made, such as the parking-protected cycle track on Guadalupe St. southbound and the preservation of use on Speedway as a shared space. The 1999 Pelli Campus Master Plan[38] also mentions bicycling on campus but stops short of detailing any specific action to benefit bicyclists on campus. The University has addressed bicycling for quite some time, but tangible provision for bicycling has been more or less dedicated to the installation of bicycle parking racks, as mentioned in the Campus Landscape Master Plan.[39] University policies will be addressed later in this report.

Figure 3.1: Campus Master Plan: Campus Bike Map



The University of Texas at Austin, 2013

3.2 Main Campus Streets

Figure 3.2: Speedway

Speedway is the main inner campus north/south bicycle route. Not only does the street pass through the heart of the campus, it also acts as an arterial street for bicyclists to distribute in various directions on the perpendicular streets.

Figure 3.3: Guadalupe St.

Guadalupe is a major multimodal thoroughfare for the UT Austin community and the City at large. It acts as the effective border of the west side of campus. Many students living in the West Campus neighborhood walk or ride across Guadalupe to enter campus but some bicyclists also ride on Guadalupe going north and south. From 24th St. to 21st St., the southbound portion of the street has a parking-protected bike lane and the northbound portion has a buffered bike lane. North of 24th St. and south of 21st St. have traditional painted bike lanes.

Figure 3.4: San Jacinto Blvd.

San Jacinto is the main inner campus north/south transit street. It also carries a decent amount of bicycle traffic despite the fact that there is no bicycle infrastructure. The 15 mph speed limit is slow enough for bicyclists to feel safe on the street.

Figure 3.5: Dean Keeton St.

Dean Keeton St. is the main east/west route from Guadalupe St. to Interstate-35 and East Austin. This street has bicycle lanes on both sides with some portions being buffered and others being traditional bike lanes. A serious drawback of this street is that it is also a busy automobile and transit corridor. Bicyclists must be very cognizant of the parked cars and traffic, as passing cars often move faster than the 30 mph speed limit.

Figure 3.6: 21st St.

21st St. is a street that is part of multiple transit routes and that also has a solid amount of bicyclists. The traffic gate adjacent to the Perry Castañeda Library is a good instrument for reducing the speed of traffic and ensuring only the appropriate vehicles pass through campus.

Figure 3.7: Red River St.

Red River St. is on the eastern side of campus and operates more like a city street than a campus street. It has painted bike lanes but also has a considerable amount of traffic that could be considered intimidating for the average bicyclist.

3.3 Bicycle Parking

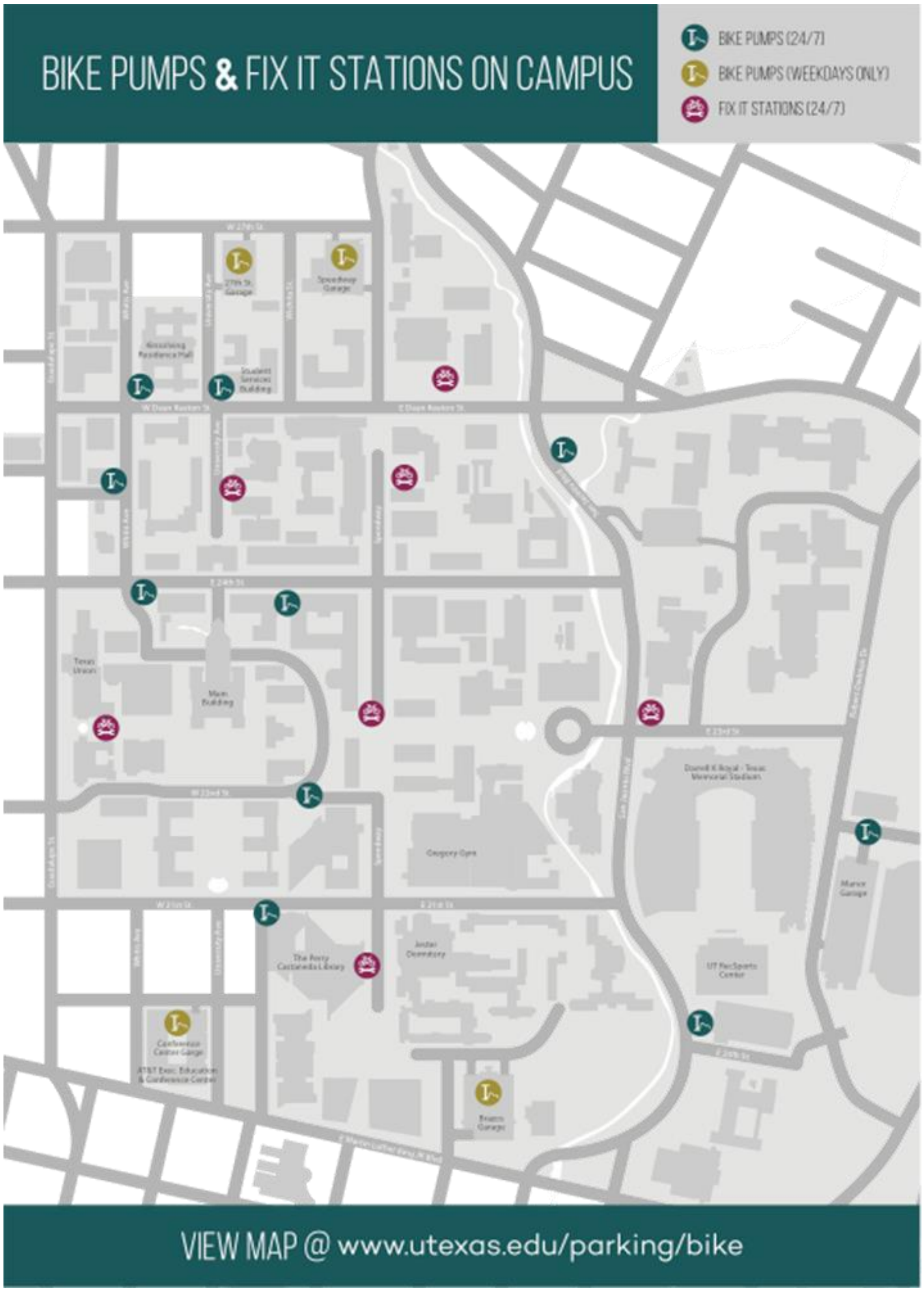
Figure 3.8: Bike Parking Near Robert Lee Moore Hall

The 2012-2013 Parking and Transportation Services (PTS) Annual Report states there are over 5,200 bicycle parking spaces on campus.[40] However, since this report, PTS has increased the number of bicycle racks on campus by roughly 100. Each bike rack is capable of accommodating approximately fourteen bikes at a time. Therefore, there are roughly 6,600 bicycle parking spaces on campus. Bike parking is one of the main factors being considered with regard for the bike friendliness of the campus. Even with the high number of bike racks, many of them fill up and bicyclists are forced to utilize other stationary objects like guardrails and signposts, despite this at times being illegal.

3.4 Bicycle Pumps and Fix-It Stations

PTS has supplied other amenities for bicyclists as well. There are four bicycle pumps located in separate parking garages. However, these four pumps are only accessible during weekdays due to their locations in the parking garages. There are ten more bicycle pumps located along sidewalks throughout campus that are available 24 hours a day, 7 days a week. Seven fix-it stations are also available around campus at busy bicycle junctions 24 hours a day, 7 days a week. In addition to bike pumps, the fix-it stations are equipped with Philips and flathead screwdrivers, an Allen wrench set, pedal wrenches, box wrenches, and tire levers.[41] These bike pumps and fix-it stations are very beneficial for students because they enable them to make minor fixes for their bicycles conveniently.

Figure 3.9: Bike Pumps & Fix-It Stations on Campus



UT Parking and Transportation Services

3.5 PTS Transportation Mode Survey

Completed in the spring semester of 2012, the transportation mode survey was created to identify opportunities for traffic demand management. The survey was distributed online and included 25 questions, three of which were topical. Overall, the survey had a total sample size of 1,713 responses from students (49%), faculty (10%), and staff (50%). The aggregate is greater than 100% due to some respondents identifying as more than one option (i.e. student and staff).[42]

The survey garnered 1707 responses for the question pertaining to choices of travel to campus. The responses were very diversified and none of the modes had a true majority. Forty six percent of respondents stated that they drive alone each day, 21% use public transit, 13% commute by bicycle or skateboard, 10% walk and another 10% use other modes.[42] From 2009 to 2012, there was an increase in single-occupancy automobile use but another key point to note is that bicycling increased as well over that time; although it lists bicycling as a single mode in the 2009 survey, the 2012 survey lists it as bicycling *and* skateboarding. While this may have altered the numbers slightly, it is safe to conclude that bicycling increased dramatically. In any case, bicycling and skateboarding both contribute to the University's sustainability goals and each are beneficial in their own right.

The increase in bicycle commuting to campus is certainly beneficial, however, a significant number of individuals still choose not to bicycle to campus for a variety of reasons. When surveyed about the reasons they choose not to commute to campus by bicycle, 33% stated that it's too dangerous, 31% stated they do not have a bike, 22% said the network of bicycle infrastructure was insufficient, 22% stated they had no place to shower or change clothes, and 16% attributed their lack of bike commuting to there being too many hills.[42]

On the other hand, respondents that utilize active transportation to commute to campus were also surveyed about the reasons why they choose the modes they do. Fifty one percent stated that the cost of driving is simply too high, 41% have good access to the UT Shuttle system, 40% stated the difficulty finding parking, 33%

stated their enjoyment of bicycling or walking, and 31% chose active transportation due to environmental concerns.[42] Both of these portions of the survey provided 10 questions and reported the 5 most common choices, which incidentally does not amount to 100%.

One of the key considerations for people driving to campus is where they will be able to park their vehicles. Of the people who drive to campus, 77% park in a campus parking garage, while 18% use off campus street parking, and 5% use off-campus parking garages. Of all the survey respondents, 19% owned a student parking permit, 43% a faculty/staff permit, and 38% did not have a permit.[42] The high percentage of those not owning a permit is likely due to use of alternative modes of transportation.

3.6 Bicycle and Automobile Interaction

Generally speaking, interactions between bicyclists and automobiles are positive. This is mostly due to the fact that even with the current allowance of cars on campus, there is a clear understanding that pedestrians and bicyclists have the right of way. That stated, there are areas where interactions between bicyclists and cars can become problematic. The junction of 24th St. and Speedway on the core of campus is one place that does get a decent amount of interaction between the two modes. Most often, there is a great deal of movement at this junction and car drivers usually defer to bicyclists (and pedestrians). This is very good for the most part; however, the common deference that bicyclists receive has facilitated an environment where many bicyclists roll directly through the stop sign without even slowing down. To be clear, this does not usually happen when cars are in view but there is definitely a relaxed adherence to the rules on the side of bicyclists.

3.7 Bicycle and Pedestrian Interaction

Figure 3.10: Signage for Shared Space

The area of Speedway between 24th St. and West 22nd St. is one of the busiest shared spaces for bicyclists and pedestrians. There is usually a noticeable amount of interaction on this stretch of street and there are also many opportunities and potential scenarios that could result in bike and pedestrian collisions. This is mainly due to the intensity of use of the area by both modes but also due to distractions that keep bicyclists and pedestrians from paying attention to one another (i.e. socializing and/or the use of mobile phones). The East Mall crossing of Speedway is also a very heavily pedestrianized area through which bicyclists pass. This crossing is challenging because there are many pedestrians and bicyclists and there are few street markings to caution the street's users. In addition, bicycling dismount areas often see bicyclists continue riding despite signage that prohibits it. Many of these bicyclists are on their way to bike racks that are situated in areas that are not directly accessible by bike.

Figure 3.11: Signage for Dismount Zone

There are also areas of campus that can be problematic for interactions between bicyclists and pedestrians due to a lack of pedestrian infrastructure and little clarity for where each mode should go. The junction of Inner Campus Drive and West 22nd St. has a sidewalk section that is obstructed by a staircase requiring pedestrians to walk in the street. This same area allows bicycle traffic in both directions and often has multiple bicyclists going in each direction. This type of barrier can be very problematic in maintaining safety between the bicyclists and the people walking on the street due to the obstructed sidewalk.

Figure 3.12: Pedestrian Barriers

3.8 Bike Infrastructure

In general, there is little on-street bicycling infrastructure/provision. There are a few signs to direct bicyclists but they are used mostly to communicate the existence of dismount zones and areas that exclude bike parking.

3.8.1 Bike Lanes

- Dean Keeton St. (from Guadalupe St. to its junction with Manor Rd. just east of the campus boundary)
- Guadalupe St. (on the western border of campus)
- Martin Luther King Blvd. (southern side of campus)
- Red River St. (east side of the main section of campus)
- San Jacinto Blvd. (from Dean Keeton St. to Duval St.)

Figure 3.13: Signage for Speed Limit

Red River is the only street that has a bicycle lane that runs through campus. The others are located on the campus periphery but presumably handle a sizeable amount of individuals from the UT Austin community traveling by bike. Due to the campus-wide speed limit of 15 mph, the other streets on campus operate as shared streets. Some of these streets are marked with sharrows, but there are currently no cycle tracks, grade-separated bikeways, or truly viable bike/ped trails on campus. Moreover, there are also no streets that are exclusively for bicycles and pedestrians. Speedway is the most bicycle friendly corridor due to its prohibition of automobile through traffic; however vehicles are still allowed to access the street space to park as of spring 2016.

The City of Austin Bicycle Map acknowledges that nine bicycle routes pass through or on the periphery of campus. All of them have been determined to be medium-comfort routes, with the exception of Guadalupe St. southbound (from 24th Street to 20th Street) with its protected bike lane separated by car parking. This section is considered high-comfort.

3.8.2 Traffic Lights

Street junctions on campus often create the most difficulties for users, especially when there are a variety of modes present. The UT Austin campus context is no different with upwards of forty intersections connecting the campus property with the City of Austin.

Many of these intersections include pedestrian signals, which also enable bicyclists to navigate the crossing at the same time. This provides a clear benefit for cyclists, because it prevents them from having to cross automobile traffic in the intersection. At the same time, the sheer number of pedestrians and bicyclists at intersections can be problematic due to people traversing the space in different directions. Still, the pedestrian signals that give bicyclists the ability to pass through the intersection should be considered a benefit to bicyclists and a part of the bicycle infrastructure.

There is also a pedestrian crossing at the West Mall terminus at Guadalupe St. This crossing of Guadalupe is equipped with a traffic light and use of the

Figure 3.14: West Mall and Guadalupe St. Crosswalk

crosswalk for those entering and leaving campus is significant. Some bicyclists traveling on Guadalupe St. dismount in order to walk their bicycles across the street to campus. Unfortunately, those with bicycles crossing the street from west to east quickly find themselves approaching multiple staircases and are often surrounded by other people crossing as well. There are wheelchair accessible ramps on both sides of the staircases, but they are fairly removed and inconvenient for people in a hurry as can be the case for students or faculty rushing to class. Moreover, people walking with bikes can find it difficult to navigate through numerous other pedestrians going in various directions. Crossing through this group of people could even become dangerous as pedals or other objects could bump into passersby.

There are also a handful of traffic lights on the eastern side of campus, particularly on Red River St. and the junction of Clyde Littlefield Dr. and Manor Rd. However, within the core campus where bicycle traffic is highest, there are no traffic lights. Still, there are quite a few intersections throughout campus, especially in the core. Nearly every one of these campus intersections are managed by stop signs. The ones that are not fitted with stop signs are not four-way but rather three-way or T-junctions. Stop signs are generally a positive mediator of traffic for bicycle users, but for them to work at peak efficiency it is very important that bicyclists heed the rules. It becomes very dangerous very quickly when bicyclists ride through stop signs with the expectation that motorists will give them deference. As mentioned earlier, this happens most often at the 24th St. and Speedway intersection.

3.8.3 Pathways/Trails

Waller Creek runs north/south through the center of campus just west of San Jacinto Blvd. The Waller Creek Trail is a greenbelt situated adjacent to the creek and is most often used by pedestrians and/or for recreation. However, there are portions of the trail that are accessible for bicyclists even though there are obstacles like stairs or areas where the trail simply terminates. Given this fact, the trail is not a truly viable bicycle route. It would also likely be cost prohibitive to direct funding to the trail to make it usable by bicycles.

3.8.4 Showers

Showers are probably not the first things that come to mind when considering the state of bicycling infrastructure. Nevertheless, they can be a great incentive or the lack thereof can be a legitimate obstacle for people commuting to campus on bikes. This is especially true for people who rely on a car for longer commutes of 3+ miles. For many of these people a shower is as important as a pleasant, high-comfort bike route. The locations for the showers on campus are in the recreation complex at Gregory Gymnasium, the Rec Sports Center, the Anna Hiss Gymnasium and Bellmont Hall. These facilities, and their showers, are accessible to all students by way of their student fees and faculty/staff for a relatively reasonable semester cost. Outside of these facilities, there are a handful of other showers around campus but are not necessarily publicly accessible to the UT Austin community.

3.9 Policy

In an effort to facilitate greater utilization of bicycles for transportation, PTS has a full-time bike coordinator to run all of the operations and projects regarding bicycling on campus. Below are the projects currently in operation:[43]

Figure 3.15: The Kickstand

UT Parking & Transportation Services

The Kickstand: This project is a bicycle repair and retail station operated by student workers that offers quick fixes like patch kits and air pumps, among other things. The Kickstand also distributes maps and other literature about riding on campus and around Austin safely and legally. The station is open four days a week from Monday to Thursday and is located on Speedway at the intersection of the East Mall.

Bike registration: In order for bicycles to be parked on campus, the user is required to register the bike with PTS. Although there are many people who register their bikes, the reality is that it's hard to determine exactly what percentage of bicyclists follow this rule. Registering a bike with PTS is free and can be done online at the department's website, in-person at the Kickstand, or at the PTS office in the Trinity Parking Garage. Some students seem to feel that the need to register their bikes could negatively affect them; however, bike registration is actually most beneficial to the owner. If a bike is lost or stolen, the owner can inform PTS and the registration allows the bike to be tracked and returned by pairing the serial number to the owner's PTS account. Moreover, if a bike needs to be moved to another location due to campus construction or other uncommon occurrences, PTS is able to notify the owner and allow them to personally relocate their bike. In addition, if for some reason a bicycle is impounded, the owner can be contacted to pick up the bike using the information from their bike registration.

Both active and new bicycle registrations have gone down over the last few years from 14,189 in 2010-2011 to 9,591 for 2013-2014.[44] This is particularly interesting because the 2012 Transportation Mode Survey states that the bicycling/skateboarding mode share increased. Although they are evident, it is unlikely that the increase is attributed exclusively to skateboards. Bicycles far outnumber skateboards on campus. Therefore, I can presume a larger percentage of bicycle commuters are not registering their bikes.

Figure 3.16: PTS's Green on the Go

Green on the Go: This is an alternative transportation policy that the University has undertaken to create a more sustainable campus, which also benefits the growth of the bicycle transp UT Parking & Transportation Services minimize the amount of single-occupancy automobiles that are used to reach campus. It leverages the UT Austin Shuttle service, Capital Metro city bus service, the E-bus service, carpools/vanpools, car share/ride share and active transportation options like bicycling and walking. Not only does it provide multiple alternatives to single-occupancy car trips, but it also allows for the linking of modes. UT Austin Shuttles and Capital Metro buses are fit with bike racks that hold a minimum of two bikes and most with space for three bikes.

Figure 3.17: The Orange Bike Project

UT Parking & Transportation Services

Orange Bike Project (OBP): This is yet another program operated through PTS and the University. This program is particularly important because of its multiple facets. First, the OBP has a bike shop located in the 27th Street Parking Garage that allows students to come and learn different skills for bike maintenance and to even repair their bikes. Second, the OBP runs a bike-sharing program that offers daily and semester long rentals at affordable prices. This bike-share is great because Austin's B-cycle bike share program is still in an early stage of development and most of its stations are located in the downtown area. Finally, the OBP creates an enthusiasm for bike riding and the functionality that it offers not just college students but also everyone else in the UT Austin community. The implicit encouragement to ride bikes is a truly beneficial element of the OBP for developing a more robust bicycle community at the University.

3.10 PTS Car Parking Permits

Parking permits have increased substantially from 31,071 in 2011-2012 to 36,074 in 2013-2014.[44] This increase in the purchase of parking permits is correlative to the increase in the automobile mode share as well. As the University continues providing parking and automobile infrastructure, it is likely that the number of parking permits will continue to rise.

CHAPTER 4:

4.1 WHERE WE GO FROM HERE:

In the initial phase, literature was reviewed on bicycle friendly communities and universities, and how bicycling affects sustainability. Through this, I learned that there are many policy and design approaches that are being utilized to benefit sustainability and create more dynamic environments for bicyclists. Much of the literature shows that policy and infrastructure design are integrally linked and should complement one another. The literature on actual infrastructural designs was also reviewed, many of which have been implemented within the City of Austin.

The evaluation of the University's bicycle environment showed that there are some very positive elements but also proved that much more needs to be done to ensure the scalability of the bicycle transportation mode share to a greater proportion of commuters. The campus context creates an atmosphere where not every design and policy is appropriate but some are more than suitable. The University has employed a number of policies that are benefiting the bicycle mode share and should continue to benefit it. With that stated, there are still more opportunities for the development of infrastructure and policies that have strong potential to encourage bicycling to and from campus. Moving forward, I will discuss the data collection and analysis from Phase 2.

CHAPTER 5:

5.1 PHASE 2:

After gaining a deeper understanding for the context of bicycling on campus from Phase I of this research, I began Phase 2, which entailed a robust collection of data to gain measurable and quantifiable metrics for understanding where and why people choose to ride. I'll begin this section by detailing my approach to the data collection and go into detail about the methodologies used and the results from each. I will then discuss the limitations of the methods.

5.2 DATA COLLECTION:

I collected data using four methods in order to compare and contrast the data of the most heavily used corridors and intersections on campus. The purpose of collecting the data was to determine the best places to focus policy and infrastructure development with limited future resources. Thus, I leveraged multiple data collection methods to help inform a more comprehensive understanding of the context and to ensure that the study was accountable and consistent. Often times, data collection can have serious limitations and my goal was to mitigate these limitations for this project, as much as possible, by soliciting data using both technological and manual methods. The methods I used are addressed below.

5.3 METHODS:

5.3.1 Surveys

Surveys were distributed in-person and online to student and faculty organizations and the general population on the University's campus. The in-person surveys had seven questions and the online surveys had the same seven questions with two follow-up questions. The questions were geared toward soliciting information on where people ride and on their preferences for bicycling on campus.

5.3.2 Eco-Counters

Figure 5.1: Eco-Counter

Eco-Counter

Eco-counter is a technology that enables data collection automatically through pressurized tube counters installed on the street. After installation, eco-counters collect information autonomously and provide a precise and constant stream of data. They are appropriate for collecting data over lengthy periods of time, such as weeks or months. For the purposes of my study, I utilized them to gather data for one-week increments. Throughout the spring semester I installed the eco-counters at four entrances to campus. The four entrances I selected were chosen based on the busiest entrances determined from my previous survey results. However, one of the entrances was experiencing significant construction which forced me to select the next busiest entrance. The four entrances were: Speedway and Dean Keeton St., 24th St. and Guadalupe St., 22nd St. and Guadalupe St., and San Jacinto Blvd. and Dean Keeton St.

5.3.3 Manual Bicycle Counting

Manual bicycle counts were also performed at the busiest entrances determined from the surveys. In this case, however, construction did not inhibit the manual counting, and I was able to gather data from the four busiest entrances to campus. They were: Speedway and Dean Keeton St., 24th St. and Guadalupe St., 22nd St. and Guadalupe St., and 21st St. and Guadalupe St.

5.3.4 Smartphone Application

With the increase in smartphone usage over the last decade there has been a correlative increase in smartphone application development and usage. While many of the most popular apps are focused on entertainment, there are numerous that can be operated for enormous utility. One such app is called Strava. Strava uses smartphone GPS technology to track a variety of metrics for cyclists and runners. In 2013, Strava expanded its platform, calling it Strava Metro, in order to provide data to cities for the purpose of helping to inform decision-making regarding active transportation provisions.

Figure 5.2: Strava Metro

Strava Metro, 2016

As more people use the app, the dataset grows and provides a stronger picture of where people are choosing to ride. Using the Strava Metro platform, I was able to garner a dataset from January 1st to December 31st of 2015 that allowed me to dig deeper into the preferences of cyclists on and around campus. The data types I utilized in my study were street segments and nodes (street intersections). After organizing and cleaning the data for my purposes, the data was mapped using the geographic information system, ArcGIS. More than just using the data for the purposes of visualization, I was able to get substantial and valuable information from the attribute tables of each of the data files. I then developed assumptions based on the patterns found in the data, such as where people choose to ride and which intersections they use, etc.

5.4 FINDINGS & ANALYSIS:

In each of the data collection methods, I was able to obtain a legitimate amount of data, which provided me with detailed insights and enabled me to develop informed recommendations on actions the University can take to effect greater transportation sustainability. While each method had varying amounts of data, when aggregated, the datasets proved to be ample for my study purposes. I will address the findings of each method below.

5.4.1 Surveys

I began the data collection phase by distributing in-person and online surveys to members of the UT Austin community. Each in-person survey contained seven questions and each online survey contained the same seven questions with two extra follow up questions.

Listed below are the questions used:

1) How many days per week do you ride your bike to campus?
2) What is the distance of your bike commute going one-way?

3) Which campus street do you ride your bike on most?
4) Which campus entrance (intersection) do you use most frequently?
5) What bicycling improvements would you like to see on campus?
6) What factors encourage/discourage your decision to commute by bike?
7) In which seasons do you bike?
8) On which campus street(s) do you not like to ride?
9) If you do not like a campus street, please list why.

The first seven questions were used for both the in-person and the online surveys. The last two (questions 8 and 9) were used only for the online surveys.

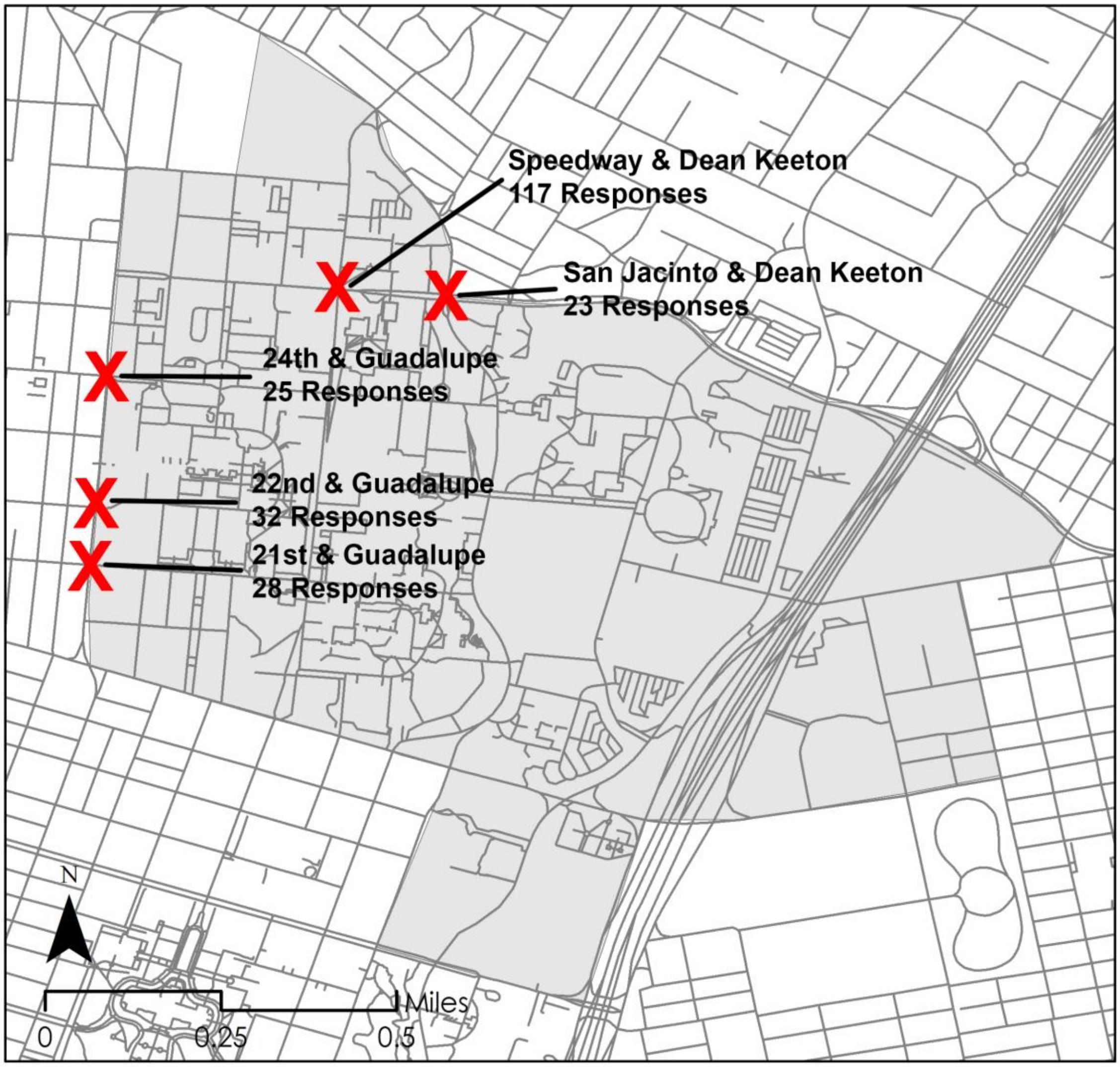
The combined sample size for the in-person and online surveys was 318 responses. Eighty-five surveys were completed in person and 233 were completed online. Given the qualitative nature of many of the questions, I was able to gain a detailed understanding of UT Austin community member preferences in addition to more measurable and quantifiable metrics.

When reviewing the survey responses, I learned that a majority of the respondents (53%) commute to campus by bike five or more days per week and a little more than 14% do not commute to campus by bike at all. Of the people that do commute by bike, 84% are within three miles of campus, which is appropriate given the central location of the campus in the City of Austin. Only 5.9% of bike commuters stated they travel more than 5 miles to get to campus.

Weather might appear to be a meaningful factor for bicycling, but according to respondents, seasonal weather changes don't have significant impacts on bike commuting given that most commuters ride throughout the year. However, the responses showed that summer and winter were preferred least by those using bikes for transport. This is not surprising given the extreme temperatures and weather experienced in these two seasons. The milder spring and fall seasons were preferred more by bike commuters. Therefore, I can conclude that comfort is valuable but not mandatory for bicycling regarding weather.

When respondents were asked about the campus streets they use most, Speedway was listed overwhelming as the busiest street on campus with 54% of the responses. Speedway was listed nearly four times more than any other street. Still, Dean Keeton was the second most listed campus street at 14.1%, followed by 24th St. (10.0%), Guadalupe St. (6.8%), and 21st St. (5.5%). Not surprisingly given the high street usage of Speedway, the Speedway and Dean Keeton intersection was listed as the most highly trafficked entrance to campus as well. Forty-four percent of respondents claimed they use this entrance to campus most frequently followed by 22nd St. and Guadalupe (12.1%), 21st St. and Guadalupe (10.6%), 24th St. and Guadalupe (9.5%), and San Jacinto and Dean Keeton (8.7%).

Figure 5.3: Survey Responses for Busiest Campus Entrances



As we know, infrastructure provision is also very important for encouraging people to commute by bicycle. When respondents were asked about the types of bicycle improvements they would prefer on campus, a few options stood out from the rest. Better street surfaces and bike/pedestrian separation were the two options suggested by 25% or more of the respondents. Preferences for better, smoother street surfaces are not surprising given the conditions of many campus streets and the relatively high allowance of cars on campus. However, the preference for separation of cyclists and pedestrians enables me to make the assumption that there is probably a substantial amount of conflicts between the two. These sorts of conflicts are a serious matter and create unsafe environments for both types of travelers on campus. Bike lanes received the third highest number of responses (19.2%) further affirming the desire of people for greater clarity and safety between bicyclists and pedestrians, as well as with automobiles and transit vehicles. Additional bike parking was the only other improvement receiving more than 10% of responses (15.0%). Still one other important improvement that was defined was more and better provision of signage on campus for bicycling. This is an easy factor to overlook but it should be considered seriously for a hospitable bicycle environment.

Next, respondents were asked about the factors that encourage their choice to commute by bike. Nearly 30% chose to commute by bike because it is the most time efficient option. Conversely, weather was the most prevalent factor that discouraged commuting by bike, although not significantly—which correlates with my earlier analysis. The negative weather circumstances were largely centered on heavy rainfall and extreme temperatures.

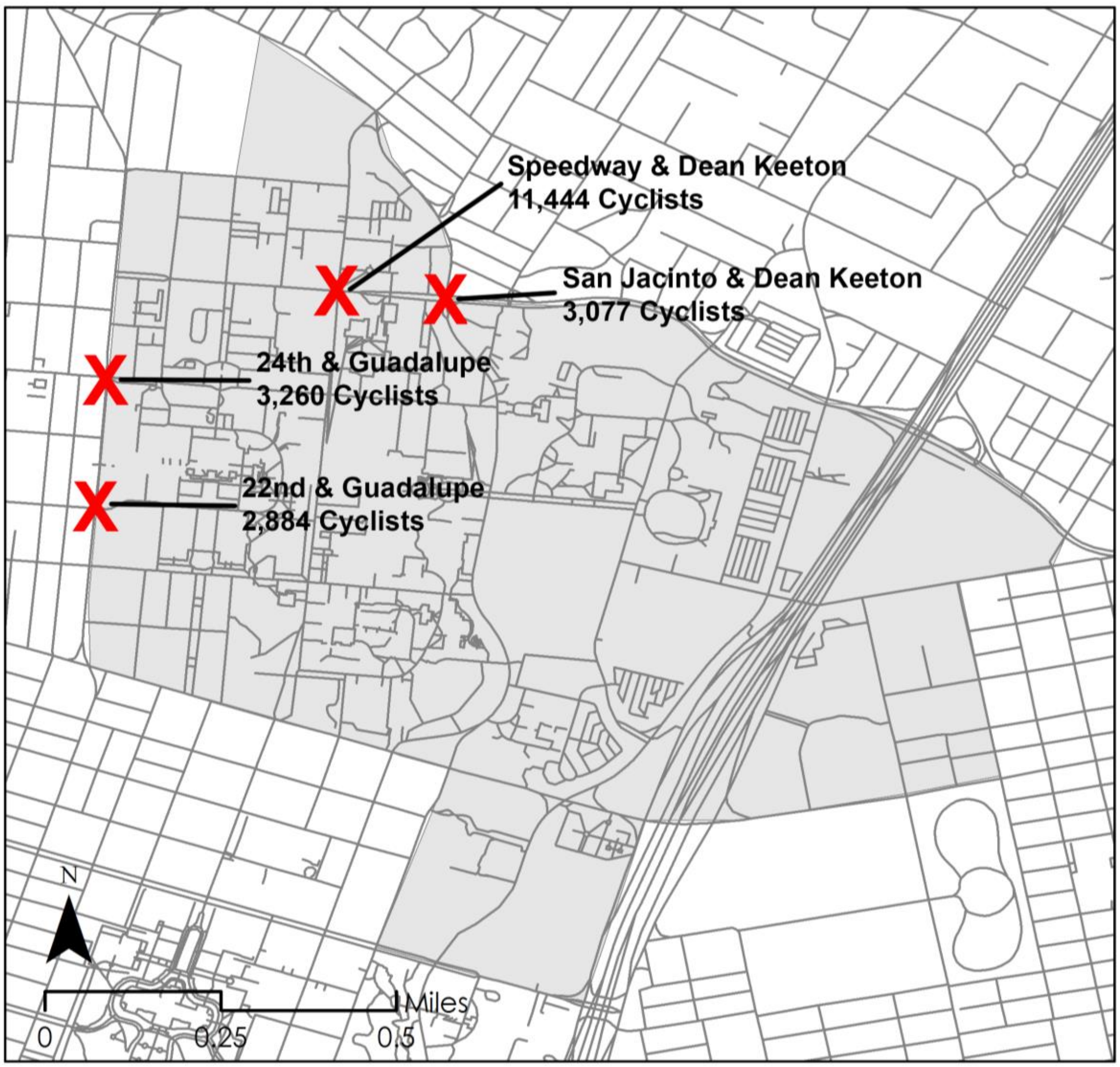
I then asked online survey respondents to select the campus streets on which they do not like to ride to try to pinpoint corridors on campus that have more pronounced issues. 34.1% of respondents stated they do not like to ride on Speedway, followed by Dean Keeton St. (28.7%), 24th St. (12.0%), and 21st St (10.9%). Interestingly, the street that proved to be far and away the busiest and most traveled is also the street that received the highest percentage of responses for this question. Likewise, it's also worth noting that the streets that had the highest amount of usage also had the highest amount of discontentment from users. This correlation enables many suppositions, such as a general discontentment of bicycling on campus, a preference for less busy streets, and the fact that the busiest streets for bicycling are also the busiest streets for automobiles as well. The follow up question asked respondents to specify the reasons they don't like the streets and the most noted responses were that they didn't enjoy the amount of pedestrian interactions on these streets, prevalence of automobiles, and the poor surfaces of the streets. This is consistent with the responses claiming that people would like more separation between bikes and pedestrians as well as better street surfaces.

Analyzing the results of the surveys, I learned that there are many factors contributing to the way people use bikes on campus. The locations of where people live is unsurprisingly a large factor in their choice to ride or not ride. Considering this, end of route facilities should be considered to enable greater comfort upon arrival to campus and encourage people to ride even if they do not live within three miles. Convenience also proved to be key. The busyness of Speedway is not surprising due to its central geography and correlative convenience. This corridor is extremely valuable for bicyclists due to its proximity to much of campus. The fact that time efficiency is a major factor in the choice to ride demands that focus be given to increasing campus accessibility and reducing obstacles that make trips longer. Further, the stated preferences for separation of bicyclists and pedestrians is always going to be a topic of concern on university campuses, but the numerous responses help draw the conclusion that signage and clear delineation of space is lacking on campus and should therefore be more widely implemented.

5.4.2 Eco-Counters

Consistent with each of the other data collection methods, the busiest intersection measured by the Eco-counters was Speedway and Dean Keeton St. Over the course of one week, the Eco-counters at this location tracked 11,444 bicyclists. This count was much higher than the other intersections and continued to affirm my expectation that this intersection is by far the busiest entrance to the core of campus. The next busiest entrance was 24th St. and Guadalupe St. (3,260), followed by San Jacinto Blvd. and Dean Keeton St. (3,077), and 22nd St. and Guadalupe St. (2,884). The constant tracking of bicyclists each week provided a strong dataset and useful sample sizes for comparison. Whereas the other methods were subject to small time intervals (i.e. 1 hour), the Eco-counters obtained constant data from daytime and nighttime hours each week. The results varied slightly from the manual counts and surveys counts, but overall the constant data collection provided important credibility and validated the general consistency with the aforementioned methods.

Figure 5.4: Eco-Counter Counts for Busiest Campus Entrances



5.4.3 Manual Counts

After reviewing the data collected from the in-person and online surveys, I then began to collect data through old-fashioned manual bicyclist counting. Taking the four busiest campus entrances based on the responses from the surveys, I performed counts for one-hour durations at the four intersections on three separate occasions. In an effort to gain object evidence, I performed the counts at various times of the day. Each intersection was counted on three different dates and at multiple times of the day. In total, twelve one-hour counts were completed over the course of the spring semester. The results of the manual counting showed distributed counts that correlated with the responses of the surveys. One particular note should be made that the manual counts were exclusively counting bicyclists entering campus, whereas the other methods counted both entering and exiting bicyclists. However, this difference did not contribute any legitimate change to the correlation. The campus entrance with the highest number of bicyclist counts was Speedway and Dean Keeton St. with a total of 384 bicyclists over the three one-hour periods. Next was 24th St. and Guadalupe St. with 263 bicyclists, followed by 21st St. and Guadalupe St., and 22nd and Guadalupe St. with 155 and 111 respectively. For every count, the number of male bicyclists outnumbered that of female bicyclists. Although the ranking of busiest campus entrances was not the exact same for manual counts and survey counts, they both nonetheless had the same top four entrances.

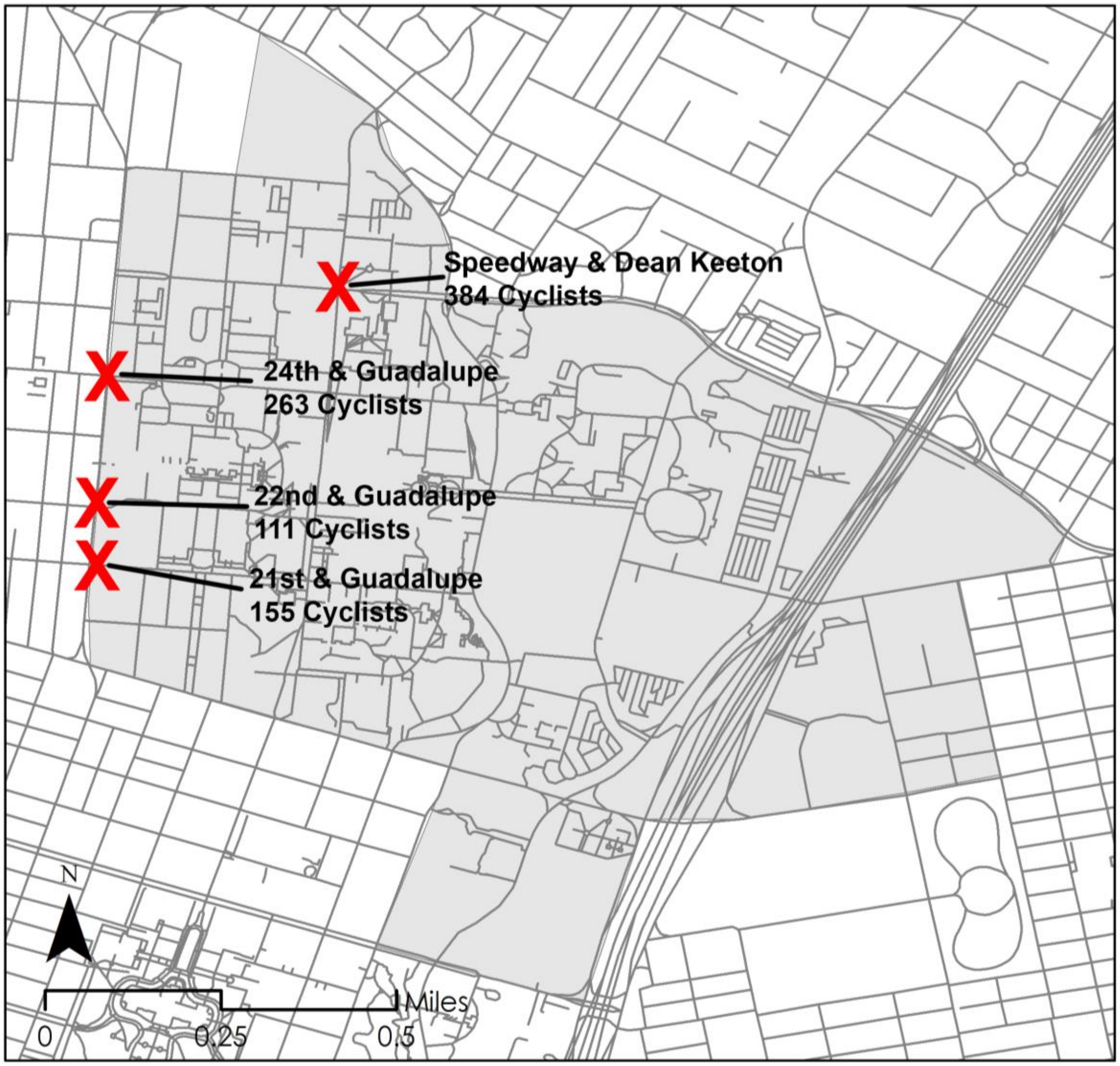
Table 5.1: Manual Bicyclist Counts at the Busiest Campus Intersection

Date: 2/16/2016			
Location: Intersection of Speedway and Dean Keeton			
	Female	**Male**	**Total**
12:15PM - 12:30PM	10	55	65
12:30PM - 12:45PM	8	21	29
12:45PM - 1:00PM	5	12	17
1:00PM - 1:15PM	2	11	13
Sum	25	99	124

Date: 3/29/2016			
Location: Intersection of Speedway and Dean Keeton			
	Female	**Male**	**Total**
9:30AM - 9:45AM	10	35	45
9:45AM - 10:00AM	7	17	24
10:00AM - 10:15AM	6	10	16
10:15AM - 10:30AM	5	15	20
Sum	28	77	105

Date: 4/7/2016			
Location: Intersection of Speedway and Dean Keeton			
	Female	**Male**	**Total**
10:15AM - 10:30AM	8	16	24
10:30AM - 10:45AM	14	35	49
10:45AM - 11:00AM	19	44	63
11:00AM - 11:15AM	6	13	19
Sum	47	108	155

Figure 5.5: Manual Counts for the Four Busiest Campus Entrances

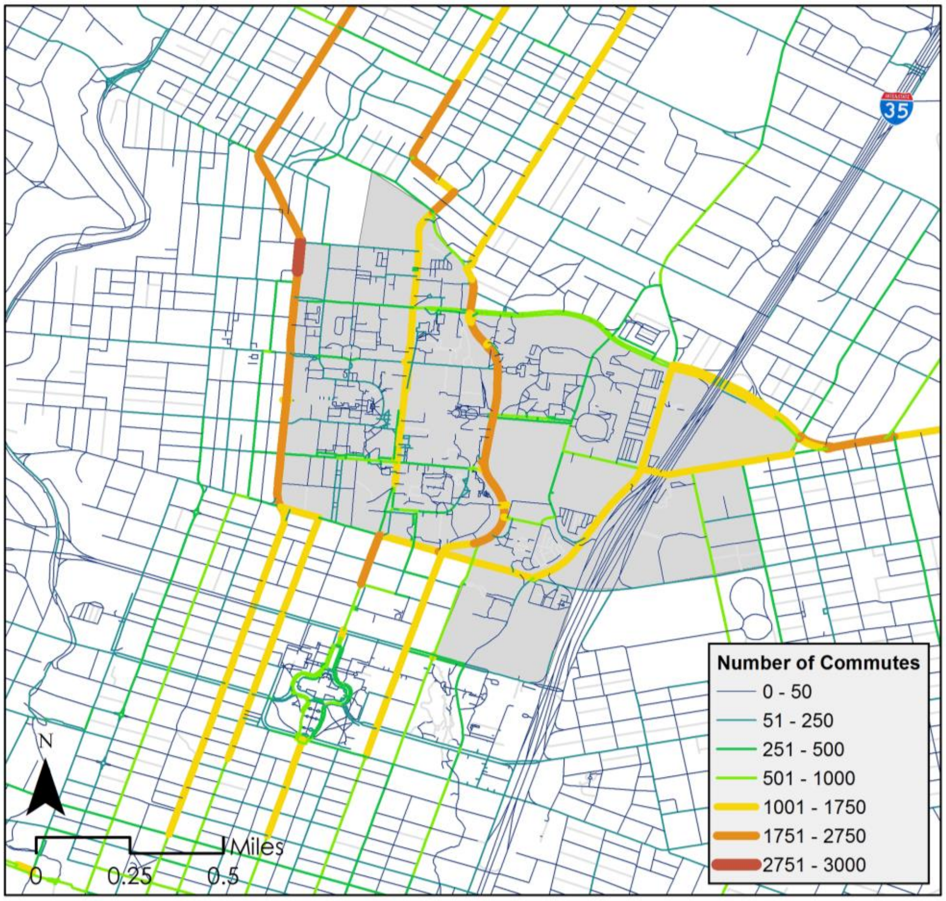


The manual bicycle counts corroborated the results from the surveys. Once again, Speedway showed the highest usage for bicyclists which further affirmed that this is the busiest area of campus. Interestingly though, the 24th St. and Guadalupe St. entrance showed higher levels than 22nd St. and 21st St. despite having less bicycle amenities than the two. This result could be consistent with the idea that the geographical location within the transport network is the primary determinant of usage.

5.4.4 Smartphone Application

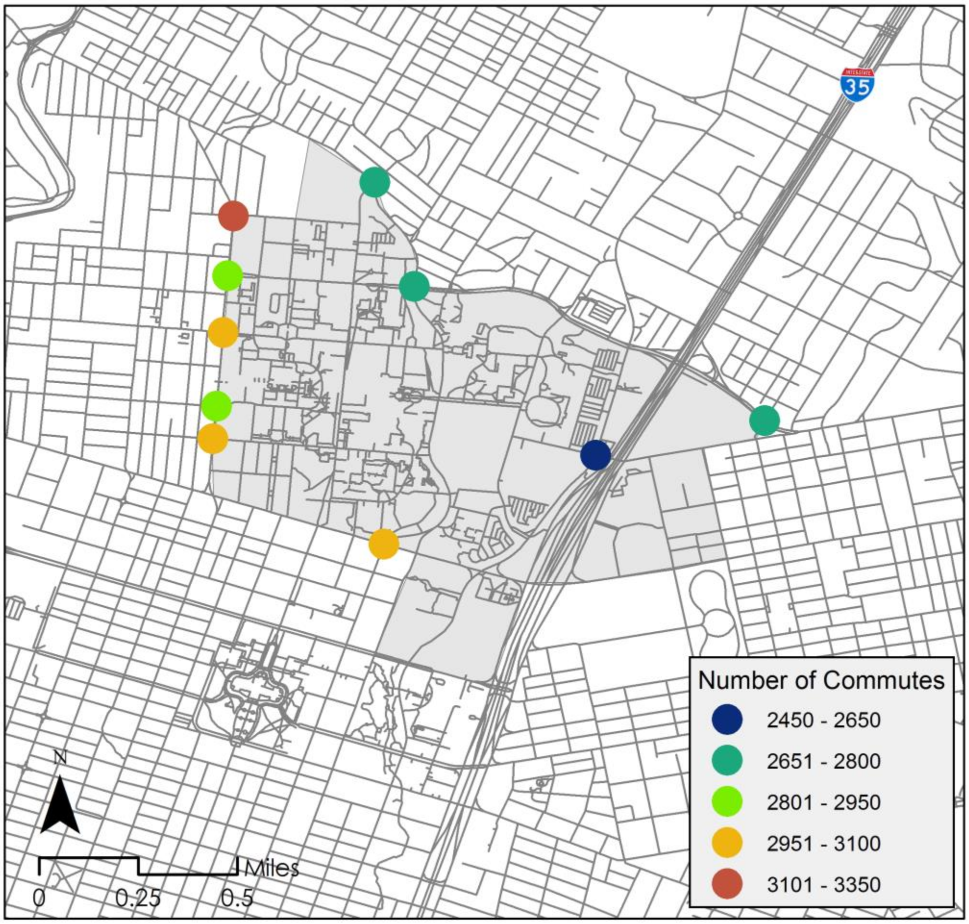
After obtaining the Strava Metro dataset, I mapped a variety of types of data to determine the busiest streets and busiest entrances to the core of campus. The process of data analysis involved organizing the data to appropriately convey the ideas about which I was hoping to learn. After I plotted the street segment data, I created a heat map to discover the busiest corridors for bicycling in and around campus. The heat map affirmed much of what I learned from the other data collection methods but also had a number of variances. For instance, while the data clearly showed that the north/south campus streets handle much of the bicycle traffic, the dispersion of that traffic appeared to be focused more on the edges of campus. The Speedway corridor showed high usage, but relative to San Jacinto Blvd. and Guadalupe St., it actually appeared to be a less frequented route. There are a number of reasons why the data would reflect such differences. One of which is that many students do not track their commutes to campus with the Strava app. While the app does measure a large number of commutes (2+ million in 2015), it certainly doesn't measure all commuters traveling to campus. Another reason may relate to the types of routes represented. For instance, Guadalupe St. is a busy urban arterial street with the purpose of moving traffic fluidly. Although this is often not the case during the morning and evening rush hours, the reality is that bicycle traffic has fewer stops due to the bike lanes and traffic light sequencing. Speedway, on the other hand, is more of a neighborhood collector street with stop signs in addition to traffic lights. The fact that bicycle traffic on Guadalupe St. flows more freely could also make people more interested in tracking their bike trips than on stop and go streets like Speedway. Nonetheless, the busiest routes tracked by Strava are not inconsistent with the other data collection methods.

Figure 5.6 Strava Metro Busiest Street In and Around Campus



These same sorts of differences were partially evidenced in the Strava data for busiest campus entrances as well. The five busiest entrances reflected by this data were all located on the western edge of campus on Guadalupe St., except for the Martin Luther King, Jr. Blvd. and Trinity St. entrances. The busy entrances from the Strava Metro data closely parallel the busiest street segments with Guadalupe St. and San Jacinto Blvd. reflecting the highest counts. Again, this could be explained by the same reasons discussed for the busiest street segments. However, correlative to the other data collection methods, the entrances at 24th St. and Guadalupe St., 21st St. and Guadalupe St., 22nd St. and Guadalupe St., and San Jacinto Blvd. and Dean Keeton St. are all also represented in the ten busiest core campus entrances ranking.

Figure 5.7: Strava Metro Busiest Campus Entrances



5.5 AGGREGATED DATA ANALYSIS:

When interpreting the data from an aggregated framework, we see that bicycle usage appears to be more pronounced on the western and central portions of campus. This is not surprising given that the West Campus neighborhood is densely populated by students and that the North Campus neighborhood—also with many student residences— relies on Speedway as its main transport corridor. All of the methods showed that Guadalupe St. and Speedway are busy campus bicycle thoroughfares despite the issues that people stated regarding them. Comparing these two corridors to other campus streets, one can see they are unique in their central locations and their continuity to and through campus. Interpreting the results collectively, I found factors contributing to the high usage of these corridors for bicyclists include bicycle infrastructure, corridor accessibility, geographic location, and even potential trip chaining with transit along these corridors. However, the greatest factor contributing to the high usage on these two routes is the geographic location within and around campus.

Moreover, the aggregated results also stated that more provision for bicycles need to be made using policies. The survey respondents explicitly identified issues resulting from a lack of university policies such as poor street surfaces and interactions between bicyclists and other transport modes. Policies curtailing the allowance of automobiles on campus and educating the community about how to bicycle safely would be invaluable for issues such as these.

5.6 LIMITATIONS:

As mentioned earlier, in an effort to reduce the limitations of this analysis, I sought data from multiple methods and aggregated results for a more complete and holistic understanding of the context for bicycling. However, there are still limitations that should be addressed. For instance, there were differences in the results of the busiest routes and entrances to campus between the Strava Metro data and the other methods. This is likely correlated with the fact that Strava is more widely used as a recreation app. Although I mapped the routes based solely on commuter data, clearly not all commuters use the Strava app. A reasonable assumption is that the app is used primarily by recreational cyclists but also by some commuter cyclists as well. This reality probably has some ramifications for the variances in route preferences.

Another limitation is the slight variances in the data collection methods. For instance, as stated, the manual counts were exclusively counting the number of bicyclists entering campus whereas the other methods counted those entering and exiting. This difference had no measurable impacts but nonetheless should be noted. Also, the survey method measured stated preferences, compared to the other methods, which measured realized preferences. The stated and realized preferences proved to be consistent and the different preferences even provided the study more qualitative data. Finally, the sample size of the in-person and online surveys should be acknowledged. Together the sample size of 318 is strong for this type of research in these circumstances; however, it is still rather small for a campus community of well over 50,000 people. While the survey was open for six weeks in the spring 2016 semester, university regulations prevented a simple and comprehensive distribution of surveys. Therefore, I had to extrapolate the insights I gained for the broader community.

CHAPTER 6:

6.1 PHASE 3:

The third and final phase involves the development of policy and infrastructural design solutions to benefit bicycling on campus and advance the University's sustainability goals. In this section of the report, I'll explore the most appropriate solutions based on this study of the UT Austin bicycling community.

6.2 SOLUTIONS:

As noted, it is important when seeking to affect transportation mode choice decisions to employ a multi-pronged approach. The communities that have developed the strongest sustainable transportation systems have often utilized a "carrot and stick" approach to facilitate the adoption of active transportation. Therefore, I believe the same sort of approach should be leveraged to positively impact the sustainable transportation mode share on campus. For the transportation modal split to reflect a more robust proportion of bicyclists and thus be more sustainable, simply seeking to provide more amenities for bicyclists has shown to be largely ineffectual, especially in light of even greater amenity provisions for automobiles. Like many other decisions, the nature of transportation decisions makes mode choice dependent on total cost (time cost, economic cost, environmental cost, etc.). According to Rietveld and Daniel[23] in the literature review, as total costs are decreased for one modal option, they should also be increased for other options in order for a legitimate transition to occur for overall mode choice. Such a tipping of the scale is a proactive way to shape sustainable transportation demand while still preserving personal choice.

Therefore, policies need to be crafted that promote bicycling rather than solely excluding other modes. An example of a policy to promote bicycling is ensuring that all new construction on campus is mandated to include shower facilities to encourage bicycling. Different policies will clearly have different effects, and it’s import to build policies that are context sensitive. A policy like the example just listed will likely have a larger impact in Austin where the summer temperatures get very high and become prohibitive for active transportation. In light of this, I’ve developed a number of recommendations for “carrot and stick” actions that the University can take to boost the bicycling mode share—particularly those that ride two or fewer days per week which according to my survey is roughly 27%—and benefit the sustainability of campus. The following sections of this report seek to answer the main research question and address the ancillary questions as well.

6.3 Policy Approach:

Given its role in the University’s transportation system, PTS is a great place to start crafting policies for better bicycling. While PTS has been integral to developing the mode share to the point it currently is, there is still room for progress with this department. When speaking to UT Austin community members, I learned that many people don’t fully understand what PTS has to offer when it comes to cycling, which is unfortunate. As mentioned in the first section of the report, PTS has a number of programs that seek to benefit sustainable transportation to and from campus. In light of this, there should be defined policies for promoting how PTS serves bicycling.

One such policy could be allocating funds to be used for the distribution of promotional materials about the work of PTS for other, more sustainable transportation modes. A corollary to such a policy is leveraging freshmen orientation. Freshmen orientation is an appropriate program with a captive audience to distribute such materials and encourage people to ride their bikes for transportation. In fact, other universities, such as UC Davis, have found legitimate merit in communicating the benefits of bicycling in this sort of way. The bicycling programs offered on campus, such as the Orange Bike Project, are yet more PTS incentives to get around by bike and would benefit everyone if more people knew of such programs. PTS could also use such a platform to shed light on the misunderstandings that many people have about their work. Many on our campus misinterpret bike registration as a potentially negative thing and a brief PTS address at orientation could be instrumental in compelling cyclists to register their bikes and understand the benefits of doing so. Moreover, orientation addresses many elements of student life, and transportation options (in addition to the connected impacts of health, sustainability, and convenience) are a significant factor in student life that should be addressed.

Leveraging advocacy groups could also greatly benefit bicycling on campus. Another strong policy option for the University is continued development of the Bicycle Committee. UT Austin's bike coordinator, Jeremy Hernandez, began the Bicycle Committee in the spring semester of 2016 to facilitate the discussion about how PTS can best serve the bicycling community on campus. Many stakeholders are included in the Committee, which provides transparency and accountability for a diverse group of stakeholders. It would be a valuable use of resources to invest in such groups to catalyze conversation about bicycling and create channels of communication to the greater UT Austin community.

As the University continues growing, it's also important that policies be put in place to shape the future of campus. Ensuring that all new construction on campus is mandated to include at least one shower facility to encourage bicycling is a good policy to shape the future of active transportation on campus. This sort of "carrot" policy will not necessarily create a dynamic bicycle mode share right away but it can open peoples' minds to the idea of bicycling to campus in all seasons. It will also provide an element of comfort for people when they know they can clean up after their commute.

A different sort of policy that has shown to have legitimate impacts on mode choice is reducing the allowance of automobiles on campus. This "stick" approach, again taken by UC Davis decades ago, has had the effect of now making their core campus car-free. There are many reasons why this sort of policy is appropriate for our campus, including the extremely high amount of pedestrians and cyclists and the general fact that campus was not designed around the automobile. Our campus currently has measures in place that benefit a policy like this. UT Austin presently prohibits through-traffic on most of its streets, so this approach can be graduated over time to reduce automobile usage on the core campus. Complementary to reducing the allowance for cars is traffic calming. Traffic calming policies should be integrated into the entirety of campus, particularly on its periphery where traffic speeds are higher. Providing areas of exclusive access for certain modes and reducing traffic speeds on all campus streets are examples of traffic calming policies. Combining these approaches with positive infrastructural design can create a community environment that is far more human-oriented and scaled for all transportation users.

In the same vein, creating safer streets may not always result in a win-win situation. Prohibiting right turns at red lights is a good example of this and the tradeoff needs to be considered valuable enough to implement such policies at entrances to campus. Clear signage is important in this setting, so that people are genuinely responsible for their behavior. This should be done with a level of accountability as well, using tools such as traffic cameras. The hope is not to encourage people to disregard the rule but to ensure adherence to the law for the safety of other street users. The allowance of right turns at red lights is clear evidence that convenience for the automobile has long been paramount in our communities. However, as the University seeks to encourage more sustainable transportation options, small "stick" policies like prohibiting right turns at red lights act as an opportunity to begin to shift the paradigm, even if only slightly. After all, the policy allowing right on red was only implemented relatively recently and many communities throughout the world never allowed it or are repealing it. The entire continent of Europe even prohibits right on red[45] and the City of Seattle has recently begun prohibiting it at certain downtown intersections.[46] Thus, it is a defensible policy.

Another issue that has become very contentious is the reduction of automobile parking. Often times, people feel entitled to car parking; however, in an urban context like that of the UT Austin campus, there is simply not enough space to continue allocating for parking. Automobile parking is very much an incentive that encourages car usage. Our campus has even experienced this directly. Over the last few years as automobile parking has increased, the University's automobile mode share has also increased noticeably. It should be noted that a causal relationship is not being claimed here, but this correlation is interesting nonetheless. While the City of Austin, particularly its urban core, is increasing in density—which usually correlates with multimodal transportation—UTs population arriving to campus by car is shockingly growing at a rapid rate. Even if there is in fact no causal relationship between parking provision and automobile use, increasing car parking still should be viewed as an incentive, if only for the resources it solicits.

There are also ways to indirectly impact the demand for automobile parking using parking permit cost adjustments. Over the 2015-2016 academic year, PTS sold out of their available parking permits (meaning all parking spaces were purchased). This is a clear indication that parking permits could and should be priced higher. There are multiple types of permits with varying costs, so I suggest a universal increase that is reasonable at 5%-10%. As permits increase in cost, the incentive is reduced and the new disincentive can dissuade people from driving. Moreover, this increase can also grow the revenue—or at least offset the reduction due to less permits sold—for the automobile commuters who continue to purchase the permits. According to the 2012 PTS mode survey, over 50% of active transportation users stated they do not use automobiles because the costs are simply too high. Given that, it stands to reason a greater increase in automobile usage costs, such as parking permit price increases, would encourage more people to choose a more sustainable option like bicycling.

In addition, another policy approach to impact the environment for bicycling indirectly is stronger enforcement of the rules of the road on campus. The UT Austin campus has multiple dismount zones and yet cyclists can regularly be seen breaking this rule. If bicyclists are held responsible, it works to the benefit of both cyclists and pedestrians and can help maintain a safer environment on campus. For rules to be respected, it's important that accountability measures are also included. Enforcement is a legitimate issue pervasive in transportation systems worldwide. Drivers often exceed speed limits if they believe they won't be caught and bicyclists often disregard stop signs or traffic lights if they deem it safe to pass with no chance of retribution. Still, many bicyclists are even unsure they are obligated to abide by similar laws that other modes are. For such reasons, enforcement is key to building credibility for bicyclists and respect between the various modes. Facilitating a community environment where users of each mode are held to account is vital for having a more cohesive and courteous relationships between everyone. There are also productive ways to integrate education with enforcement. One such example is allowing offending bicyclists/drivers to attend a bike safety/bike transportation course in lieu of paying the cost of a ticket. In this way, people who have broken rules are able to learn about the offense and gain insight on other transportation laws. Enforcement is an important factor that can shape the transportation culture and ensure complementary use of multiple modes.

Finally, as the University continues to expand its approach to developing a strong bicycle network, it should work with the city to develop policies that integrate its bike routes and thoroughfares with other City of Austin bike routes. The City's newly adopted Vision Zero policy also provides leverage for the University to facilitate the interaction between the two entities. As many cities around the world have sought to eliminate traffic fatalities on their streets, the University should be no different. While the campus may not be riddled with traffic fatalities per se, transportation related injuries are not uncommon. UT Austin only stands to benefit from a similar approach to street safety. Additionally, to my knowledge, no such program exists for a university. In that way, UT Austin could also be a forerunner in developing policies that will contribute to holistically safer streets. By developing and adopting a type of Vision Zero policy, the University could really innovate and have other universities look to it for leadership.

6.4 Built Environment Design Approach:

Designing and providing appropriate infrastructure is as important as crafting useful policies. For the purposes of my recommendations, I want to expand what is traditionally considered infrastructure to include any built forms that serve bicyclists. This includes factors that impact bicycling directly and indirectly through a variety of characteristics.

For starters, bike parking is rarely thought to be the most intriguing type of bicycle infrastructure; however, it is very important to ensure people have the option and choose to ride. In fact, 15% of my survey respondents stated they would prefer more bike parking on campus, and frequent and high quality infrastructure like bicycle parking has shown to encourage more bicycling.[47] Not to mention, providing bike parking is a relatively noninvasive approach to infrastructure provision that is also affordable. Taking it a step further is making greater provision of bike lockers and/or secured bike parking.

Figure 6.1: Bike Locker

UT Parking and Transportation Services

PTS currently operates bike lockers in each of the seven parking garages on campus. The issue reducing locker utility at this time is that the parking garages are not conveniently located on campus. So if bicyclists seek extra protection for their bikes, they are required to go out of their way to access the lockers. A better approach would be to distribute bike lockers throughout the core of campus so that convenience is not sacrificed for the added security. New bike lockers could be located in building alleyways and away from immediate building entrances in order to reduce the intrusiveness of the structures. An example for a new location of a bike locker is on the western side of Goldsmith Hall and/or the Texas Union between the buildings and the sidewalk. Currently, bike racks are located in the vicinity but ample, discrete space is available to house a bike locker structure as well.

Figure 6.2: Arizona State University Secured Bike Parking

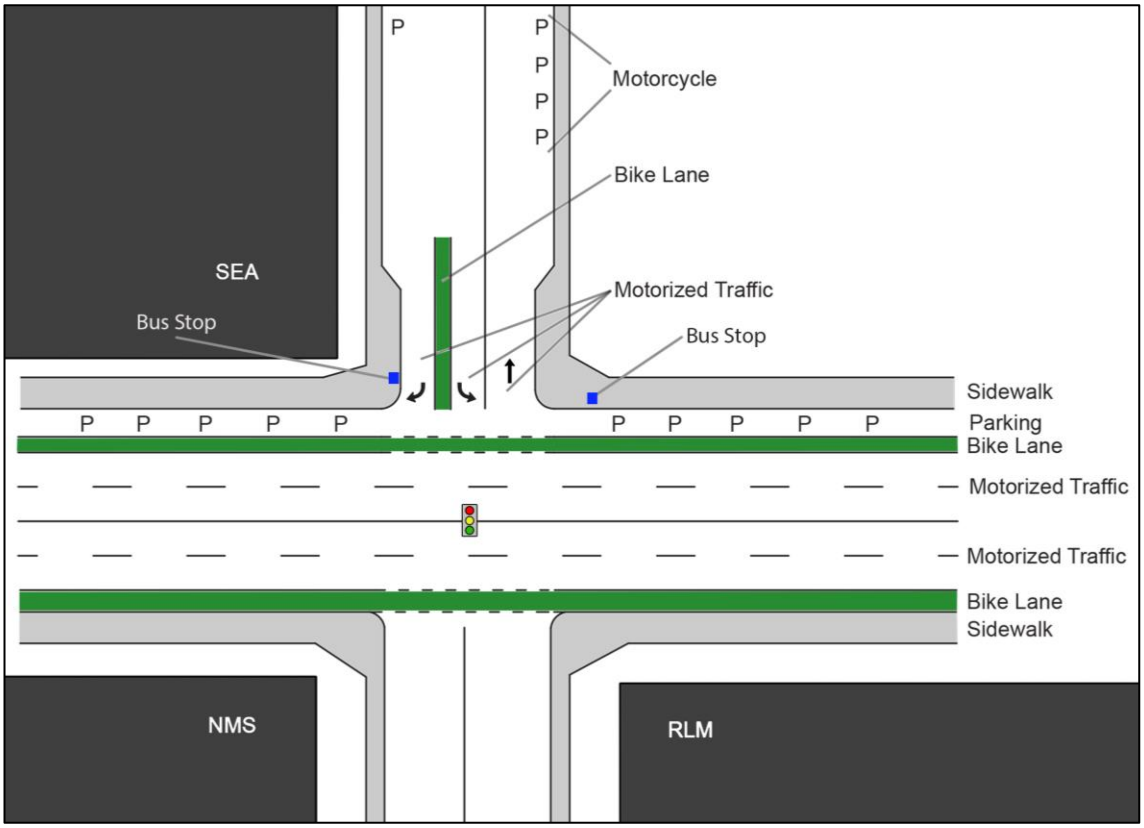
Shereen Shaw, 2014

Secured bike parking is another viable option for providing safe and secure bike parking. Although it is more expensive, automobile parking permit costs can offset the expenditures for such a structure. Arizona State University has been a pioneer in implementing secured bike parking and has done so to the benefit of campus bicyclists. Their secured parking structures are accessible only by a university ID and house more than 60 bikes each on a first come first served basis.[48] Similarly, these facilities are funded through revenue coming from automobile parking permits.[49] This program is evidence that innovative bike parking schemes can be implemented and even funded by adjusting budgets to incentivize sustainable transport. In addition, all new secured bike parking areas on the UT Austin campus can be furnished with PTS fix-it stations to increase their utility even more.

Although ensuring showers are provided in new campus construction was mentioned in the policy approach, it should also be considered infrastructure to support bicycling. In order to ensure that providing shower facilities is not cost prohibitive, a good option is to construct shower facilities in single occupancy bathrooms. This allows both women and men to access the showers and prevents the need to build multiple showers in each building. This opportunity would be dependent on the campus building codes, but could be included for structures undergoing construction rehabilitation or updating.

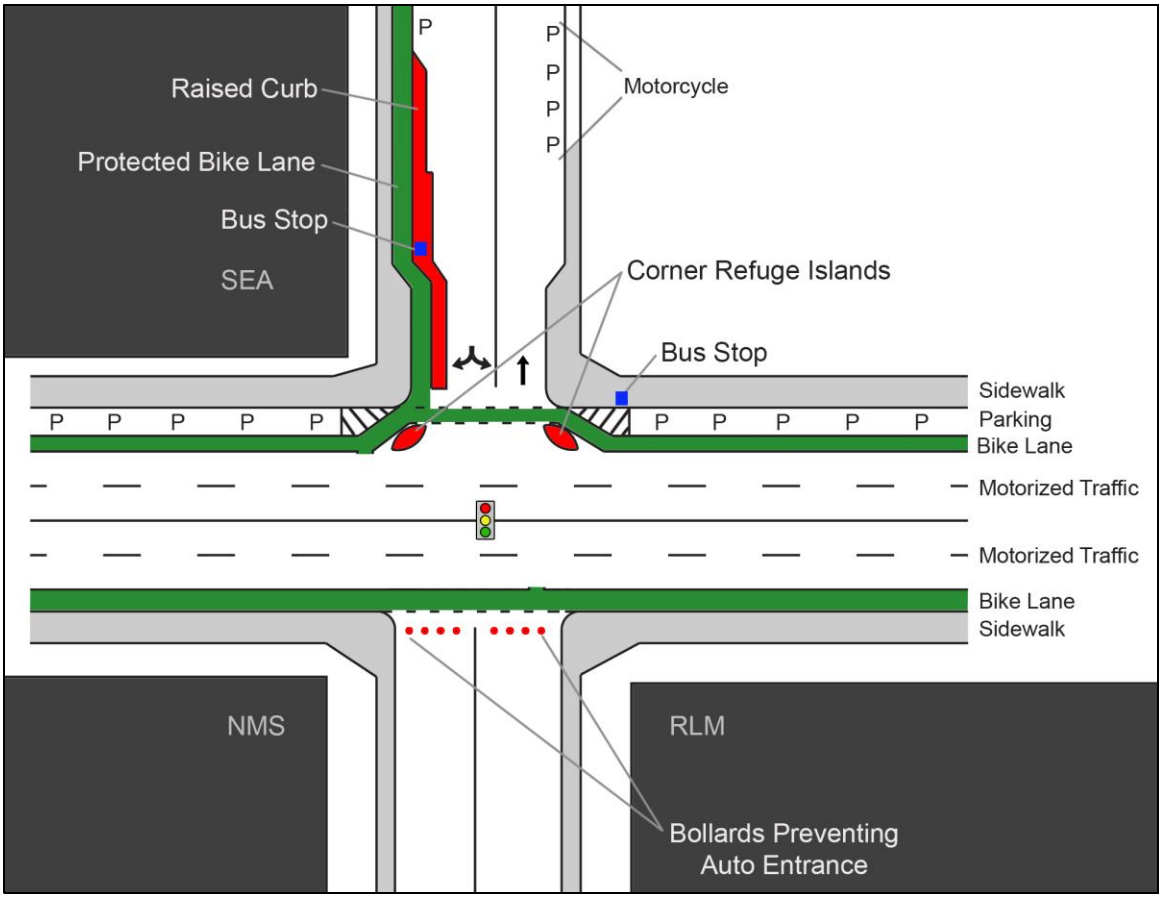
Changing directions a bit, I'll discuss the virtues of some of the more intriguing types of bicycle infrastructure. Due to their importance, intersections will be addressed first. The designs of our campus intersections are remnants of a historical and outdated paradigm. While intersections are places where cyclists are most vulnerable, this is precisely where bike infrastructure frequently disappears in our communities. The redesigning of intersections particularly at entrances to campus is arguably the most significant provision of infrastructure to benefit cycling the University could undertake. The Netherlands is particularly renowned for their safe and intuitive intersection designs that accommodate all modes, including those that are motorized. Many respondents to the surveys also acknowledged that campus intersections can be difficult to maneuver alongside cars and pedestrians. For this reason, I am recommending that more effort be devoted to designing campus intersections for safer interactions between cyclists and all other users. The design that the Dutch have made famous is appropriate for multiple campus intersections and should be considered, especially at the busiest intersections (i.e. Speedway and Dean Keeton St., 24th St. and Guadalupe St., 21st St. and Guadalupe St., 22nd St. and Guadalupe St., and San Jacinto Blvd. and Dean Keeton St.). My detailed design shows a context sensitive intersection design at one of the busiest entrances to campus, Speedway and Dean Keeton St.

Figure 6.3: Current Speedway and Dean Keeton Intersection Design



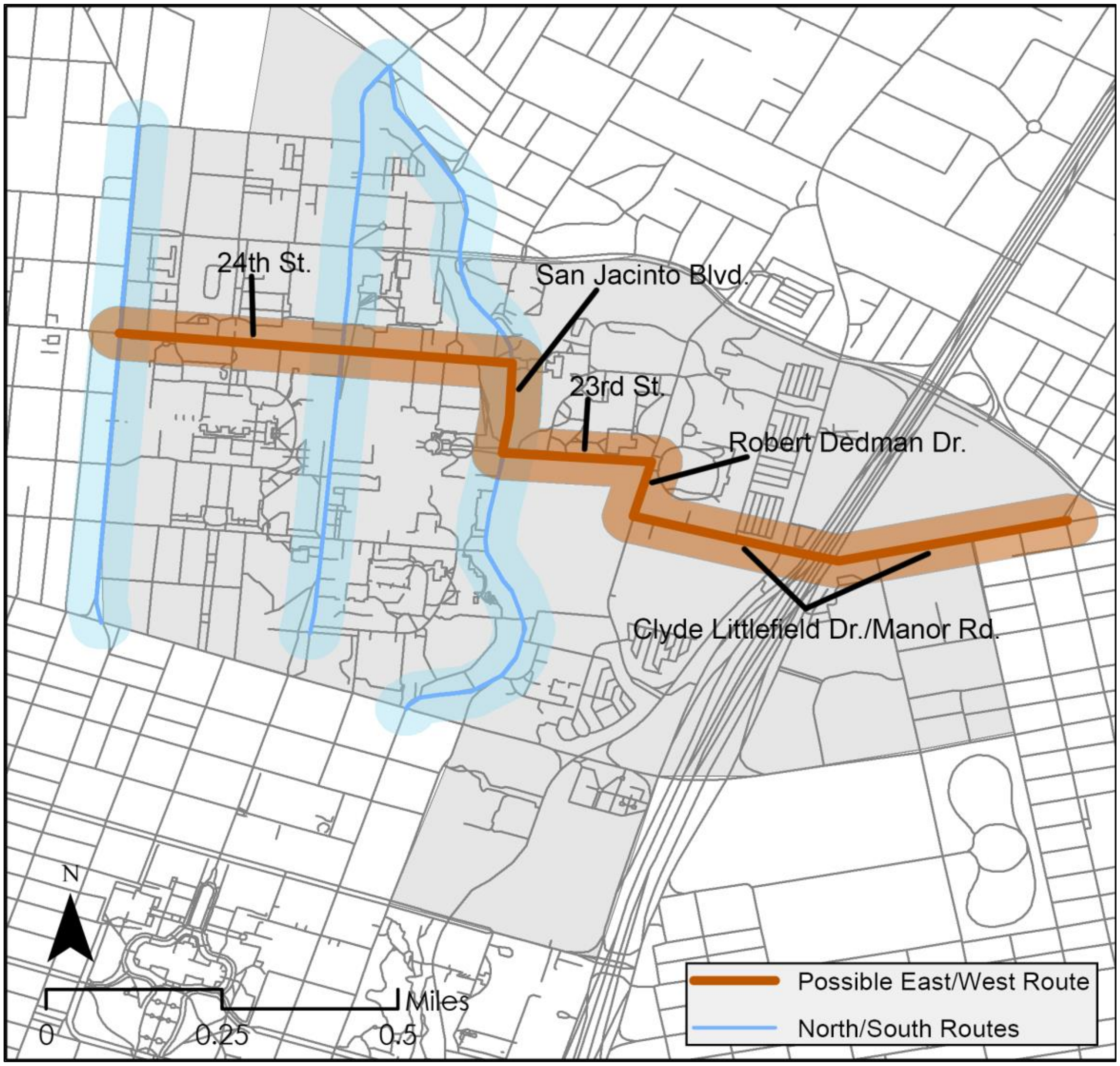
The current intersection design encourages dangerous mixing of traffic, especially with Speedway's southbound right turn lane. To remedy the issues, I am suggesting that the right turn lane be discontinued and the bike lane prolonged adjacent to the curb with grade separated protection. Corner refuge islands, also grade separated, should be installed on the north side of the intersection to safely sort traffic and provide barriers between cyclists, pedestrians, and turning vehicles. Additionally, a bus stop bypass could be instituted for the bus stop that is currently situated on the northwest corner of the intersection. The bus stop bypass would relocate the stop to a refuge island between the bike lane and the automobile traffic on Speedway. This design paired with the policy to prohibit right turns at red lights would drastically improve the safety and comfort of this intersection for bicyclists and pedestrians. At the same time, bike boxes should be utilized at less busy intersections where grade separation is not as necessary.

Figure 6.4: Recommended Intersection Redesign



Safe intersections should also be integrated into a network of safe bike routes. Bicycle infrastructure must be implemented with consideration for a broader, more expansive network; otherwise, dead ends will limit functionality and use. Providing great infrastructure in a piecemeal and segmented approach commonly provides only marginal benefits. It's only when bicycle thoroughfares connect with other bicycle friendly streets that people feel confident making trips by bike.[50] Defining a network of bike routes on campus is important for enticing non-bicyclists to make the switch and bike lanes were also listed as a highly preferred campus improvement. Currently, our campus streets are oriented in a north/south direction. North and south bicycle routes are important and should be developed but they should also be linked with east/west bicycle routes. The only east/west route that could currently be considered expansive is Dean Keeton St. However, as I learned in the survey feedback, this street is hindered as a bicycle corridor due to the high amount of motorized traffic and high traffic speeds. Therefore, an interior campus route should be defined to act as an east/west bicycle thoroughfare. Few interior campus streets are uninterrupted, so connecting multiple streets is likely necessary to complete a strong campus bike network. One possible option would be connecting 24^{th} St. with 23^{rd} St. by way of San Jacinto Blvd. The route could then be extended to Clyde Littlefield Dr./Manor Rd. by way of Robert Dedman Dr. This simple chaining of streets could provide a strong east/west spine for bicycle traffic on campus. After defining the network, the next step is enabling the network with appropriate infrastructural designs and signage to ensure the route is safe, intuitive, and easily navigable.

Figure 6.5: Recommendation for Possible East/West Campus Bike Route



Chief among the designs should be elements that work to calm traffic and preserve the quality of the street surfaces so that people enjoy bicycling. After all, street surfaces and automobile traffic are two of the greatest concerns of the campus bicycling community. Until the main campus bicycle routes are car-free, *bicycle boulevard*-style street designs should be utilized to reduce the speed of traffic and maintain the integrity of the street surfaces.

Figure 6.6: Bicycle Boulevard in Portland, OR

National Association of City Transportation Officials

These treatments should be prioritized for the main bicycle routes but also be employed comprehensively throughout campus. In this scenario, I am not suggesting the implementation of cycle tracks because they would be unnecessary given the 15mph campus speed limit, and even more so if campus moves toward being car-free. Still, implementing traffic calming and correlative street surface maintenance designs into the streetscape would create immense functionality for all users of the street.

Delineating space for the various modes is another way to make cycling intuitive on campus. People often feel unsafe riding bikes because they are unsure about their place in the transportation system. Bicycling is a unique mode because bicyclists have characteristics that make them similar to pedestrians and characteristics that make them similar to rapid transport as well. For this reason, space should be defined clearly to ensure that all users have a high level of comfort. Many of my survey respondents stated that greater separation between bicyclists and pedestrians was preferred. This can be done a number of ways, but simplicity should be at the heart of the approach. The most intuitive demarcation of space is that sidewalks are for pedestrians and streets are for higher speed transportation options. This is ultimately a hierarchy of access for different modes and can quickly become a cloudy subject without clear signage; however, this demarcation is a good rule of thumb.

Clearly not everyone adheres closely to this type of separation of space, but rather than dismissing this rule, there should be appropriate measures taken to propagate the concept to the fullest. Street markings and grade separations should then be used to define the street space between speedier transportation options, and signage is yet another complementary tool that is integral to convey the concept of the separation of space. Additionally, the greater proliferation of media prescribed in the policies section should also play a significant role in communicating these guidelines. Streetscape design is fundamental to peoples' interpretation of the separation of space. Significant redesigns require more financial resources and are not likely to be adopted overnight. Nevertheless, human-oriented designs should be consistently prioritized in order to create safer streets for bicyclists and pedestrians in the future.

Finally, it's important that the University accommodate smaller scale access issues that need to be addressed. The UT Austin campus has many areas that are hilly, and sidewalks often have stairs to navigate the changing topography. Because most of our campus was built before the mandate for accessibility of the Americans with Disabilities Act, stairs are frequently the only option for ascending these slopes. One such example of this is evidenced in the area between Goldsmith Hall and the West Mall Building. If bicyclists dismount between these two buildings with the intent to get to the West Mall, they will have difficulty towing their bikes up the multiple flights of stairs to park at the racks located at the top on the West Mall. One simple design application for this type of issue is bicycle stairway slots.

Figure 6.7: Bicycle Stairway Slot

Jemae Hoffman, 2011

Not surprisingly, bicycle stairway slots are ubiquitous in the Netherlands and Denmark due to their enormous utility. These subtle designs can easily be used to retrofit existing stairways to accommodate bicyclists. Addressing issues like this, while seemingly less significant, can have a pronounced impact on the accessibility of all areas of campus for bicyclists. These slots can also benefit general bicyclist behavior by enabling them to access bike parking racks more easily rather than fastening their bikes to the nearest light pole, which can be illegal. Moreover, this approach is relatively low cost and sends a clear signal to the campus community that bicyclists are welcomed, valued, and even encouraged for transportation to, from, and on campus.

CHAPTER 7:

7.1 CONCLUSIONS:

Ultimately, a direct approach must be taken to effectuate a strong representation of bicycling on campus and create a more sustainable modal spilt for UT Austin. Many communities have implemented "carrot and stick" policies that have dramatically increased the rate of bicycling.[51] As such, the development of policies and infrastructure should be definitively comprehensive as opposed to concessionary. In addition, the policies and infrastructural designs should be based on the feedback gained from such data collection methods as were utilized in this report. The methods should be sufficiently varied and leveraged to formulate a contextual understanding of the needs of the community. In my approach, I learned that qualitative feedback (e.g. from the surveys) is extremely valuable in understanding the nuances of transportation mode choices, particularly regarding active transportation.

Moreover, each transportation policy that is developed and each infrastructural design should be made with expressed consideration for sustainable transportation modes such as bicycling. Tying the development of the built environment directly with policies from a "carrot and stick" orientation is foundational to the realization of a sustainable transportation system at the University of Texas at Austin. Given the limited resources, the approach should also be one of triage, seeking to serve the areas with greatest users and potential first as identified throughout the report to be those in the core of campus, such as the Speedway corridor.

Further, the research methods I used are applicable in nearly any community context. Adjustments could be made to the particular types of data collection, given the characteristics of the community. With greater resources, the study could also leverage additional cutting edge technologies for the collection of data. These adjustments would simply provide a more detailed understanding of the context and enable a more tailored approach to the development of policy and infrastructure solutions.

It should be noted that in all scenarios, the outcomes of actions are directly correlative to the actions themselves. So, a conservative approach to sustainable transportation will likely result in marginal and underwhelming results. At the same time, a calculated and substantive approach to providing for transportation sustainability will undoubtedly help the University of Texas at Austin and other communities achieve goals of holistic sustainability.

REFERENCES:

[1] The University of Texas at Austin. Apr 2008. Campus Sustainability Handbook of Operating Procedures. The University of Texas at Austin. http://www.policies.utexas.edu/policies/campus-sustainability

[2] Hayhoe, Katherine. 2014. "Climate Change Projections for the City of Austin." ATMOS Research and Consulting. Accessed Sept 2015: https://austintexas.gov/sites/default/files/files/Sustainability/atmos_research.pdf

[3] American Lung Association. 2014. State of the Air. http://www.stateoftheair.org/2014/states/texas/travis-48453.html

[4] Youcanbikethere.com. 2015. "Bike Commute Calculator." Accessed 26 Feb 2015: http://www.youcanbikethere.com/bike-commute-calculator

[5] Telegraph Men. May 2015. The Telegraph. Accessed Sept 2015. http://www.telegraph.co.uk/men/active/recreational-cycling/11603491/Cyclists-are-40-per-cent-less-stressed-than-other-commuters.html

[6] Gordon-Larsen, Penny, Janne Boone-Heinonen, Steve Sidney, Barbara Sternfeld, David R. Jacobs Jr., and Cora Lewis. Jul 2009. Active Commuting and Cardiovascular Disease. The CARDIA Study. Arch Intern Med/Vol. 169 (No. 13).

[7] Andersen, Lars, Peter Schnohr, Marianne Schroll, and Hans Ole Hein. Jun 2000. All-Cause Mortality Associated With Physical Activity During Leisure Time, Work, Sports, and Cycling to Work. Arch Intern Med/Vol. 160.

[8] Pachauri, R.K., and L.A. Meyer. Climate Change 2014 Synthesis Report. Intergovernmental Panel on Climate Change. 2014.

[9] Buehler, Ralph, and John Pucher. 2011. Sustainable Transport in Freiburg: Lessons from Germany's Environmental Capital. International Journal of Sustainable Transportation. Pg. 43-70.

[10] Van Twuijver, Mireille, and Madelon Shreuders. 2004. Why People Do or Do Not Use Their Bike on Short Trips: Modality Choices in the Netherlands. Association of European Transport.

[11] AAA. 2014. "Owning and Operating Your Vehicle Just Got a Little Cheaper According to AAA's 2014 'Your Driving Costs' Study." Accessed Nov 2015. http://newsroom.aaa.com/2014/05/owning-and-operating-your-vehicle-just-got-a-little-cheaper-aaas-2014-your-driving-costs-study/

[12] Sierra Club. Pedaling to Prosperity: Bicycling Will Save Americans $4.6 Billion in 2012. http://vault.sierraclub.org/pressroom/downloads/BikeMonth_Factsheet_0512.pdf

[13] Sparshott, Jeffrey. Congratulations, Class of 2015. You're the Most Indebted Ever (For Now). The Wall Street Journal. May 2015. http://blogs.wsj.com/economics/2015/05/08/congratulations-class-of-2015-youre-the-most-indebted-ever-for-now

[14] Cotman, Carl W., Nicole Berchtold, Lori-Ann Christie. Sept 2007. Exercise Builds Brain Health: Key Roles of Growth Factor Cascades and Inflammation. Trends in Neuroscience. Volume 30, Issue 9, P. 464-472. Cell Press.

[15] Dill, Jennifer. Bicycling for Transportation & Health: The Role of Infrastructure. Journal of Public Health Policy, 2009.

[16] Takemoto-Weerts, David. Aug 2013. League of American Bicyclists Bicycle Friendly University Application.

[17] Buehler, Theodore. 2007. Fifty Years of Bicycle Policy in Davis, CA. Institute for Transportation Studies, UC Davis. http://www.davisbicycles.org/docs/BuehlerThesisFinalDraft.pdf
[18] The League of American Bicyclists. 2014. Bicycle Friendly University All Awards Through 2014. http://bikeleague.org/sites/default/files/BFU_Master_Award_List_2014_.pdf
[19] Emanuel, Martin. Jun 2012. Constructing the Cyclist: Ideology and Representations in Urban Traffic Planning in Stockholm, 1930-70. The Journal of Transport History, Vol. 33, No. 1.
[20] The Local. Jun 16, 2015. Zurich Voters Back Bike Lane Expansion Plan. Accessed Oct 2015. http://www.thelocal.ch/20150616/zurich-voters-back-bike-lane-expansion-plan
[21] Rosenthal, Elisabeth. Jun 2011. Across Europe, Irking Driver is Urban Policy. The New York Times. Accessed Oct 2015. http://www.nytimes.com/2011/06/27/science/earth/27traffic.html
[22] Soot-free for the Climate Campaign. 2015. 2015 City Ranking. http://sootfreecities.eu/city
[23] Rietveld, Piet, and Vanessa Daniel. Jan 2004. Determinants of Bicycle Use: Do Municipal Policies Matter? Transportation Research Part A. Pg. 545.
[24] Krizek, Kevin and Eric Stonebraker. 2010. Bicycling and Transit: A Marriage Unrealized. Transportation Research Board. Transit 2010, Vol. 2. Pg. 161-167.
[25] CROW. Jun 2007. Design Manual for Bicycle Traffic.
[26] National Association of City Transportation Officials. Mar 2014. Urban Bikeway Design Guide. Island Press.
[27] Pucher, John, Ralph Buehler. Jul 2008. Making Cycling Irresistible: Lessons from The Netherlands, Denmark, and Germany. Transport Reviews. Vol. 28 Issue 4, Pg. 523.
[28] Cambridge Cycling Campaign. 2014. Making Space for Cycling: A Guide for New Developments and Street Renewals, 2nd Edition. Cyclenation.
[29] Andersen, Michael. The Protected Bike Lane Ridership Bump, City by City (Infographic). People for Bikes. June 2014. Accessed Jun 2016.
[30] Andersen, Michael. NYC and DC, Protected Lane Pioneers, Just Doubled Biking Rates in Four Years. People for Bikes. Sept. 2014. Accessed Jun 2016.
[31] Goodyear, Sarah. Can the Least-Loved Bike infrastructure Be Improved? Oakland Tries a Makeover for the Humble Sharrow. City Lab. Oct 2015.
[32] Lindsay Walker, Mike Tresidder, Mia Birk. 2009. Fundamentals of Bicycle Boulevard Planning & Design. Initiative for Bicycle and Pedestrian Innovation, Center for Transportation Studies. Portland State University. http://nacto.org/wp-content/uploads/2012/06/Alta-and-IBPI.-2009.pdf
[33] Van der Zee, Renate. Jul 2015. How Groningen Invented a Cycling Template for Cities All Over the World. Accessed Sept 2015. http://www.theguardian.com/cities/2015/jul/29/how-groningen-invented-a-cycling-template-for-cities-all-over-the-world
[34] Dill, Jennifer, Christopher M. Monsere. Jan 2012. Nathan McNeil. Evaluation of Bike Boxes at Signalized Intersections. Accident Analysis and Prevention. Vol. 44 Issue 1 Pg. 126.
[35] Andersen, Michael. Four U.S. Cities are Racing to Open the Country's First Protected Intersection. People for Bikes. May 2015.
[36] Pedestrian and Bicycle Information Center. Accessed Oct 2015. http://www.pedbikeinfo.org/planning/facilities_bike_wayfinding.cfm

[37] Sasaki Associates. 2012. The University of Texas at Austin Campus Master Plan Fall 2012. The University of Texas at Austin.
[38] Cesar Pelli & Associates and Balmori Associates, Inc. 1999. The University of Texas at Austin Campus Master Plan. The University of Texas at Austin.
[39] The University of Texas at Austin. 2014. Landscape Master Plan & Design Guidelines Spring 2014. The University of Texas at Austin. http://www.utexas.edu/campusplanning/masterplan/documents/UTLandscapeMP_20150106.pdf
[40] UT Parking and Transportation Services. 2012-2013 Annual Report. The University of Texas at Austin. http://www.utexas.edu/parking/about/annual_report/annual_report_1213.pdf
[41] UT Parking and Transportation Services. Bike Pumps & Fix It Stations Map. The University of Texas at Austin. http://www.utexas.edu/parking/bike/tools.html
[42] UT Parking and Transportation Services. 2012. Transportation Mode Survey: Executive Summary. The University of Texas at Austin.
[43] UT Parking and Transportation Services. http://www.utexas.edu/parking/
[44] UT Parking and Transportation Services. 2014. Annual Report 13-14. The University of Texas at Austin.
[45] Burleigh, Timothy. German Bicycle Laws. Bicycle Germany.com. Accessed May 2016.
[46] Sean Keeley. Say Goodbye to Right on red at These Ten Seattle Intersections. Sept. 2015. Accessed June 2016.
[47] Hull, Angela and Craig O'Holleran. Bicycling Infrastructure: Can Good Design Encourage Cycling? Urban Planning and Transport Research. 2014. Accessed May 2016.
[48] Biking at ASU. Arizona State University. n.d. https://cfo.asu.edu/bike
[49] Lewandowski, Donna. Personal Interview. 20 May 2016.
[50] Andersen, Michael. Great Bikeways Only Work If They Connect To Great Bikeways. People For Bikes. May 2016. Accessed Jun 2016.
[51] Pucher, John, Charles Komanoff, and Paul Schimek. Bicycling Renaissance in North America? Recent Trends and Alternative Policies to Promote Bicycling. Transportation Research Part A, Vol. 33. 1999.