BIG IDEAS
CONNECTED COMMUNITIES

FINAL PROPOSAL FOR

I-BIKE

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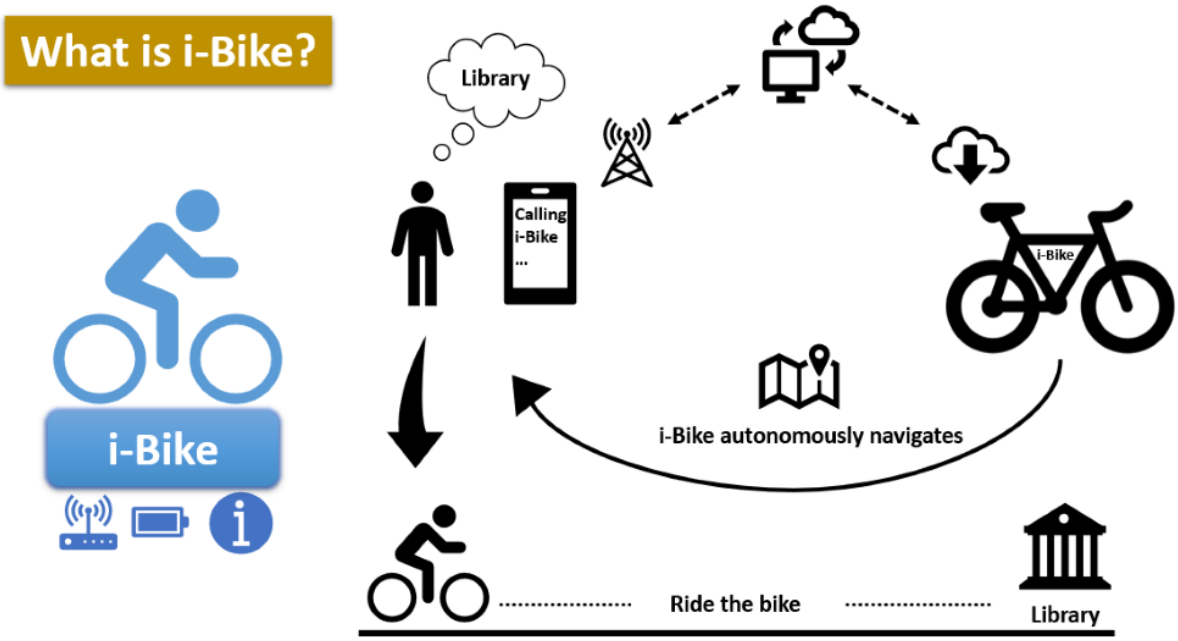
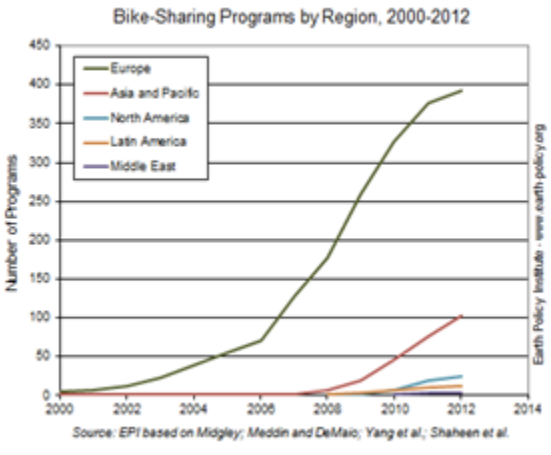


Problem Statement

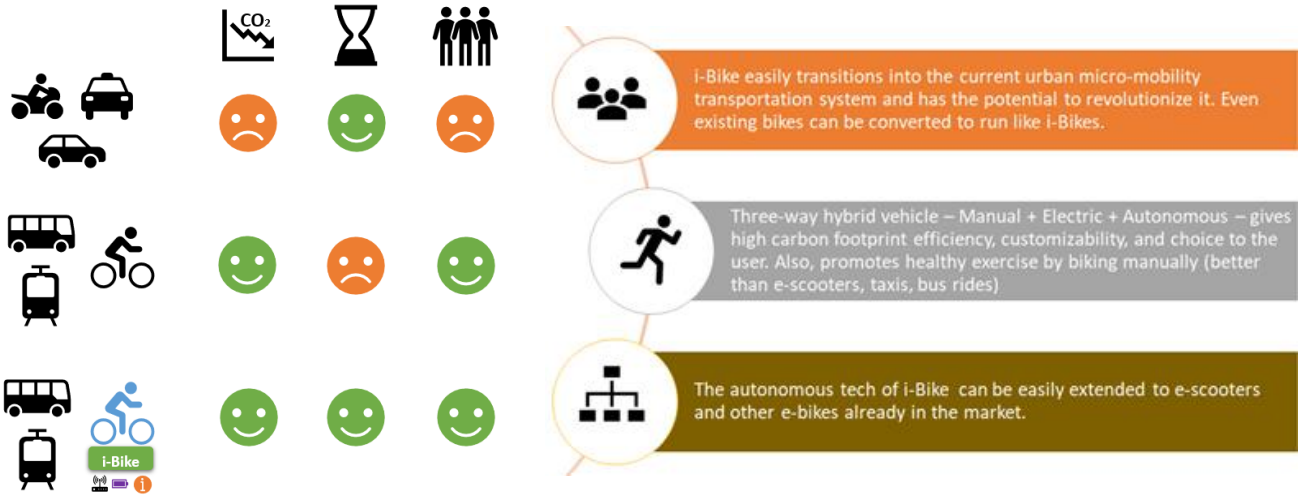
Due to degrading environmental conditions all over the world and growing demand for micro-mobility, many countries in Europe, USA, China, Canada, and Korea have initiated public bicycle sharing systems. One can use these bicycles to travel between locations and thereby reduce their carbon footprint. These initiatives face challenges achieving mainstream adoption because of several issues associated with the last mile transport. People face difficulty to find stations to pick up a docked bike or to drop it off close to their destinations (cite survey) and installing bicycle sharing stations is a big infrastructural burden (cite report). Other confounding factors such as proper parking, public outlook, and safety are common obstacles in most other alternatives to last-mile transport.

All these problems motivate us towards building an innovative and intelligent bicycle that can easily fit into the systems already in place. We call our product the “i-Bike” - a bike system utilizing autonomous technology to enable bike hailing and simplifying parking. It is an autonomous bicycle at its core but can also be used as a normal bike, and in fact, to develop an i-Bike, we use the bikes that are on the road, just customize it, and turn it into an i-Bike. We believe that i-Bikes could revolutionize the last-mile transport since most issues with the bike-sharing systems pointed out above would be trivialized by the existence of autonomous share-able bikes.

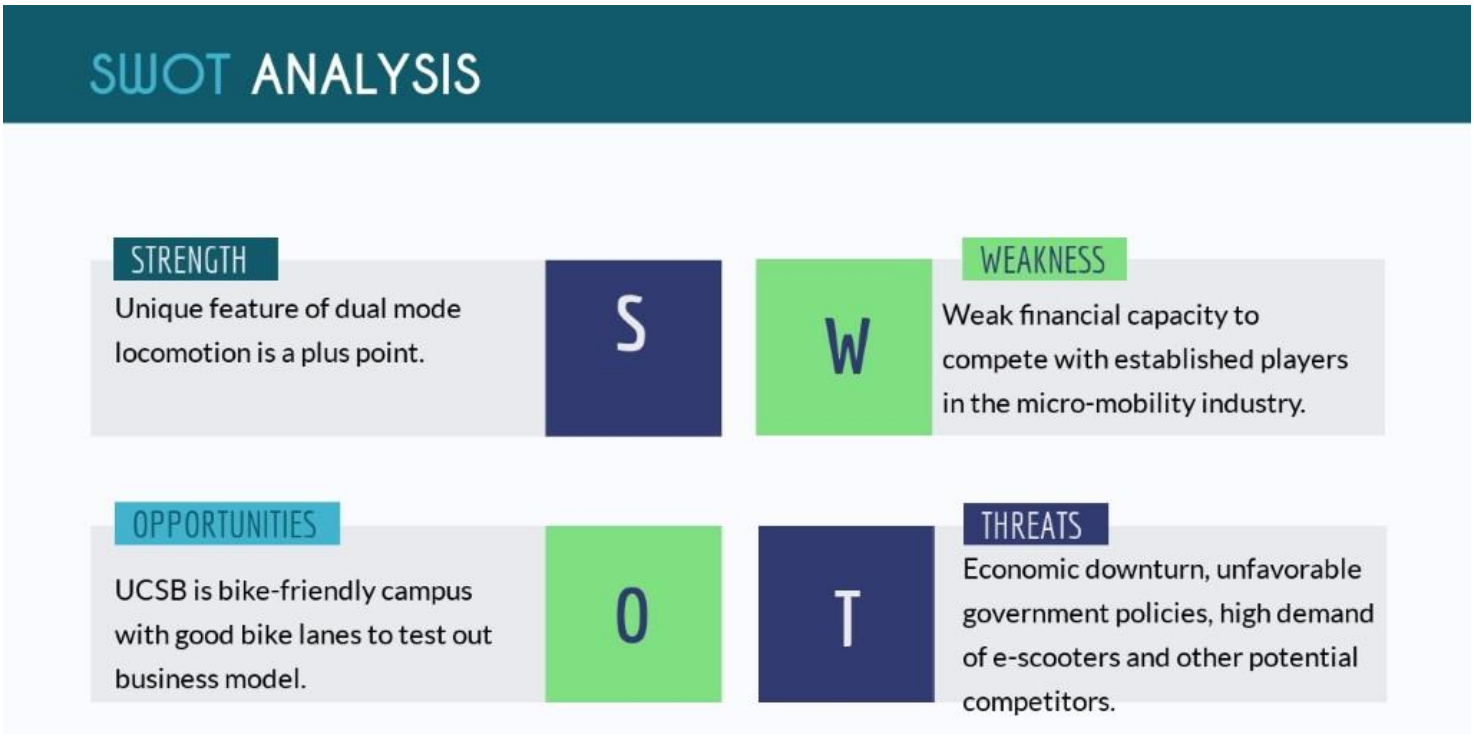


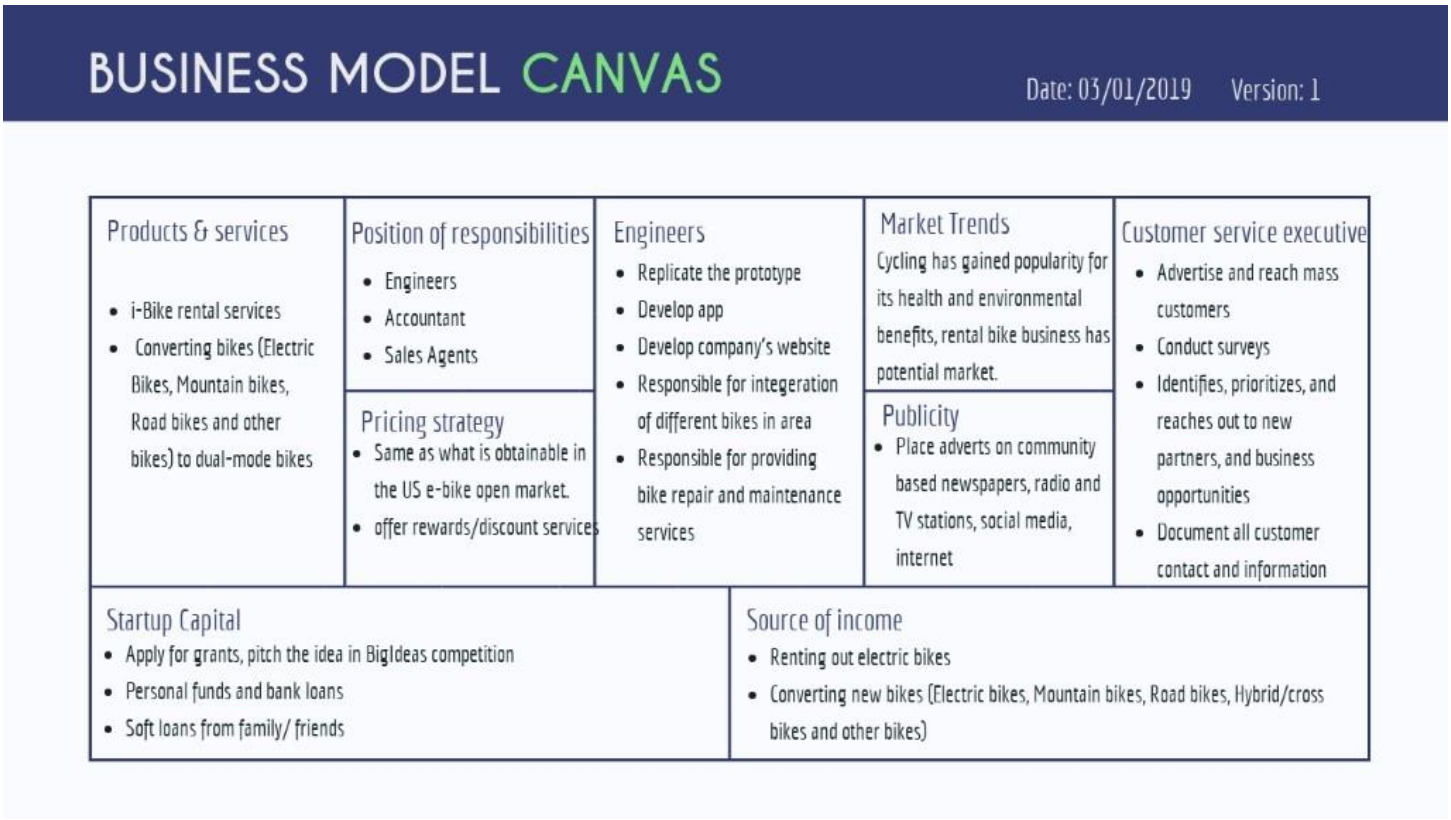
Moreover, with all the other features that we propose to build for the bike including network connectivity, user-friendly interface, anti-theft technologies and transformative customizable designs, i-Bike solves the many challenges that we face in urban commute today. i-Bikes would even reduce the infrastructure cost for bike-sharing system and hence lower down the carbon footprint that comes with the construction of these stations. The product aims to solve the last mile transportation in bicycle sharing systems as well as the end-mile transportation problem like parking. For our product development and testing we would focus on implementation in a closed campus such as a university or a business complex. Ideally, UCSB campus is a perfect fit for initial testing due to its bike-friendly nature and the availability of bike lanes everywhere.

Advantages and Key Features



Business Model





Existing Solutions

In the past few years we have seen an exponential growth in the usage of e-scooters and e-bikes all around the world. The push towards cleaner fuel economies by the governments and general awareness among people are the major reasons for this growth in the micro-mobility industry. Our product addresses the limitations and the pain points of the micro-mobility industry such as unmanaged or non-existent parking services for shared e-scooters, limited availability of a vehicle for the last-mile transport on demand, and the consumers' need of a comfortable and hassle-free ride. With the innovative i-Bike technology we propose to solve these challenges efficiently.

In the table shown below, we compare some of the existing products in the market and some of the solutions that are currently being developed by the industry or the research labs. It is clear from the table that the i-Bike solves the major challenges that impede the growth of other competitors by providing a much more user-friendly, scalable, and a structured solution to the problem of the last-mile transportation.

Last-mile and micro-mobility transportation

This comparison chart compares i-Bike to the other products that are already in the market or are currently being developed at research labs all around the world. Although, i-Bike is completely unique on its own and there is no product in the market that has the same functions as the i-Bike, it is important to compare it to other products that are currently being used in the same market segment - micro mobility and last-mile transportation.

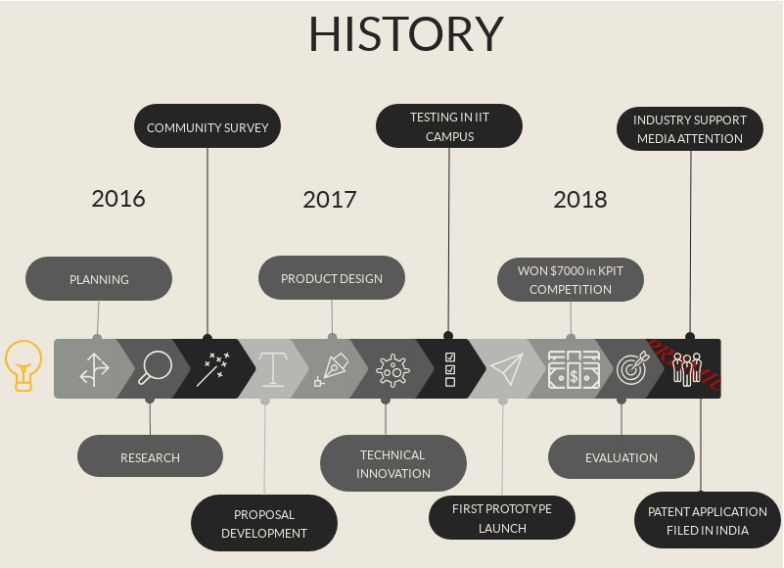
	AUTONOMOUS	COST	AVAILABILITY	CARBON FOOTPRINT AND RANGE
TRIKE - ELCANO, UW	Yes	Not yet in the market. Proposed $5000/pc	Personal vehicle	More than e-bikes. No manual drive option.
E-BIKES	No	>$500	Personal vehicle	Lesser footprint than cars. Can manually drive.
E-SCOOTERS	No	$0.20/min >$500/pc	Shared, no parking management/guarantee	Similar footprint as e-bikes.
FOLDING BIKES	Some research in this direction, none in the market.	>$400/pc Autonomous not yet available	Personal vehicle	More than e-bikes.
OTHER AUTONOMOUS BIKES	Yes, but not robust.	None available in the market	None available in the market	More than e-bikes. No manual drive option.
I-BIKE	Yes	$0.20/min $5000/pc	Shared. Hail-able like a taxi, managed parking (autonomous)	Similar to e-bikes. User may drive - increased range and healthy rides.

Proposed Innovation

USP
- A normal bike is modified to make it autonomous without losing its natural functionalities, hence achieving dual mode of locomotion.

Software
- i-Bike remains in a wireless cloud network that provides live tracking and safety features.
- The software architecture is simple and allows the bike to follow lanes while avoiding obstacles

Mechanical
- An autonomous steering mechanism, a drive-by-wire control for braking and translation, and an autonomous balancing retraction mechanism,
- All modifications are minimal and customizable allowing for wide variety of applications.



The work on the prototype shown above started back in 2016. The history timeline shows the progress made with the prototype. The next section describes the technical innovations and the proposed new innovations. We propose development on top of this prototype to develop a network of i-Bike and show the functionality of hailing a bike from this shared bike network. The innovations in the prototype will be crucial as we develop a product for the micro-mobility market. We would also file for a US Patent with the tech and IP presented in this section. Using this proposed technology, we can solve the challenges discussed in the previous sections.

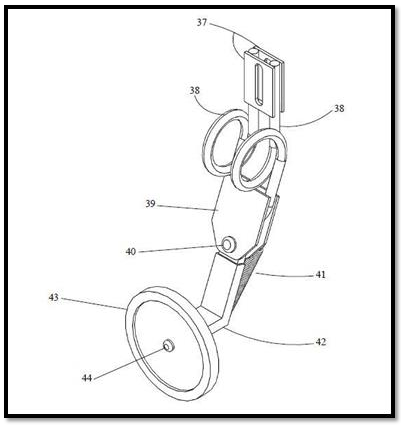
Technical Innovations and IP

Retractable Balancing

Bikes are unstable! They fall unless there is a force that aims to balance it. For years, researchers have aimed to design active electronic control systems so that a bike could be stabilized without human intervention. Unsurprisingly, none of those approaches have led to a viable and robust design that we could use to design an autonomous bike for urban commute.

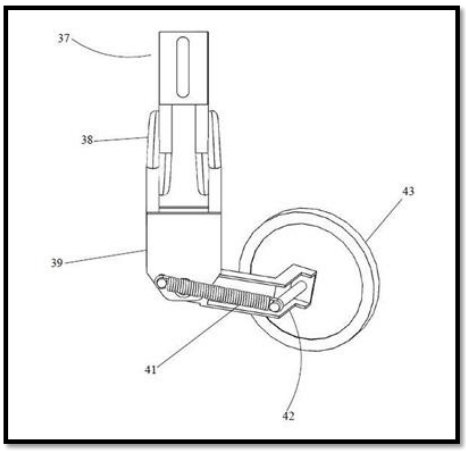
We propose to solve this problem by using a passive control mechanism that uses torsional springs to help navigate the bike autonomously while also providing highly robust stability behavior. It is also retractable so that the user can drive the bike manually – just like a normal bike. Refer to the Appendix for more details.

In Autonomous Mode

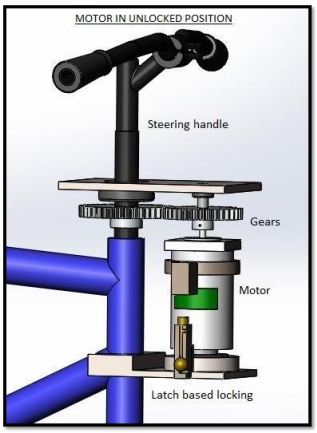


Retracts to

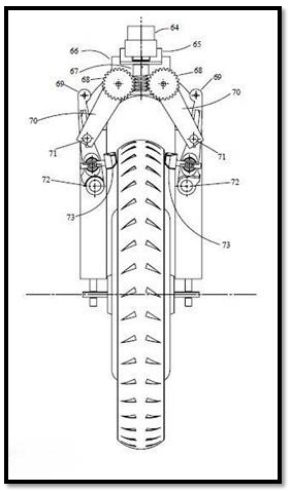
In Manual Mode



Autonomous Bike-Steering



i-Bike needs an autonomous steering mechanism that helps it navigate the obstacles while on the road. We propose a motor control mechanism installed on the steering chamber of the bike that enables control of the steering. Further, we propose an innovative mechanism that uses a lever-based latch mechanism to retract the motor so that the bike could be driven – just like a normal bike steering. Refer to the appendix for more details about the retraction mechanism and the description of the motor control of the steering.

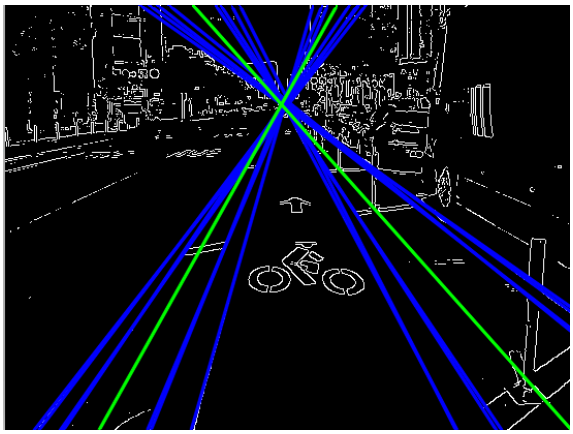


Drive and Control

The drive and control subsystems of the i-Bike consists of the braking mechanism, the drive-by-wire wheel motion, and the electronic control design of the overall system. We propose a servo-based braking mechanism on the rear wheel for braking in autonomous mode. Since, the original brakes of the bike are not altered they can be used when the i-Bike is being driven manually. Electronic controllers would be implemented to control the translation of the bike forward.

Navigation and Planning

For autonomously driving the i-Bike, we propose using laser-based sensors, a camera, and other feedback sensors for accurate control system design. All of the software systems can be easily turned off when the bike needs to be driven manually. For more details about the autonomous driving and the sensing systems, refer to the Appendix.



Particularly, for navigation and planning on a bike lane, we propose the implementation of the state-of-art autonomous driving algorithms for the i-Bike that uses the input from camera and obstacle detection sensors to navigate through without a driver.

Proposed Cost Analysis

As a first step we will attempt to license the technology to some existing company or enter in a partnership with another industry that is already working in the same market. This would enable a quicker launch of the product into the market. In this case, we would need to demonstrate the proof of concept of the technology and also working prototypes of a network of i-Bikes. The tables below discuss such costs, however, in this case, we would not be working on the manufacturing of the bikes at a larger scale. Hence, those costs are not relevant. However, it is likely that we decide to enter into the market with our own bike-share business.

In case we decide to set up our own business of a bike sharing company that uses the i-Bikes, we would need to account for the costs for setting up a business and also for manufacturing of the bikes. The table below on the left describes a preliminary analysis of the costs that would be incurred in setting up a business to manufacture i-Bikes. On the right, we have presented the projected costs of manufacturing each i-Bike at the industrial scale.

Minimal prototype costs

Item	Cost
e-Bikes	$500 x 3
Mechanisms (balancing + steering + drive)	$2000 x 3
Testing and prototyping (sensors and software)	$10000
Business registration and legal expenses (Patent application, other insurance and legal issues)	$5000
Marketing and promotion (Website, market analysis, Other sponsorships)	$3500
Potential hires (interns) (Software Engineer, Business Analysts, Hardware and Electronic Engineers)	$20/hour
Miscellaneous	$10000

Manufacturing cost per i-Bike (in bulk)

Item	Cost
e-Bike	$500
Mechanisms and electronics (Microcontrollers, machining costs, other mechanical and electronic parts)	$500
Sensing and actuation (SONARs, LASERs, Camera, Motors, Servos, autonomous navigation software)	$2000
App and cloud services (app development, AWS cloud subscription, internet services)	$50
Labor	$20/hour
Total	≈ $4000
Projected scaled down cost	$3000

We expect the business setup and maintenance costs to go up a notch once we scale up and consequently, we also expect the costs of manufacturing each i-Bike to go down when we manufacture i-Bikes at an industrial scale.

TIMELINE

Jun

RESEARCH

Survey, Market Analysis, Interviews, Rules & regulations, Law & policy

2019

Jul

RECRUITMENT

Hire two interns to replicate the prototype

Sep

APP DEVELOPMENT

Launch the product to be used within UCSB campus

Nov

FEEDBACK

Improve the product to meet the need of users

Oct

TRAINING

Educating potential costumer about the usage

Jan

COLLABORATION

Collaborate with a company and leverage their services to test the product

Mar

COST ANALYSIS

Budget analysis, Carbon footprint analysis, Customer feedback incorporation, Data analysis, Potential market

2020

Jun

EXPAND

Increase the community reach

2021

LAUNCH

Team

Shailja is a graduate student at the University of California, Santa Barbara in the Electrical and Computer Engineering department. In 2016, she received her bachelor's degree from the Electrical Engineering department at IIT Kharagpur, India. Her interests lie at the intersection of image processing, design and analysis of algorithms, and software engineering. She is also interested in the applications of her work to robotics and has previously worked at major robotics labs at University of Washington and IIT Kharagpur. Shailja has been focusing on the scalability of the i-Bike project by developing a system where multiple bikes in a network can be used effectively to solve challenges in last-mile transport. She is also developing all of the software for i-Bike and the mobile application.

Ayush is a graduate student at California Institute of Technology in the Electrical Engineering department. In 2017, he received his bachelor's and master's degree from the Electrical Engineering department at IIT Kharagpur, India. He is interested in control theory and its applications to various areas of engineering. He has more than five years' experience working on robotics. Particularly, he led a student team at IIT Kharagpur that developed prototypes for a self-driving car. He was also the founder and the team leader of the student group that worked on i-Bike at IIT Kharagpur. He worked on the i-Bike project for two years to develop the first working prototype as a proof-of-concept. Since 2018, working along with Shailja, he has been interested in the scalability of the i-Bike technology with the aim of launching i-Bike as a product in the market.

Potential hires

Market analyst – An experience professional in the automotive and the micro-mobility industry who would support the team with the analysis of the market for i-Bike. Particularly, the market analyst would be responsible for assessing the possible markets where i-Bike could be successful and also to understand and address various challenges from the consumer and market point of view.

Business development manager – Initially, we would hire a student intern to work on a business plan for the i-Bike and then pitch the idea along with the business plan to perspective venture capitalists. In the long run, we plan to hire a business development manager who has active collaborations in the industry so they could help i-Bike launch as a successful business or license the technology to develop the product in collaboration with the existing industries in this segment.

IP Counsel - The patent for the i-Bike and other innovations described in this proposal has been filed at the Intellectual Properties, India office. Moving forward, we would like to follow up with a US Patent for the same. We are looking to potentially hire an IP counsel who would assist us with the patent filing and other legal matters. They would also be responsible to connect with and work with the city governments and authorities to help with a smooth transition of i-Bike as a product on the roads.

Support and Advise

Mentors

Kelly Schmandt Ferguson

Director, Market Transformation, LA Cleantech Incubator

Ankita Joshi

Control Systems Engineer, General Motors, Michigan

Past mentors and supporters

IIT Kharagpur

Media mention

Other media stories that covered i-Bike can be found on this link.
References and Appendix with other supplementary information is available at this link.
The video for the Video Submission is available on YouTube – Technical animations and App.