Addressing the needs of Penn State's bicycle needs through a temporary rental system

Siemens Corporation

EDSGN 100
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The purpose of this design challenge was, given the urban nature of University Park, to design or redesign elements of the PSU University Park campus to be sustainable. In this case, a rentable bike program with improved public bike paths was developed for use by students and faculty throughout the campus. The bike rental program consists of 1,500 rentable bikes, costing $250 apiece that could be docked at one of our 30 docking stations. Bikes are checked in and out of each docking station, and each docking station is powered by solar energy. The bikes will have a 3-speed gear hub and puncture resistant tires designed to increase durability. The implemented bike paths would run along College Ave, Pollock road, and Curtin road. These bike paths are separate from sidewalks.

TABLE OF CONTENTS

Introduction 2 - 7

PROBLEM STATEMENT 2

CONCEPT OF OPERATION 2

SPECIFICATIONS 4

SCHEDULE OF PROJECT 6

Concept development 7 - 10

CONSIDERED IDEAS / SELECTION OF DESIGN 7

EXPLANATION OF SELECTION 9

EVALUATION 10

SYSTEM DIAGRAM 10

Detailed Concept development 11 - 15

BIKE SYSTEM OVERVIEW 11

BIKE KIOSK SYSTEM OVERVIEW 12

DESIGN SOLUTION: RENTAL SYSTEM 14

DESIGN SOLUTION: THE APP 15

Conclusion 16 - 17

LESSONS LEARNED 17

References 18

Appendixes 19 - 20

Introduction:

Siemens Corporation, an international company specializing in electronics and electrical equipment presented the challenge of designing and or redesigning elements of The Pennsylvania State University's urban campus to make the campus more sustainable. In our case, our area of interest for this project is to design a concept that would help Penn State to "Go Green", by finding a new and environmentally friendly method of transportation that would reduce the university's carbon footprint and can better accommodate the current student population.

Concept of Operation

To begin development of this urban sustainability system, Sean's Avengers first established a "concept of operation." For this project, the team determined that the area to redesign to improve urban sustainability was to focus on the redesigning the transportation around campus.

The main problem with Penn State's transportation system is that Penn State is on a rapid pace of expansion. For example, the newer buildings on Penn State's campus are in the North and East section of campus. The new Smeal Business building is approximately a 22-minute walk from the industrial engineering and manufacturing building, despite many students having class in both buildings. To compound this problem, Penn State's future development can only occur even more east and more north of these areas. Current public transportation is barely sufficient for students to even go to class on time. This has led to a sectioned approach by Penn State in terms of class offerings. Business students will spend much of their day in a different area of campus

than engineers will. We plan to solve this problem by focusing on the Penn State campus, as opposed to the surrounding areas. We are also planning a slow implementation because currently, the transportation issue is not as big of a problem as it will be in the future.

Our main idea is the bike rental idea combined with a new bike path system to facilitate the transition from a primarily walking campus to a more bike friendly environment for Penn State.

Figure 1: Bixe rentable bike

Currently out of roughly 45,000 students at University Park, there are only about 10,000 bikes on campus, according to the Penn State department of transportation. Among those, there are only 5500 registered bikes. There are also no major bike paths across campus. We see bicycles as a very sustainable option that is in many ways superior to other transportation. We chose bikes are much preferred over public transportation like buses or trolleys because it is completely environmentally friendly. It does not hinge on any energy sources at all. Also, the rental system can be economically sustainable, because we plan on implementing a timing system, in which bikes can only be rented out for a certain allotted "grace" period, before renting the bikes costs money. This is dually useful in terms of getting more available bikes because people return them quicker, and to make

Figure 2: Rentable bike kiosk

money to sustain the bikes. The bikes themselves should cost around $500 a bike according to Bixe, a private bike rental company. The bike rental program consists of 1500 rentable bikes, could be docked at one of our 30 docking stations. Bikes are checked in and out of each docking station, and each docking station is powered by solar energy. The bikes will weigh 55 pounds, more than a traditional bike to increase durability and have a 3 speedo gear hub and puncture resistant tires designed to increase durability as well. The implemented bike paths would run along College Ave, Pollock road, and Curtin road. These bike paths are separate from sidewalks. These stations will be stationed across campus outside major buildings and if we start now, we plan to have this in place by 2015. It is also socially sustainable because we are also implementing bike paths. The only negative social externality currently stemming from bikes are that there are not separate bike paths, so pedestrians can feel threatened when a bike zooms by them. By having separate bike paths, we ensure social balance. The exact placement of our bike stations can by found in Appendix B.

Specifications

As stated previously, the goal we pursued in this project primarily revolved around the need to remove the constraints put on the university's development by what we see as a poor transportation system. With that in mind there were several specifications that emerged through research and information obtained from stakeholders in the project. The specifications used in determining an appropriate solution fell into five general categories. First was that the solution needed to be sustainable, in terms of cost and energy usage throughout its implementation and maintenance. Secondly, the solution needed to be appropriate for our audience, meaning it was both appealing over other options, and accessible to as many as possible. Third, the system

needed to be able to handle the volume of people we anticipated would use the campus transportation system. Fourth, the university as it is now needed to be able to accommodate the system with little alteration of the campus, while still providing widespread service. Finally, the overall idea needed to be feasible in terms of the technology it relied on, and its implementation. The full list of specifications is as follows:

Specifications List

1. Reduce costs to university
    a. Lower cost to maintain
    b. Low costs to construct

2. Energy
    a. Systems runs on alternative energy if applicable or possible

3. Appropriate for target audience
    a. Accessible for majority of target audience
    b. Able to draw users away from other options
    c. Provide service at little to no cost to the user

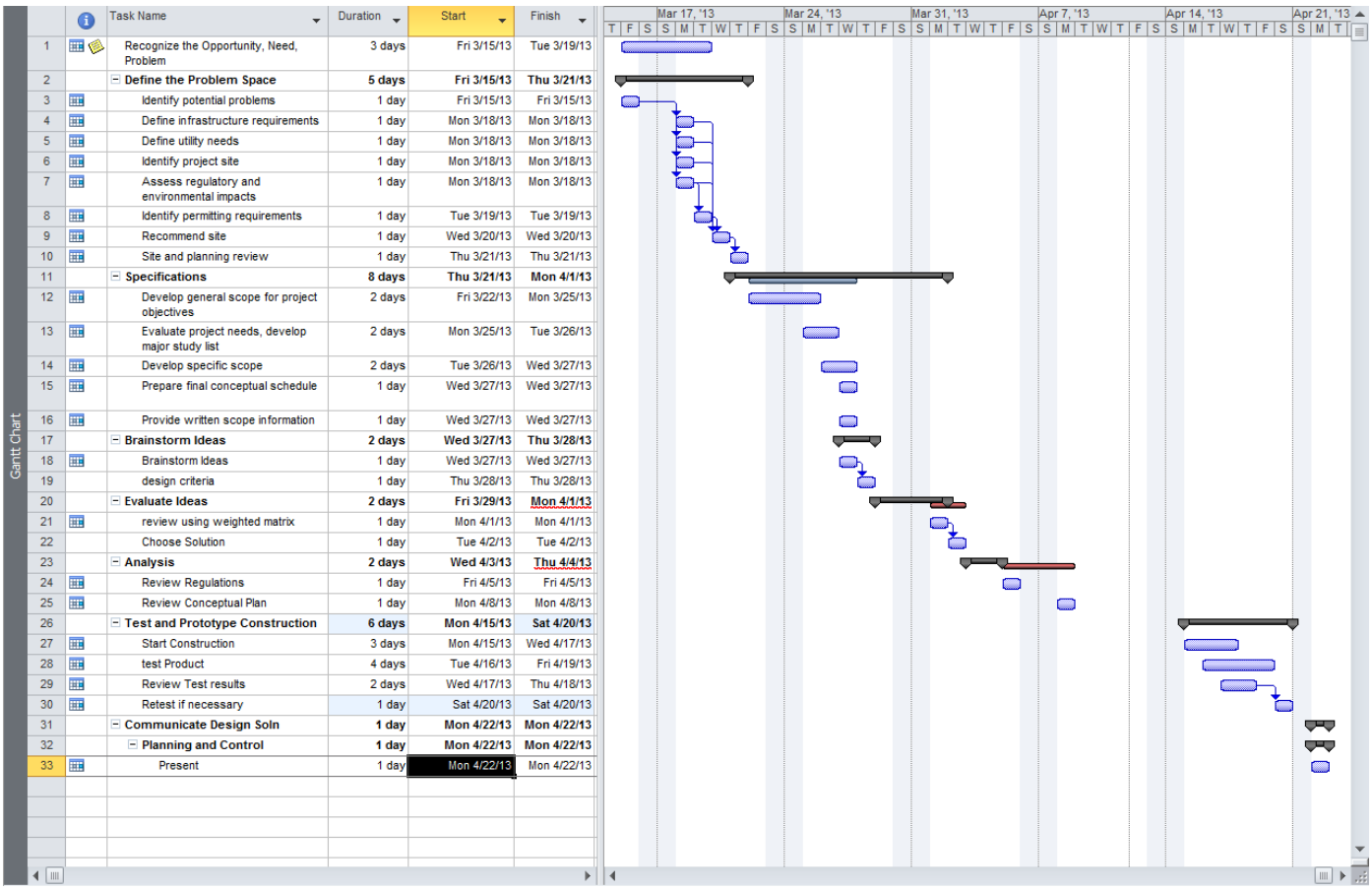
4. Meet transportation demands
    a. Able to accommodate large volume of users

5. University able to accommodate system
    a. Implementation requires little to no modification to current campus
    b. System does not interfere significantly with pedestrian traffic
    c. System is able to service large majority of campus

6. Feasibility
    a. System relies on technology already in existence or possible
    b. Total cost to implement is low

Schedule of Project

The schedule of the project spanned over a month and a half. The first goal of our teams was to create a problem statement and design criteria. We devoted five days to thinking about the design product and the opportunities that we could take advantage of. We explored several ideas and



	Task Name	Duration	Start	Finish
1	Recognize the Opportunity, Need, Problem	3 days	Fri 3/15/13	Tue 3/19/13
2	**Define the Problem Space**	**5 days**	**Fri 3/15/13**	**Thu 3/21/13**
3	Identify potential problems	1 day	Fri 3/15/13	Fri 3/15/13
4	Define infrastructure requirements	1 day	Mon 3/18/13	Mon 3/18/13
5	Define utility needs	1 day	Mon 3/18/13	Mon 3/18/13
6	Identify project site	1 day	Mon 3/18/13	Mon 3/18/13
7	Assess regulatory and environmental impacts	1 day	Mon 3/18/13	Mon 3/18/13
8	Identify permitting requirements	1 day	Tue 3/19/13	Tue 3/19/13
9	Recommend site	1 day	Wed 3/20/13	Wed 3/20/13
10	Site and planning review	1 day	Thu 3/21/13	Thu 3/21/13
11	**Specifications**	**8 days**	**Thu 3/21/13**	**Mon 4/1/13**
12	Develop general scope for project objectives	2 days	Fri 3/22/13	Mon 3/25/13
13	Evaluate project needs, develop major study list	2 days	Mon 3/25/13	Tue 3/26/13
14	Develop specific scope	2 days	Tue 3/26/13	Wed 3/27/13
15	Prepare final conceptual schedule	1 day	Wed 3/27/13	Wed 3/27/13
16	Provide written scope information	1 day	Wed 3/27/13	Wed 3/27/13
17	**Brainstorm Ideas**	**2 days**	**Wed 3/27/13**	**Thu 3/28/13**
18	Brainstorm Ideas	1 day	Wed 3/27/13	Wed 3/27/13
19	design criteria	1 day	Thu 3/28/13	Thu 3/28/13
20	**Evaluate Ideas**	**2 days**	**Fri 3/29/13**	**Mon 4/1/13**
21	review using weighted matrix	1 day	Mon 4/1/13	Mon 4/1/13
22	Choose Solution	1 day	Tue 4/2/13	Tue 4/2/13
23	**Analysis**	**2 days**	**Wed 4/3/13**	**Thu 4/4/13**
24	Review Regulations	1 day	Fri 4/5/13	Fri 4/5/13
25	Review Conceptual Plan	1 day	Mon 4/8/13	Mon 4/8/13
26	**Test and Prototype Construction**	**6 days**	**Mon 4/15/13**	**Sat 4/20/13**
27	Start Construction	3 days	Mon 4/15/13	Wed 4/17/13
28	test Product	4 days	Tue 4/16/13	Fri 4/19/13
29	Review Test results	2 days	Wed 4/17/13	Thu 4/18/13
30	Retest if necessary	1 day	Sat 4/20/13	Sat 4/20/13
31	**Communicate Design Soln**	**1 day**	**Mon 4/22/13**	**Mon 4/22/13**
32	**Planning and Control**	**1 day**	**Mon 4/22/13**	**Mon 4/22/13**
33	Present	1 day	Mon 4/22/13	Mon 4/22/13

Figure 3: This chart shows the time frame for developing the alternative transportation methods. It gives details as to how many days were devoted to each aspect of the design process.

concepts to improve the transportation. Our general research and analysis lasted for roughly two weeks until we gathered enough information on our suggested ideas. Afterwards, we decided our best idea and invested more time into researching and designing our rental system to create

the best possible concept to prevent to the class. We made drawings and calculations to further help the class visualize our ideas. The Gantt chart for the Siemens project is pictured above.

Figure 4: This is an example of a train system

Concept Development

In order to find the optimal alternative transportation method for the project, a detailed selection process was used. The first step was to brainstorm ways to travel around campus. A list was A list was made with various methods of transportation including, trains, trolleys, and bikes. After the list was finished, our team researched each method. All transportation methods had already been adapted by at least one university and most of our research came from each concepts success at the other universities. Our research resulted in 5 different concepts that were plausible. The ideas are as follows:

1. Train or tram system.
    i. This idea would accommodate many people and be accessible to many, but the entire system would have had to be built from scratch and the campus as it is would not accommodate it.

2. System of trolley like vehicles.

i. Like the trains, trolleys are accessible and accommodate many people, but the entire system would be built from scratch and the idea in general was fairly unfeasible.

Figure 5: This is an example of a trolley system

3. Make improvements to the current CATA bus systems.
    a. This idea would generally be cheap and easy to implement, but it would not really allow for any improvements in sustainability to be made and it other ideas could service more of campus.

Figure 6: This is an example of a bus system

4. Bike rental system.
    a. This idea would be generally be very sustainable, low cost, and the university could easily incorporate a new system into the existing campus. The drawback is that students must be able to ride a bike and the system in general would not accommodate handicapped individuals.

Figure 7: This is an example of a bike system

5. Expand the ability for cars to enter campus.
    a. This idea did not end up being very sustainable, and as it required roadways, it

Figure 8: This is an example of a car system

could only service as much area as a bus system already can.

In the end we used a standard selection matrix to choose our final design concept. As such we have determined that the bike system would be the best solution to our problem, and will develop that idea as our final solution.

Design/ Idea	Reduce Cost	Alternative Energy	Accessible, appropriate for Audience	Handle Large volume of users	Service Majority of Campus	University can accommodate system	Feasible	Totals
Tram/Train	--	+	+	+	0	--	--	0
Trolley	--	+	+	+	--	--	--	-1
CATA Improvement	0	--	+	+	0	+	+	3
Bike Program	+	+	--	0	+	+	+	4
Car/ auto system	0	--	--	+	0	+	+	1

Criteria	**Weight**	**Tram**		**Trolley**		**CATA**		**Bike**		**Car**	
Reduce Cost	5%	1	.05	1	.05	3	.15	4	.2	1	.05
Alternative Energy	10%	2	.2	2	.2	2	.2	5	.5	2	.2
Accessible	10%	3	.3	4	.4	4	.4	2	.2	2	.2
Meets volume demand	20%	5	1	4	.8	2	.4	4	.8	2	.4
Service majority of campus	15%	3	.45	3	.45	3	.45	5	.75	3	.45
Accommodation	20%	2	.4	3	.6	2	.4	3	.6	2	.4
Feasibility	20%	1	.2	2	.4	4	.8	4	.8	4	.8
Total	100%	2.6		2.9		2.8		3.85		2.5	
Rank		4		2		3		1		5	

Selected Idea

The bike program idea we selected as we envision it has multiple parts to it. The central point of the idea revolves around the creation and implementation of a bike-rental system similar to those seen in some big cities. In addition to this we have anticipated that for such a plan to be implemented other aspects of a bike system would have to be examined, such as the possibility of bike paths or similar items. Additionally we have already identified several issues we will have to address in the final design. Some of these issues include figuring out how to provide enough bikes to meet the demand we anticipate, determining how to prevent abuse (i.e. excessive use) of the system or theft of the bikes, and figuring out how to make the idea appealing to students who are either unable to ride a bike, or unwilling. Such issues will likely be addressed as the design is further developed and hopefully we will be able to develop effective ways to address these problems.

Best Solution: Bike Program

Detailed Concept Development

Bike System Overview

The bike prototype that is being designed is a unit that can be ridden by users of all heights. Each bike will be equipped with an adjustable saddle that allows the rider to move the saddle up and down to their desired height in order for a comfortable ride. The bike will also be a three-speed bicycle in order to have to ability to ride up and down hills and on flats with ease and speed. The gears and derailer will be located in the rear of the bike with three different sprocket sizes and one main chain ring located in the front. The gears in the rear was chosen in order to allow the addition of a plastic chain guard around the front chain ring and crank shaft in order to prevent grease and dirt from dirtying pants, socks, sneakers, etc. The bicycle will also be equipped with two 750x35mm heavy-duty street tires. These tires were chosen because of the use of non-puncturing tires would not be feasible in terms of cost. The heavy-duty tire should discourage the occurrence of flat tires if all tires are properly inflated to the correct PSI. The tires will also have a heavy-duty tube inside which consist of a thicker rubber, which would resist puncturing if PSI should fall below an undesirable level. The bicycle will also be equipped with front and rear disk brakes. Common padded brakes are not that less of an expensive piece and disk brakes offer greater safety in terms of reliability and stopping speed no matter what the level of velocity or acceleration is. Fenders would be installed on each bike on both the front and rear tires to prevent mud, dirt, and water from dirtying the rider. The fenders would be made of plastic because they are lighter and cheaper to repair should an accident occur. Each bicycle

would also have a basket attached to the handlebars for convenience. The user can put bags, books, and groceries in it during their commute. The overall frame of the bike would be constructed of aluminum since it is recyclable, cheap, strong, and light. Each bike would also be fitted with lights and reflectors in order to provide safety for early morning and nighttime riders to prevent incidents with other riders or motor vehicles. Along with these safety features, a bell would be attached to the handlebars to let forward riders that they are being passed from behind. Rich Adams, an engineer with a degree from Lehigh University and part owner or Around Town Bicycles, Wilkes-Barre, PA would lead the build on these bikes. With the parts being machined and fabricated in Pennsylvania, the price of each unit, along with accessories would be priced out at $250 to $300 a piece. We estimated that 1000 to 1500 bikes would be most practical for our design and A-Town bikes would be able to supply the bikes in bulk for the design. The total cost for such bikes would roughly be $300,000.00.

It is difficult to pinpoint how quickly the bike system will be adopted, but by looking at the data for the London Barclay's bike program we can estimate that we will only need to provide roughly 1/3 of the total needed bikes at the start of the program and scale up our production from there. The exact adoption information for the Barclay's bikes can be found in Appendix A.

Bike Kiosk System Overview

While having actual bikes to rent out is an obviously important point for this design, something equally important is where they will be stored. We designed a kiosk that would house the entirety of each rental station. The Kiosk is pictured below.

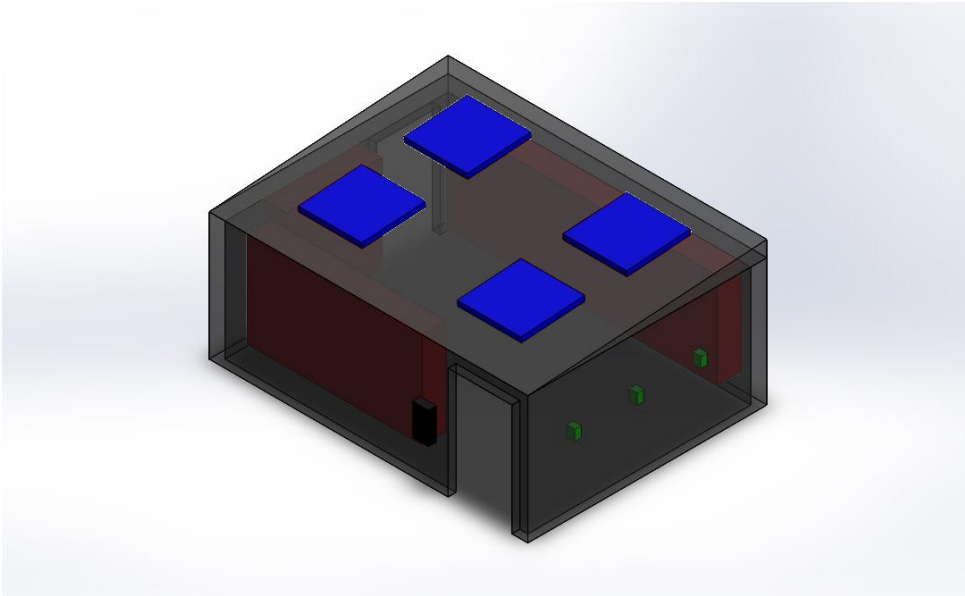


Figure10: The bike rental station digital prototype

The important features of the kiosk include….

1) Each kiosk is designed to be 15ft. / 20 ft. / 8 ft. , and each one would have 2 entrances, designed to be in/out doors.

2) We plan for each kiosk to hold approximately 50 bikes, and for about 30 kiosks to be placed around campus

3) One wall of each kiosk contains 3 ID scanners. The scanners connect to the system that keeps track of the bikes and links the rented bike to the student.

4) The remaining wall space contains the bike racks that will store the bikes, and be unlocked when someone rents a bike

5) The kiosk is entirely powered by solar power, with 4 solar panels on the roof of each kiosk. (Note only the panels in the power system are shown).

6) Each Kiosk has a sign that monitors and displays the number of bike currently available beside the front door to each kiosk.

Design Solution: The Rental System and the Student ID

As previously stated the rental system is tied to the student ID. In the most basic sense, you must have an ID to rent a bike. The details are as follows…

1) To rent a bike, a student would swipe their ID in one of the ID scanners, which would unlock a bike.

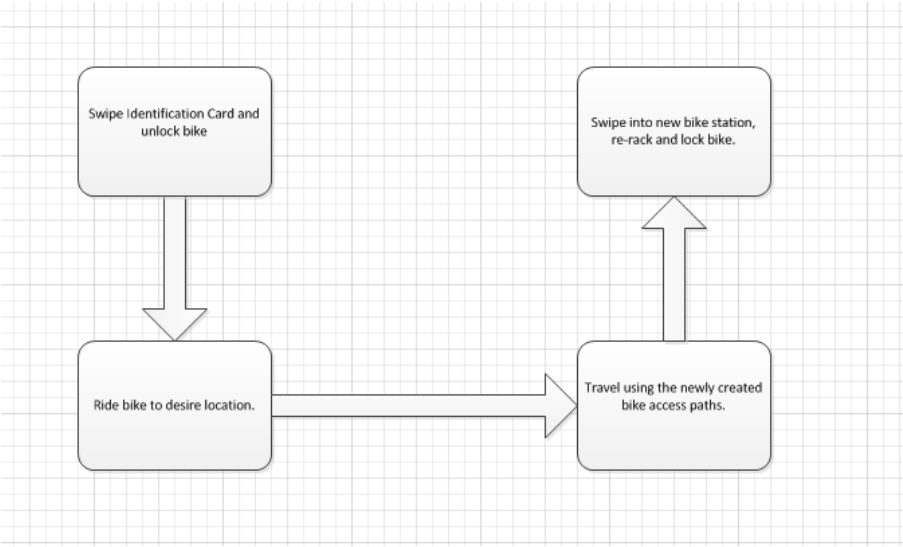


Figure 11: System overview for the bike rental system

2) When a bike is rented, the ID number of the bike is tied to the student until it is returned.

3) Any charges related to the use of the bike are the responsibility of whomever the bike is tied to. Examples include damage to the bike, loss of the bike, or failure to return the bike in a timely manner.

4) The first half hour of rental, no charge is incurred for the student. For every additional half hour after that the renter would be charged until the bike is returned.

5) To return a bike, the student places the bike on the rack, then swipes their card and indicates the location of the bike. If done correctly the system locks the bike in place and the student is no longer tied to that bike and its use.

6) All station will also feature a way to lock a particular bike out of the system if it is damaged, that way no student can be charged for damage they did not cause.

7) Finally, the process of renting a bike will involve a built in agreement waiving the university from responsibility for personal injury or injury to property caused while using a rented bike.

Design Solution: The App

The final portion of the solution includes the creation of an app that can be downloaded by potential users. The app links to the system in each kiosk that monitors the number of bikes available and allows a user to view these numbers at any time. We hope that this would allow

people to monitor the bike levels at different kiosk and avoid either overcrowding at an empty station or frustration from users if a station is empty. The app itself would be free to download and we aim for it to be supported by most devices.

Conclusion

The best way to make campus more sustainable is an improved transportation system, which is accomplished through our bike rental system. Our system will lower the current demand for CATA buses and motivate more people to use bikes. This will make travel quicker, healthier, and environmentally cleaner. This system is also forward thinking, as it takes advantage of the fact that the campus will grow in the future, so our system will still be significant and applicable. The rentable bicycle system combined with the improved bike paths will decrease the amount of people using cars, and public transport by up to 1500 people. 30 Bike stations will be needed to house the bikes around campus. The bike kiosks are 300 ft^2 making them practical in tight spaces.

An advantage of this design is that the cost of the bikes will be included into tuition along with the cost for CATA, so there will be no extra fees for students to use for short term trips.

However, the availability of these bikes is dependent on how long people decide to check the bikes out for. If people decide they can afford to check the bikes out for a long period of time, then there will be fewer bikes for people to use to travel to classes.

The bike kiosk structure is enclosed, meaning that the bikes will be at less risk of water damage making the bikes more durable. The roof-mounted solar panels take advantage of a source of power that is readily accessible considering the low energy costs required to run the kiosk.

Further development for the bicycle rental idea is possible. The number of bikes that we can put around campus is limited to the number of bike stations that we can build around campus and the state college area. This limit could be extended by replacing the bicycle stations with open-air bike racks that could easily fit into tight areas. However, a loss of security for the bikes may arise and it would be more difficult to place the solar panels to charge the station, but there should be enough space for the panels to provide the necessary for the concept of operations.

Lessons Learned

This engineering design project helped us improve out time management and group communication. Given the relatively short amount of time to complete the project, research on topics had to be completed very quickly. Learning how to brainstorm properly and apply our ideas was also a key learning moment throughout the project. From completing our specific project, realized that you don’t have to invent new technology to make a difference. By using

existing designs and brainstorming new applications, one can engineer new uses and designs from it.

References

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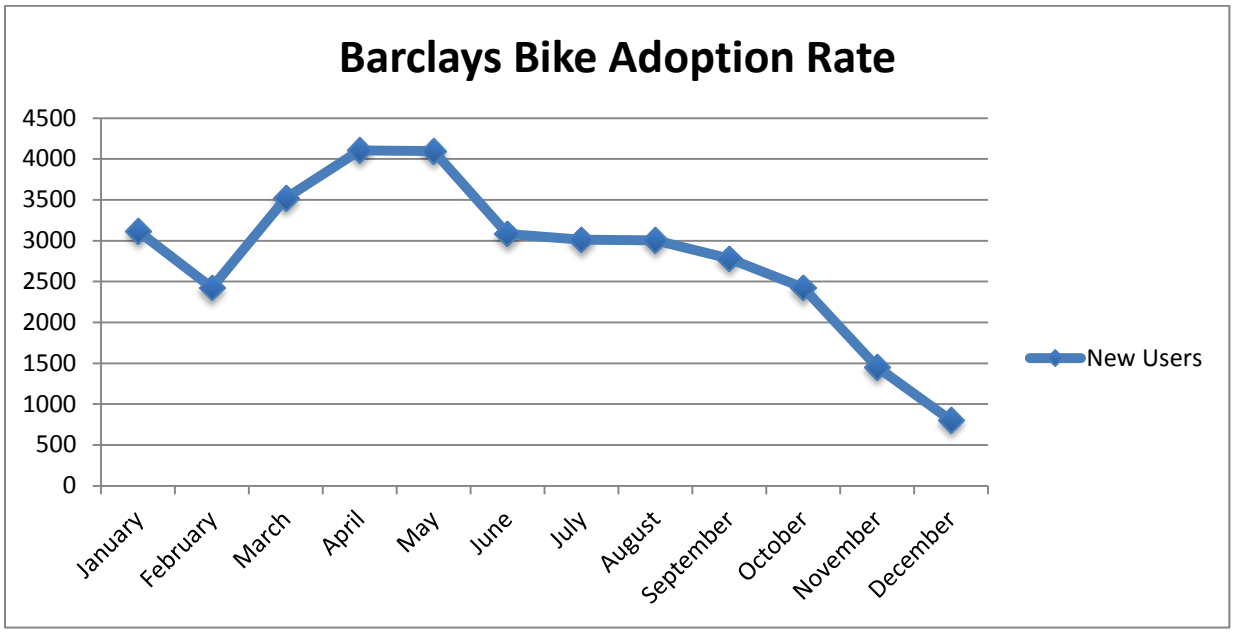
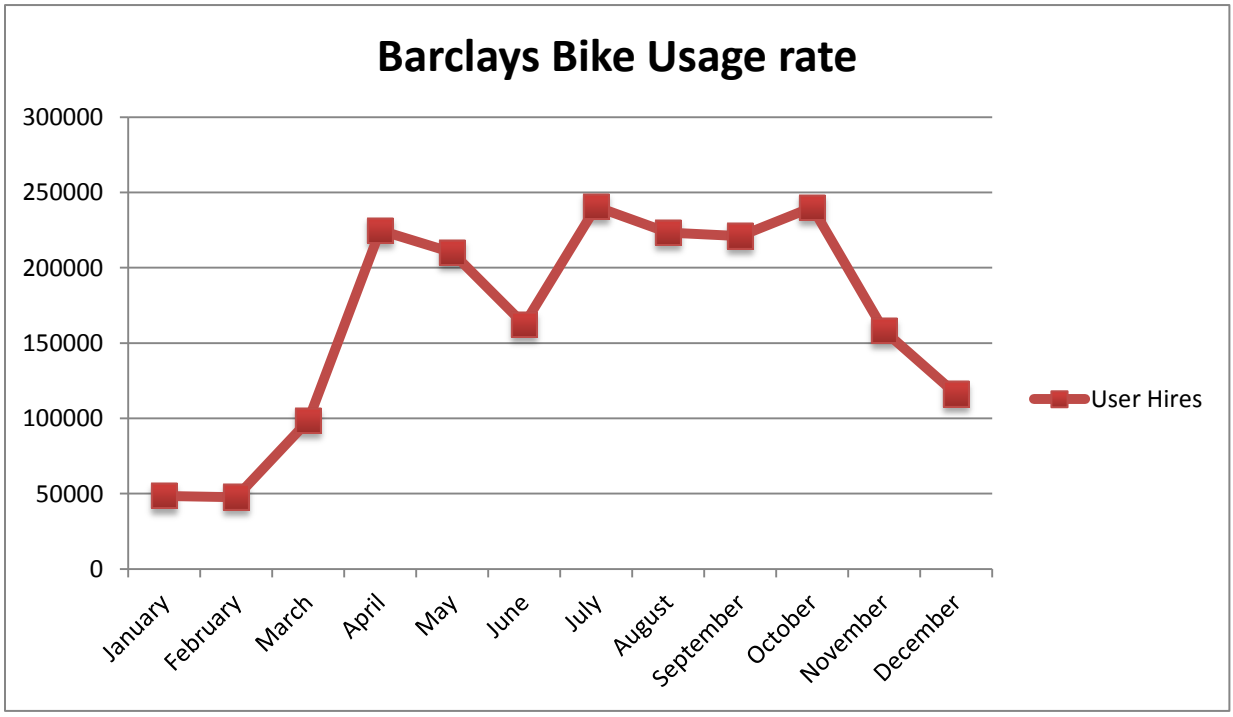
Appendix A


Barclays Bike Adoption Rate
4500
4000
3500
3000
2500
2000
1500
1000
500
0
January
February
March
April
May
June
July
August
September
October
November
December
New Users


Barclays Bike Usage rate
300000
250000
200000
150000
100000
50000
0
January
February
March
April
May
June
July
August
September
October
November
December
User Hires

Appendix B

Our expansion of the bike routes is pictured below. The red lines stands for existing bike paths and the black lines stand for ones we will construct.

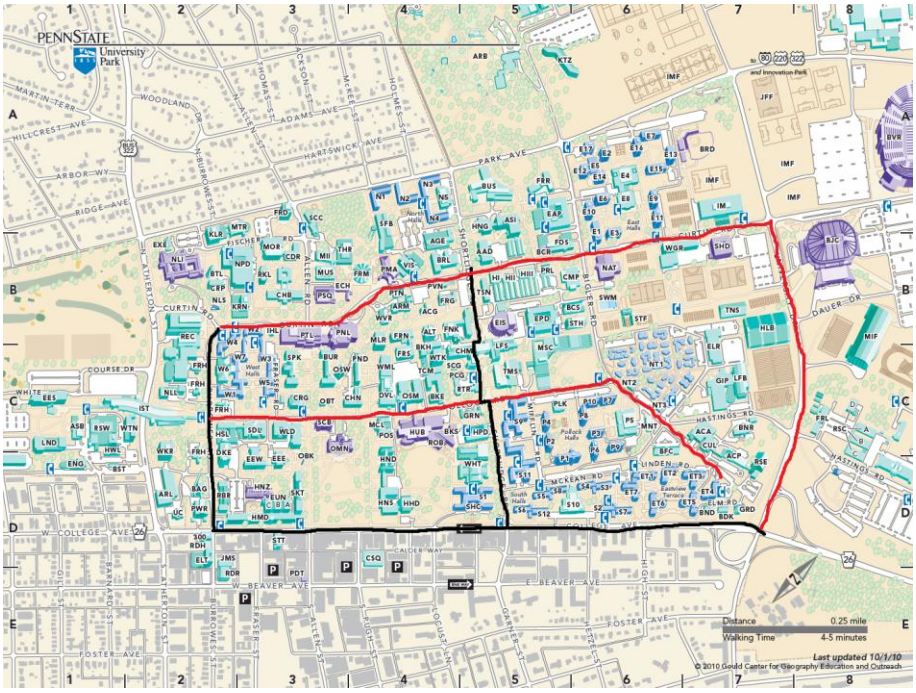


Figure 9: A map of the planned bike routes on campus