A smart security device for bicycles

Enlin Quental
Sr. Interaction Design
IDC School of Design, IIT Bombay

Guide: Prof. Girish Dalvi

Problem Statement

Existing cable locks for bicycles have problems in usage. The user has to adjust his **posture for locking & unlocking** the bicycle. As these locks are **not upgraded to latest technology**, these locks are vulnerable to **vandalism** causing bicycle theft.

So there is an opportunity to upgrade the cable lock which will make bicycles more secure and convenient to use.

Goals

- Suitable for all cycles.
- Convenient to use.

Scope

- Users: IITB cyclists.

Primary Research

Conclusions of Research Papers

- High cycling usage in Europe, Eastern China and America.
- People love for novelty.
- Most users use bicycle for leisure trips.
- Sponsored users(employees) used bicycle as more utilitarian.
- Paid users used bicycle on weekends while sponsored users used on weekdays.
- Weather and time affects bicycle usage.

* Robert B. Noland and Muhammad M. Ishaque. 2006. Smart Bicycles in an Urban Area: Evaluation of a Pilot Scheme in London. Journal of Public Transportation, Vol. 9, No. 5. pg 71- 95.

Primary Research

Conclusions of Research Papers

- Non-usage of bicycle, rendered mechanical problems.
- Reduced bicycle theft by making custom bicycle parts and tools.
- Paid cyclists preferred to go for downhill rather than uphill.
- Lack of promotion may drop bicycle usage from sponsored users.

* Peter Midgley. 2011. Bicycle-sharing schemes: enhancing sustainable mobility in urban areas. CSD19/2011/BP8.
* Paul J. DeMaio. 2003. Smart bikes: Public transportation for the 21st century. TRANSPORTATION QUARTERLY / WINTER 2003. pg 9-11.

User Study

Participants

1. IITB cyclists
2. Cyclists outside IITB

User Study

1. IITB cyclists

Number of users interviewed	:	26
Age group	:	18 — 36 years old
Profession	:	Student
Number of boys	:	21
Number of girls	:	5
Number of semi - pro cyclists	:	2
Number of cycle enthusiastic	:	2

User Study

1. IITB cyclists

Questions

- About problems faced while they were cycling.
  Eg: during traffic, long distance travelling, comfort, navigation.
- The problems related to their cycle had experienced.
  Eg: maintenance & service, flattening of tyres, locking, parking, tracking cycle, theft, mudguard design

User Study

1.1 Problems

Parking problems at hostel 12, 13, 14

Bicycle service location near hostel 4

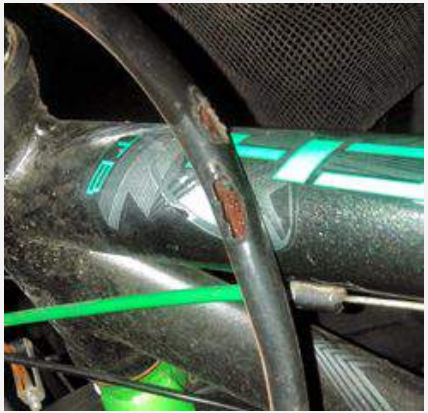
User Study

1.1 Problems

Lock placement problems

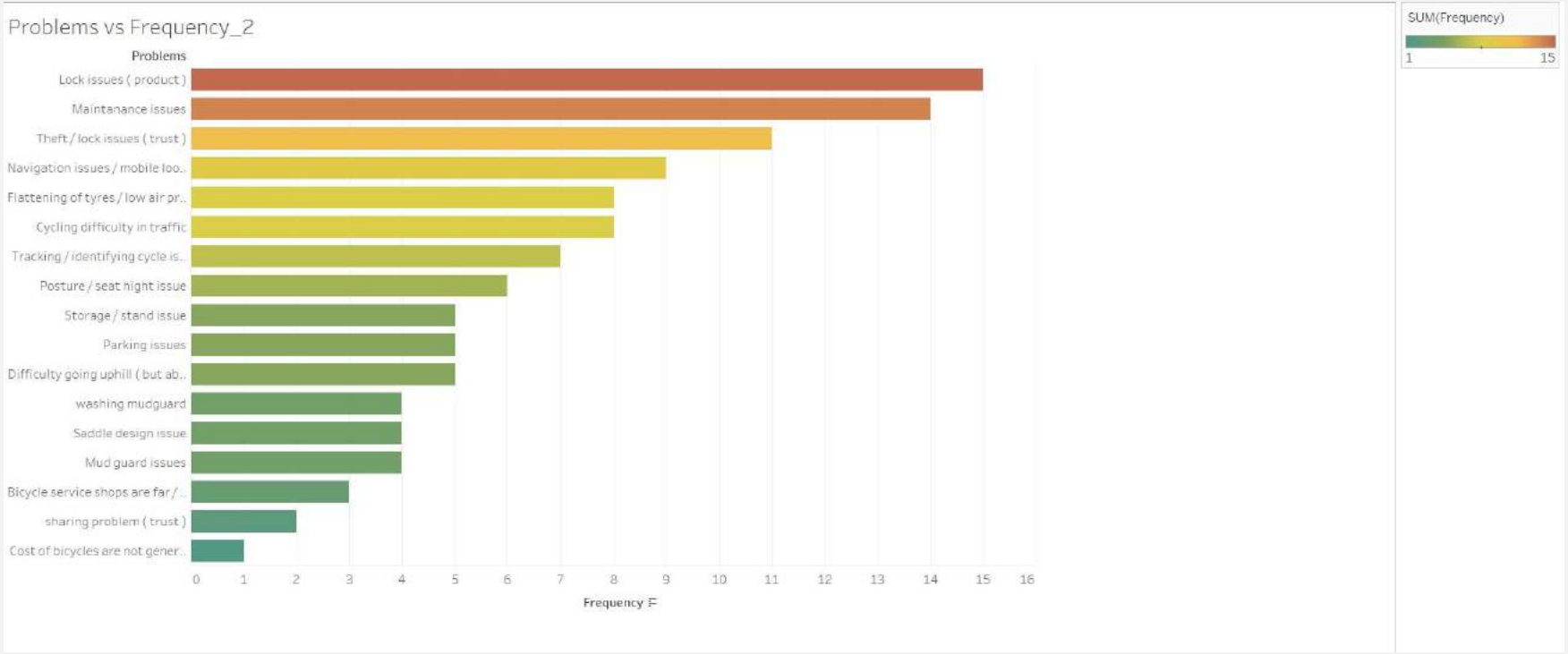
User Study

1.1 Problems



Theft and vandalisms

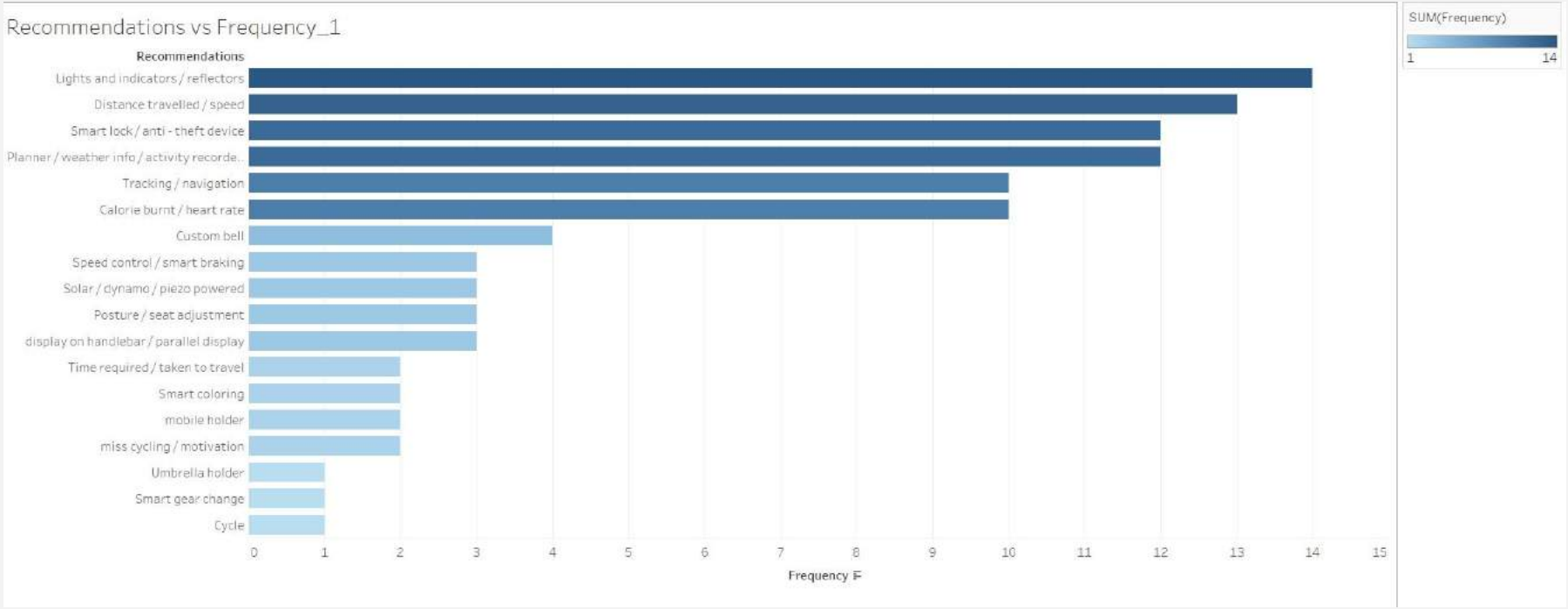
Mudguard problems


Problems vs Frequency_2
Problems
Lock issues (product)
Maintanance issues
Theft / lock issues (trust)
Navigation issues / mobile loo..
Flattening of tyres / low air pr..
Cycling difficulty in traffic
Tracking / identifying cycle is..
Posture / seat hight issue
Storage / stand issue
Parking issues
Difficulty going uphill (but ab..
washing mudguard
Saddle design issue
Mud guard issues
Bicycle service shops are far / ..
sharing problem (trust)
Cost of bicycles are not gener..
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Frequency F
SUM(Frequency)
1
15

User Study

1.2 Recommendations

- Distance travelled/speed
- Smart lock
- Lights and indicators
- Planner/weather info/activity recorder/maintenance notifier


Recommendations vs Frequency_1
Recommendations
Lights and indicators / reflectors
Distance travelled / speed
Smart lock / anti - theft device
Planner / weather info / activity recorde..
Tracking / navigation
Calorie burnt / heart rate
Custom bell
Speed control / smart braking
Solar / dynamo / piezo powered
Posture / seat adjustment
display on handlebar / parallel display
Time required / taken to travel
Smart coloring
mobile holder
miss cycling / motivation
Umbrella holder
Smart gear change
Cycle
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Frequency F
SUM(Frequency)
1
14

User Study

1.3 Conclusion

- Common problems: Maintenance, air pressure, navigation, locking, and mudguard.
- Redesign: Bicycle locks.
- A second study was then done focusing on the problem faced during locking and unlocking of cycles.

User Study

2. Cyclists outside IITB

- Place : Hiranandani, R-city mall and Nahar
- Number of users interviewed : 10
- Age group : 18 - 56 years old
- Profession : Professor, Student, Mechanic, Delivery Man, Flower Seller.

User Study

2. Cyclists outside IITB

Questions

- The lock they had for their bicycle.
- How much you they trust their bicycle lock.
- Preference of the current lock.
- About problems faced during locking and unlocking their bicycle.
- The usual places you put your lock on the bicycle.
- Convenience of their bicycle lock.
- Opinion towards digitalizing the bicycle lock or making the lock smart.
- Features that a bicycle lock should have.

User Study

2.1 Findings

- Commuters use classic bicycle.
- Bicycles had mounted lock.

User Study

2.1 Findings

Bicycles used for delivering products to customers. *Place : Nahar and Hiranandani*

User Study

2.2 Conclusion

- Problems of lock were faced by those users who had sports bicycles and locks of type cable lock.
- Increase in bicycle usage, demand and development in Mumbai in near future.

Secondary Research

1. Bicycle locks





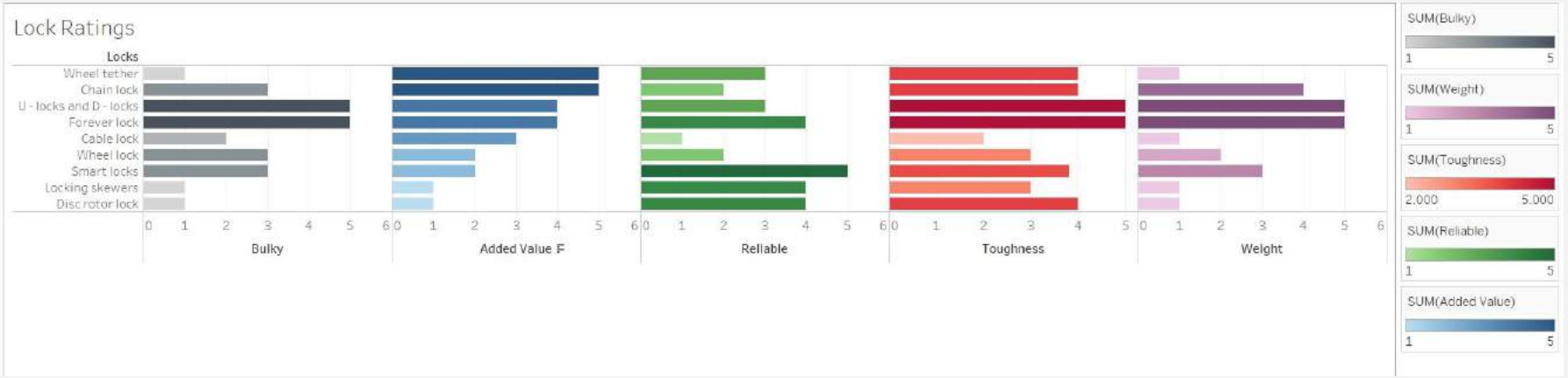




Secondary Research

1. Bicycle locks

Locks	Toughness	Bulky	Weight	Flexible	Reliable
U - locks and D - locks	5	5	5	4	3
Chain lock	4	3	4	5	2
Cable lock	2	2	1	3	1
Wheel lock	3	3	2	2	2
Locking skewers	3	1	1	1	4
Wheel tether	4	1	1	5	3
Disc rotor lock	4	1	1	1	4
Smart locks	3.8	3	3	2	5
Forever lock	5	5	5	4	4

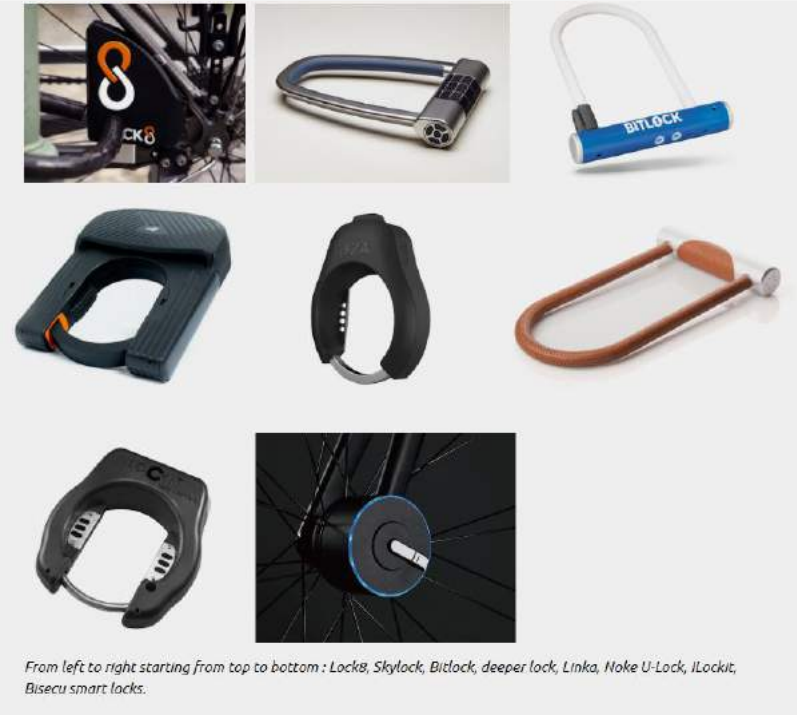


- Smart locks were mostly used for security.
- Smart locks assist cyclists.

Secondary Research

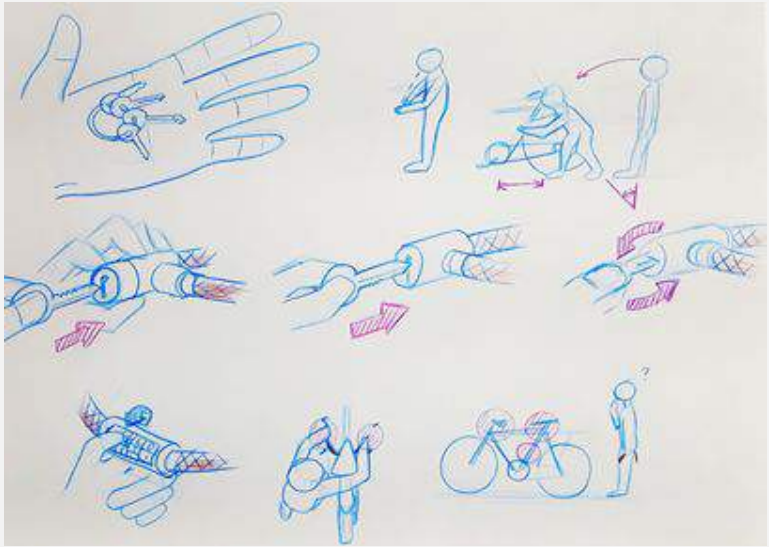
2. Smart bicycle locks

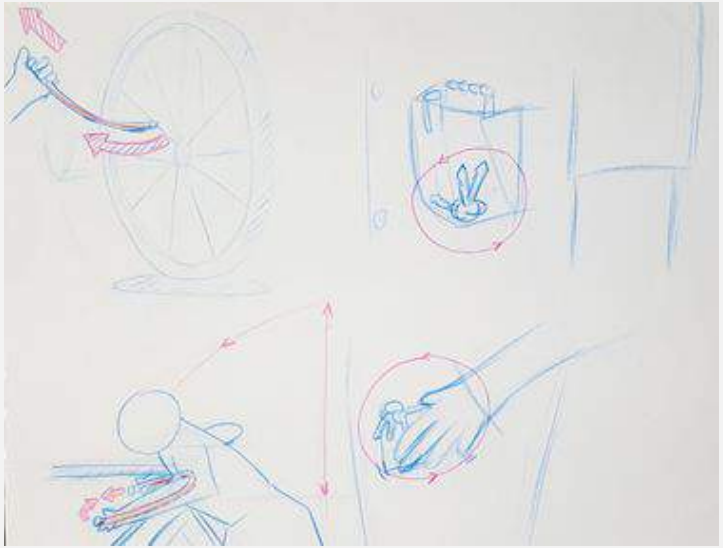
- Proximity locking and unlocking
- Tap button password
- Tracking, theft and motion sensing alert as
  push notification and 110 dB alarm
- self charging - induction and solar powered
- usb charging
- sharing
- GPS, GSM and BLE connectivity



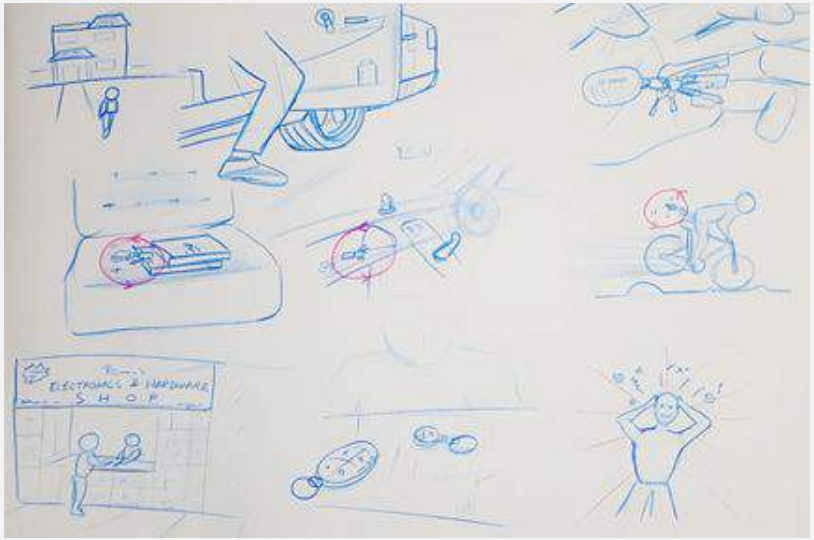
From left to right starting from top to bottom : Lock8, Skylock, Bitlock, deeper lock, Linka, Noke U-Lock, iLockit, Bisecu smart locks.

Problems and Gaps





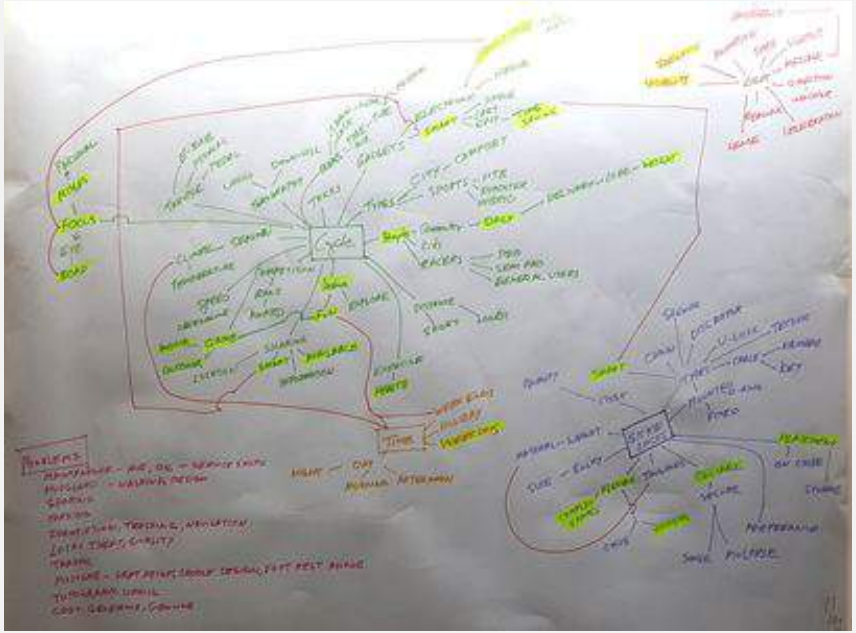
Problems and Gaps



Concepts

Focused on convenience.

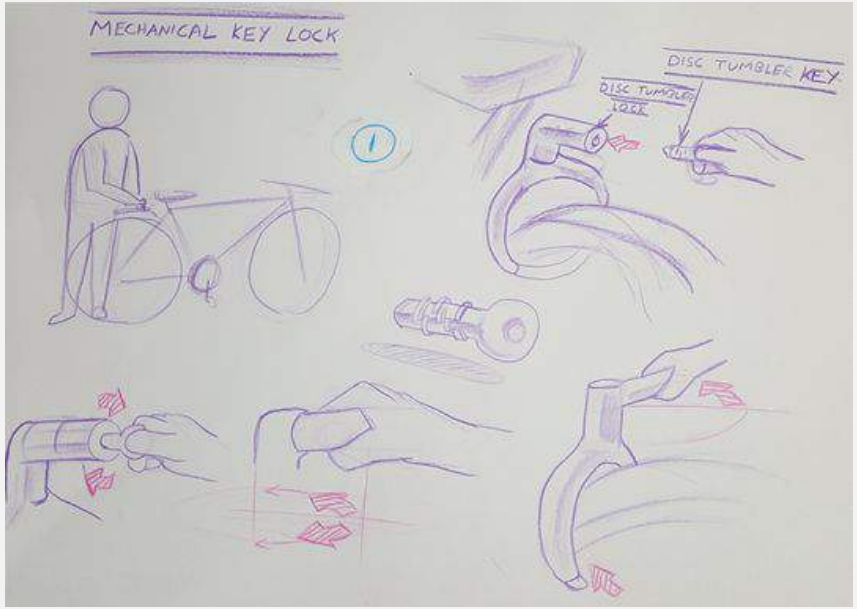
- Mechanical Lock
- Electrical Lock
  - Automatic system
  - Manual system



Concepts

1.1 Mechanical

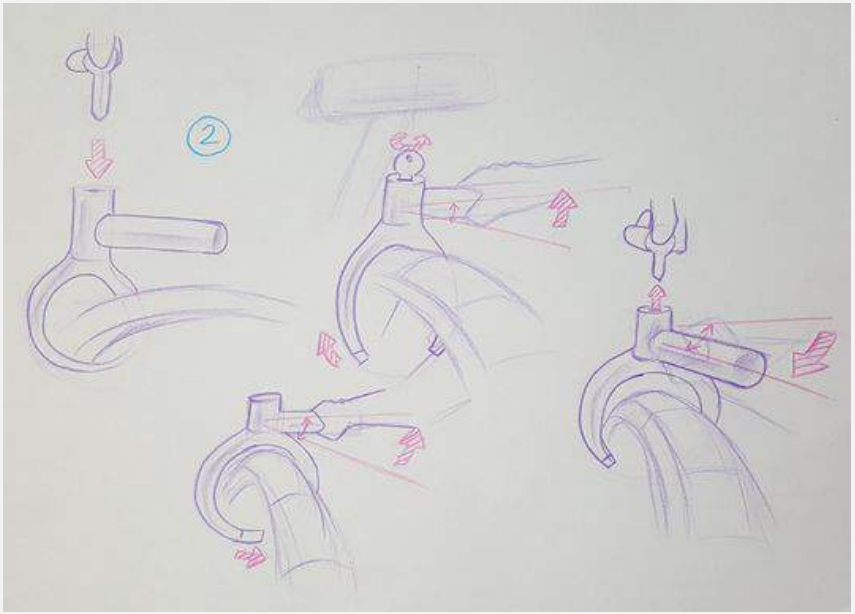
Manual Locking system v 1.0



Concepts

1.1 Mechanical

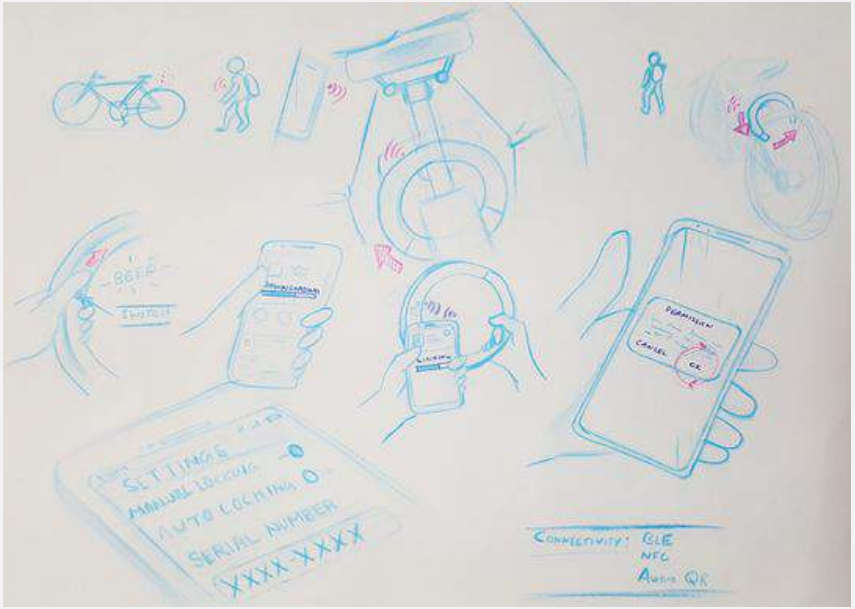
Manual Locking system v 2.0



Concepts

1.2 Electrical

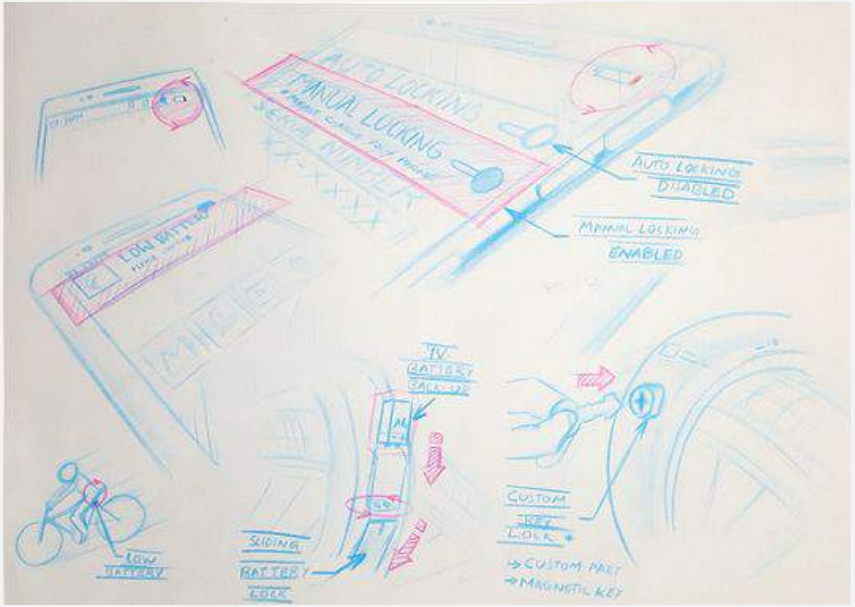
2.1 Mounted lock



Concepts

1.2 Electrical

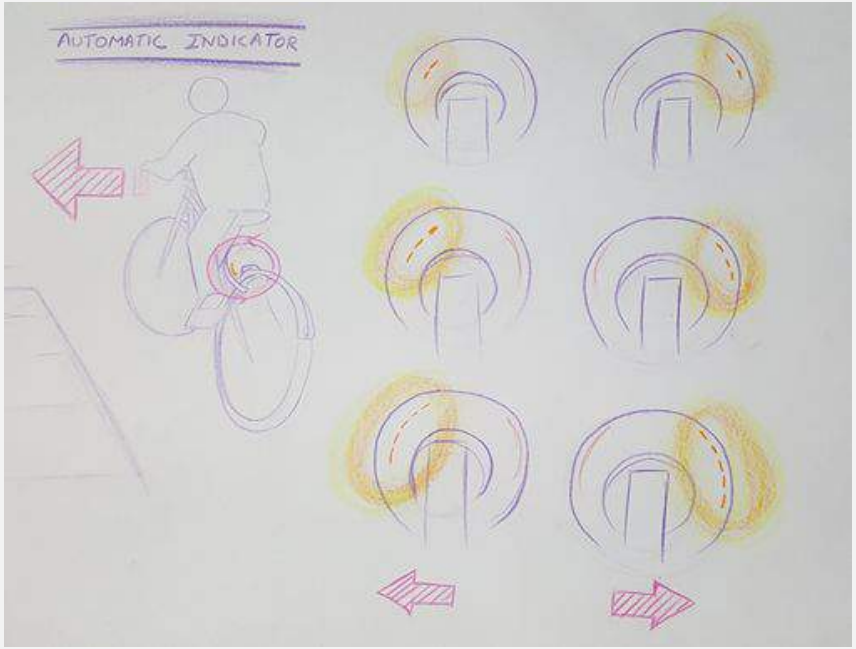
2.1 Mounted lock



Concepts

1.2 Electrical

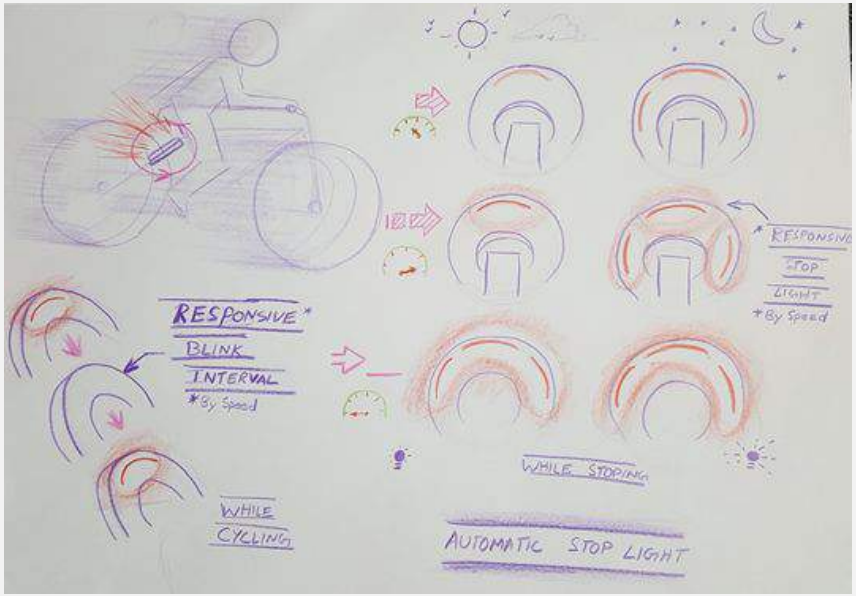
2.1 Mounted lock



Concepts

1.2 Electrical

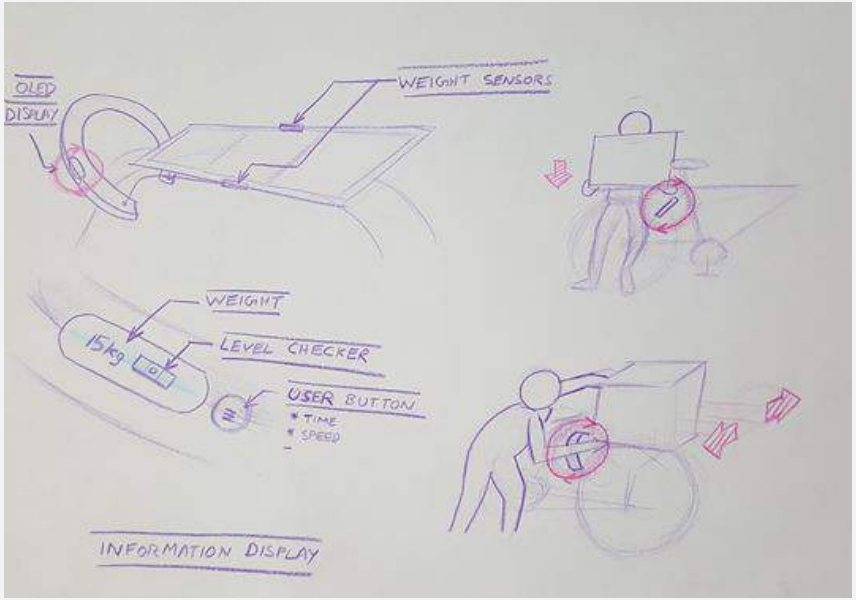
2.1 Mounted lock



Concepts

1.2 Electrical

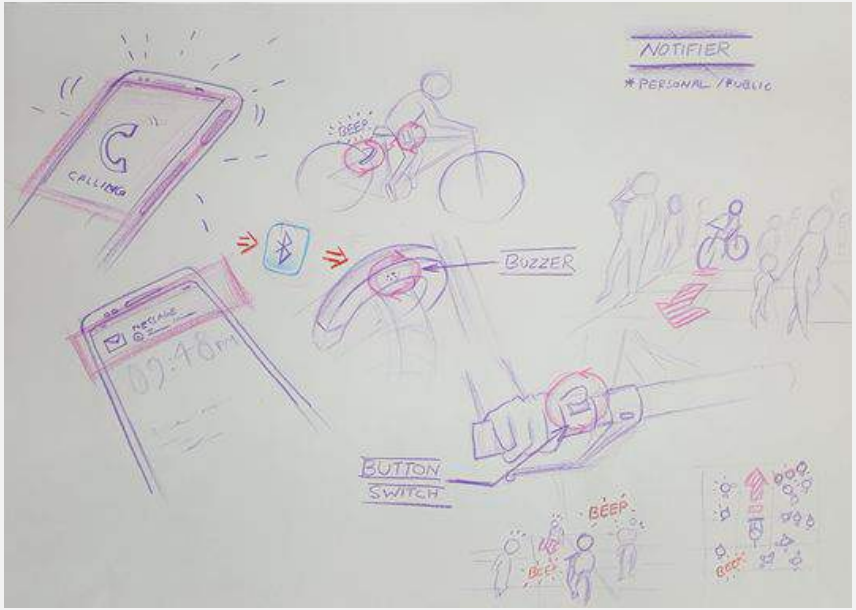
2.1 Mounted lock



Concepts

1.2 Electrical

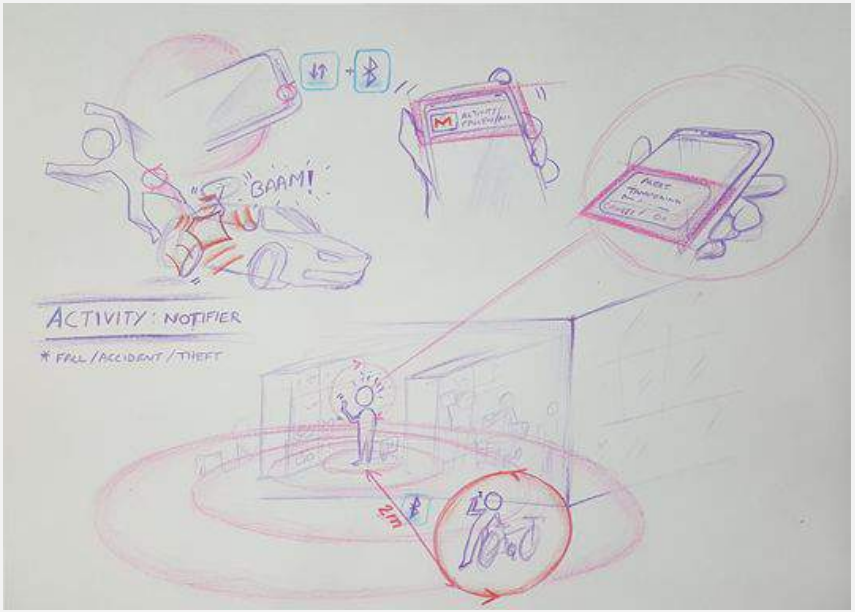
2.1 Mounted lock



Concepts

1.2 Electrical

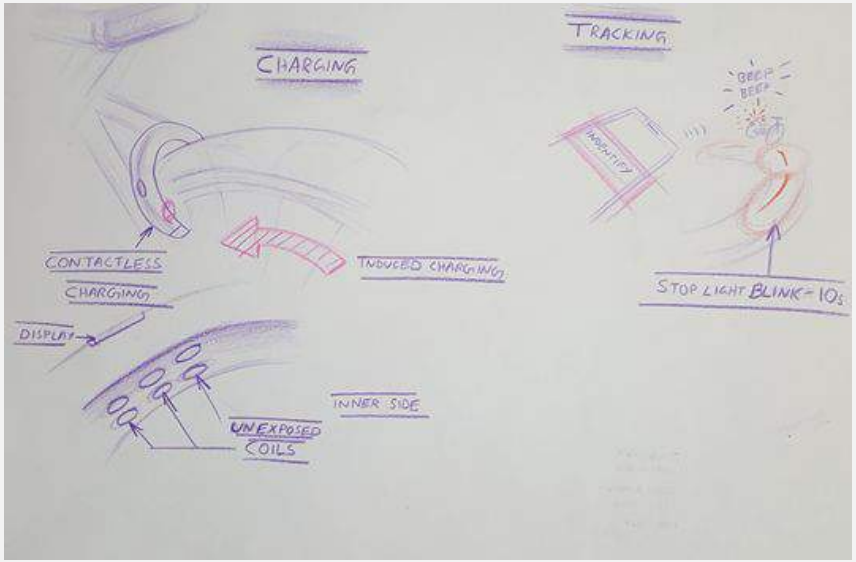
2.1 Mounted lock



Concepts

1.2 Electrical

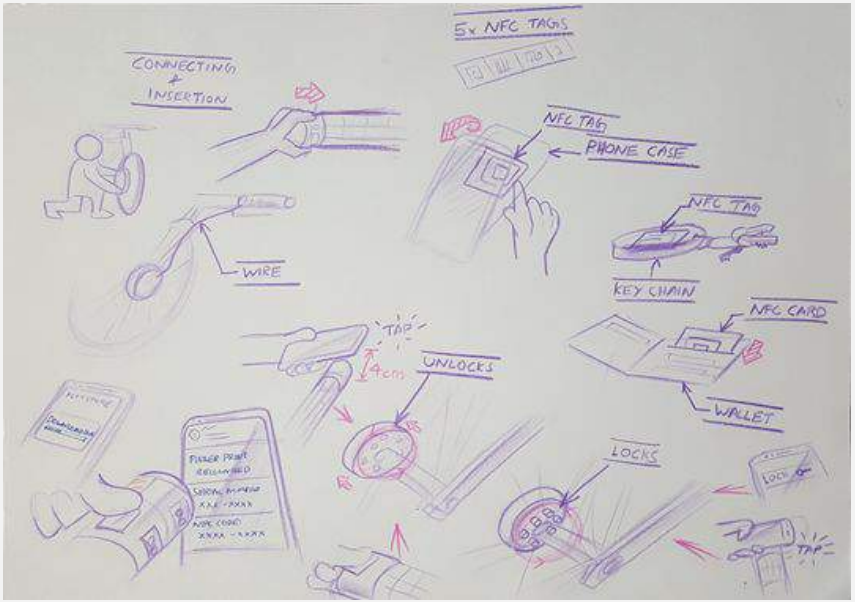
2.1 Mounted lock



Concepts

1.2 Electrical

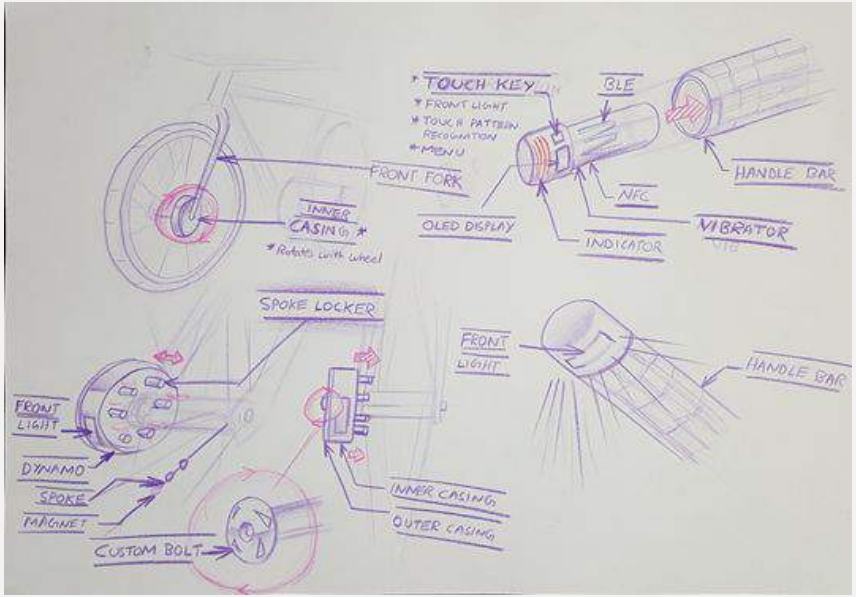
2.2 Spoke locker



Concepts

1.2 Electrical

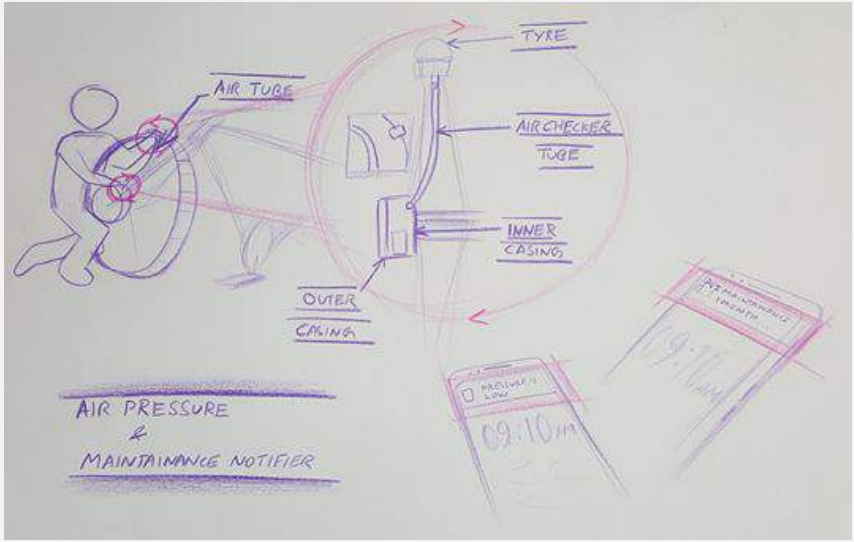
2.2 Spoke locker



Concepts

1.2 Electrical

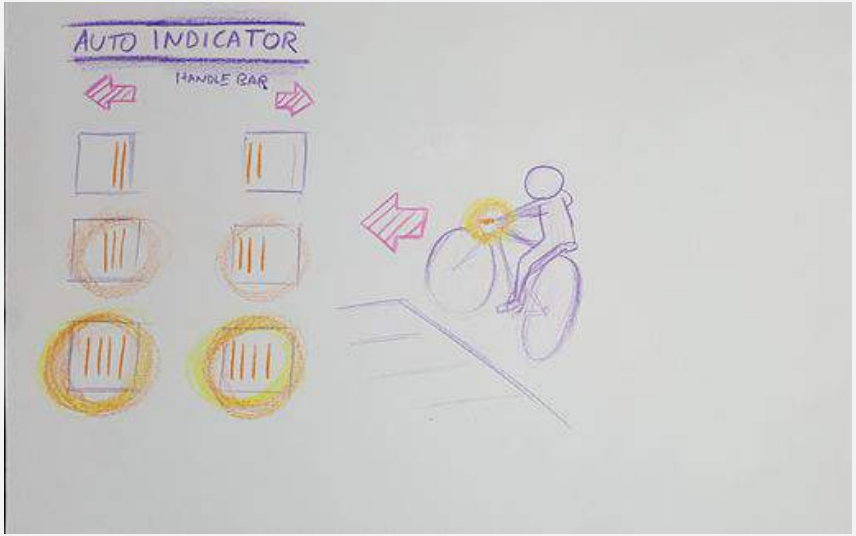
2.2 Spoke locker



Concepts

1.2 Electrical

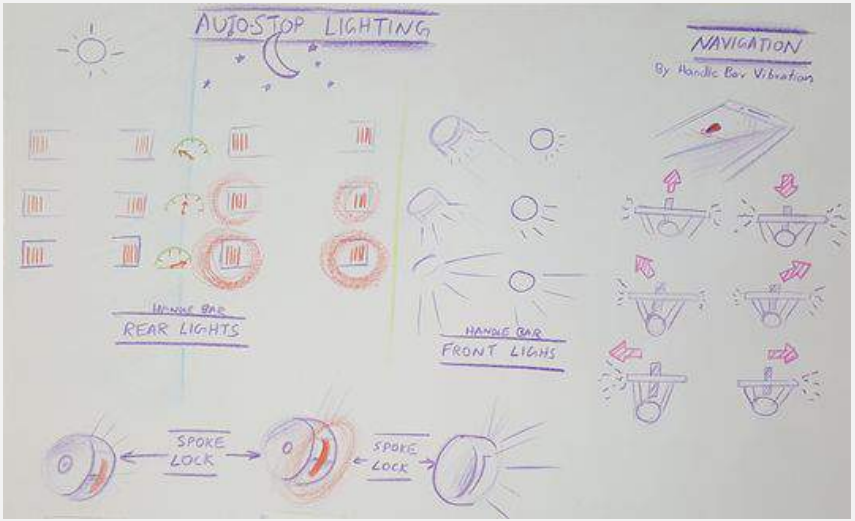
2.2 Spoke locker



Concepts

1.2 Electrical

2.2 Spoke locker



Concepts

2. Conclusion

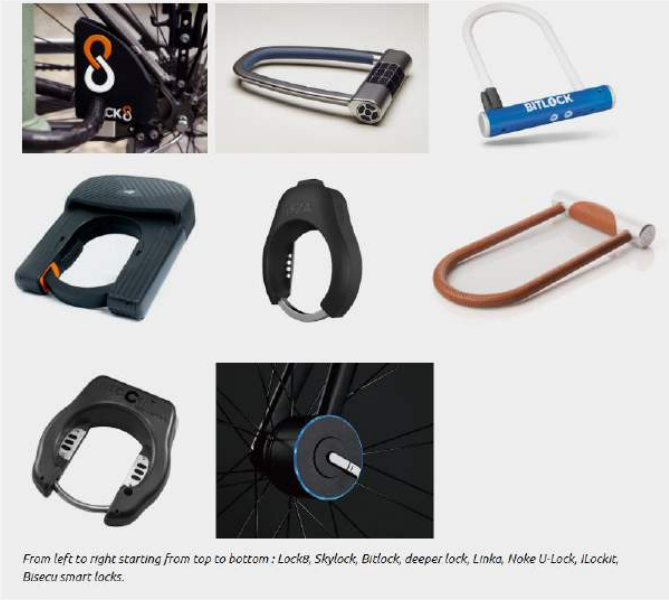
Redesigning mounted lock —

Concept 2.1 : mounted lock

Smart Locks

1. Features in existing smart locks

- Proximity locking and unlocking
- Tap button password
- Tracking, theft and motion sensing alert as push notification and 110 dB alarm
- Self charging: induction and solar powered
- USB charging
- sharing
- GPS, GSM and BLE connectivity

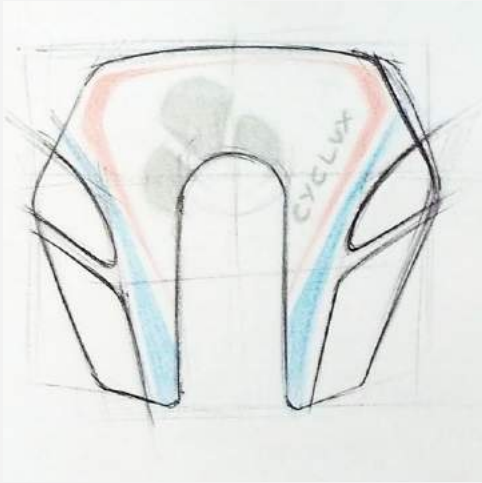


From left to right starting from top to bottom : Lockit, Skylock, Bitlock, deeper lock, Linka, Noke U-Lock, iLockit, Bisecu smart locks.

Smart Locks

2. Proposed smart lock, Cyclux — unique features

- Stop lights, and indicators
- Electronic rotary combination lock
- Navigation assist — light and sound
- Bicycle identification — light and sound
- Load distribution info — light
- E - horn, emergency light
- Cylindrical lock shackle



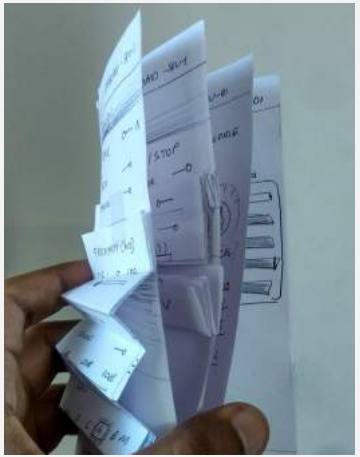
Wireframe

Low fidelity

Paper prototypes

Helped

- putting ideas faster
- Grouping
- Order

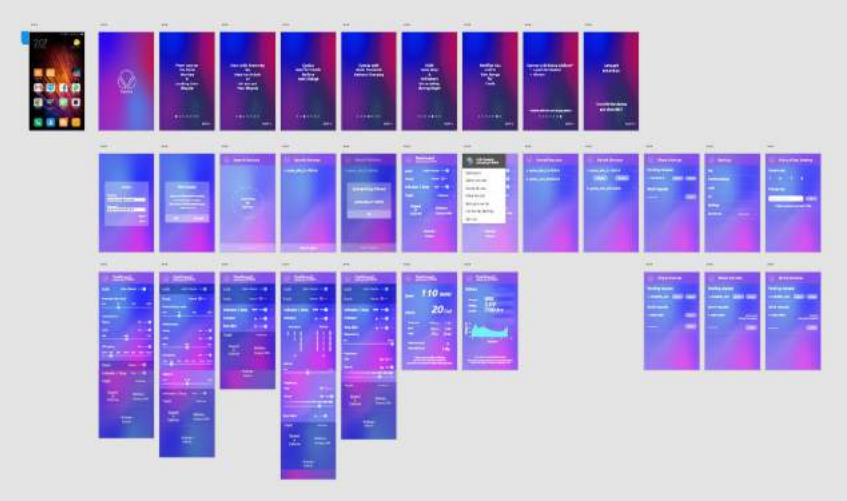


Wireframe

High fidelity

Adobe XD

Link -
https://xd.adobe.com/view/29ad7c88-6ed0-4f9e-7ff2-6f83862ae8aa-5f9c/?fullscreen



Cyclux

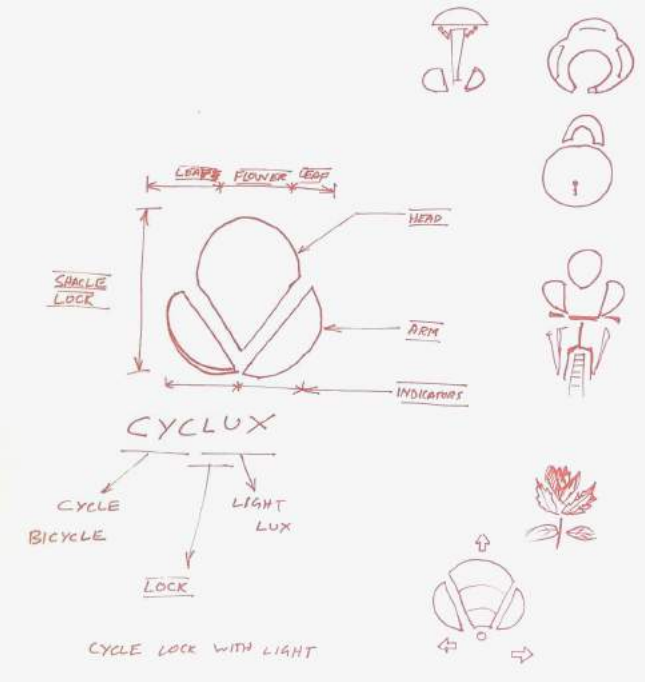
Mood palette

Cyclux

Logo

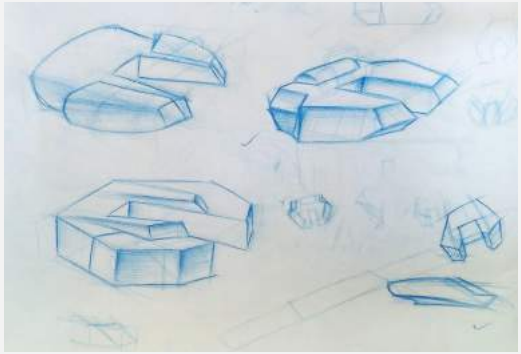
Abstract image :

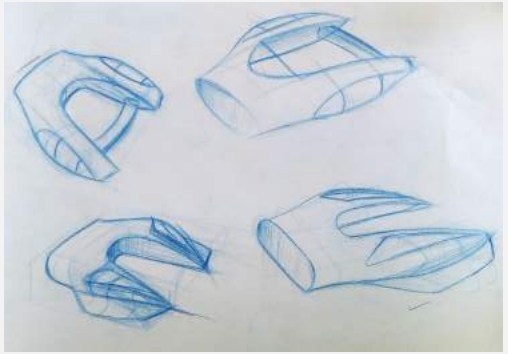
- Shape - shackle lock
- Head of a cyclist with arms on handlebar
- Petal and sepals - flower bud, representing green & eco-friendly
- Form - a stop light and indicators on either
  side, which comes below a saddle
- Vision coverage of a person

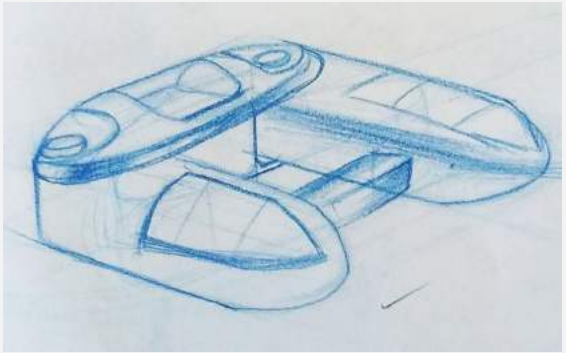


Prototyping

Form exploration — sketches

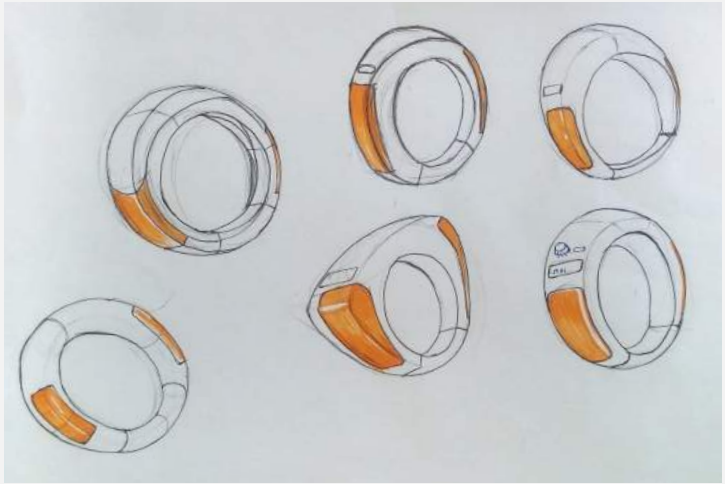


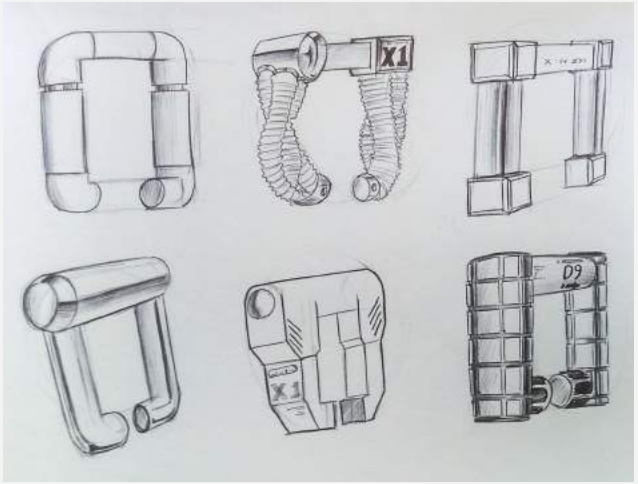




Prototyping

Form exploration — sketches

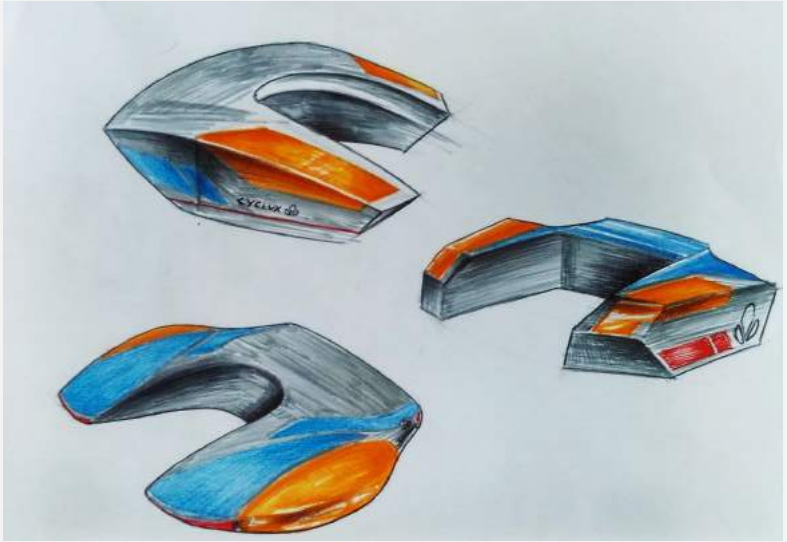




Prototyping

Form exploration — sketches

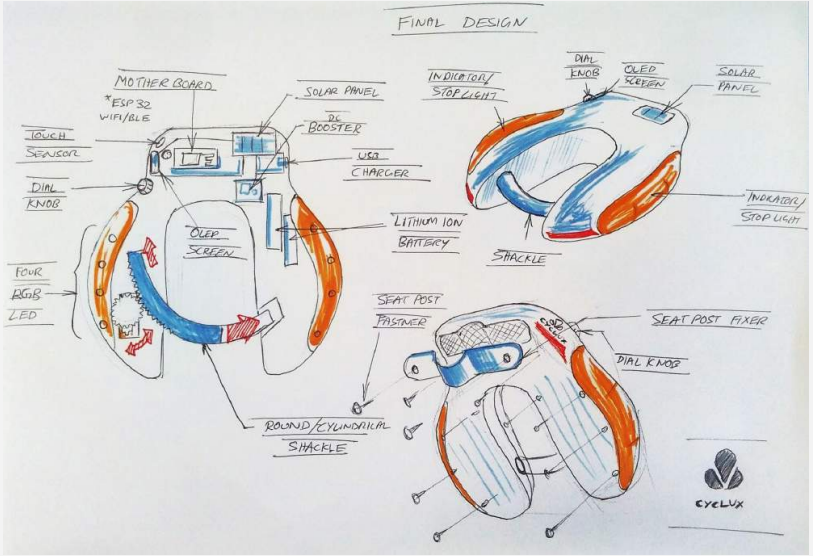
Proposed pre-final products and color theme.

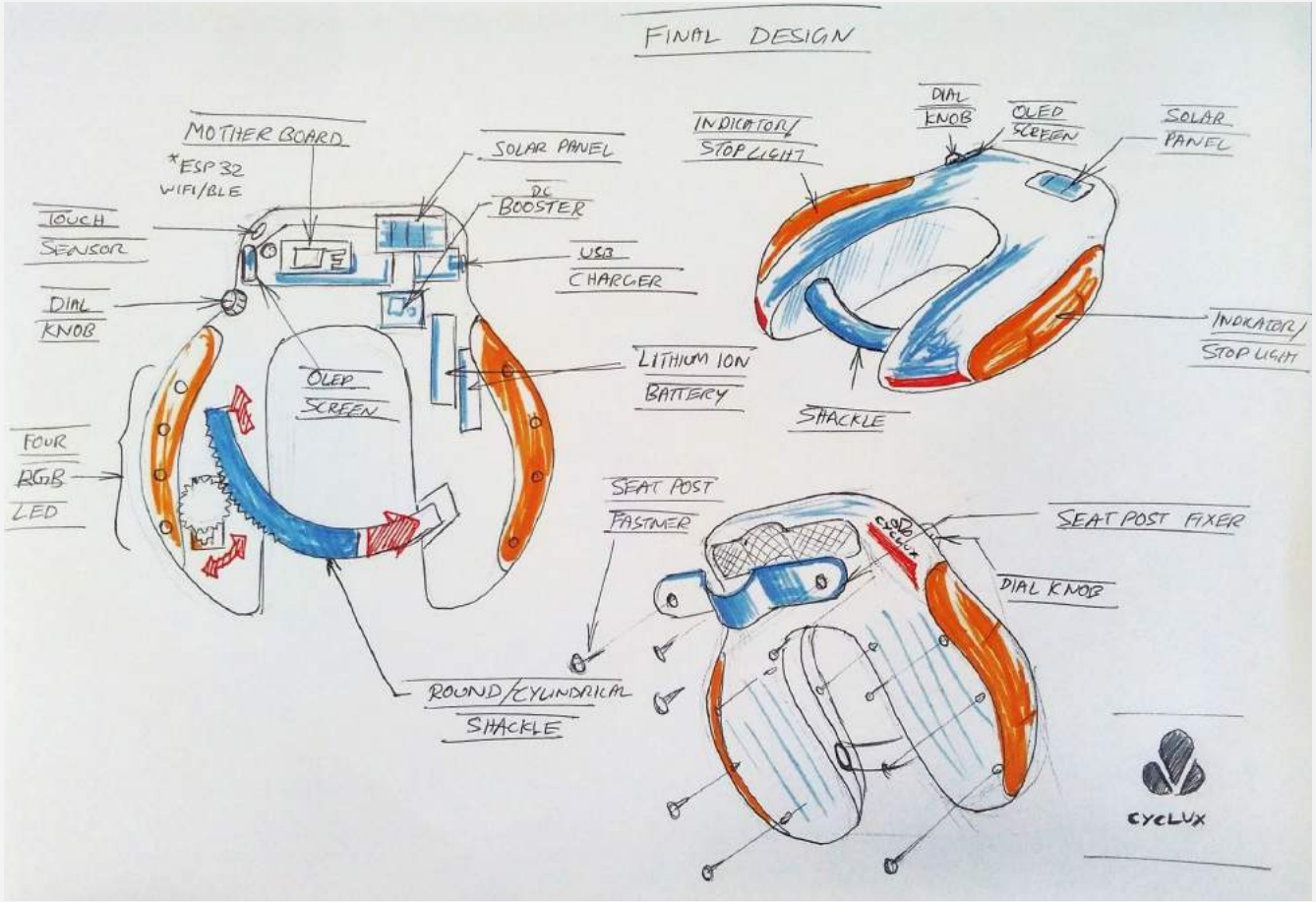


Prototyping

Form exploration — sketches

Proposed final product




FINAL DESIGN
MOTHER BOARD
*ESP 32
WIFI/BLE
SOLAR PANEL
DC
BOOSTER
TOUCH
SENSOR
USB
CHARGER
DIAL
KNOB
OLED
SCREEN
LITHIUM ION
BATTERY
FOUR
RGB
LED
ROUND/CYLINDRICAL
SHACKLE
INDICATOR/
STOP LIGHT
DIAL
KNOB
OLED
SCREEN
SOLAR
PANEL
INDICATOR/
STOP LIGHT
SHACKLE
SEAT POST
FASTNER
SEAT POST FIXER
DIAL KNOB
CYCLUX

Prototyping

Form exploration — physical

Prototyping

Form exploration — physical

Prototyping

Form exploration — physical

Prototyping

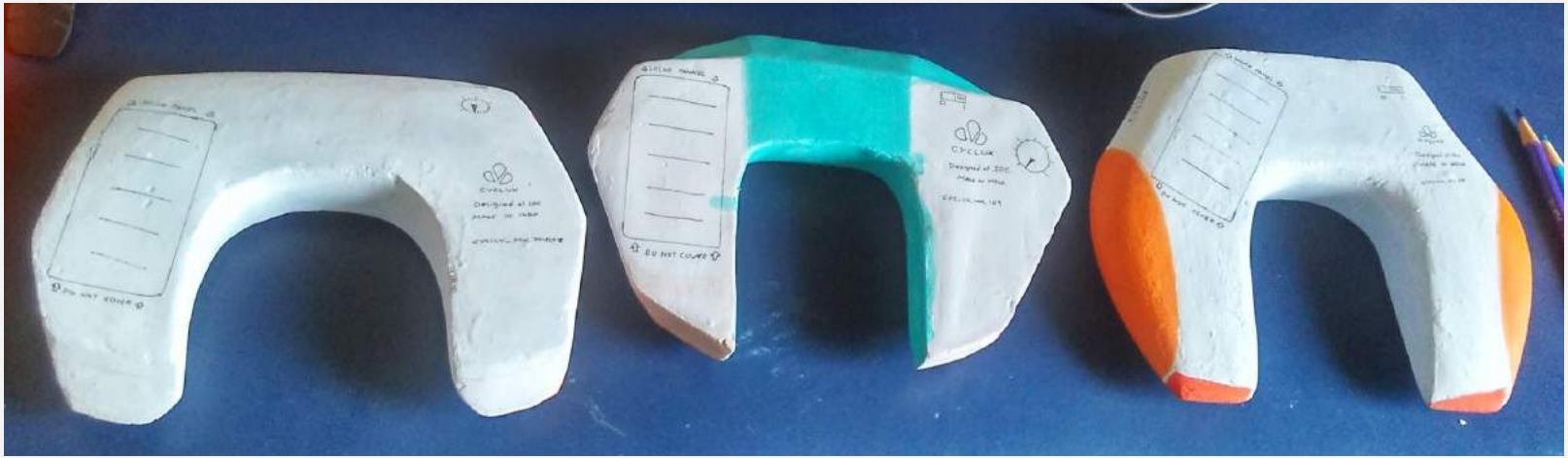
Form exploration — physical

Prototyping

Form exploration — physical

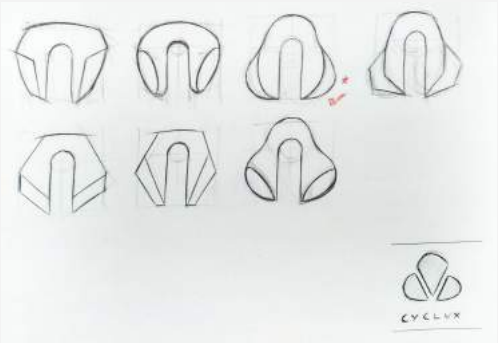
Prototyping

Form exploration — physical



Prototyping

Form exploration — physical



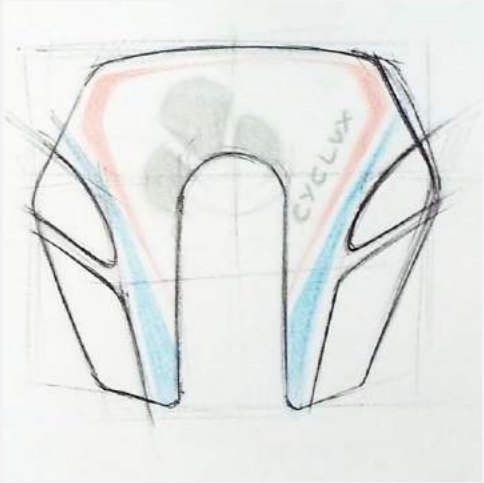
Prototyping

Form exploration — physical

Prototyping

Form exploration — physical

The final design



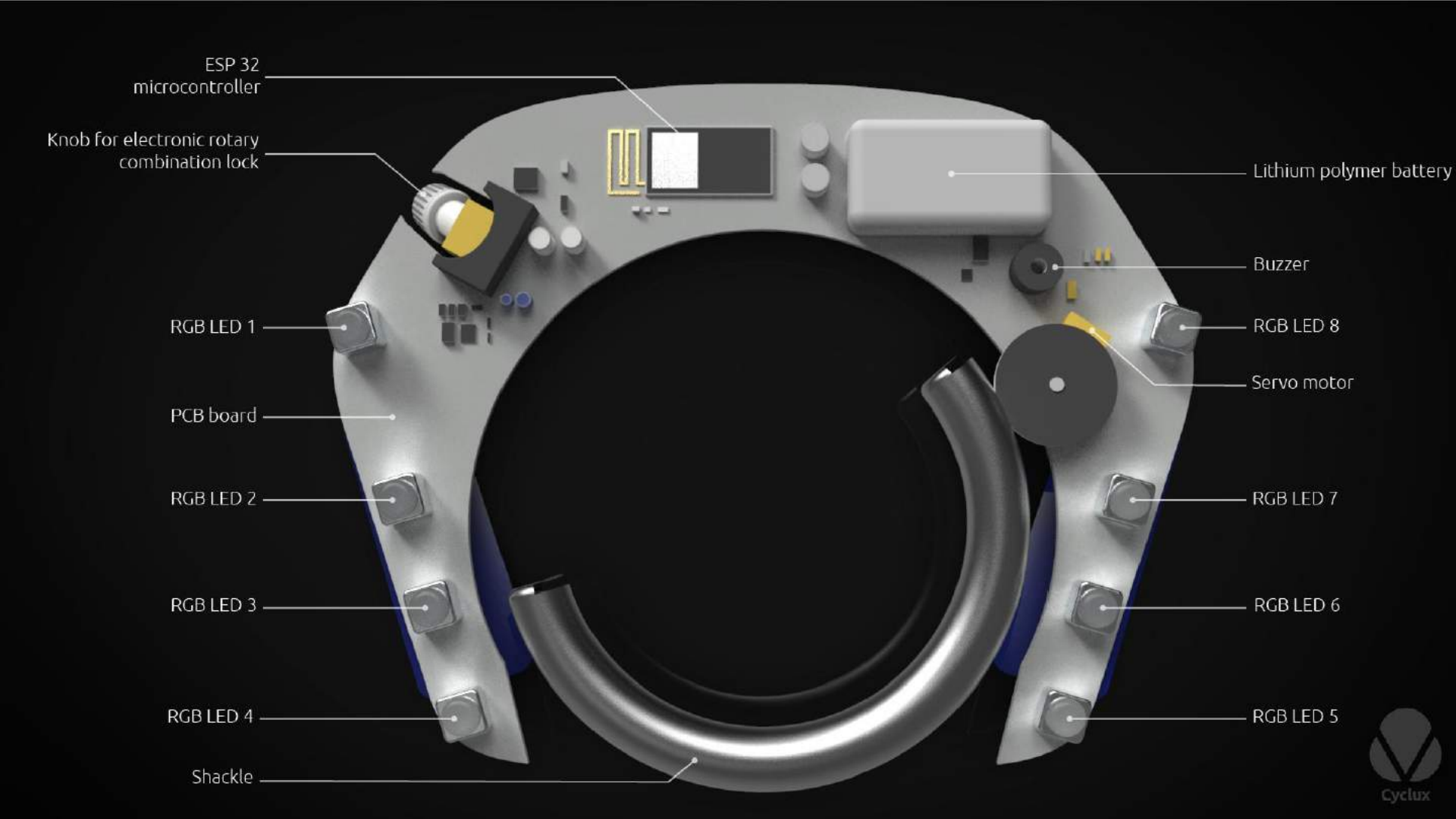
Prototyping

Final Renderings

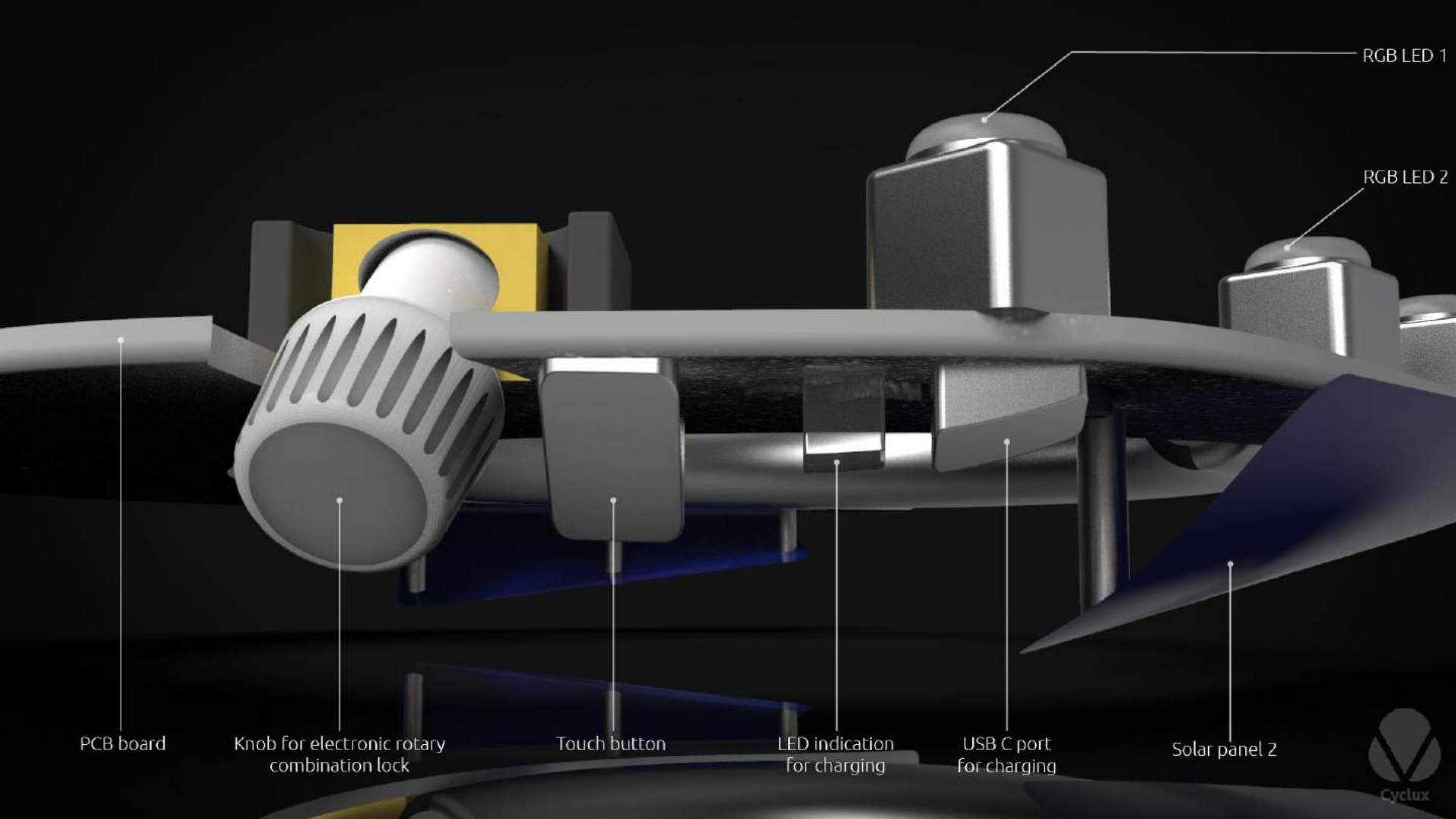

Hardenend steel body
LED indicator group 1
LED indicator group 2
Cyclux
Polcarbonate cover
LED indicators group 1
LED indicators group 2
Hardenend steel
cylindrical shackle
Cyclux


Knob for electronic rotary combination lock
Touch button
LED indication for charging
USB C port for charging
Solar panel 2
Solar panel 1
Cyclux


Knob for electronic rotary combination lock
Touch button
LED indication for charging
USB C port for charging


ESP 32 microcontroller
Knob for electronic rotary combination lock
Lithium polymer battery
Buzzer
RGB LED 1
RGB LED 8
Servo motor
PCB board
RGB LED 2
RGB LED 7
RGB LED 3
RGB LED 6
RGB LED 4
RGB LED 5
Shackle
Cyclux


Knob for electronic rotary combination lock
Touch button
LED indication for charging
USB C port for charging
Solar panel 2
Solar panel 1
Shackle


RGB LED 1
RGB LED 2
PCB board
Knob for electronic rotary combination lock
Touch button
LED indication for charging
USB C port for charging
Solar panel 2
Cyclux


Cyclux


Cyclux

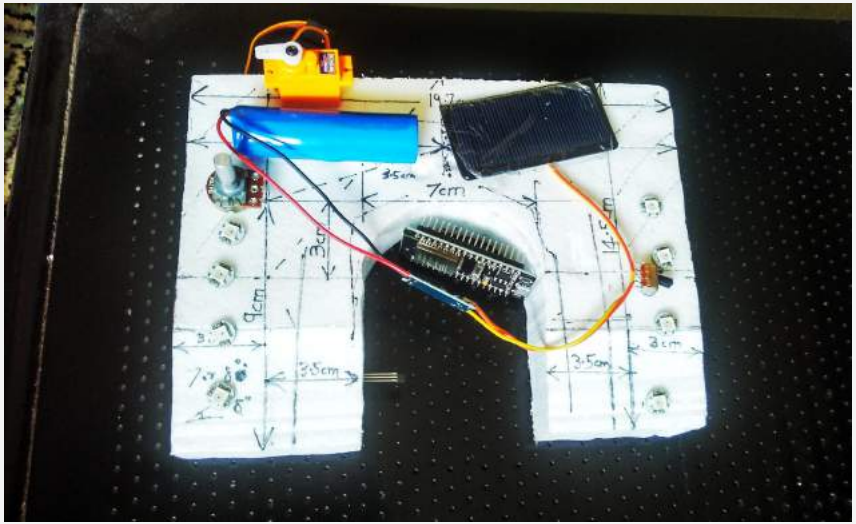
Prototyping

3D printed form

Prototyping

Mockup model

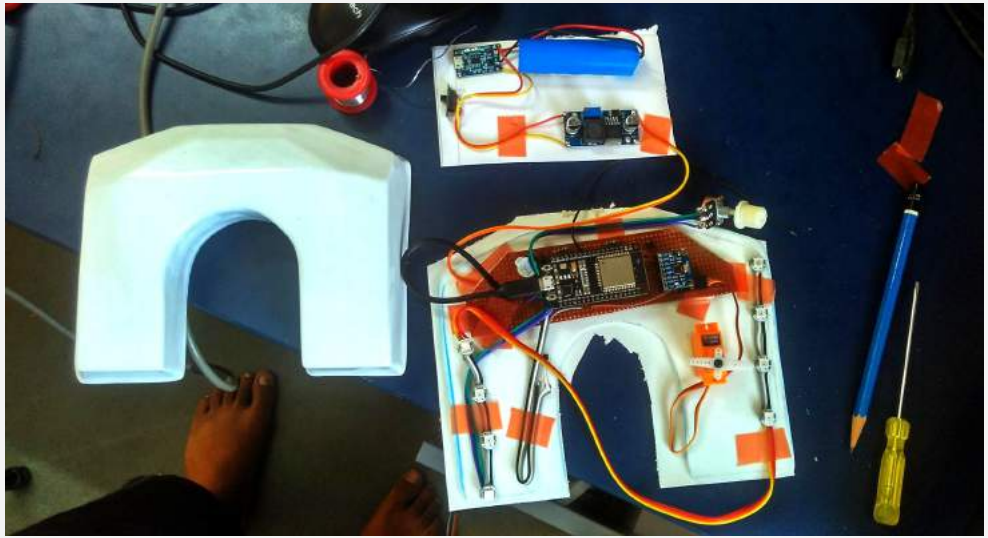
Electronics component placement checking on the template.



Prototyping

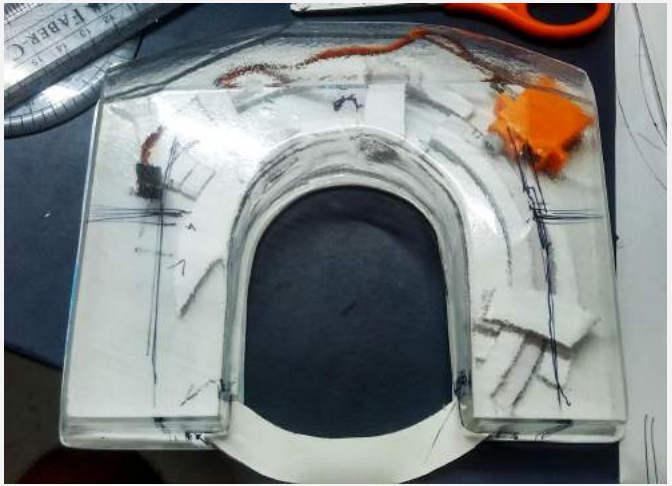
Mockup model

Electronics component on the vacuum formed pre-final product.



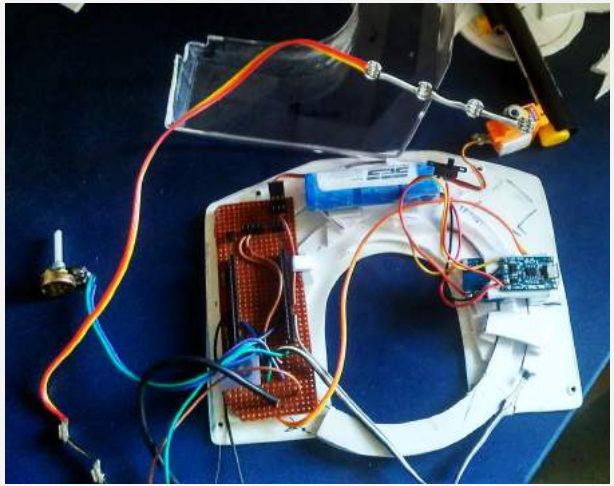
Prototyping

Working model — the making



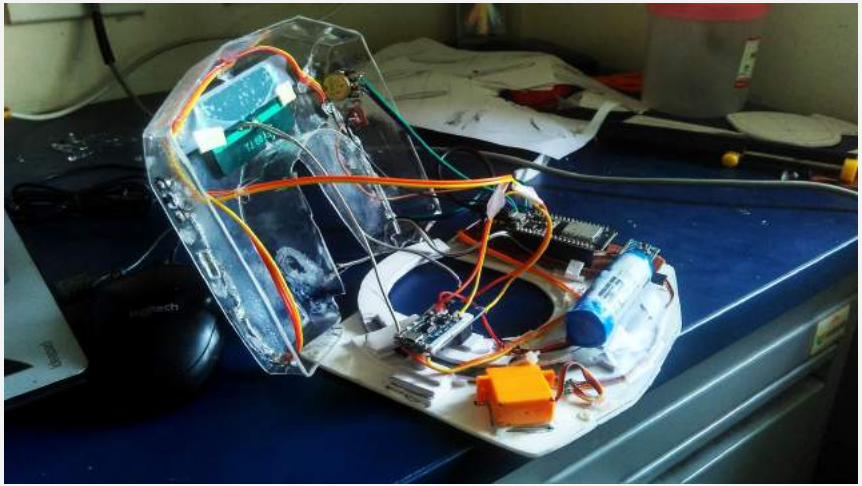
Prototyping

Working model — the making



Prototyping

Working model — the making



Prototyping

Working model — the making

Prototyping

Working model — the making

Evaluation

Evaluation on :

- Product form
- Working prototype

Evaluation

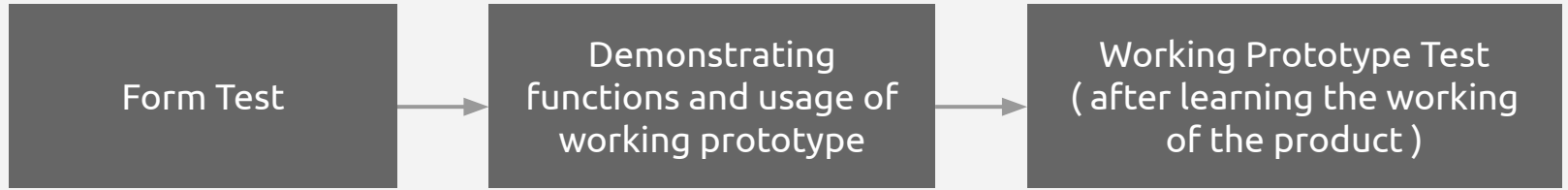
Protocol

- **Users:** 10 IITB cyclists
- **Session Duration:** 45 minutes per user

Evaluation

Protocol

Time :
45 minutes per user



Evaluation

Protocol

Questions

- Form matches with the bicycle
- Color matches with the bicycle
- Suitable for all bicycle
- Convenience
- Assisting features for cyclist
- Security
- Overall

Evaluation

Protocol

Method

User is presented with the 3D printed form and shown reference images of the rendering on the form from a laptop.

User is asked to explore the form in 5 minutes.

After the given time, the user will be asked to evaluate on the form and color scheme used on it, from the given questions.

Evaluation

Protocol

Method

After answering the initial round of questions, the user is shown the working prototype, which was fixed to a bicycle.

Demonstration on the functions and usage of the working prototype was given.

User was given 5 — 10 minutes to use the working prototype by riding the bicycle.

User was asked to evaluate on the working prototype from the given questions.

Evaluation

Findings — form

- Product perceive as spaceship, joystick, lock and remote control.
- Product is for MTB cycles.
- Smart security device.
- Colors are funky, edgy, sporty and towards young audience.
- Colors does not go all bicycles.
- Form does not fit in all bicycles.

Evaluation

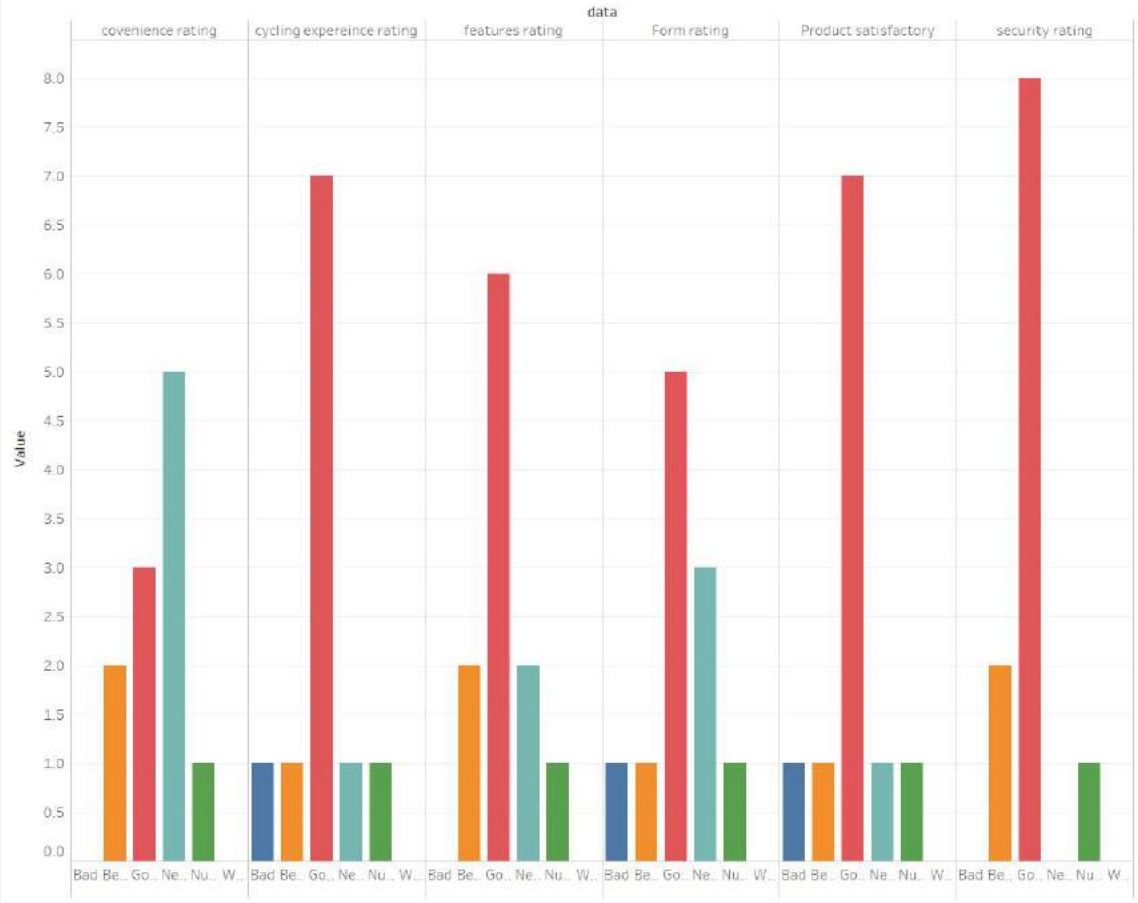
Findings — working prototype

- Easy to lock and unlock bicycle.
- False triggers for auto-indication.
- Displaying informations of speed, distance travelled, calories burnt and weight loss are useful.
- It is an upgrade to the user’s lock and improves security.
- False anti-theft alert detection.
- Rotary dial lock process is effective but complex process.

Evaluation

Overall

Overall Ratings



Measure Names
- Bad
- Best
- Good
- Neutral
- Number of Records
- Worst

Future scope

- Compact form and better product placement for bicycles.
- Color variations for the product.
- Calibration for auto-indicators.
- Improving anti-alert trigger.
- USB port for charging phones.

Conclusion

Users liked the product and the product had created a positive influence among users.

Acknowledgements

I would like to thank my guide, Prof. Girish Dalvi, for his extreme support, valuable suggestions and guidance throughout my project.

I thank Angela Simon, without whom my user studies outside the campus would not have gone smoothly.

Thank you, D.K. Kini, Rajat Patle, Saijith. M. S, Nipurn Solanki, Kiran Prasanth R, Senior Industrial and Mobility design friends, for helping me out with my product development.

A very special thanks to my brother, Aidren Quental, for 3D printing my product, which otherwise I wouldn't had come with the actual physical model.

Thank you, Malay Dhamelia, for helping me out on my user evaluation plans and brothers of cycle service shop at Y-gate, IITB, for giving away the tyre tube.

I thank all the participants and my IDC friends for their valuable feedback and suggestions on my project.

References

- Robert B. Noland and Muhammad M. Ishaque. 2006. Smart Bicycles in an Urban Area: Evaluation of a Pilot Scheme in London. Journal of Public Transportation, Vol. 9, No. 5. pg 71- 95.
- Peter Midgley. 2011. Bicycle-sharing schemes: enhancing sustainable mobility in urban areas. CSD19/2011/BP8.
- Paul J. DeMaio. 2003. Smart bikes: Public transportation for the 21st century. TRANSPORTATION QUARTERLY / WINTER 2003. pg 9-11.
- Simon D.S. Fraser & Karen Lock. 2010.Cycling for transport and public health. pg 739 - 743.
- John Pucher & Ralph Buehler. 2017. Cycling towards a more sustainable transport future. TRANSPORT REVIEWS, 2017 VOL. 37, NO. 6, pg 689–694.
- https://www.students.org/2014/04/16/bicycle-commuting-benefits-students/
- https://www.indiegogo.com/projects/skylock-the-worlds-first-solar-powered-connected-bike-lock#/

References

- https://www.kickstarter.com/projects/lock8/lock8-the-worlds-first-smart-bike-lock
- https://bitlock.co/
- http://deeperlock.com/
- https://www.linkalock.com/
- https://www.kickstarter.com/projects/fuzdesigns/noke-u-lock-worlds-smartest-u-lock
- https://www.ilockit.bike/en/
- https://www.bisecu.com/
- https://en.wikipedia.org/wiki/Bicycle_lock

Thank you