EDSGN 100

Design Project #2

Preliminary Design Review

Project: Re-Cycle

Introduction to Engineering Design
EDSGN 100 Section 024

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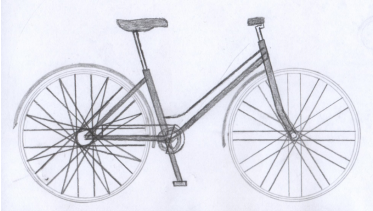

Submitted to Prof. Bilén
Date: 11/18/13

Executive Summary

The ultimate goal of our project was to make the University Park campus of The Pennsylvania State University more sustainable by utilizing aluminum and its properties. After research, consideration, and discussion, we decided to design a bicycle sharing system. Information was gathered from outside sources in order to gain an understanding of the necessary parts of the system. Throughout the process, we strived to create a system that increased campus sustainability while satisfying the needs of both the students and the local community.

Project: Re-Cycle

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1.0 Introduction

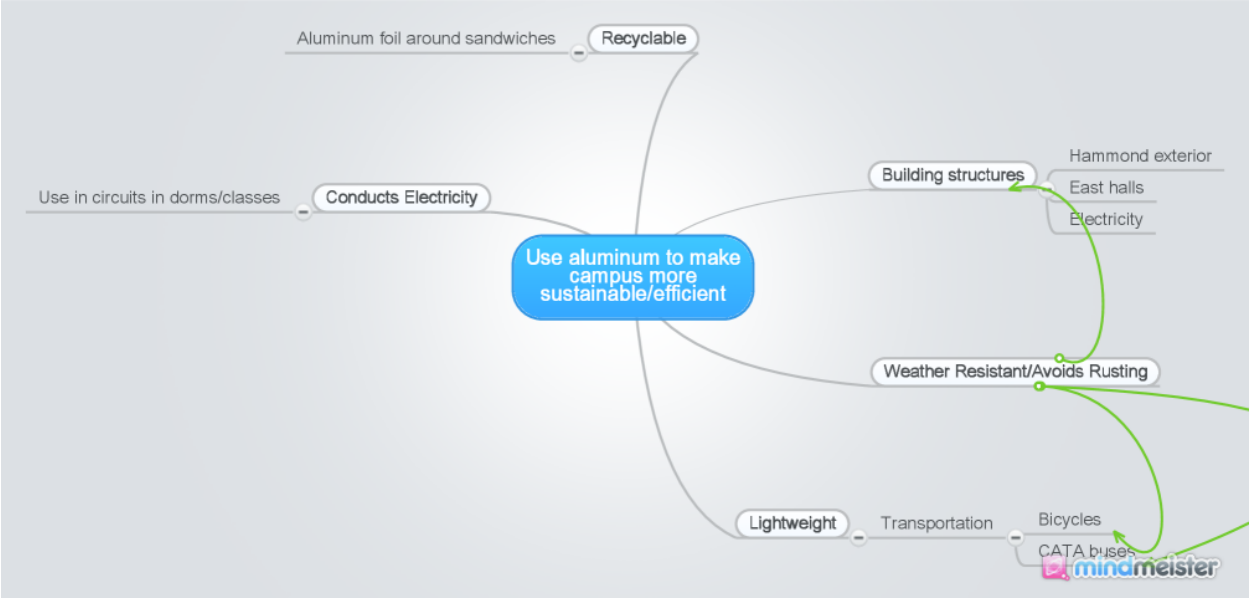
The problem addressed throughout this project was fostering sustainability and efficiency of the Penn State University campus using aluminum. As this was a very open-ended task, we created a more specific problem statement that pertains to our particular strategy for creating a more sustainable campus. In this preliminary design review, we outline our narrowing of our problem statement (Section 1), our customer needs collection and assessment (Section 2), the external research of other solutions to our problem (Section 3), and our development and selection of concepts (Section 4).

1.1 Initial Problem Statement

Make the campus of the Pennsylvania State University more sustainable and/or efficient by utilizing aluminum

1.1.1 Analysis/Exploration of Initial Problem Statement

Facing a very broad task, we felt the need to look at the problem in many different ways. What about the campus is inefficient? What could be made more sustainable? What are aluminum's properties and how might they be used in order to improve campus? These were the topics that we explored in our mindmap.



1.2 Revised Problem Statement

Make the campus more sustainable by utilizing aluminum in implementing a bicycle sharing system.

1.2.1 Goals/Implications of Revised Problem Statement

We felt that a bicycle sharing system would accomplish many things that would improve campus sustainability, such as:

- decreasing dependence on CATA buses, lowering university's oil consumption, fewer greenhouse-gas emissions
- aluminum bikes are relatively low maintenance
- more cost-efficient for people to share bikes than to buy individual bikes
    - decreases bike theft opportunity (which has been a problem at Penn State)
- economically self-sustaining, will generate revenue once implemented (but will cost a lot to implement)

1.2.2 Importance of Aluminum

Once we decided to design a bicycle sharing system, we knew that we would be using aluminum in a couple different ways because of its useful properties. We planned on making the bikes themselves out of aluminum because aluminum is lightweight, durable, and strong. We also planned on making the bike racks/stations out of aluminum because it requires little maintenance due to its durability in difficult weather conditions, which is ultimately what is necessary for the stations since they will be outside.

2.0 Customer Needs Assessment

We interviewed students around campus to develop a list of customer needs. We interviewed students because they are the group of people who would be using our product, so we figured they would provide us with the most valuable information. We tried to gain information from them about what they look for in bikes, any experiences they've had with bicycle sharing systems and any problems that may have been apparent, why they might not ride a bike around campus right now, and how they would prefer to pay for the privilege to ride a bicycle.

2.1 Weighting of Customer Needs

To develop this list, we asked very specific questions.They are as follows:

1. Why don't you ride a bike around campus?/Why don't you ride your bike more often?
2. Are you familiar with any bike rental/sharing systems? What do you like/dislike about them?

3. What do you look for in a bike?
4. How would you prefer to pay for such a system?

Table 1. Initial Customer Needs List for Payment Options Obtained from Individual Interviews

cheap
quick
many options
convenient

Table 2. Initial Customer Needs List for Bikes Obtained from Individual Interviews

cheap
lightweight
durable
aesthetically pleasing
easy to ride
comfortable

Based on the frequency of these needs being mentioned, we created a hierarchical list of needs

Table 1. Hierarchical Customer Needs List for Payment Options

1.cheap
2. quick
3. convenient
4. many options

Table 2. Hierarchical Customer Needs List for Bikes

1. cheap
2. light weight
3. easy to ride
4. comfortable

5. durable
6. aesthetically pleasing

3.0 External Search

Our external search began as soon as we decided to implement a bike sharing system on campus. This is because the idea came to us as a result of our experience with bike sharing systems (such as Capital Bikeshare in Washington DC). In terms of the overall system, there are many things to consider. To ensure ample consideration of all of these factors, we looked to the development of other bicycle sharing systems, specifically that at The University of Illinois at Urbana Champaign.

3.1 University of Illinois Bicycle Sharing

Since University of Illinois is fairly similar to Penn State in terms of student population, it is an apt model off of which to base our bicycle sharing system. However, it is also important to keep in mind the differences in physical campus size, community urbanization, and culture in mind. In the feasibility study which was conducted at Illinois, they talk about the problems of previous bike sharing systems, the effect of a growing bike culture on the community, necessary infrastructure in bike sharing systems, and recommendations for planning of bike sharing systems.

3.1.1 Problems of Bike Sharing Systems of the Past

One of the major problems of early bike sharing systems was user accountability. This is because some of the first bike sharing systems were free for users, and there may or may not have been locking devices for the bikes. This led to a great amount of both theft and vandalism of the bikes. Furthermore, the maintenance of many of the early systems was carried out by volunteers who might not have had the time to devote to the project as paid counterparts might.

3.1.2 Effects on Community

There are a wide variety of stakeholders in a project of this magnitude. First, the target users of this system would be the students of Penn State. By implementing a bike sharing system, we would be changing the culture of the campus. Specifically, we would be encouraging bike culture, changing many students' behavior with regard to their methods of traversing campus. However, an extensive bicycle

sharing system would also affect the State College community. With more bikes on the road (particularly downtown), anyone driving in that area will notice the change. Although our goal only has to do with making the campus more sustainable, it is important that we consider the far-reaching effects (both positive and negative) of a system such as this, for they extend beyond the borders of campus.

3.1.3 Necessary Infrastructure

One of the major problems reported with the Illinois system was the need for better biking infrastructure. Namely, conflicts often arose as a result of roads being shared by bikes and cars. While this could be solved by infrastructure such as bike paths, it was also often reported that many bikers and drivers were not aware of the rules of traffic when there are both bicycles and cars. This makes education an important part of implementation of a new large-scale bicycle sharing system. Another problem reported was that the existing bike paths on campus were old (some constructed over 30 years ago) and not maintained as well as they should have been. So, the development and maintenance of both on and off campus bike paths will be important pieces to consider. Lastly, infrastructure involving the parking/storage of the bikes will be necessary. One of the big problems reported in the Illinois system was a lack of indoor storage. This led to some deterioration and overall lack of protection of the bicycles. However, in our case, we will be using aluminum as the main material in both our bike and parking station. Due to aluminum's innate ability to avoid rusting (actually it rusts very quickly but develops a protective layer around it once it rusts), it should be very durable and fairly easy to maintain.

3.2 Capital Bikeshare

This is the bicycle sharing system in Washington DC. Since it is a very different setting than that of State College, we could not base our system largely off of theirs. However, we did gain some more insight into the methods of payment and user accountability from this system. In the Capital Bikeshare system, when a person takes out a bike, a security deposit is taken from the account used to pay for using the bike. This way, if a person does not return the bicycle after a designated amount of time, they lose that money. This is a possible solution to the accountability problem seen in the bike sharing systems of the past.

4.0 Internal Search

We searched internally for solutions to many problems within our system. We decided the best way to

generate concepts for a system would be to use the method of decomposition.

4.1 Concept Generation

4.1.1 Payment System

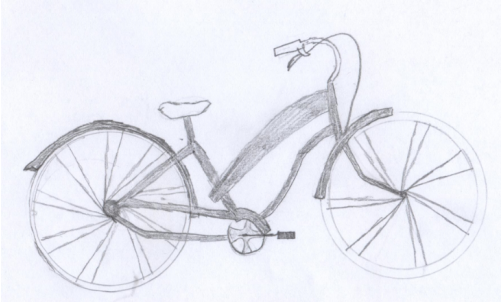
The generation method we felt would be most effective was decomposition. Decomposition addresses multiple aspects of a complex system. We identified components such as payment method, bike rack locations, bike type, and bike paths. Payment method and bike type were the two components we felt could be expanded into multiple, specific concepts. To develop specific concepts, we adhered to the 7 rules of IDEO Brainstorming: defer judgement, encourage wild ideas, build on the ideas of others, stay focused on the topic, one conversation at a time, be visual, and go for quantity. The first concept was "membership only", which forces students to register for the service online with a flat rate, unlimited use contract. Our second idea was pay per ride, where students use LionCash to pay for each individual trip (based on the amount of time the bike is used). Our third concept was "levels membership". Levels membership is like the campus meal plan in the respect that users buy a membership level based on how much they expect to use the service. The last concept generated was "cash toll booth". This method works kind of like a toll booth, where cash is inserted and the user can take a bike.

4.1.2 Bike Type

We also generated concepts for bike type. We stuck to existing general bike types, because the point of our project is not to design a new innovative bike, but to design a system that encourages the bike culture of Penn State, in order to foster sustainability and efficiency. The four bike types were road bike, mountain bike, urban bike, and cruiser. When evaluating each of these, we decided that all of them would be made out of aluminum because that would make the bikes lightweight, strong, and fairly weather resistant. Furthermore, many bicycles are already made out of aluminum. Each bike has its own unique features, strengths and weaknesses. Our job was to decide which bike would best satisfy our customers' needs.

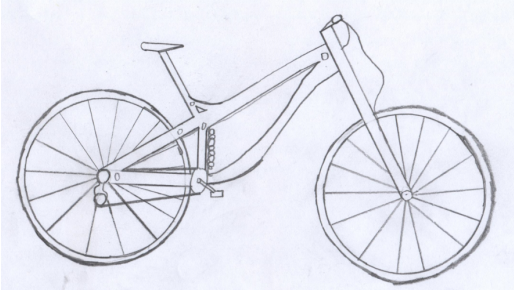
Concept A: Cruiser

The cruiser features high aesthetic appeal for a low price. The downside is that in being cheap, it is not of high quality. Also, cruisers are relatively heavy, and therefore hard to ride up hills.

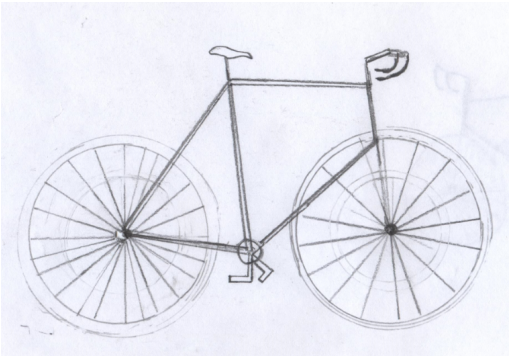


Concept B: Mountain Bike

The mountain bike features high quality suspension, durability, and aesthetics. It is relatively heavy, and expensive.

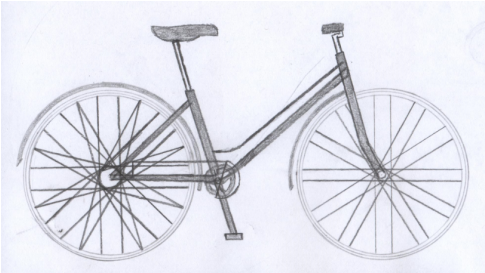


Concept C: Street Bike



The street bike is lightweight, fast, and durable. It is aesthetically pleasing as well. The only downside is that it is very expensive, and not as easily ridden for leisure.

Concept D: Urban Bike

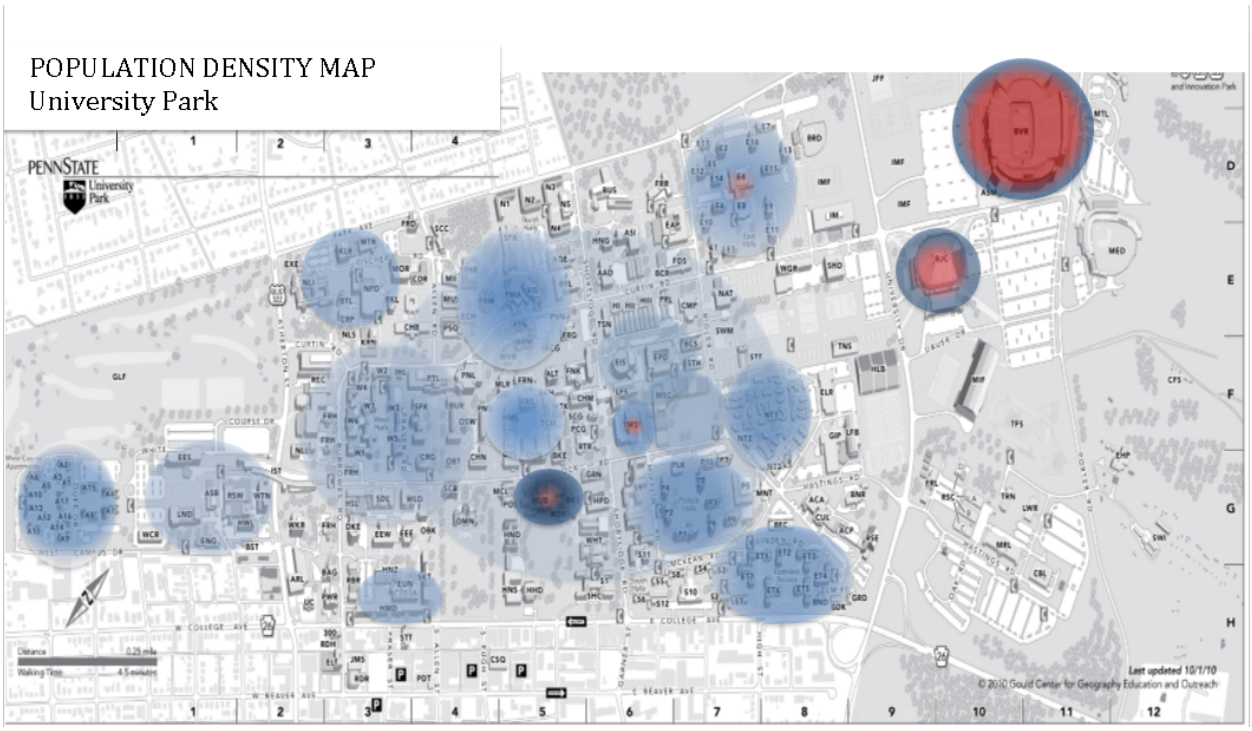


The urban bike is cheap without sacrificing quality, relatively light, and easy to ride. It is aesthetically pleasing as well. It is generally used for leisure or transport.

4.1.3 Paths and Stations

We did not need a concept generation session for bike paths and bike stations. Rather, we collected information about the buildings that held the most people for events or classes, and considered the foot traffic through certain buildings (such as the HUB-Robeson Center). This helped us later decide where we needed bike racks on campus.

The map below shows where people concentrate during a typical week on campus. This helped us come up with our eventual map of bike station placement. We generated this map based on our knowledge of campus happenings.



4.2 Concept Selection

The concepts were weighted against the following customer needs: cheap, convenient, having many options, and quick to use. Here are the results:

		A		B		C		D	
		Membership Only		Pay per Ride		Levels Membership		Cash Toll Booth	
	%	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted
Cheap	30	4	1.2	2	0.6	5	1.5	2	0.6
Convenient	25	3	0.75	4	1	3	0.75	1	0.25
Options	15	1	0.15	1	0.15	3	0.45	1	0.15
Quick	30	4	1.2	4	1.2	4	1.2	1	0.3
	Total		3.3		2.95		3.9		1.3
	Continue	combine		combine		combine		no	

With these results, and with the customer need of "options" in mind, we decided to combine A, B, and C into one final payment concept. The bike rack will have a computer system, in which the user can register online for a levels plan, or a more expensive unlimited use plan. In order to include non-regular users, we will also implement a computer on each bike rack, where the user can use his or her lion cash for a time-based payment. However, an id+ card must be used, because there must be a way to identify a user who fails to return a bike. The exclusive use of an id+ card is a better security method than a large security deposit placed on each user, such as that imposed by Capital Bikes.

As for the bikes, we rated each bike type against the customer needs of cheap, lightweight, durable, aesthetically pleasing, easy to ride, and comfortable. The results were as follows:

		A		B		C		D	
		Cruiser		Mountain		Street		Urban	
	%	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted
cheap	20	5	1	3	0.6	2	0.4	4	0.8
lightweight	20	1	0.2	1	0.2	5	1	4	0.8
durable	10	3	0.3	4	0.4	4	0.4	3	0.3
aesthetically pleasir	10	5	0.5	3	0.3	3	0.3	4	0.4
easy to ride	20	3	0.6	2	0.4	5	1	4	0.8
comfortable	20	5	1	3	0.6	2	0.4	4	0.8
Total			3.6		2.5		3.5		3.9
Continue?		no		no		no		yes	

We decided to go on with the urban style bike, because it has the aesthetics of a cruiser, the ease of use of a street bike, and the durability of a mountain bike. It is a compromise of all customer needs. In order to give a bike target, we will model our bicycles after the Schwinn Hinge Unisex bike. It is a simple, aluminum urban bike that is lightweight and is a single-speed bike that will make it easier to pedal uphill, since campus is very hilly.

4.2.1 Target Specifications

Since we are largely modeling our bicycle after the Schwinn Hinge Unisex, our target specifications are that of the Schwinn bike. We translated some of our qualitative customer needs into quantitative metrics. Next to the quantifiable metrics are corresponding customer needs in parentheses. Below are our target specifications for our bike.

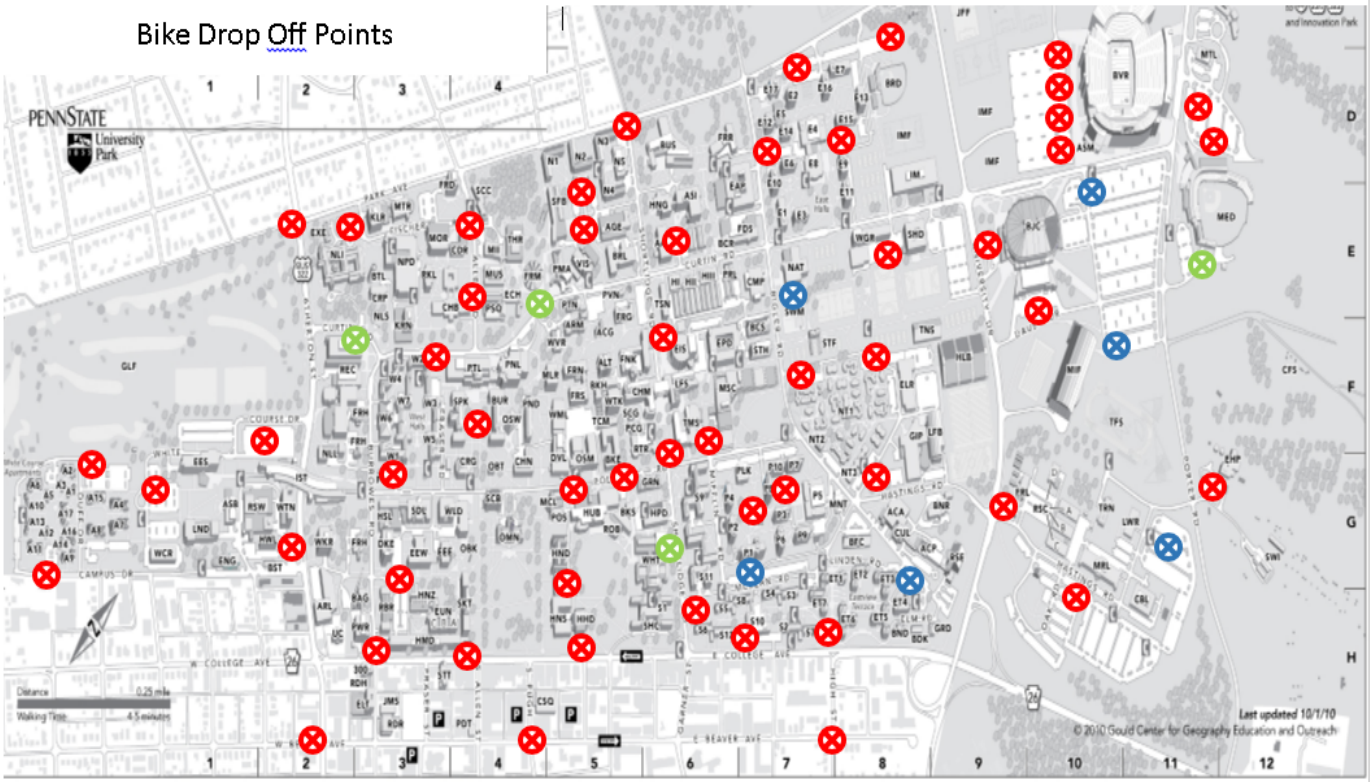
	Ideal	Marginally acceptable
Unit price on market (cheap)	$163	$220
Weight (lightweight)	37.44 pounds	40 pounds
Durable	Made out of aluminum	N/A
Aesthetically pleasing	Blue and White, PSU theme	N/A
Speeds (easy to ride)	1-speed	N/A
Comfortable	Urban bicycle	N/A

Our only other quantifiable target specifications for the project have to do with the total number of bikes and bike slots in the system. We gained these numbers as from our research on the bicycle sharing system at the University of Illinois at Urbana-Champaign. The total number of bikes in the system will be 1160 and the total number of bike slots will be 5800. There must be more slots than bikes in the system because there will not be a completely even student density throughout campus.

4.2.2 Large-Scale Implementation Concepts

Although the selection matrices above deal with our concept on a unit basis (that is, the design of each bike station and bike), we still had to use our knowledge of campus and nearby off-campus areas combined with our population density data in order to design the actual system, locating the bike stations and bike paths that will be necessary in this system. Below we have the maps of the locations of the bike stations, the proposed bike path locations around the sports complex, on campus, and off campus.

Bike Drop Off Points

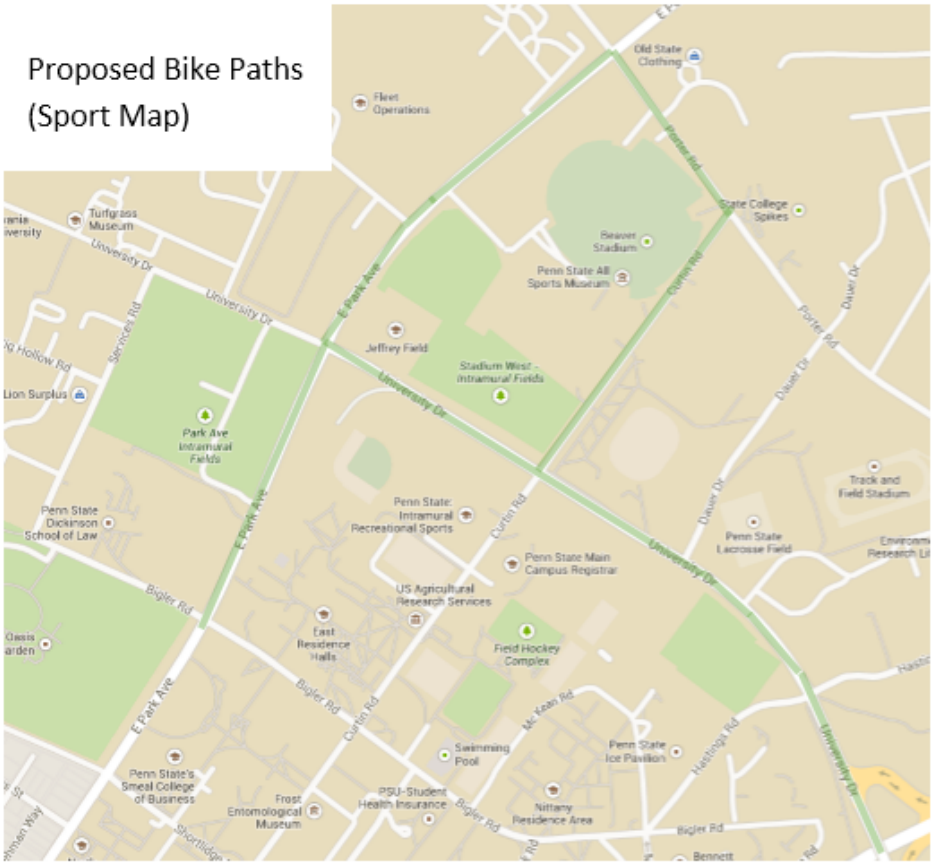


= 25 bike slots

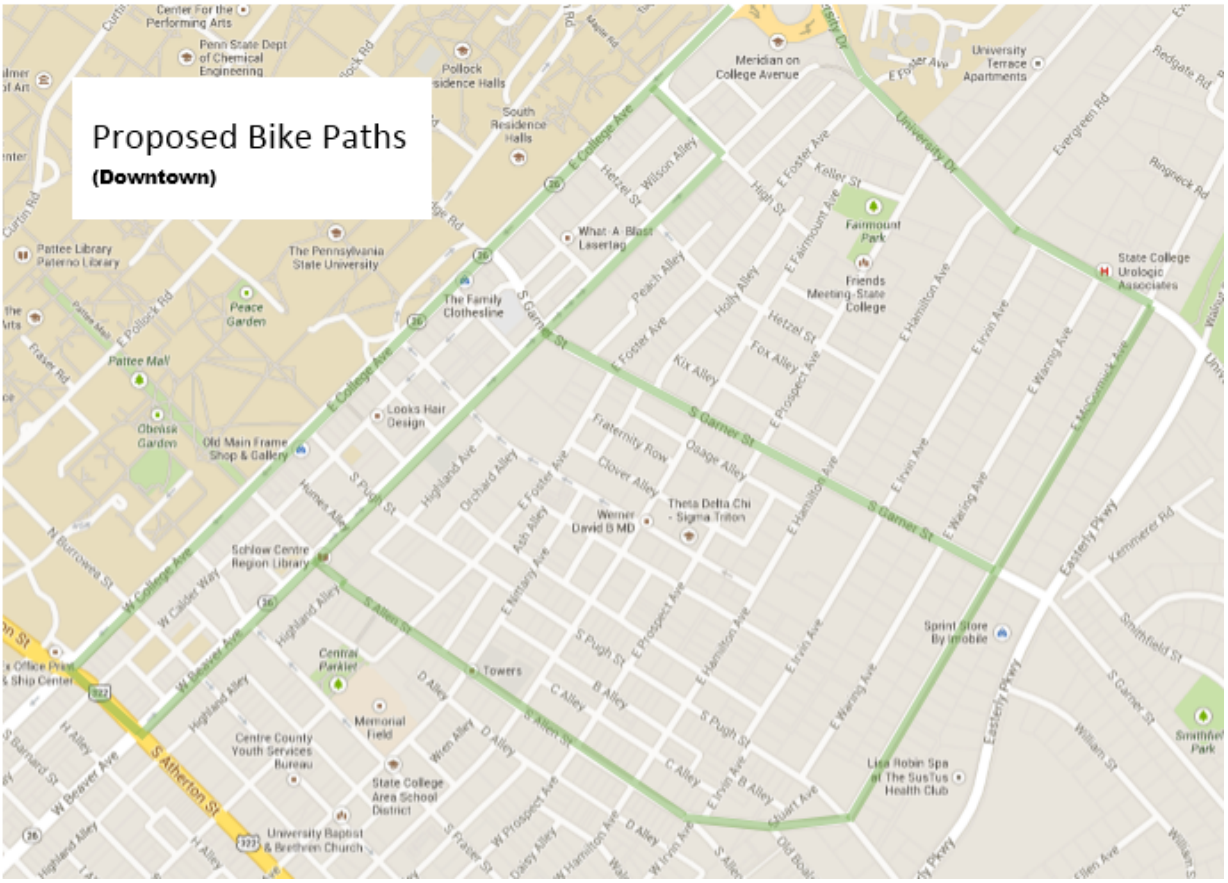
= 50 bike slots

= 100 bike slots

Proposed Bike Paths
(Sport Map)

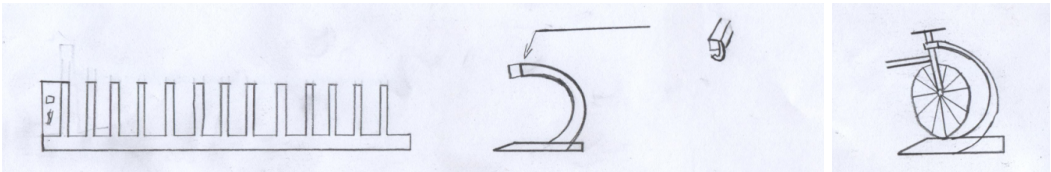


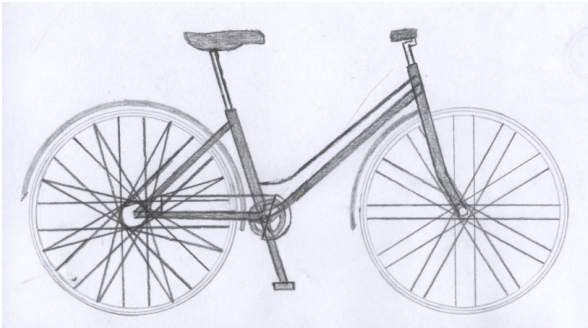
Proposed Bike Paths
(on campus)



4.2.3 Final Concepts for Bike and Rack/Station

The bike rack shown below uses electromagnets to hold a hook-shaped lock in place. Accepted payment will cause the current to stop, thus releasing the bike.





Resources

http://icap.sustainability.illinois.edu/files/project/109/Bicycle%20Sharing%20Feasibility%20Study%20Final%2011-30-12.pdf
http://www.openideo.com/fieldnotes/openideo-team-notes/seven-tips-on-better-brainstorming
http://capitalbikeshare.com/
http://www.schwinnbikes.com/usa/bikes/urban
http://www.walmart.com/ip/Schwinn-20-Unisex-Hinge-Steel-Frame-1-Speed-Bike/20581533