BIKING ON GROUNDS

Engineering Division

Global Sustainability, Fall 2011

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ABSTRACT

As the engineering design team, the principle task for completion dealt with the creation of a tangible solution for improving cycling on grounds. Multiple avenues were explored in an effort to determine which needs were most pressing for the community. The identified areas of need included concerns associated with cycling safety due to unregulated interactions with pedestrians and motor vehicles at both intersections and along roadways throughout campus. Concerns with deficient bike lane access and parking facilities were also identified as strong deterrents for biking.

In reviewing the potential solutions for each of these four areas of improvement, it was determined that the most significant impact could be made by addressing the deficiency in parking space. Adding more bike lanes to city and campus streets would have been financially impossible and possessed major concerns with determining exactly who owns and operates each section of road. Any effort associated with improving pedestrian or motorist behavior would have been mostly focused on education and advertisement efforts, both of which are being addressed by alternate groups within the larger project scope. Therefore the engineering design was focused on collecting data and making recommendations for campus parking.

With a principle focus on the McCormick Road corridor running from Clark Hall to Observatory Hill, data was collected from around grounds in an effort to determine areas requiring additional or improved bike parking facilities. Two areas along McCormick Road, Wilsdorf Hall and the Chemistry Bus Stop, were identified as needed additional capacity in order to prevent overcrowding, with a recommended increase of 10 and 4 spaces respectively. Observatory Hill Dining Hall warranted the largest recommendation for capacity increase with 30 spaces. It should be noted that Newcomb Dining Hall was intentionally omitted from the study due to unknown confounding effects presented by the current construction projects in the vicinity. The recommended increases in capacity call for the use of “U” shaped racks that allow for the parking of two bikes per installed system. This style of parking was preferred over linear rack designs because of its flexibility of application geometry and its increased level of bicycle protection and improved ease of use. Consideration was also given to the potential implementation of long term (i.e. overnight) storage for persons desiring to leave their bikes on grounds while using alternative means of transportation for entering and leaving the campus area.

THE PROBLEM

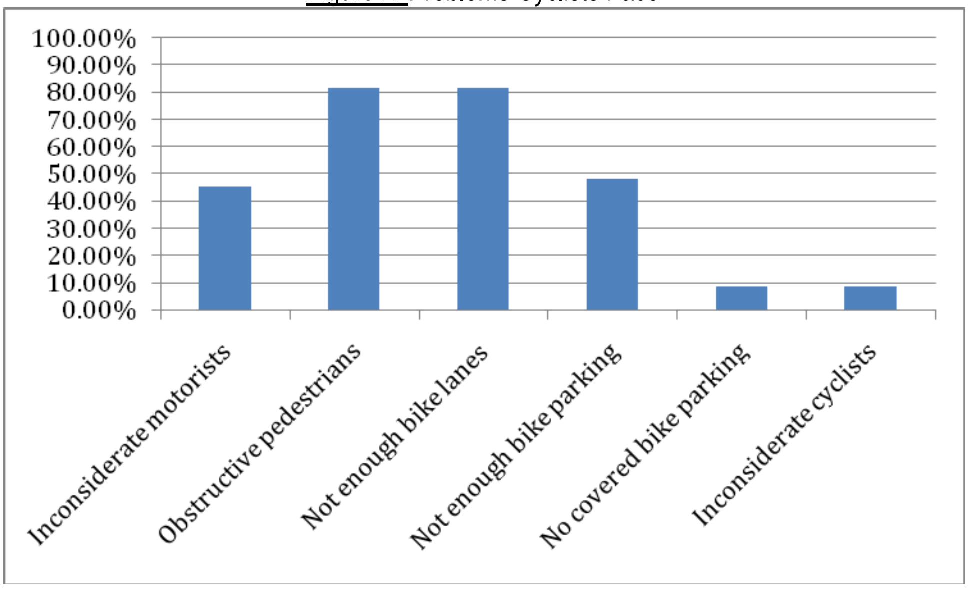
A lack of structural parking capacity for bikers on grounds has limited the number of students and faculty using bikes to commute around campus. This restriction presents both a financial and logistical challenge in terms of designing and implementing an upgraded system of bike storage. The Office of the Architect Parking and Transportation has requested that the engineering group assess the university's lack of tangible assets with which to address this parking shortage in an effort to gain information necessary for improving biking around grounds.

Survey

To facilitate such gaining of information, we decided to implement a preliminary survey to assess the situation. Before tackling the problem, we had to see where the problems actually lay. We created a separate survey each for cyclists and non-cyclists to better tailor our questions to their potential concerns, and received 135 responses in total, of which 33 were active cyclists. While this is by no means a large sample group, it formed a working foundation from which to proceed. The complete survey questions and raw data are listed in Appendix 2 at the end of this report. Elaborated here are the most pertinent and relevant results.

First, we asked cyclists what problems they were facing. Their responses are outlined in the chart below:

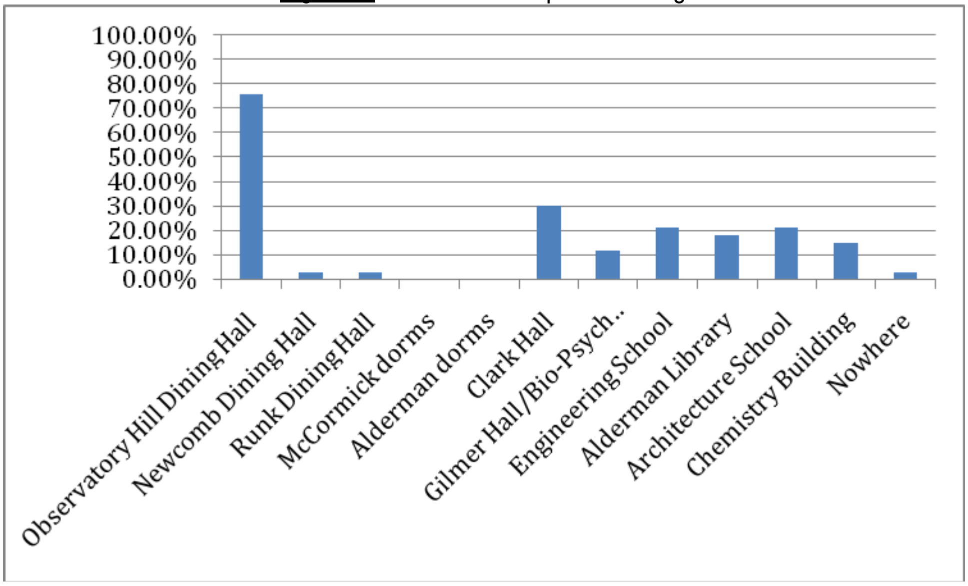
Figure 1: Problems Cyclists Face



Over 80% of cyclists felt that pedestrians were obstructing them, and that there were not enough bike lanes. Unfortunately, the education of pedestrians on how to better accommodate cyclists (and vice versa) is not within the jurisdiction of this group. However, seeing that bike lanes were a problem, we decided to look at that. In addition, almost half of the cyclists felt that there was not enough bike parking. Although not shown here, we found that 65.39% of non-cyclist respondents indicated an increase in bike parking would significantly encourage them to start cycling. This made us decide to also look into increasing the amount of bike parking on grounds.

Since parking was a problem for almost 50% of cyclists, we had to see which areas were the most problematic –at least to the small sample pool that responded. Our findings are as follows:

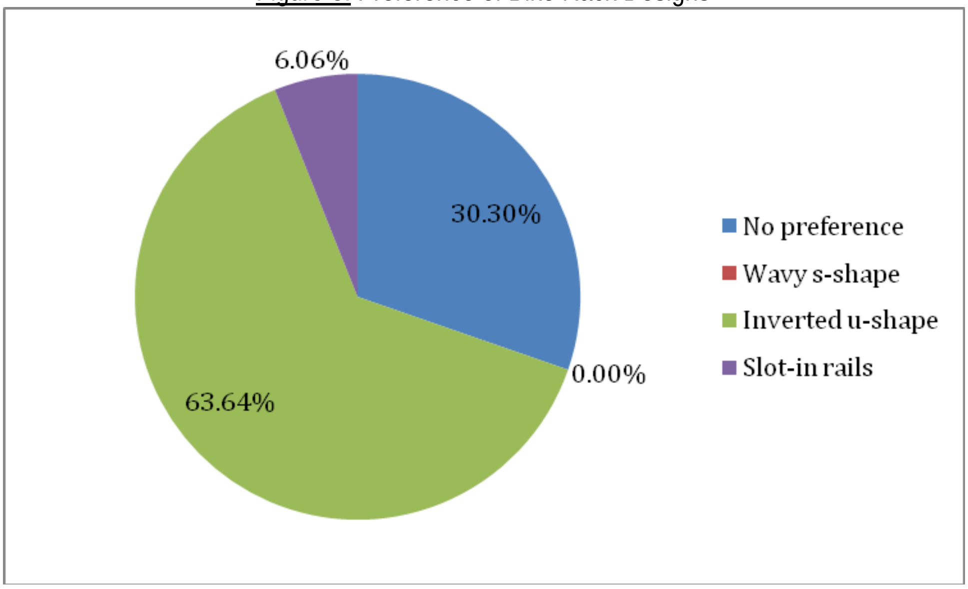
Figure 2: Areas of Inadequate Parking



From the chart, it was evident that Observatory Hill Dining Hall currently creates the most parking problems, in addition to a host of McCormick Road locations. As a result of this, we decided to focus our research and our efforts on improving the parking in and around the McCormick Road area – of course including Observatory Hill. We eventually found that our research data fit quite closely to our initial survey results, as will be elaborated on later.

If we were to improve the quantity of parking, however, we had to make sure that whatever we implemented was of good quality and would satisfy actual cyclists. As such, we also polled them on what their preferred bike rack design was, as seen below:

Figure 3: Preference of Bike Rack Designs



While 30.30% of respondents were indifferent to the type of bike rack they used, almost two thirds of the sample pool felt that the inverted u-shape bike rack was the best. The overwhelming vote of confidence for this design influenced our decision to give it serious consideration during our search for a suitable solution, and it would in fact end up being the design that met our criteria for a good bike rack. This will be explained later in the report.

It should be noted that 47.06% of the non-cyclist respondents said dangerous road conditions was one of the top three reasons why they did not current cycle. Although not the responsibility of this engineering group, it should be seen as an area to address by other groups or in future projects.

GOALS

We want to provide a bike rack system, on the University of Virginia's (UVA) grounds, that will support the capacity of not only the present bikers but also allow for an increase in the number of bikers on campus. A structural system that will accomplish this must have a bike rack design that maximizes bike parking while not compromising the safety of the bike or pedestrians. The bike infrastructure must have bike racks that are placed in the right quantities and in the right locations to ensure that a biker on campus will always have a place to safely and legally chain their bike should they need to stop at a given location.

Figure 4: Rack at Less than 75% Capacity Appears Almost Full

To be conservative and insure the system's future value, any percentage occupancy over 75% will be considered evidence supporting the need for increased capacity. Bike racks with a current occupancy of 75% or more are considered to be subject to increased occupancy with an influx of bikers, thereby requiring a need for improvement. This system should also take into account the variety of commuters that will comprise its target audience. A large number of UVA students live off-grounds so, depending on the distance, they may not want to bike to campus. However, this does not mean they will not bike around campus. Therefore, we must also design bike racks that will provide shelter and a more secure locking system so that people will feel safe leaving their bikes on-grounds overnight and then use them to commute about campus during the day. Through these measures, we aim to increase the number of cyclists and thereby reduce both pedestrian and bus traffic.

Community Partners

The engineering group will seek to conduct this project with the continuous involvement of our community partner, interfaced through communication with Jon Monceaux and Rebecca White in the Office of the Architect Parking and Transportation. The University of Virginia's Department of Parking and Transportation is responsible for providing assistance and relevant input regarding the provision of a viable fee parking system; provision and operation of a safe, efficient bus service that supports the academic, cultural, operational, and social activities of a comprehensive University, and provides timely service to and from the Grounds and areas of the surrounding community. The Department is also committed to the maintenance and development of requisite parking and transportation equipment and facilities while preserving the visual and physical integrity of the University Grounds. They also review budgets and appropriate fees for parking and transportation services and enforcement. With the help of our community partner we were able to conduct a thorough breakdown regarding the costs for potential bike racks and maintenance. Harsh Jain will also be providing supervision and feedback during the evolution of the project.

METHODS OF APPROACH

The physical nature of the issue being addressed really only lends itself to a single solution, namely the increase of bike storage on campus. This solution however, can be approached from several different design angles and with multiple combinations of resource allocation. In order to develop a design that meets our goals, we propose that we accomplish the following:

Bike Rack Design for Short-term Parking

A bike rack design must be selected that is resistant to tampering and provides the needed number of spaces in which to properly lock a bike in the short-term – that is, for a few hours during the day. A properly locked bike is one that has the frame of the bike locked to the bike rack, not a wheel. If a poorly designed bike rack is selected, theft and a lack of space will remain a problem continuing to limit both the bike capacity on campus and the willingness to bike on grounds. To select such a bike rack we will go about comparing a variety of commercial bike racks. Using a set of criteria, listed below, we will select the one best suited to accomplish our design goals.

Efficient Placement of Bike Racks

It is important that the bike racks be placed where they are most needed and in sufficient numbers to meet the demands of bikers even during peak hours of bike commuting at that location. This will largely be determined by statistical analysis of where and when students commute. Since it is likely that specific data on bikers commute locations is not available we will rely on the data of class times and sizes to estimate the number of bikers expected in a given location. We will look at the overall trend of selected academic majors to ensure that proposed locations for bike parking upgrades will be relevant for several years to come and not be outdated by the following years' changes in student population dynamics.

Bike Rack Design for Long-term Parking

In order to find the best long-term bike rack design we will look to other places implementing long-term storage and learn from their designs. By "long-term", we mean parking overnight or over the weekend. 24.44% of survey respondents indicated that the provision of such parking would most encourage them to start biking, which would indicate that such changes are warranted to a degree. Thus, we will choose a long-term bike rack design using other case studies as inspiration. The implementation of a bike share program may limit the number of spaces needed in a long-term bike rack, but we believe that some people would still prefer to use a nicer personal bike instead of a shared bike.

Discarded Approaches

In addition to the structural system of bike parking, there was the potential for us to explore an alteration to the local roads. With the potential influx of bikers comes more congestion on the roads. In an effort to mitigate traffic and potential accidents, better on-road signals could have been explored. The implementation of bike lanes, striping, and shared lane markings ("sharrows") could potentially increase awareness between bikers and drivers, therefore reducing potential accidents. 54.55% of survey respondents listed an increase in the number of bike lanes around grounds as the one change that would most encourage them to start cycling. Also, while bike lanes should normally carry cyclists in the direction of traffic, there are some locations where there is a strong demand for cyclists to travel against the normal flow of traffic. In these areas, contraflow bike lanes could be introduced. Painting these signs on roads would also encourage students to bike more since there would be a designated area for them to commute without interference from passing cars.

However, we decided not to explore this implementation due its restrictions. First, there is the difficulty of determining which roads belong to the University and which to the state of Virginia. Second, location of these potential bike lanes could create conflict between UVA and the state. Lanes within grounds would eventually come to an end and the state may not want to continue the lanes. The influx of bikers on the state's roads may cause problems regarding safety. Lastly, bike lanes and contraflow lanes can only be painted on roads that are a certain width. Many of the roads in UVA are not wide enough, and due to their proximity to historical buildings, are not able to be widened. Even if they could be, it would entail high construction costs, and these costs may not be worth it if the lanes are underutilized. Therefore, we discarded this potential approach.

CRITERIA FOR CHOOSING BIKE RACK DESIGNS

Short-term Bike Rack Designs

We considered seven criteria when selecting a bike rack design for short-term parking. The criteria were chosen based on our personal experience with biking, the concerns of our community partners, the experiences of fellow University students, the experience of the National Pedestrian and Bicycle Information Center, and information from (bikeparking.com).

1. Rack capacity: A rack must be able to meet the minimum capacity requirements.
2. Cost: Within reason, the cost of the bike rack will only be considered when comparing our final few selections of bike racks. The reason being that having a bike rack with high quality in all the other criteria is more important than having a cheap bike rack and poor quality in the other criteria. It is also likely that a higher upfront cost will result in lower maintenance and replacement costs in the future.
3. Security: The bike rack must be designed in such a way that for every bike designed to be parked on the rack there must be a space were the bike can have its frame locked to the bike rack. If people can't safely secure their bikes people will not bike.
4. Durability: A bike rack that will stand up to the abuse it will receive. Any bike rack on campus will likely be used several times daily year round and will also be subject to humidity, a variety of different weather, and potential attempted vandalism. Thus in order to ensure that the bike infrastructure remains functional the bike rack we select must be durable.
5. Space efficiency: There is a limited amount of space where bike racks can be placed so it important that a bike rack has no inefficient use of space.
6. Aesthetics: The University of Virginia is well known for being one of the most beautiful campuses. Purchasing a bike rack that is glaringly out of place in color, material, or any other way would damage the universities aesthetics which is the last thing we wish to do.
7. Ease of use: Given the time constraint in which people are often faced when parking their bikes, it is important that the bike rack is easy to use. Clearly defined instructions would help those unaccustomed to parking bikes. Clearly defined places to put bikes would help avoid people trying to cram several bikes into one space or accidentally locking someone else's bike along with their own.

Long-term Bike Rack Designs

Each long term bike parking rack would be site-specific but all of the designs would be based on the following eight criteria.

1. Cost: Given the need for more shelter and increased security the cost of the long term biking racks will be higher than that of the short term racks. Nevertheless, a rack must be designed that is cost-effective or else it will never be built.
2. Parking Capacity: Of course, the rack must be able to meet the minimum capacity requirements expected at that location.
3. Security: The rack must have a high level of security since the bikes will stored inside overnight, when pedestrian traffic will not be providing passive security and a potential thief would have more time to try and steal a bike. This means heavier duty metal used as well as a potential closed in space with fencing and a designated lockup schedule. Signage claiming video surveillance, even if there is no actual surveillance, could also provide additional security.
4. Durability: Given the fact that a long-term parking spot will be more of a structure and more expensive it is important it be constructed so that it is durable. Durability here has the same benefits as durability for the short-term biking spots but to a larger degree.
5. Shelter: Since bikes will be parked here for much longer periods of time it is important that some shelter be provided so a person's bike does not become damaged.
6. Space efficiency per bike: There is a limited amount of space where bike racks can be placed so it important that a bike rack has no inefficient use of space.
7. Visual Aesthetics: The University of Virginia is well known for being one of the most beautiful campuses. Building a bike rack that is glaringly out of place in color, material, or any other way would damage the universities aesthetics which is the last thing we wish to do.
8. Ease of Use: People will not use a long term biking rack if it is difficult to remove and place there bike in the long term rack. This is especially important to keep in mind since it is often tempting for long term bike racks to cram in bikes without realizing how hard it can be to remove a bike when you are in a rush.

SCHEDULE

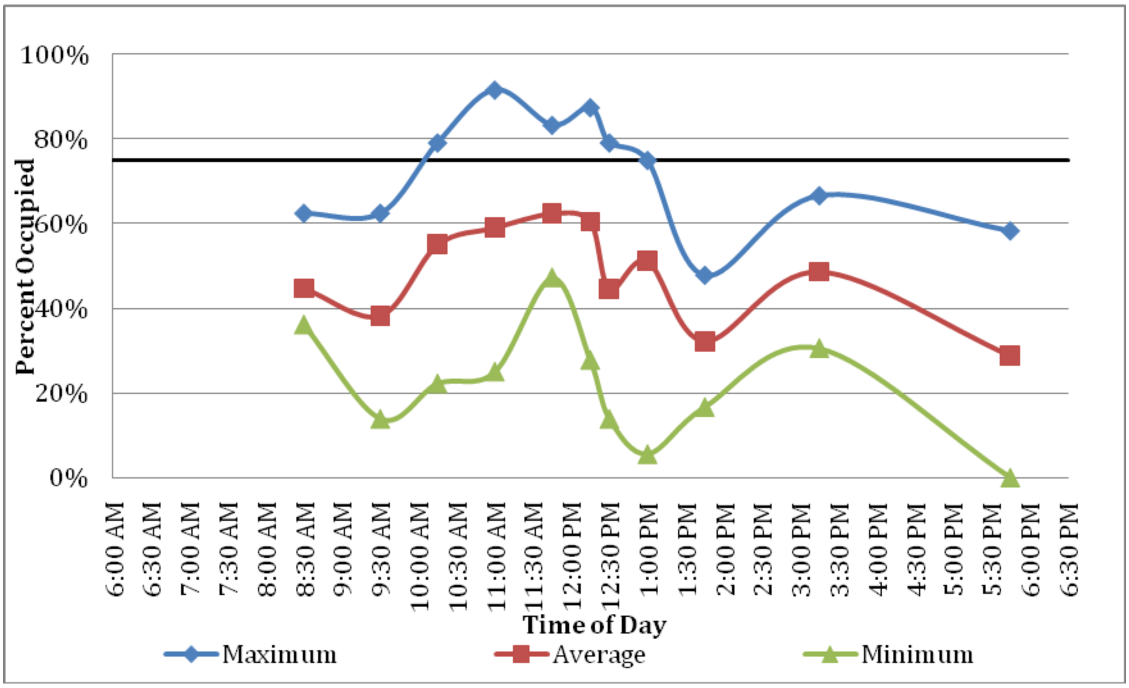
Date	Task	Responsibilities
10/03/11 – 10/18/11	Research any other potential problems existing bicyclists are facing to ensure we are addressing the proper problems. This research will consist of surveying present bikers as well as students who do not bike but have considered it.	Ted: Liaison with community partners; survey creation David, Sam: Survey dissemination Ryan: Data collation
10/03/11 – 10/18/11	Research possible bike rack locations for both short term bike parking and long term bike parking. This research will consist of determining the most congested area for bike parking during the day as well as the areas that people would leave a bike parked overnight. The research will also ensure that there are no gaps in the distribution of the bike racks and where there is physical space for bike racks to be added	Area Allocation Ted: Observatory Hill David: McCormick Road Sam: Alderman Road
10/19/11	Organization of gathered data in easily readable graphs and reports	Ryan: Data Analysis
10/20/11 – 10/27/11	Research for bike rack design both long term and short term. Given the data we will have gathered we will research the bike rack designs that will best meet the bike parking demand through the criteria that we listed above.	Sam: Design Research Ted: Cost research & estimation
10/28/11 – 11/01/11 (Due 11/02/11)	The first draft of the final report will consolidate the graphical information we have collected with the suggested bike rack designs as well as the suggestions for where bike racks should be placed.	Ted: Budget, Funding, Documentation, Assessment Ryan: Graphs and data analysis David: Goals, Dissemination Sam: Bike rack designs
11/03/11 – 12/09/11 (Due 12/10/11)	Final edit of report and evaluation of analysis and conclusion.	As with Preliminary Report
12/09/11 – 12/31/11 & beyond (To be incorporated continuously)	Implementation/construction schedules – Supplementary information to be considered as an additional exercise.	

DATA SUMMARY AND ANALYSIS

During the course of this project, data was collected via visual observations conducted within the areas of interest on grounds. All observations were recorded on weekdays during which no major adverse effects (like sporting events) were occurring. All weekdays were assumed to be approximately equal in significance as well as likelihood to produce a given data value. Observations of bike rack capacity as well as percent occupancy were made at 15 minute intervals throughout several weekdays of data collection. Note that data points displayed in chronological order (from am to pm) were not necessarily collected in that order (day to day). It should also be noted that capacity was determined by assuming that both "inverted-U" and "grid style" temporary racks had a capacity equal to one bike per repeating unit if access was only available from one side, and two bikes per unit of two-sided access was provided.

Figure 5 shows a graphical representation of the data collected along the McCormick road corridor between Clark Hall and the Observatory Hill Dining Hall. This area represents the focus of our study because of the high volumes (both pedestrian and cyclist) observed here due to its central location without grounds and proximity to first year housing.

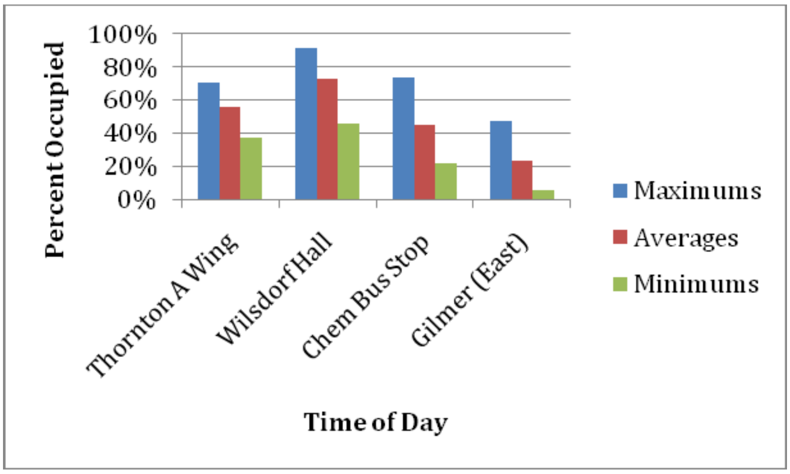
Figure 5: McCormick Road Percent Occupancy



As can be seen from the graph, McCormick road experiences its highest loading of parked bicycles between the hours of 10:00AM and 1:30PM. The horizontal black line on the chart represents 75% occupancy. This level was selected to signify the capacity beyond which we believe corrective measures are necessary. The reason that we wish to avoid 100% theoretical occupancy is because under such conditions, bikes are likely to become entangled and damaged during the process of placing and removing them from the racks. Furthermore, excessively high percentages of occupancy create unattractive "piles" of bikes which detract from the aesthetics of the University and dissuade bikers from using any remaining openings within the bike rack for the aforementioned risks of damage and inconvenience.

Given the above data and methodology of analysis, it is clear that the average occupancy along McCormick road does not present a significant problem. However, the maximum occupancy values observed during several of the time intervals exceed the 75% selection criteria and therefore indicate that certain locations within the study could benefit from increased capacity. Figure 6 shows the maximum, average, and minimum occupancy values observed for the four highest average occupancy locations observed during the duration of the study.

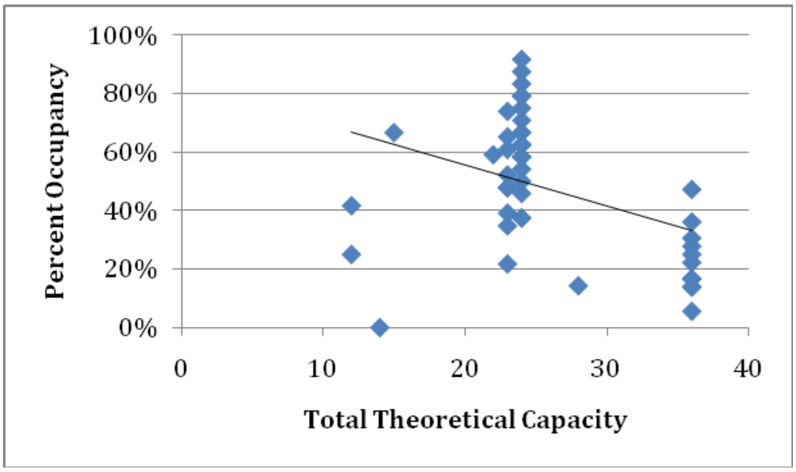
Figure 6: Observation Values for Locations of Highest Occupancy



This chart shows that both Wilsdorf Hall and the Chemistry Building bus stop have been observed near the threshold capacity of 75%. These two locations therefore warrant an increase in capacity in order to avoid excess occupancy. Increasing capacity to reduce maximum percentage occupancy to less than 65% will insure that the threshold capacity is not exceeded after the modifications. This reduced percentage was chosen as the design maximum occupancy in order to allow for future growth and increased usage due to the implementation of the proposed improvements. Currently the Wilsdorf Hall bike racks have a capacity of 24 bikes, with the maximum occupancy measured at 22. In order to reduce the percentage, the capacity at this location should be increased to at least 34 (thus making 22 bikes equivalent to 65%). The Chemistry Building bus stop has a measured capacity of 23 bikes, with a maximum occupancy observed of 17. Increasing capacity to 27 (thus making 17 bikes equivalent to 63%) will insure that this area will be capable of handling peak loadings. It is likely that these two locations represent the highest concentrations along McCormick due to the proximity to first year dorms, large and popular classrooms, and one of the busiest transit stops on campus.

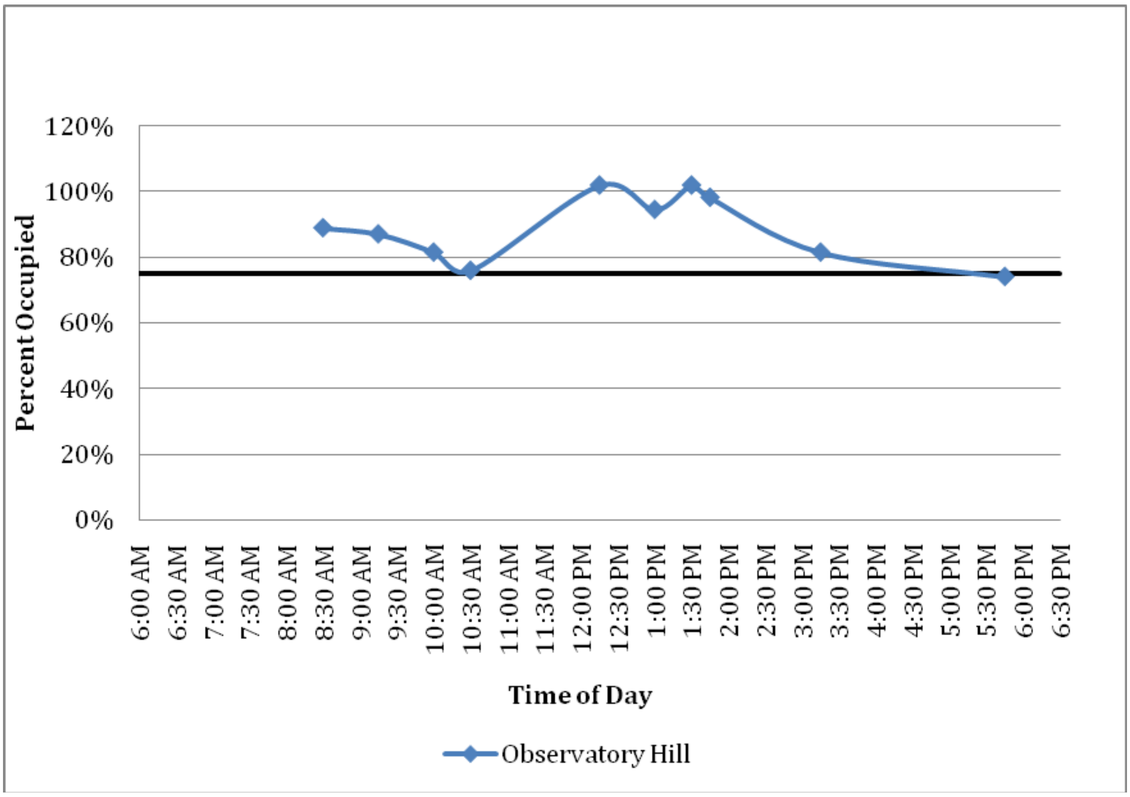
An additional artifact indirectly shown in Figure 7 is the general trend of decreased occupancy with increased capacity. For example the Gilmer east bike rack area has a capacity of 36, and yet never experiences an occupancy percentage greater than 50%. Figure 7 details this rather obvious trend within the entirety of McCormick road observations. Possible ramifications for this discovery include the possibility of reducing capacity at locations like Gilmer East (which uses mobile, twelve bike units) and allocating those resources to areas like Wilsdorf or the nearby bus stop.

Figure 7: Correlation between Capacity and Percent Occupancy



The bike capacity at Observatory Hill Dining Hall represented a secondary area of interest. During the collection of the data analyzed above, additional counts were made regarding the "U" shaped bike racks outside of the dining hall. There are currently 27 installed racks, each of which has dual access (from both the concrete and grass sides) thus bringing the total capacity to 54, which is by far the largest single volume in the study. However, despite this large capacity, the dining hall experiences a continuous over population of its bike rack, resulting in bikes being chained to adjacent trees, fence posts, parking meters or even being left complete unsecured while riders enter the dining hall. Figure 8 shows the data collected during the course of this study.

Figure 8: Observatory Hill Dining Percent Occupancy



As expected, the peak loading occurs between 12:00pm and 1:30pm, the time when many students are eating lunch in between commuting to classes. Breakfast and Dinner times represent lesser volumes possibly due to proximity to first year dorms, which allows students to walk at a more relaxed pace before or after the day's class responsibilities. In any case, all measured times illustrated a need for increased capacity. In fact, two instances (12:15pm and 1:30pm) demonstrated occupancy over 100%. With these two times as indicators of the peak loading and using a design occupancy maximum of 65%, the required capacity for Observatory hill would be at least 84 bikes. Increasing capacity by 30 will likely prove difficult due to a lack of available space, particularly options that allow two sided access to the bike rack. However, Figure 9 shows a satellite image of Observatory Hill (taken from Google Maps) with existing and proposed locations for bike racks shown (existing in red and proposed in blue). The intersection of McCormick and Alderman is shown in the top right for reference.

<u>Figure 9</u>: Observatory Hill Dining Bike Rack Location Image

As can be seen from Figure 9, the proposed area will only offer one sided access as it backs up to the building. However given its comparable size, the new area will still be able to offer half the parking volume of the existing system, thus bringing the total capacity to approximately 84 bikes. A complete copy of the raw data collected for this report can be found in the appendix.

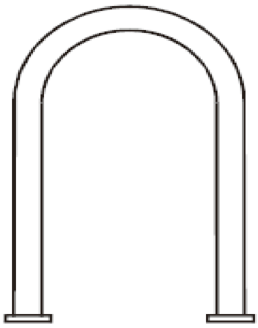
<u>Figure 10</u>: Observatory Hill Rack at Typical Lunchtime

RACK DESIGN – SHORT AND LONG TERM

Short-term Rack Design

Based on our selection criteria we chose the inverted-U bike rack for short-term bike parking. The criteria that we used to select a “proper” short-term bike rack included rack capacity, the cost, security, durability, space efficiency, visual aesthetics, and ease of use.

Figure 11: Inverted-U Bike rack



Basic Design Specs

The dimensions for the standard inverted-U bike rack are approx. 43" H, 30" L, 2.4" W, as measured by Samuel White outside Hereford Residential College.

Rack Capacity of the Inverted-U Bike rack/Space Efficiency

Each inverted-U rack has the capacity to properly secure two bikes. In terms of space efficiency, the inverted-U racks are better than other rack designs that allow for properly secured bikes. If a variety of bike racks were placed end to end there would be little difference in the space used since it is the bikes that are responsible for the largest amount of surface area covered. However, inverted-U bike racks are separate from each other and thus have the ability to be placed in a non-linear pattern. Figure 12 (below) compared with Figure 13 (below) demonstrates the difference between the placement of inverted-U racks and linear racks.

Figure 12: U Rack Flexible Design

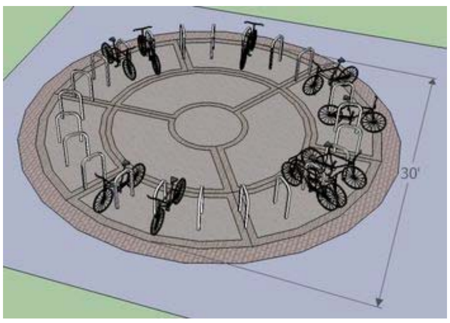


Figure 13: Inflexible linear rack

This flexibility is advantageous in areas where available space for bike racks is non-linear or not large enough to hold a large bike rack. For example consider the bike parking along upper Hereford near the Vaughn House where the road curves. Linear racks would interfere with each other whereas the inverted-U rack could be placed in a manner to take advantage of the curve since they are individual units. There are a variety of other circumstances throughout the grounds where individually placed inverted-U bike racks could make more efficient use of space then a linear bike rack.

Cost

Depending on the brand of the rack and the diameter of the piping, an inverted-U rack costs approx. $50-$100 which means it costs $25-$50 per bike (Bicycle Coalition of the Great Philadelphia Fact Sheet). However, many of the bike racks have a 5-10 year warranty and most likely have a life time double that, which means that, per bike each year, it only costs $5 - $1.25 which is an easily manageable investment. The reason the inverted-U rack is so durable is the diameter of the piping. Many of the racks around campus that just lock your wheel in not only can damage your bike but have flimsy metal frames that easily get bent out of shape and most likely have to be replaced every few years (refer to Figure 14). The inverted-U rack's piping requires tremendous force to damage. Also the thermoplastic layer (discussed in detail under the "Durability" section) prevents the need for maintenance costs after installation. The inverted-U rack is the most cost-effective option for its quality.

Figure 14:

Damaged bike rack that can also torque and destroy a bikes tires and provides little security.

Security

When it comes to security the inverted-U Bike Rack meets all the necessary criteria. Both bikes parked at the rack can be properly secured with a U lock. A properly secured bike is one that has the U lock go around both the bike's frame as well as one of the wheels (generally the front wheel since it is the most easily removed), as seen in Figure 15. It is important that this can be accomplished with a U lock since U locks are considered the highest quality bike lock that can be readily purchased. Many racks do not provide the proper width for both a tire and a frame to be locked (Figures 14, 16, 17, 18).

Another important security quality that an inverted-U bike rack allows for is the ability to lock both the frame to the rack, the rear wheel to the rack, and a removed front wheel to the rack (Figure 15). This option is crucial for people with expensive bikes to feel comfortable riding it around campus. Other than the bike rack's ability to accommodate proper locking procedures, the bike rack itself must be tough enough to not be tampered with by thieves. The inverted-U bike rack is generally made of a steel tube 2.4" in diameter and coated with a thermoplastic layer. This prevents people from being able to damage the rack and remove the bikes. On top of that, the inverted-U bike rack can either be cemented to the ground or secured with iron poles into a cement or asphalt surface preventing people from digging up the racks, bikes and all, and putting them into a truck.

Figure 15: (Inverted-U rack allows for properly security)

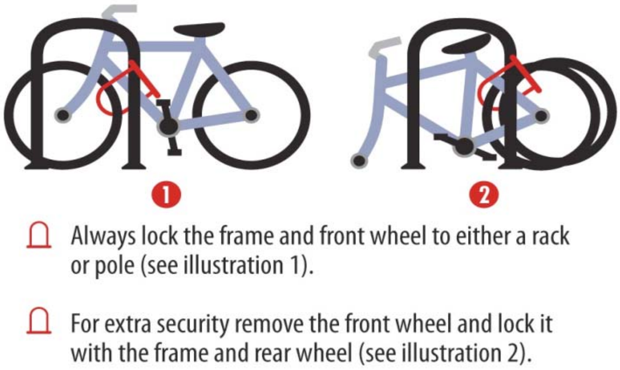


Figure 16: Rack where you can't lock frame

Figure 17: What happens when only wheel is secure

Figure 18: Only place you can lock frame is on the side of rack

Durability

The inverted-U bike rack not only is resistant to bending but also is resistant to the climate and day to day wear and tear bike racks receive. It is coated with a thermoplastic layer that does not deteriorate from exposure to the sun, cold, sudden temperature hangs, salt water spray, and humidity. This thermoplastic layer also stands up well to the daily banging of bikes and chains (Bicycle Stand). This means the inverted-U bike rack will not rust or need to be replaced early or frequently.

Visual Aesthetics

Visually the inverted-U bike rack is unobtrusive due to the subdued coloring and simplistic shape. Also the fact that it is not as large as other bike racks and there is no material between inverted-U bike racks means that there is less material intruding into the existing environment. Consider the differences between a traditional bike rack and the inverted-U rack in the images below (Figure 19 vs. Figure 20).

Figure 19: Ugly Bike Rack

Figure 20: Inverted-U bike rack

Ease of use

The inverted-U bike rack is a very simple design and is commonly used worldwide. It is hard to incorrectly position your bike next to the inverted-U rack because there is only a few logical ways a bike can be placed next to the rack. This limits the number of improperly placed bikes that prevent other individuals from using the rack or rack nearby. Also, the rack is tall enough and sturdy enough that bikes won't fall over when attached. This not only prevents damage to the bike but also allows encourages people without kick-stands to bike more often since they need not be worried about having their bikes fall. Also the simple design that quite clearly is only meant for two bikes makes it much harder for people to accidentally lock there bike and someone else's bike to a rack when they don't have space elsewhere as shown conceptually below.

Figure 21: Easy to Remove and Lock bike?

Long-term Rack Design

The variables that have changed when considering long-term parking are the bikes' exposure to the elements and the increased time for thieves to attempt to take a bike, as well as site-specific construction or space limitations. This means that in order for people to want to use a long-term bike storage facility it has to be easy to use, secure, and sheltered. There are two long-term bike storage options that meet these requirements, all of which have a roughly similar cost of $500 - $1000 per bike, but have a long lifetime around 10-20 years and which incur minimal maintenance costs. However, this cost is highly variable since existing infrastructure in parking lots etc. can offset much of the construction costs. *(Note: Do the site-specific nature of long term bike storage it will be up to our community partners to determine whether or not to pursue long term bike racks. Below are several flexible options for long term parking that our community partners can adapt should the chose to pursue such an option.)*

Option One – Bicycle Rooms

A bicycle room is quite simply a room that bikes can be stored in; however, there are several things to keep in mind when constructing a bicycle room. Unless the walls and door are very sturdy the bikes must be secured inside the room. Secure doors might be a temporary deterrent to theft but the knowledge of unsecured bikes in a bike room is an invitation for theft. Another important factor to keep in mind when designing a bike room is the ease in which people can remove and store their bikes.

With these options in mind a simple an effective bike room could easily be constructed in a parking garage if a few parking spaces are sacrificed. This can be accomplished by erecting 3 walls to connect with the existing wall, these wall can be cement, wood, brick or most other construction material but chain link fence is not recommended do to the ease in which it can be cut and the visibility it provides of the bikes. Light will have to be taken into account so have a light from the garage on ceiling above the bike storage facility will prevent the need from any new wiring. Finally, in the bike room I suggest the use of vertical bike racks. Vertical bike racks are bike racks that allow a bike to be hooked to the wall and then chained to a post on or next to the wall. These are secure, easy to use, and take up less floor space (Bicycle Parking and Planning Criteria). Example of a bike room below Figure 22:

Figure 22: Garage bike storage facility

Option Two - Bike Storage Lockers

Bike storage lockers are pre-fabricated metal or plastic boxes that built to fit one or two bikes per locker. Imagine a large gym locker designed to fit a bike. These lockers are durable, designed to be tamper proof, can be locked, provide excellent shelter. Unfortunately, unlike a bicycle room that can take advantage of existing infrastructure or be designed to adapt to specific sites, the bike storage locker being a pre-fabricated product sold by several different companies cannot be easily adapted and must be put in a place that has the dimensions that fit the lockers dimensions. Since the bike storage lockers are individual lockers it makes it easy to store and remove your bike and it also prevents people from accidentally damaging someone else bike when removing their own (Bicycle Parking and Planning Criteria). Examples are below (Figure 23 and 24):

Figure 23: Bike lockers design 1

Figure 24: Bike lockers design 2

FUNDING AND COST ESTIMATION

Single-unit Inverted-U Bike Rack Costs

The typical single-unit cost of an inverted-U bike rack is $59, and this includes the cost of freight (shipping the product to UVA), installation, and maintenance. This cost changes with the quality of the rack ordered: racks of higher-gauge steel will obviously cost more, though they come with the benefit of extra sturdiness and some slight increase in security. However, our community partner has found that this is not cost-effective, and has previously arrived at the conclusion that the quality of a $59 bike rack is adequate for purposes of both durability and security. Note that the cost of freight varies by order, so the price might differ slightly. In addition, after taking into account the labour, concrete bolts, and cost of travel required to install the racks, the total cost of implementing a single Inverted-U bike rack does not exceed $100. Assuming a 10-year lifespan, the cost becomes $2.50 per lot per year. This is very cost-effective considering each lot will probably see at least one bike per day in every year.

A recent trend in UVA has been for all new buildings to include the cost of any bike racks in and around said building into the capital costs of the project. These racks are not selected or funded by Parking and Transportation, and do not go under their jurisdiction in terms of paying for implementation or maintenance. An example of where such policies have been put into practice is Bavaro Hall. Because of this, we may have to approach other administrative departments in UVA for budget and funding concerns, should we decide to recommend the implementation of more bike racks in or around these buildings.

After taking into account the data, we need to implement 22 bike racks throughout campus, which comes to a total of $2,200. Therefore, we require a budget in this amount to implement what we believe will be productive changes as far as inverted-U bike racks are concerned.

Single-unit Long-term Bike Rack Costs

The single-unit cost of a long-term bike rack is somewhat trickier, because our community partner does not have much experience implementing such options before. However, they have entered into negotiations in the past with a rack manufacturer named Dero Bike Racks. Both this team and our community partner agree that one of Dero's products, called Dero Decker, is a viable design that we should consider. Other options include the aforementioned bike rooms and bike lockers.

A 4-bike capacity Dero Decker would cost $6703 in total, including all freight and installation costs, and one such unit has just been ordered by the community partner. This works out to cost $167.58 per lot per year, over a 10-year lifespan. While this is much more expensive than the short-term parking option, note that the siting of these long-term bike racks in car garages gives them added value such as shelter. 10 years is also a very conservative estimate, as such bike racks are commonly estimated to last 20 years. Evidently, this is a price that our partner believes is worth paying, assuming the bike rack functions as advertised and can handle wear-and-tear over an extended period of time.

At the same time, our partner is continually gathering information regarding the similar implementation of the aforementioned alternative options, to ensure that the most cost-effective and up-to-date option is always taken.

Besides the single-unit costs of bike racks both short-term and long-term, there are other costs that should be taken into account.

Bike Shelter Costs

Part of our project has been to explore the possibilities of implementing overhead shelters for existing bike racks to protect them from the elements, and of incorporating such shelters into any new bike rack installations. Our survey showed that 69.69% of respondents listed shelter from the elements as one of the two most important aspects in a bike rack, indicating a strong demand from current cyclists. Keeping bike racks sheltered from the elements means that the paint on the racks will last longer. It also ensures that both the bikes and the racks are kept dry, which slows the onset of rust on both. While bike maintenance obviously is the responsibility of the bike's owner, it is a good practice to help promote the longevity of all aspects of biking. Our community partner has furnished us with the details of what such shelters would cost, broken down by manufacturer.

Manufacturer	Dimensions	Capacity	Sides	Cost	Freight
Shelters Direct	5'x15'	10 Bikes	3, glass	$8,400.00	$550.00
Dero	3'x9'	6 Bikes	3	$9,360.00	$447.64
CycleSafe	6.5'x9.8'	6 Bikes	3, polycarbonate	$5,423.00	TBD

From these figures, it can clearly be seen that merely placing bike racks indoors would be a much cheaper option, all other things equal. However, interior space is entirely fixed once a building has been completed, and more important uses can probably be found for it. Unless space was allocated for bike racks during the design of the building, there probably will not be enough space within buildings for this purpose. As such, it may be that the only viable option to protect bikes in most locations would be to build shelters over existing bike racks. Whether the benefits gained from having a better and more complete bike rack outweighs the cost of building shelters remains to be seen, however.

Maintenance Costs

So far, the only maintenance issue that our community partner has encountered is the need to re-powder coat the paint on the racks. This has been most notable outside of Hereford Residential College. The cost of re-painting once every few months or even years is relatively minimal, and has already been accounted for in the original cost of the bike rack. Such is the benefit of low-tech designs such as the simple inverted-U bike rack that there is a very low risk of the product malfunctioning and requiring tinkering or maintenance. This may become a problem with the Dero Decker, which utilizes a hydraulic system to safely lower bikes from its upper deck back to floor level, and as such is a significant factor in determining if it is a viable option to pursue.

Replacement Costs

If a rack is damaged, it is usually replaced. This is due more to the fact that the sturdy inverted-U bike racks have so far not been structurally damaged, than to the unlikely possibility that removing the entire rack and replacing it with a fresh one is cheaper if not easier. Thus far, only the 12-foot movable racks have been damaged. These cost about $267 per unit, not including freight. The cost of labour is minimal because the units need only be driven out to the location and deployed by hand. They are seldom ever bolted into a concrete foundation, except in rare cases like the North Grounds Recreational Center, so this cost is not taken into account.

If it indeed comes to pass that these movable racks, which were implemented as temporary parking solutions, are to be replaced with permanent bike racks, there will obviously be a cost incurred identical to that of the single-unit bike rack costs explained above. As mentioned in the "Data Summary and Location Selection" portion of the report, there are areas such as Gilmer Hall where too many movable racks have been placed, resulting in under-utilized racks. This means that a lower number of permanent bike racks need to be implemented in these areas, ultimately.

Note that racks that need to be replaced are recycled as scrap metal through Facilities Management's Recycling Program, in keeping with UVA's commitment to sustainability.

Funding

We currently do not have any concrete plans to secure funding, solely because our community partner is debating which avenues of raising funds are legal for us as students to do. For example, it would be a viable option to canvass university students for donations, because this is after all a community project. The students would be helping to improve their community and its facilities through donating just a small sum per student. However, whether Parking and Transportation would accept this as a source of funding is not clear and could involve some legal issues. Our community partner currently draws on their department reserves to fund new projects, and is currently still seeking more sustainable sources of income, so it will be unclear for some time to come whether donations and other such funding can be accepted.

However, we are prepared to present our findings to Parking, and Transportation or any other budgeting committee, so that we can pitch our case and obtain official funding for the implementation of more bike racks. Since we have styled ourselves as a kind of consultant group, it is only natural that we should present recommendations to the relevant departments. Obviously, it is ultimately the university's decision whether they want to take our recommendations into account and act on them.

Once we have identified an area or areas of need, our community partner will inspect the area and consult the University Landscape Architect if need be. Our partner determines the types and quantities of bike racks required for that location, and then presents the demand for the project and costs of the project to the Associate Director of Parking and Transportation, who will either approve funding or require an alternative to be sought. Such lower-cost alternatives may include the relocation of an existing bike rack in an under-utilized area to the newly-identified area of need – in our case, Observatory Hill and various buildings along McCormick Road.

DOCUMENTATION AND ASSESSMENT

Documentation

There are three stages to this project:

1) Planning or goal setting
2) Data collection and collation
3) Reporting our recommendations based on said data.

The first phase – goal setting – was documented through the two required assignments of Project Definition and Conceptual Design. While of course an important part of the overall project, there is not much to elaborate upon as far as goals are concerned. Therefore, we do not have additional documentation on this phase.

The second phase – data collection – has been documented both by individual members who recorded their data on their medium of choice, whether it be notebook, phone, or computer, and then collated into a shared Microsoft Excel spreadsheet. As such, our data is always kept up to date and coordinated throughout the entire group.

The last phase – reporting of recommendations – was first drafted out with all group members present so that our report would be consistent. Then, we assigned parts of the report to each group member to elaborate upon individually before again coming together as a group to make the final tweaks. For the sake of simplicity and relevance, we will not be including our raw data or the rough drafts of our reports into the actual recommendation report.

Aside from using solely words to document our project, we have also turned to more visual mediums. For example, we used the data collected in the Microsoft Excel spreadsheet to create graphs, in order to present the data more simply and clearly. In addition, we have taken advantage of technology like Google Earth to visually show where exactly we recommend the additional placement of bike racks. Lastly, we have also taken photographs of the bike racks at locations where capacity has been reached, in order to demonstrate the extent of the problem.

Assessment

We have three metrics to assess the success of this project, which will involve adding a final phase to our three initial phases: post-project data collection and review. These three metrics are:

1) Have our criteria for an effective bike rack been met in practice?
2) Send out the survey again to measure if the incidence of problems have decreased
3) Is there a measurable increase in bike traffic volume?

The first metric measures whether we have indeed taken the correct approach to this survey and identified the key problems. This is due to the fact that we had to identify said problems before we were able to come up with a set of criteria that addressed these problems. Now that we have set this out in theory, the next step is to see if our measures were practical in real-world operations.

The second metric is a corollary to the first. While we can determine on the supply-side if our bike racks are meeting the criteria, the final conclusion still rests with the consumers of the product: the cyclists. As such, we will need to conduct a follow-up survey to see if our measures have in practice reduced the number of problems that cyclists face. If the survey results conclusively indicate that cyclists indeed face fewer problems, we can then look at the last metric.

The third metric measures whether we have met the ultimate goal of this biking community project – to promote safe and effective biking on grounds. Even if we determined that the new bike racks have met all the criteria needed to make them effective, it is no guarantee that they would cause more people to start cycling on grounds. Our second metric, which is unable to poll non-cyclists, would also be ineffective in determining if our project has encouraged more people to cycle. As such, this is a necessary metric to have. If bike traffic volume has indeed increased, it will be indicative of all five sub-groups' efforts to improve biking conditions in the university, and will be a clear sign that we have indeed succeeded in this project.

This phase will not be able to be completed soon, because we are still in the process of collecting data and reporting our recommendations. Should we ever in fact present our findings to a committee, that committee will then have to re-convene and decide if our recommendations are to be actually carried out. After that, there will certainly be some time lag while the bike racks are ordered, manufactured, shipped to the university, and then finally installed. The fact that the new Alderman Road dormitories – Balz-Dobie and Watson-Webb – are only now having their respective bike racks installed two months after students have moved in, despite the relevant plans and budgets having been in place some time ago, is a case in point of how long the process might take.
Therefore, the completion of this project assessment is contingent on two factors. First, the university has to act on our recommendations. Secondly, we have to allow some time for the recommended measures to be put into place. Only then can we begin work on collecting the required data and assess if our project has been a success. As such, we do not expect to complete this phase before the end of the 2011 fall semester, if at all. Should the Global Sustainability class be offered again in the 2012 spring semester, the next engineering group (if any) could follow up on this issue.

DISSEMINATION

Our sub-section of this project is unique in that we do not benefit from exposure to the "client base." Essentially, we will provide the Parking & Transportation sector of the University of Virginia with a final report to aid their existing efforts. This will consist of a collection of data and information that the University can utilize to make better decisions regarding an influx of bicyclists from an engineering perspective. With regards to daily traffic and heavy student occupancy in certain areas, we will give our recommenced bike rack model, the locations of where the bike racks should be placed, and the recommended capacity within these specified locations.

Also, the report will introduce bike storage for students and faculty who wish to leave their bikes on grounds. Specific design plans and feasible locations for long term and overnight storage will enable riders to comfortably leave their bikes in secure and protected places. Another section in the report will detail any trends regarding possible shifts in bike traffic throughout the day. These changes may impact the proposed bike infrastructure in the future and will be included in the final report.

Furthermore, with better information regarding the lack of parking spaces for bicyclists in certain areas and traffic flow, Parking & Transportation will consider our suggestions of implementing the best structural and cost efficient bike racks in specified locations on UVA grounds.

FUTURE WORK

The conducted research has identified areas of need throughout the campus and has produced recommendations for addressing those concerns. Moving forward from this position will require input from the community partner and confirmation of the availability of funds.

This will require us to present our findings to the community partner and to Parking and Transportation, possibly in a separate, more formal presentation from the final Global Sustainability class presentations. As previously mentioned, once we have communicated what the areas of need are, there is nothing more as students that we can do. Our community partner will be responsible for obtaining funding from the Associate Director of Parking and Transportation; however we will be ready and willing to assist in any way possible.

Like any scientific study, further information and data would lend more validity to our findings. Should our community partner or the Associate Director require us to increase our sample size or adopt a standard or specific research methodology, we will have to resume data gathering and conduct further analysis in the spring of 2012.

We expect that communicating our findings, obtaining the funding, and construction of the bike racks will take some time. Ideally, we will communicate our findings and obtain funding during the spring of 2012, so that the new bike racks can be fully installed by the end of summer 2012, just in time for the 2012-2013 academic year.

LESSONS LEARNED

The creation of this document necessitated the collection and analysis of data that was previously unavailable. The lack of relevant prior research made the project all the more difficult because we had to start from the ground up. None of the four group members had done a project like this before, so it led to more difficulties that – fortunately – led to a more fruitful and meaningful learning experience.

We encountered two main problems during this project. First was the difficulty of properly organizing the group. With only one engineering student (Ryan Shaw) in the so-called engineering group, we had to arrive at a methodology that did not require advanced scientific or engineering background while still remaining true to the fundamentally scientific nature of the study. However, we managed to come up with a schedule of data collection, whereby each one of us would be responsible for collecting data in certain places at certain times in a standardized and sufficiently rigorous manner. In doing this, we learnt that the intricacies of coordinating a schedule across four people – which is not a particularly large group. Therefore, this project has prepared us well for coordinating efforts in larger groups in the future.

Secondly, we encountered the problem of poor documentation. Frequently, we found that after assigning tasks to group members, the work that was submitted to the group for vetting was irrelevant or organized in a way that was not what we had originally agreed upon. In addition, we frequently encountered a kind of redundant effort in the group, whereby we would keep returning to the same ideas that we had previously discarded. All this stemmed from a lack of proper, consistent documentation that should have begun right from the inception of the project. We learnt that we could have avoided much of this wasteful effort if we had properly recorded what was discussed during group meetings and in our correspondence. If we were to do this project again, we would definitely put more effort into this. Thus, we will be more mindful of consistently taking minutes in future group projects.

At the beginning of the semester, we set out to increase the number of cyclists as well as improve the situation of currently active cyclists. Our only regret is that we did not manage to complete this project in a shorter amount of time so that we could communicate our findings to the community partner sooner and start the process of obtaining funding. Aside from not following our agreed-upon timeline strictly, we are on track to implement the changes that we had aimed for. Of course, whether our measures will indeed be successful in increasing the number of cyclists on grounds and solving biking-related problems is a different matter entirely, but judging from our survey and research data, we are reasonably confident that we are addressing real and relevant problems in a practical manner.

If we were to do this project all over again, we would keep to a more rigorous and consistent schedule of data collection, as well as document our discussions properly to avoid inefficiently discussing the same things over and over again. We would also expand our horizons to include data collection for areas in the Architecture School and other areas of the University of Virginia that we did not include this time round, in order to increase the potential impact and usefulness of this project.

Over the course of this project, we learnt that creating change is not a simple matter of coming up with a new idea and implementing it. There will always be problems, firstly within the group, and secondly within the overarching socio-political environment that we operate in. As stated above, we had problems with coordination even within a small group of four students attempting to effect change on a fairly small scale. Even at this level, there were problems with bureaucratic inertia. On state, national, or even international scales, these problems of coordination and consistency are multiplied exponentially. We know now why change takes such a long time to come into effect, and have a better appreciation for the difficulties that policy-makers and sustainability advocates face in the course of improving the world around us.

APPENDIX 1 – RAW OCCUPANCY DATA

McCormick Observations					
Date	Time	Location	Occ.	Total	Fraction
10/3/11	5:45 PM	THN A	14	24	58%
10/3/11	5:45 PM	THN A-B	4	28	14%
10/3/11	5:45 PM	THN B	0	14	0%
10/3/11	5:45 PM	Physics (East)	5	12	42%
10/3/11	5:45 PM	Wilsdorf (Road)	11	24	46%
10/3/11	5:45 PM	Chem Bus Stop	3	12	25%
10/3/11	5:45 PM	Gilmer (East)	6	36	17%
10/5/11	1:45 PM	Gilmer (East)	6	36	17%
10/5/11	1:45 PM	Gilmer (West)	11	23	48%
10/5/11	3:15 PM	Gilmer (East)	11	36	31%
10/5/11	3:15 PM	Chem Bus Stop	8	23	35%
10/5/11	3:15 PM	Wilsdorf (Road)	15	24	63%
10/5/11	3:15 PM	Wilsdorf (Side)	10	15	67%
10/6/11	12:15 PM	Alderman (South)	13	22	59%
10/6/11	12:15 PM	THN A	16	24	67%
10/6/11	12:15 PM	Wilsdorf (Road)	21	24	88%
10/6/11	12:15 PM	Gilmer (East)	10	36	28%
10/6/11	12:15 PM	Gilmer (West)	14	23	61%
10/13/11	8:30 AM	THN A	15	24	63%
10/13/11	8:30 AM	Wilsdorf (Road)	14	24	58%
10/13/11	8:30 AM	Chem Bus Stop	5	23	22%
10/13/11	8:30 AM	Gilmer (East)	13	36	36%
10/13/11	10:15 AM	THN A	17	24	71%
10/13/11	10:15 AM	Wilsdorf (Road)	19	24	79%
10/13/11	10:15 AM	Chem Bus Stop	11	23	48%
10/13/11	10:15 AM	Gilmer (East)	8	36	22%
10/13/11	11:45 AM	THN A	16	24	67%
10/13/11	11:45 AM	Wilsdorf (Road)	20	24	83%
10/13/11	11:45 AM	Chem Bus Stop	12	23	52%
10/13/11	11:45 AM	Gilmer (East)	17	36	47%
10/14/11	12:30 PM	THN A	9	24	38%
10/14/11	12:30 PM	Wilsdorf (Road)	19	24	79%
10/14/11	12:30 PM	Chem Bus Stop	11	23	48%
10/14/11	12:30 PM	Gilmer (East)	5	36	14%

10/18/11	11:00AM	THN A	13	24	54%
10/18/11	11:00AM	Wilsdorf (Road)	22	24	92%
10/18/11	11:00AM	Chem Bus Stop	15	23	65%
10/18/11	11:00AM	Gilmer (East)	9	36	25%
10/20/11	9:30AM	THN A	9	24	38%
10/20/11	9:30AM	Wilsdorf (Road)	15	24	63%
10/20/11	9:30AM	Chem Bus Stop	9	23	39%
10/20/11	9:30AM	Gilmer (East)	5	36	14%
10/20/11	1:00PM	THN A	12	24	50%
10/20/11	1:00PM	Wilsdorf (Road)	18	24	75%
10/20/11	1:00PM	Chem Bus Stop	17	23	74%
10/20/11	1:00PM	Gilmer (East)	2	36	6%

O'hill Observations					
Date	Time	Location	Occ.	Total	Fraction
10/3/11	5:45 PM	O'hill	40	54	74%
10/6/11	12:15 PM	O'hill	55	54	102%
10/6/11	1:45 PM	O'hill	53	54	98%
10/7/11	10:30 AM	O'hill	41	54	76%
10/14/11	10:00 AM	O'hill	44	54	81%
10/14/11	1:30 PM	O'hill	55	54	102%
10/18/11	8:30 AM	O'hill	48	54	89%
10/24/11	9:15 AM	O'hill	47	54	87%
10/24/11	1:00 PM	O'hill	51	54	94%
10/24/11	3:15 PM	O'hill	44	54	81%

APPENDIX 2 – SURVEY SAMPLES AND DATA

Non-Cyclists' Survey

1. Why do you **not** currently bike around grounds? (Tick up to three most important reasons)
   - o Road conditions too dangerous
   - o Afraid bicycle will get stolen
   - o Lack of parking near my class locations
   - o Not willing to spend money on a bicycle
   - o Do not live far enough away to warrant a bicycle
   - o Others:
2. Which changes would most encourage you to start biking? (Rank from 1 to 4)
   - o More bike racks
   - o Sheltered parking
   - o Overnight parking in car garages
   - o More bike lanes along roads

http://www.surveymonkey.com/s/XZBY6TW

Non-Cyclists' Survey Data

1. Why do you not currently bike around grounds? (Tick up to three)	Frequency	Percentage
Dangerous road conditions	48	47.06%
Afraid bicycle will get stolen	18	17.65%
Lack of parking near class	15	14.71%
Not willing to spend money	42	41.18%
Do not live far enough away	54	52.94%
Live too far away	3	2.94%
Do not know how to ride	6	5.88%

2. Which changes would most encourage you to start biking?	Frequency				Percentage			
(Rank from 1 to 4, 1 being most encouraging)	1	2	3	4	1	2	3	4
More bike racks	8	43	11	16	10.26%	55.13%	14.10%	20.51%
Sheltered parking	7	17	51	13	8.33%	20.24%	60.71%	15.48%
Overnight parking in car garages	22	17	18	33	24.44%	18.89%	20.00%	36.67%
More bike lanes along roads	54	14	8	23	54.55%	14.14%	8.08%	23.23%
Bike share program	4	0	0	0	3.92%	0.00%	0.00%	0.00%
Cheaper bikes	5	0	0	0	4.90%	0.00%	0.00%	0.00%
Opportunities to learn how to ride	2	0	0	0	1.96%	0.00%	0.00%	0.00%

Cyclists' Survey

1. What problems do you currently face while cycling (Tick all that apply)?
   - Motorists are inconsiderate
   - Pedestrians frequently obstruct cyclists
   - Not enough bike lanes
   - Not enough bike parking
   - Others:
2. How often do you find parking a problem?
   a. Never
   b. Up to 20% of the time
   c. 20 to 50% of the time
   d. 50 to 80% of the time
   e. 80 to 100% of the time
3. Where do you find there is a lack of parking space?
   a. Observatory Hill Dining Hall
   b. Newcomb Dining Hall
   c. Runk Dining Hall
   d. McCormick dorms (specify)
   e. Alderman dorms (specify)
   f. Clark Hall
   g. Gilmer Hall/Bio-Psych Library
   h. Engineering School
   i. Alderman Library
   j. Architecture School
   k. Others:
4. Which type of rack do you prefer?
   a. No preference
   b. Wavy S-shape
   c. Inverted U-shape
   d. Slot-in Rails
   e. Others:
5. What is most important in a bike rack to you (Rank from 1 to 6)?
   a. Ease of use
   b. Shelter from rain/elements
   c. Security (frame can be brought close enough to be locked to the rack)
   d. Sturdiness
   e. Proximity to class locations
   f. Aesthetic quality

http://www.surveymonkey.com/s/XZSNQDD

Cyclists' Survey Data

1. What problems do you currently face while cycling? (Tick all that apply)	Frequency	Percentage
Inconsiderate motorists	15	45.45%
Obstructive pedestrians	27	81.82%
Not enough bike lanes	27	81.82%
Not enough bike parking	16	48.48%
No covered bike parking	3	9.09%
Inconsiderate cyclists	3	9.09%

2. How often do you find parking a problem?	Frequency	Percentage
Never	3	9.09%
Up to 20% of the time	24	72.73%
20 to 50% of the time	5	15.15%
50 to 80% of the time	1	3.03%
80 to 100% of the time	0	0.00%

3. Where do you find there is a lack of parking space? (Tick all that apply)	Frequency	Percentage
Observatory Hill Dining Hall	25	75.76%
Newcomb Dining Hall	1	3.03%
Runk Dining Hall	1	3.03%
McCormick dorms	0	0.00%
Alderman dorms	0	0.00%
Clark Hall	10	30.30%
Gilmer Hall/Bio-Psych Library	4	12.12%
Engineering School	7	21.21%
Alderman Library	6	18.18%
Architecture School	7	21.21%
Chemistry Building	5	15.15%
Nowhere	1	3.03%

4. Which type of rack do you prefer?	Frequency	Percentage
No preference	10	30.30%
Wavy s-shape	0	0.00%
Inverted u-shape	21	63.64%
Slot-in rails	2	6.06%

5. What is most important in a bike rack to you?	Frequency						Percentage				
(Rank from 1 to 6, 1 being most important and 6 being least important)	1	2	3	4	5	6	1	2	3	4	5
Ease of use	12	3	0	6	6	6	36.36%	9.09%	0.00%	18.18%	18.18%
Shelter from rain/elements	9	14	0	0	3	6	27.27%	42.42%	0.00%	0.00%	9.09%
Security (frame can be brought close enough to be locked to the rack)	5	10	3	10	2	3	15.15%	30.3%	9.09%	30.30%	6.06%
Sturdiness	0	0	20	8	5	0	0.00%	0.00%	60.61%	24.24%	15.15%
Proximity to class locations	0	10	10	6	6	1	0.00%	30.3%	30.3%	18.18%	18.18%
Aesthetic quality	4	0	0	4	10	14	12.12%	0.00%	0.00%	12.12%	30.30%

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