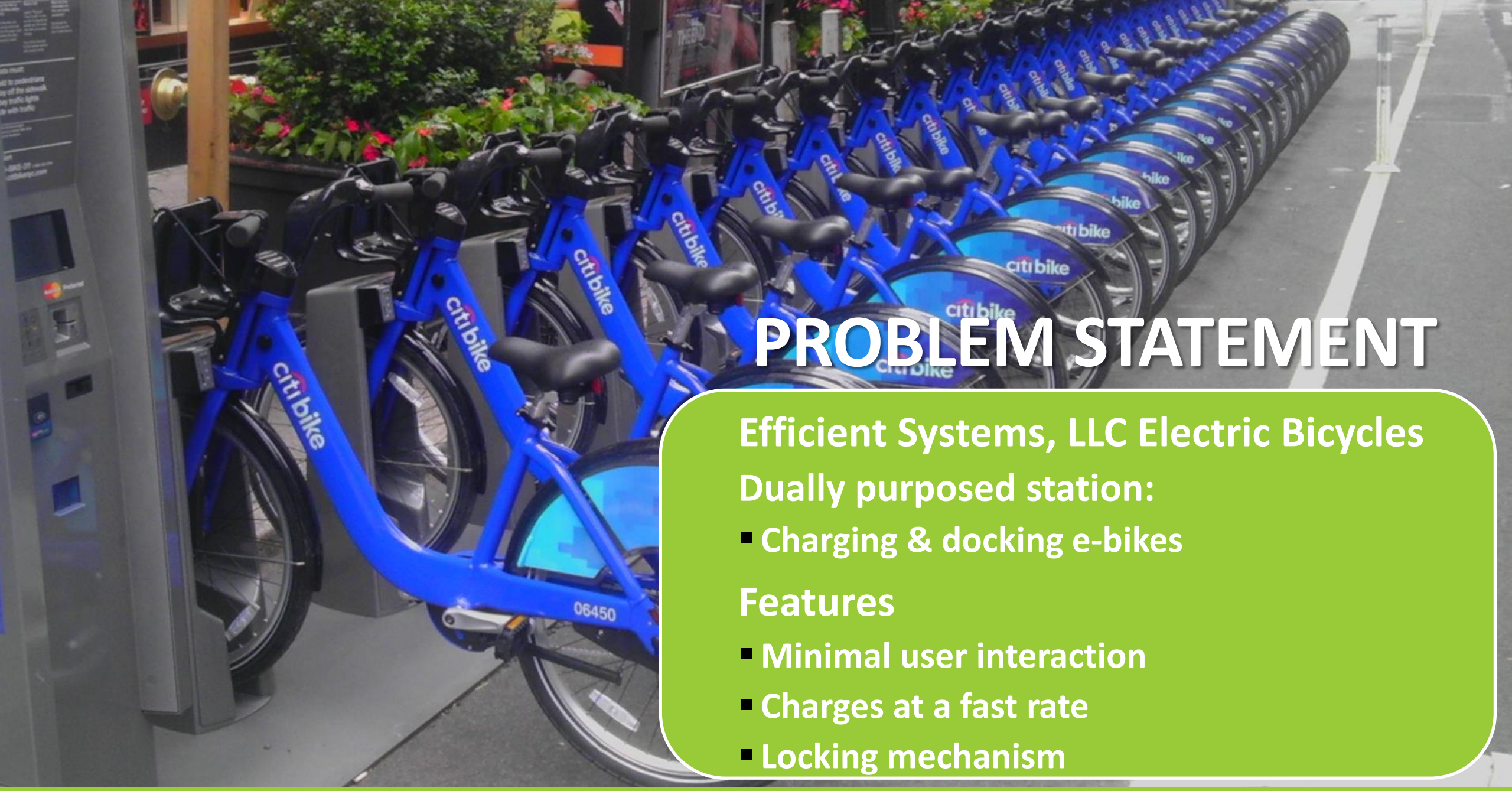
E-BIKE CHARGING & DOCKING STATION

SYSTEM LEVEL DESIGN REVIEW

BRYAN CASTRO
JUSTIN JOHNSON
SEVE KIM
JACOB KNOBLAUCH
BILAL RAFIQ



PROBLEM STATEMENT

Efficient Systems, LLC Electric Bicycles

Dually purposed station:

- **Charging & docking e-bikes**

Features

- **Minimal user interaction**
- **Charges at a fast rate**
- **Locking mechanism**

BACKGROUND

- Efficient Systems, LLC
  - Tallahassee start-up
  - Partners in South America
  - 3 current operational E-bike sharing programs

Efficient Systems

Because it makes sense!

REQUIRED CAPABILITIES

- The station must charge the electric bicycle by resonance or induction
- The station should dock the electric bicycle in place
- The station must have locking capability
- The station should be easy for the user dock and undock the bicycle with minimal use
- The station should have a modular and attractable design and be cost efficient

MECHANICAL COMPONENTS

SECTION BREAKDOWN

- Design evolution
- Final Prototype Design vs. Future Commercial Model
- Final chosen locking mechanism
- Additional housing/storage components
- Analysis and results

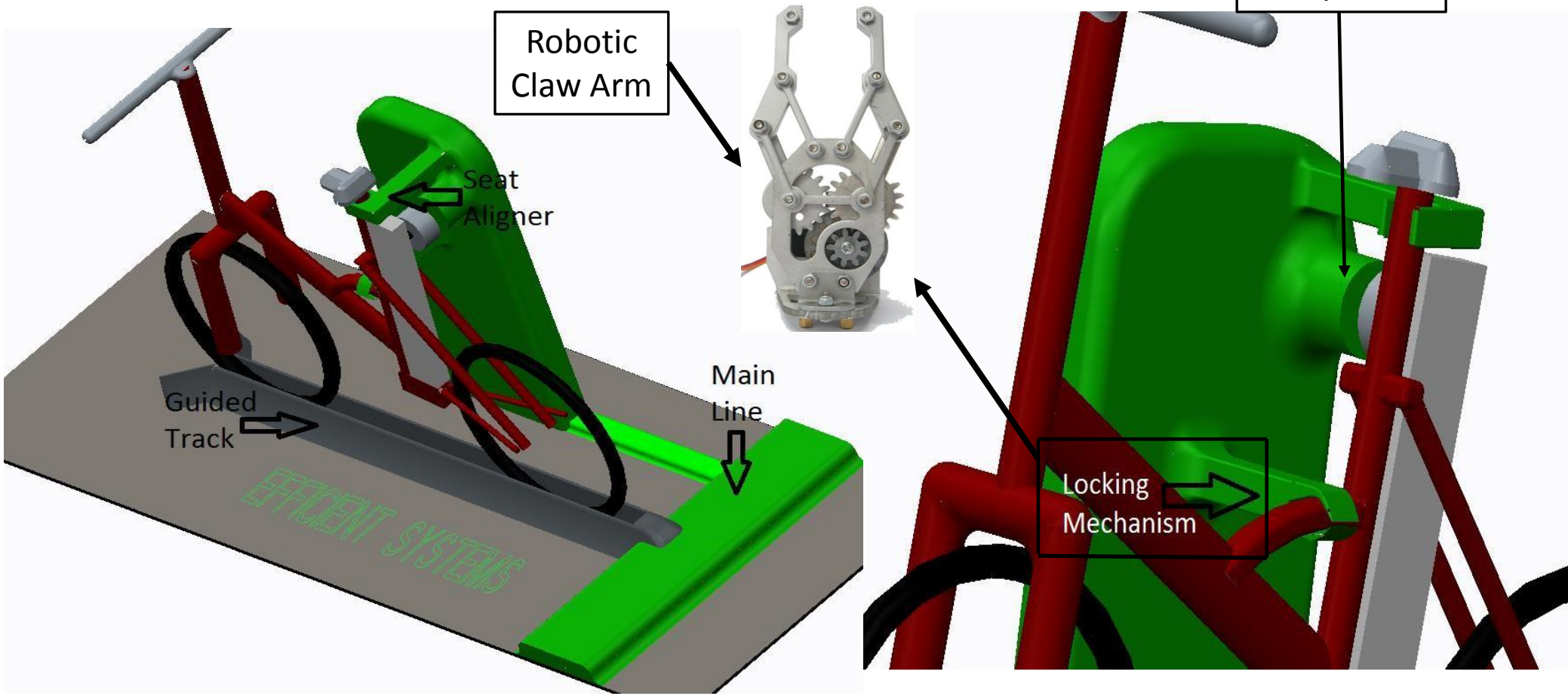
DESIGN EVOLUTION(**Design #1**)

Pros

- User friendly
- Aligns bike easily
- Aesthetically pleasing

Cons

- Locking mechanism may cause harm to user
- Clearance of guiding track may harm pedestrians



DESIGN EVOLUTION **(Design #2)**

Pros

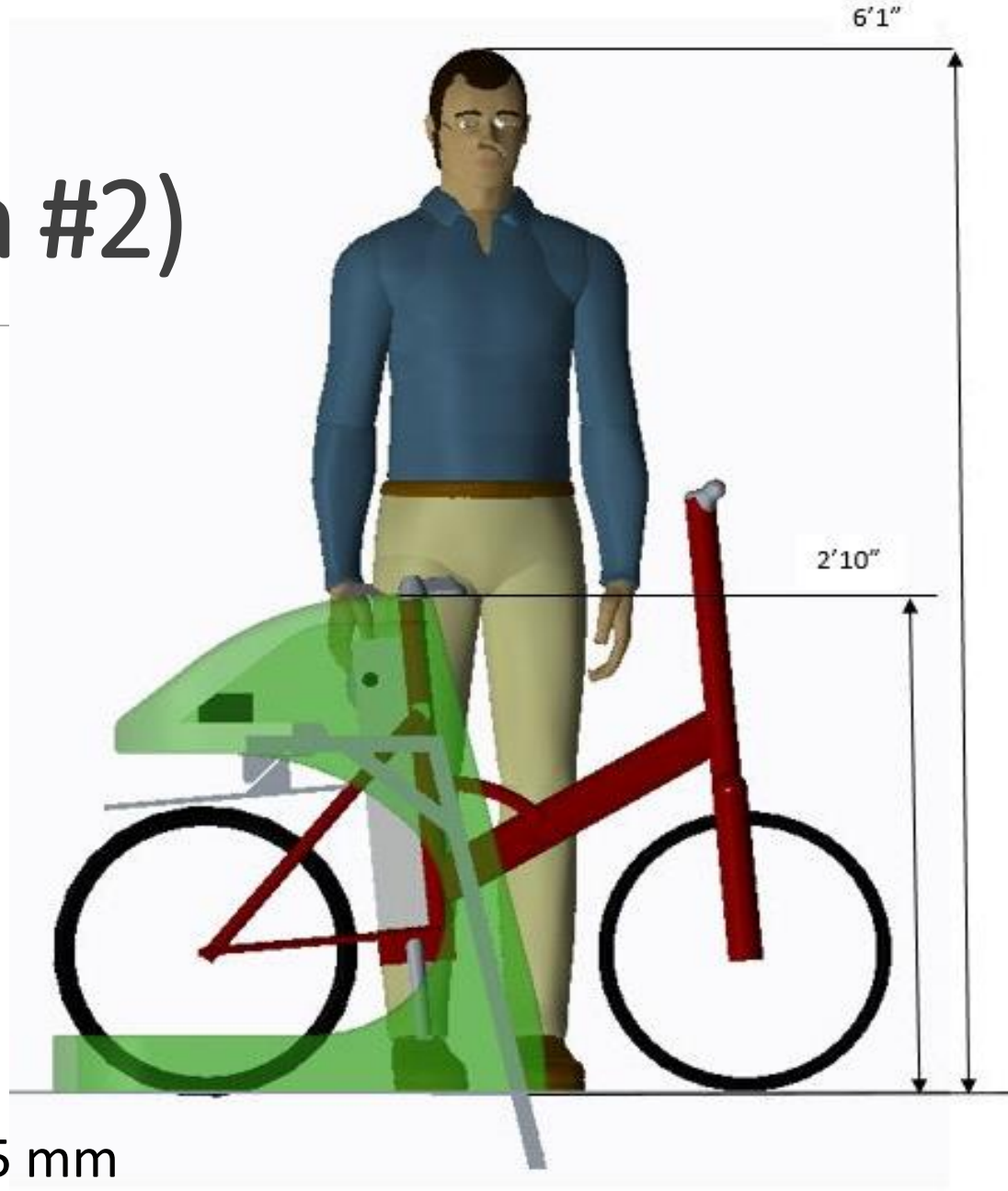
- Sleek and aesthetically pleasing
- Compact and small
- Easy to install on sit

Cons

- Complicated to build

Details

- Now Classified as **“Future Commercial Model”**
- Collaborating with Marketing Majors, Product Developers, Art Majors, etc.
- Galvanized Sheet Metal 15 Gauge(1.803 mm)
- A500 Steel Support Square Beams Thickness 4.7625 mm



FINAL DESIGN

Pros

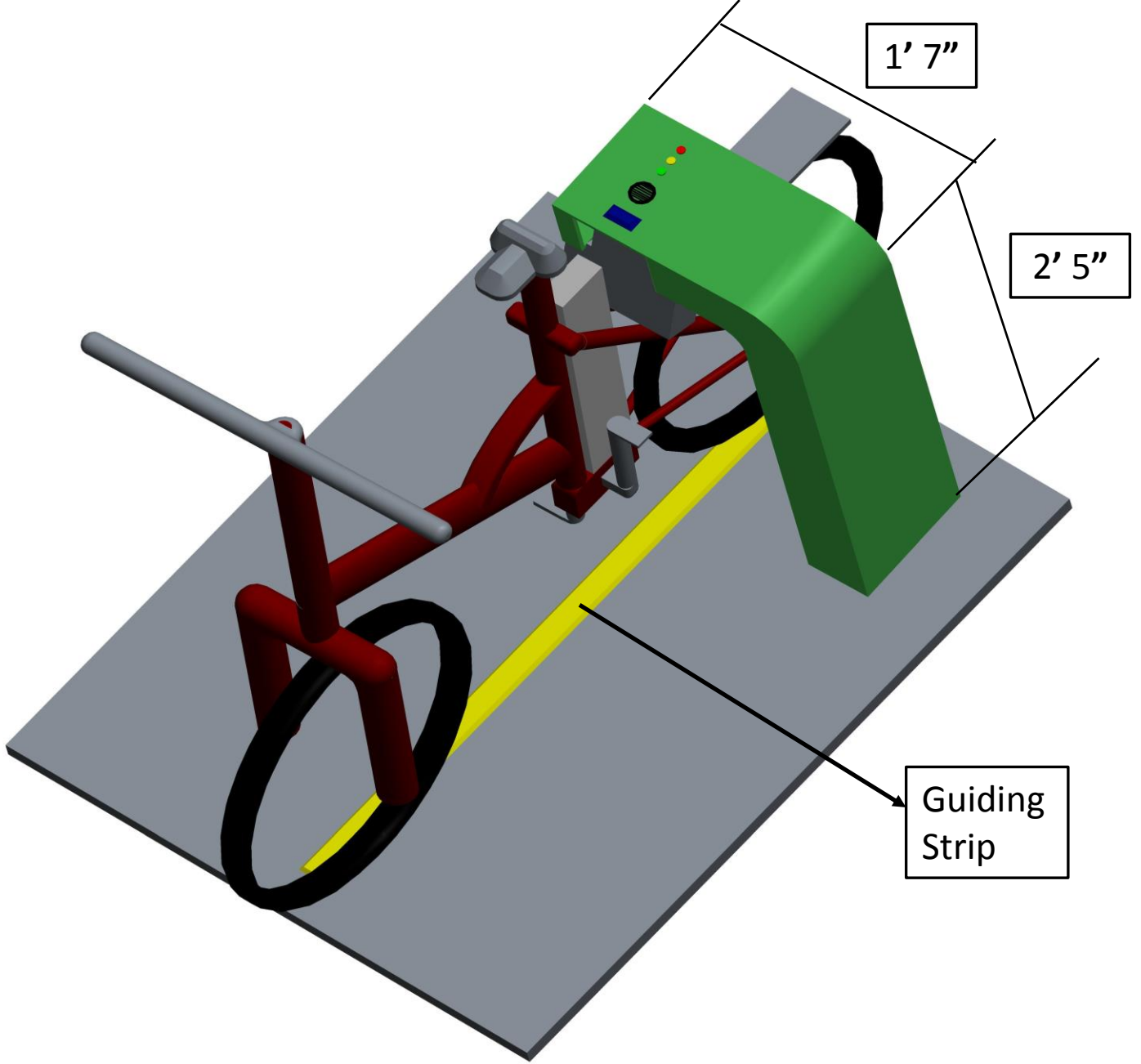
- Smaller and more compact than the previous design
- Easy to fabricate and build

Cons

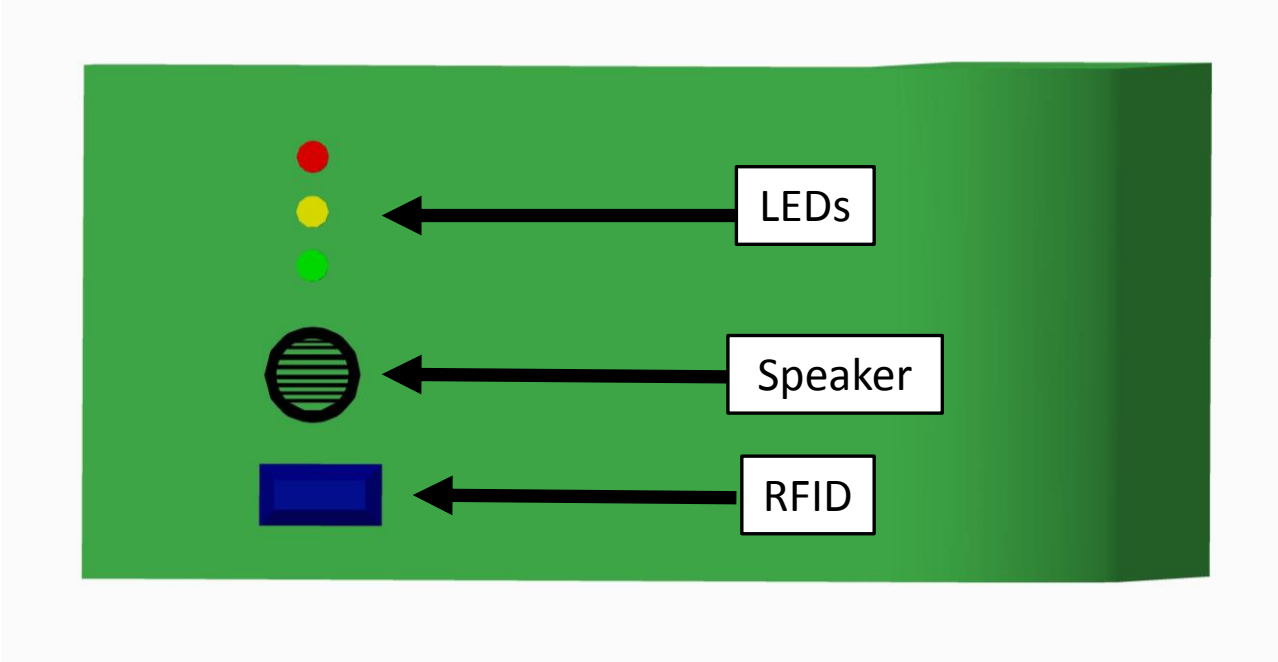
- Not aesthetically pleasing in comparison

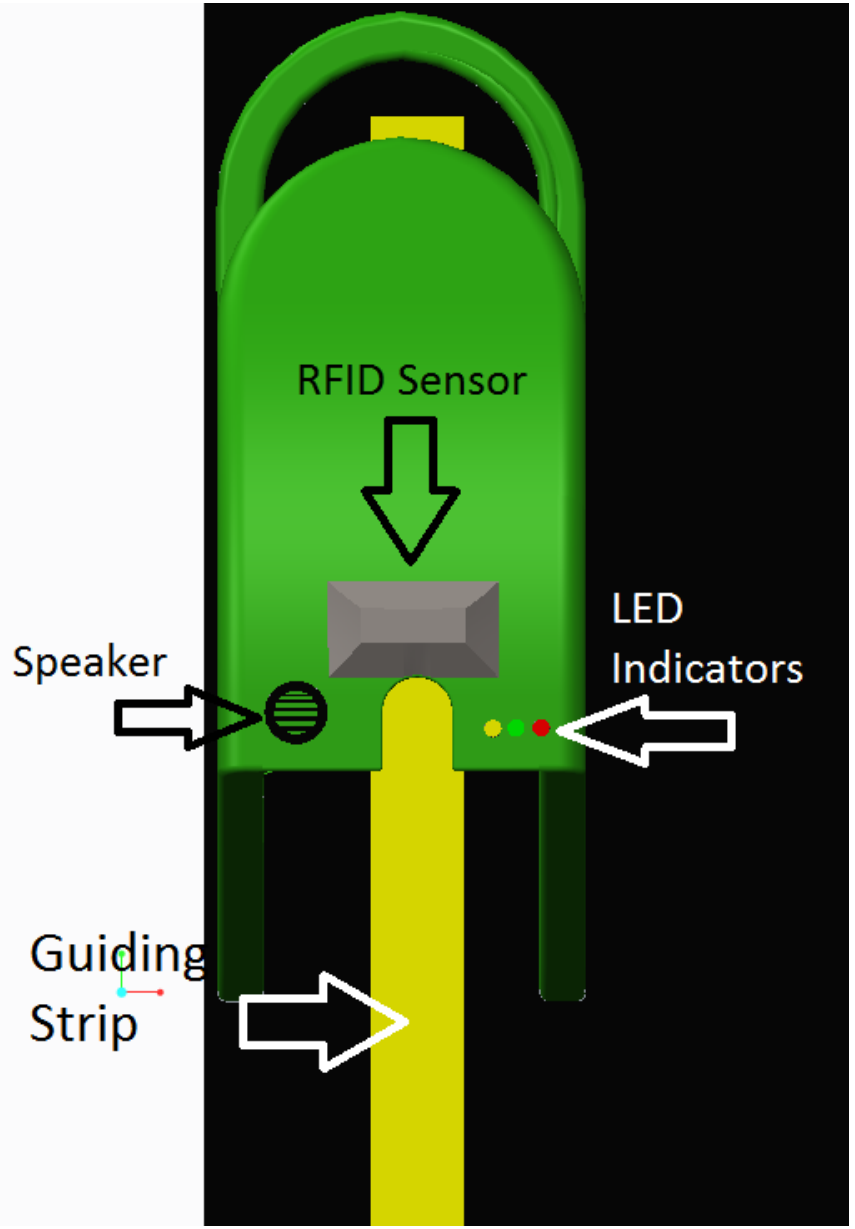
Details

- New design classified as the **“Prototype Model”**
- Compact and small
- Easy to fabricate and build

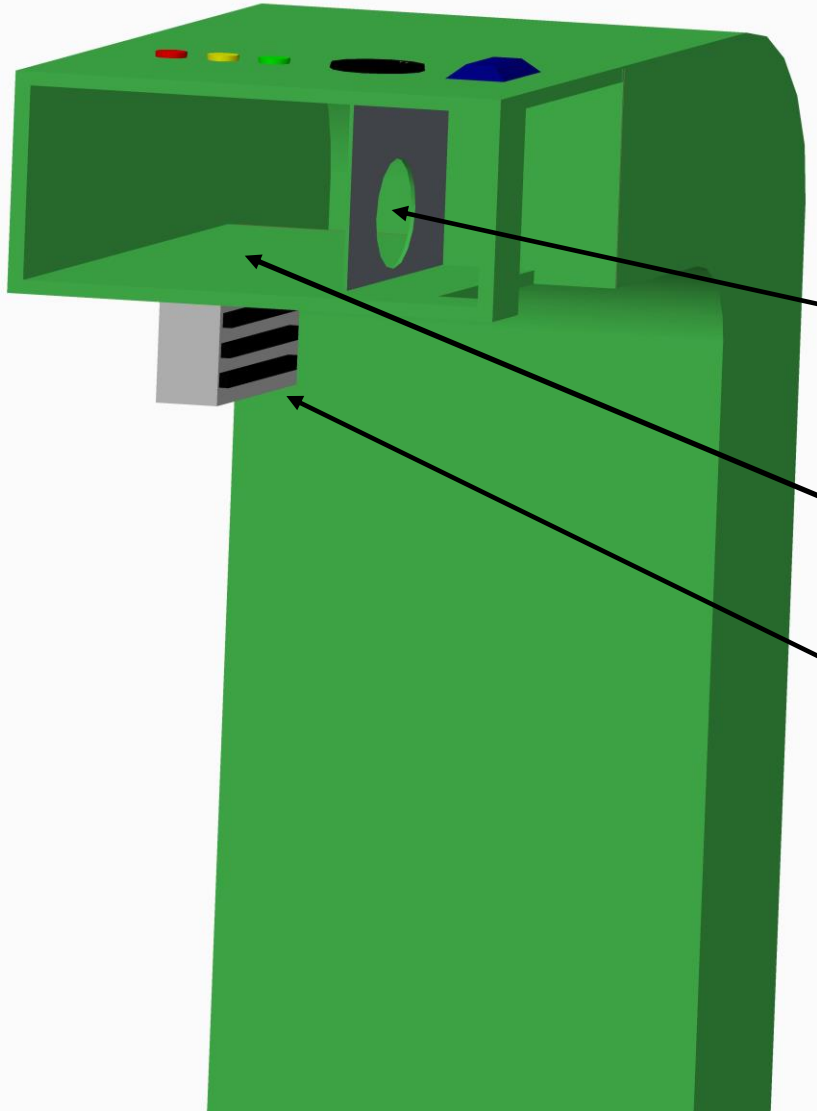


COMPARISON


LEDs
Speaker
RFID


RFID Sensor
LED
Indicators
Speaker
Guiding
Strip

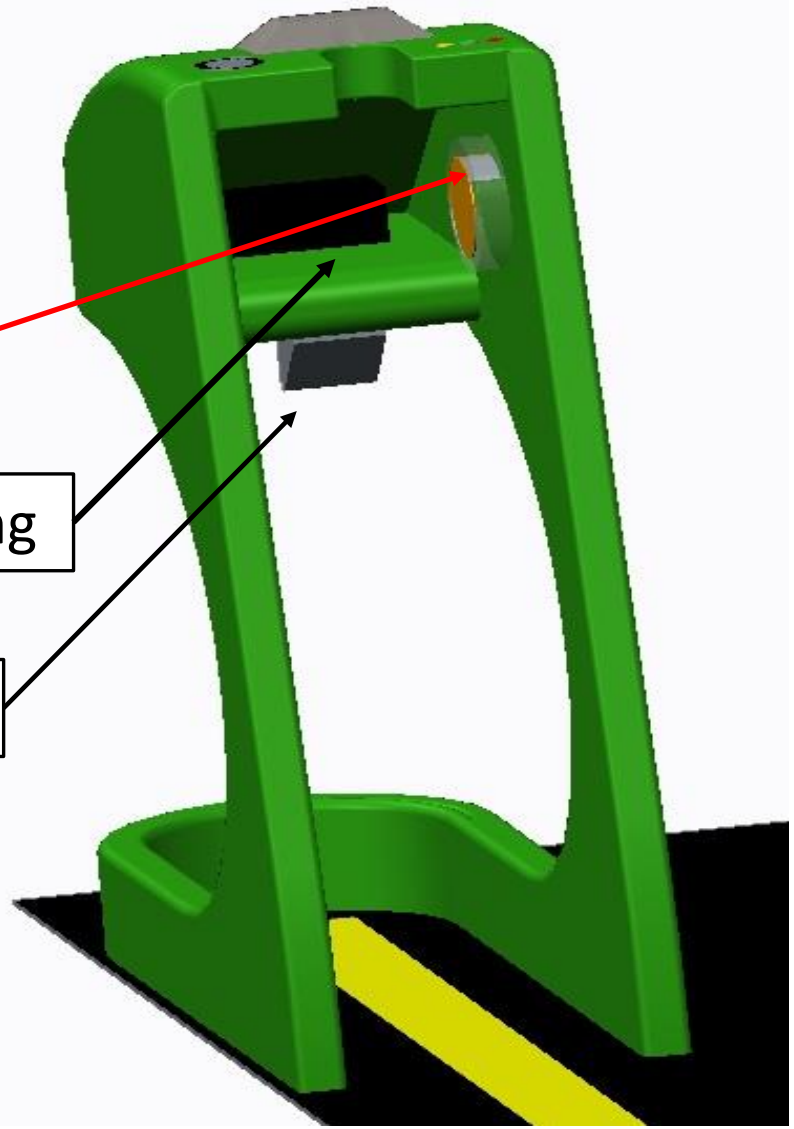
COMPARISON



Induction Plate Placement

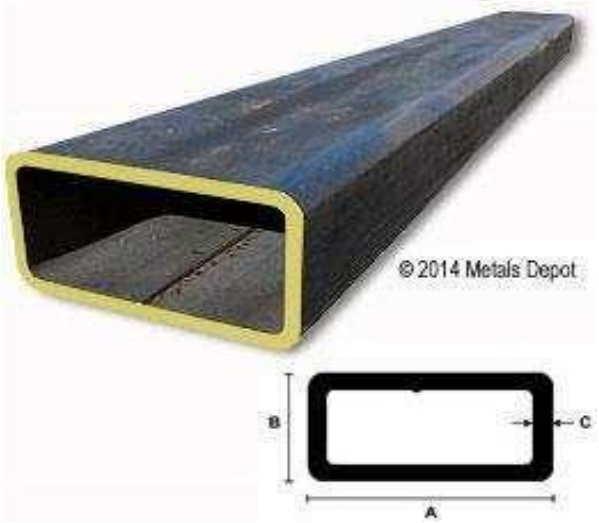
Electrical Component Housing

Electro-magnetic Lock



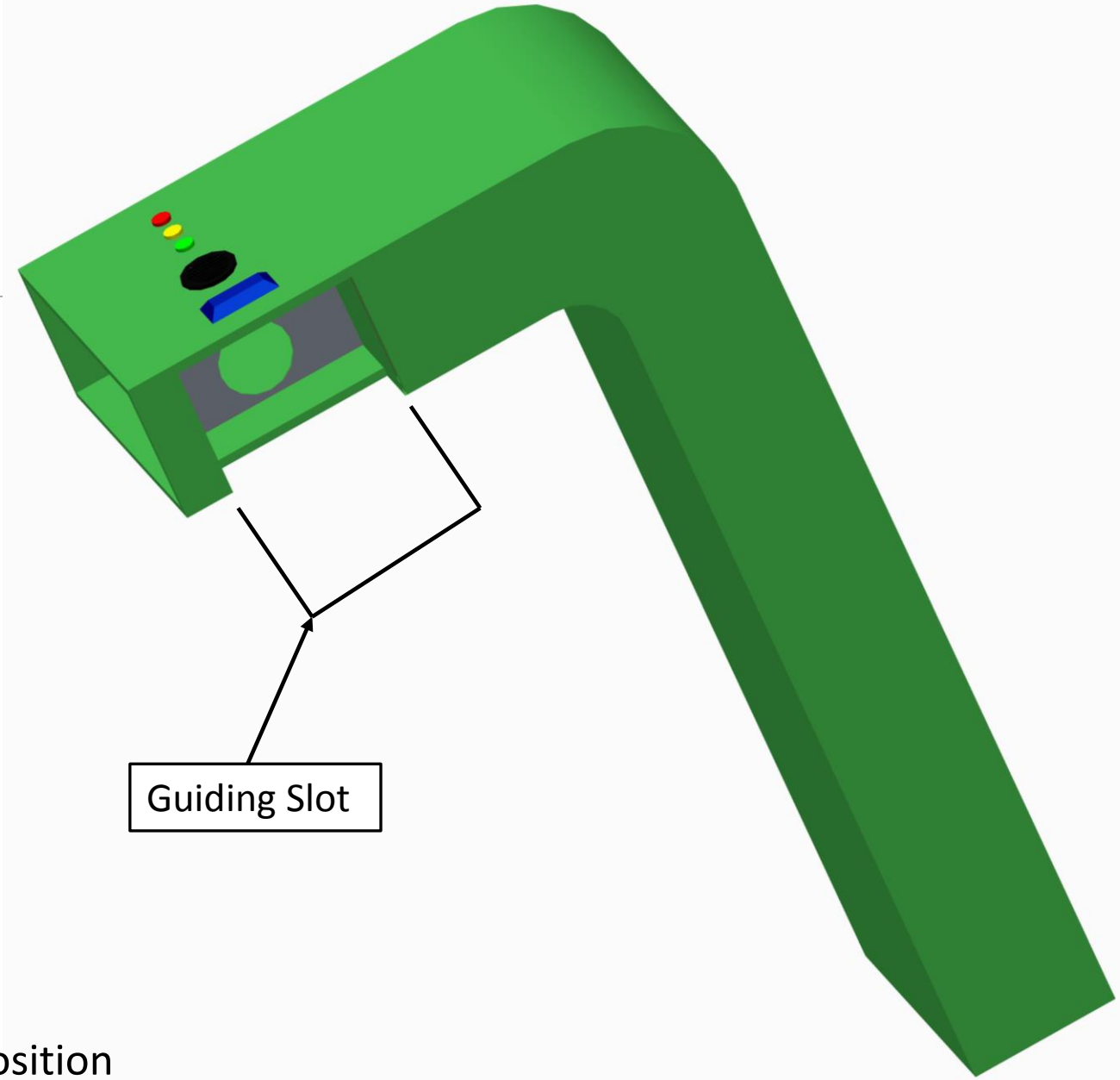
BUILDING MATERIAL AND LOCK

- **Electro-Magnetic Lock**
  - Seco-Larm 600 lbf E-941SA-600
  - I = 0.25 Amps, V = 24 Volts
  - Power Consumption = I*V = 6 Watts
- **Structural Material**
  - A500 Steel
  - 6” x 4” and 0.1875” (3/16)” thickness



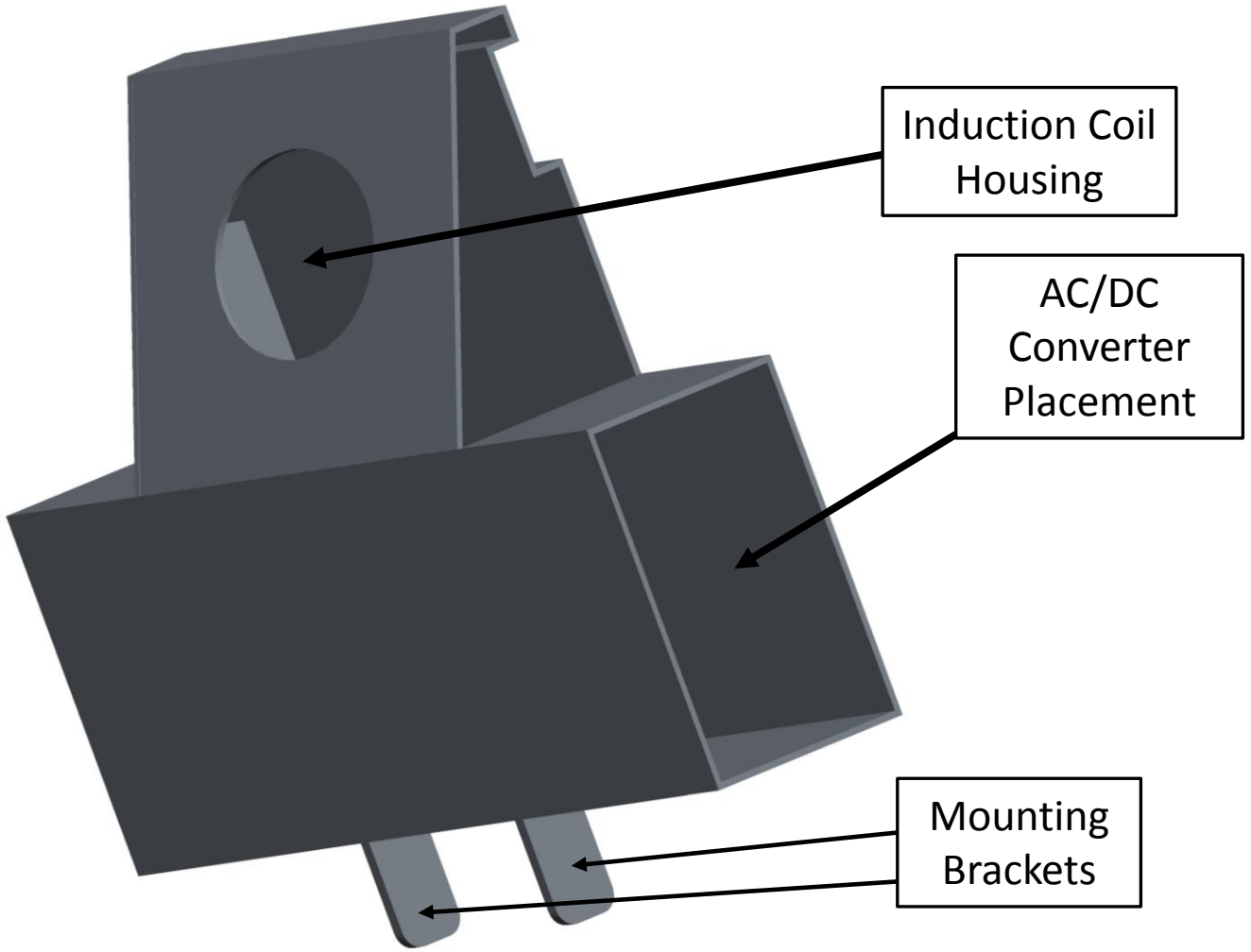
KEY FEATURES

- **RFID Sensor**
  - Unlock and Lock the E-Bike
- **Speaker**
  - Alert User in Certain Situations
  - Constant Beeping – There is an Issue
  - Descending tone – Bike Locked
  - Ascending tones – Bike Unlocked
- **LED Indicators**
  - Red – Bike Locked
  - Green – Unlocked
  - Yellow – Standby
- **Guiding Slot**
  - Assist Users in Placing Bike at the Correct Position



BIKE COMPONENTS

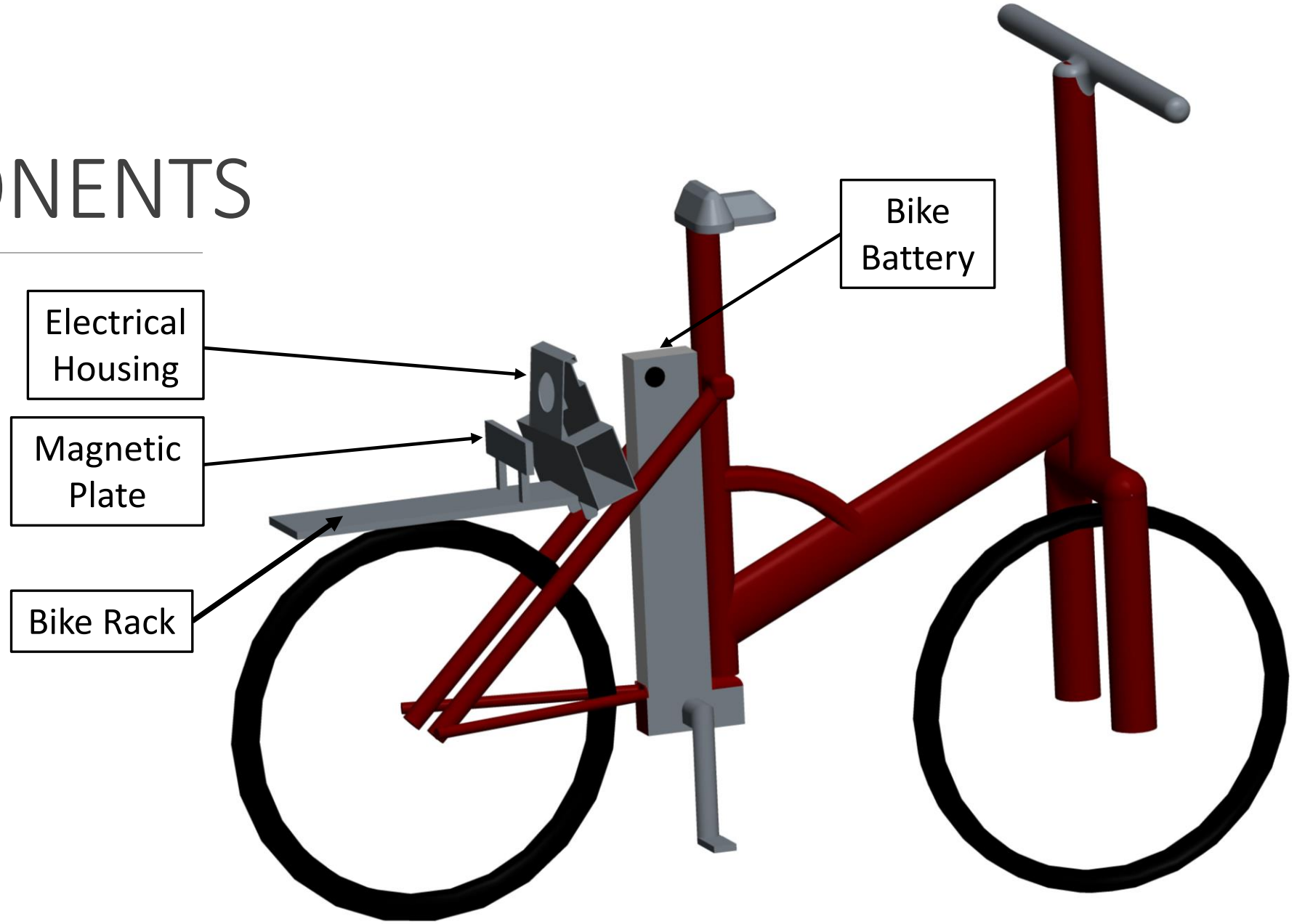
- Housing the induction plate and the AC/DC converter
- Covers wires leading to the battery
- Mounted in series to the rack
- Easy removal and minimally invasive



BIKE COMPONENTS

Details

- Minimally invasive
- Easy to implement on existing bikes
- Allow the use of bike rack for storage



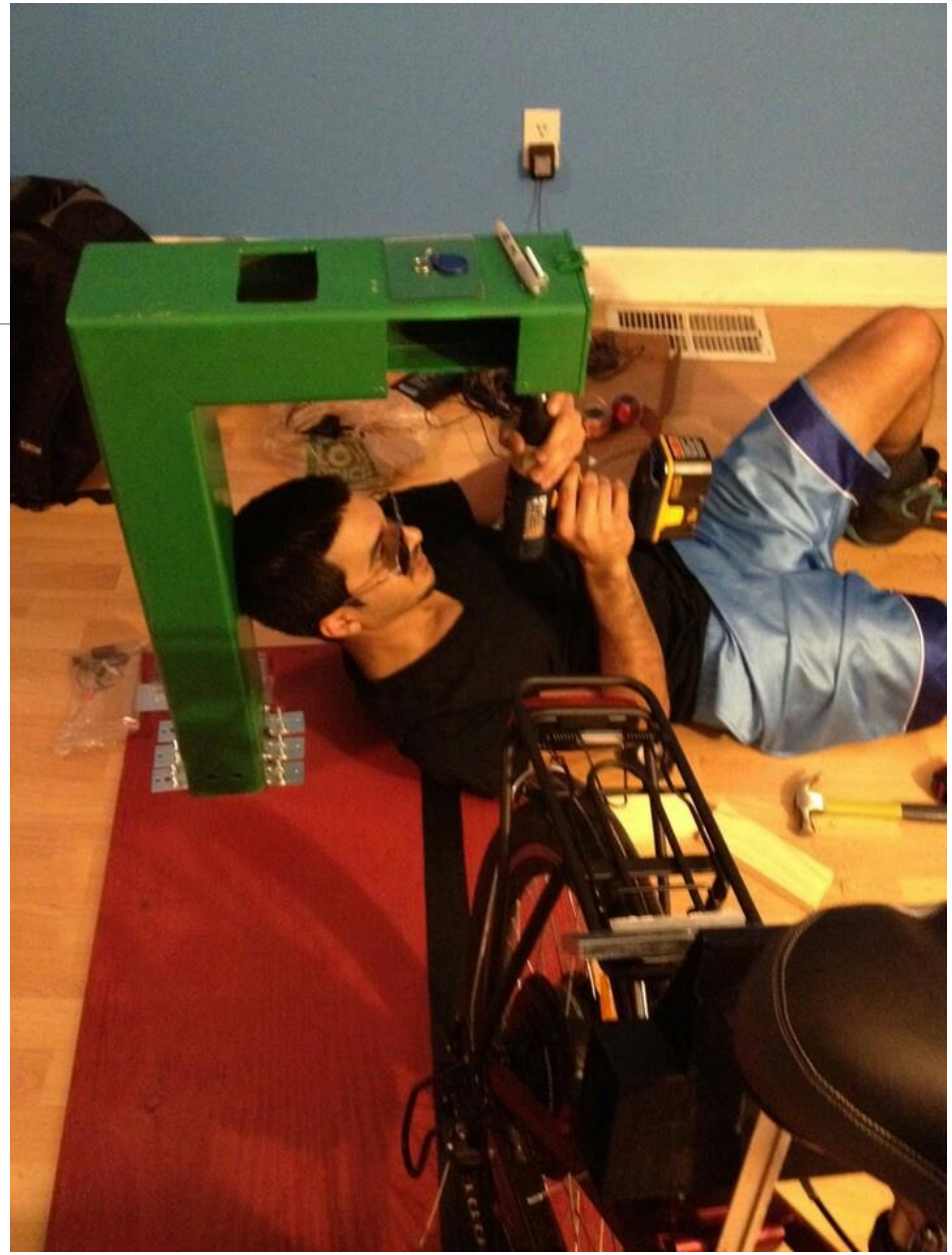
DESIGN PROCESS

Fabrication

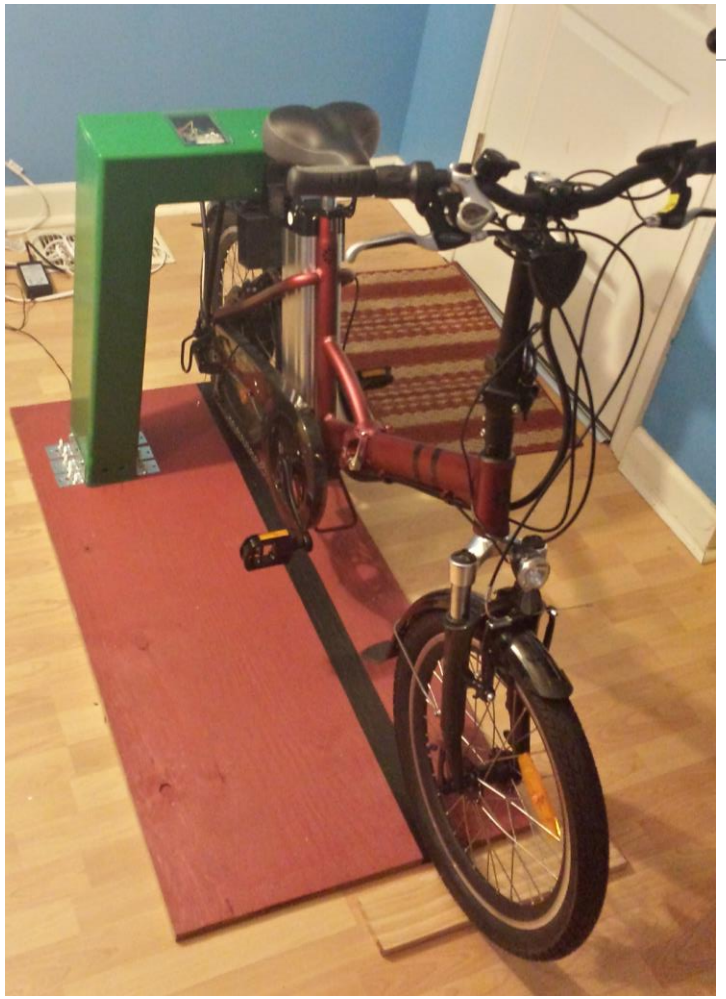
- Metal Fabrication of Tallahassee
- 3D printed case at the machine shop

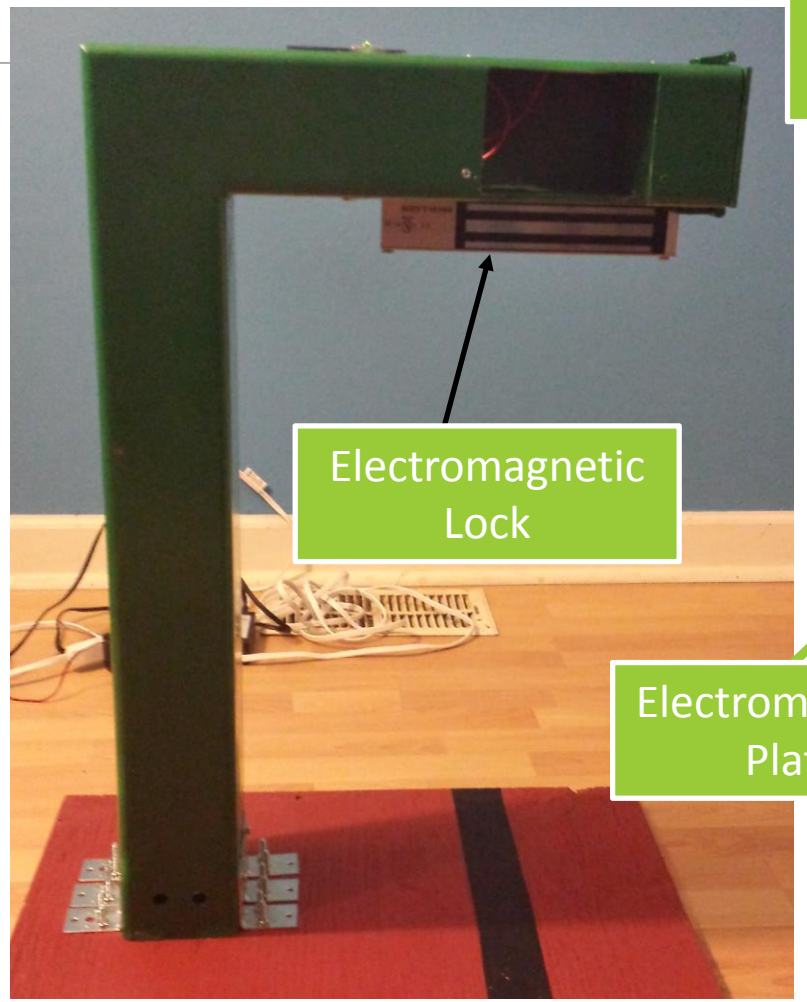
Self Installation

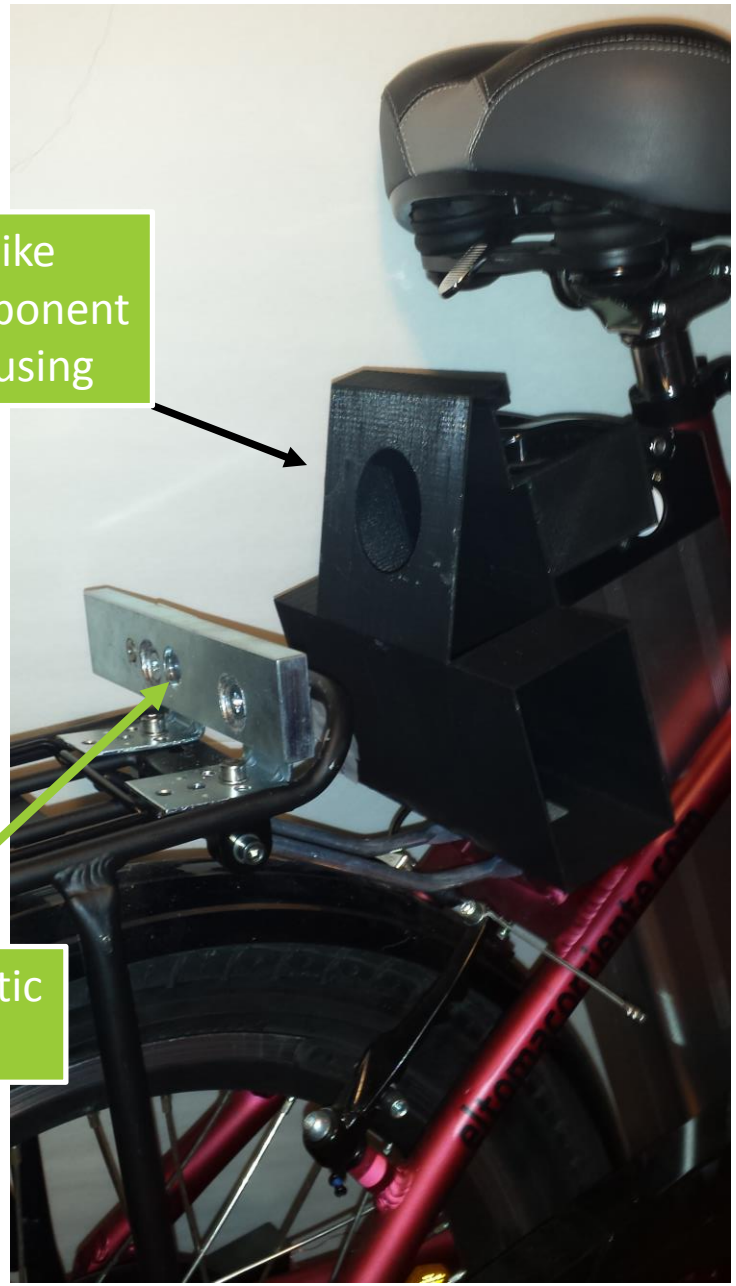
- On bike with components
- Station on wooden platform
- Electrical and other components



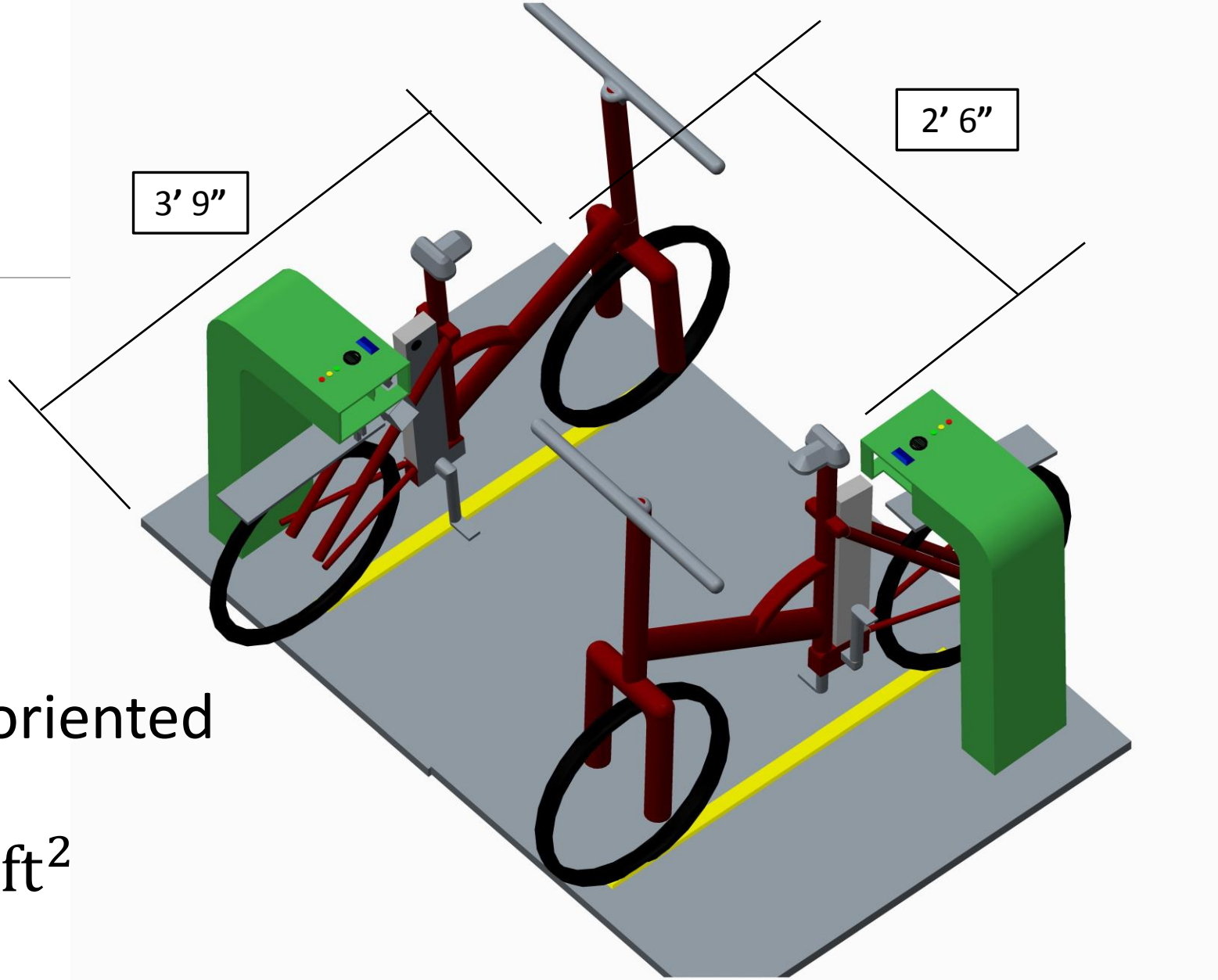
PHYSICAL PROTOTYPE





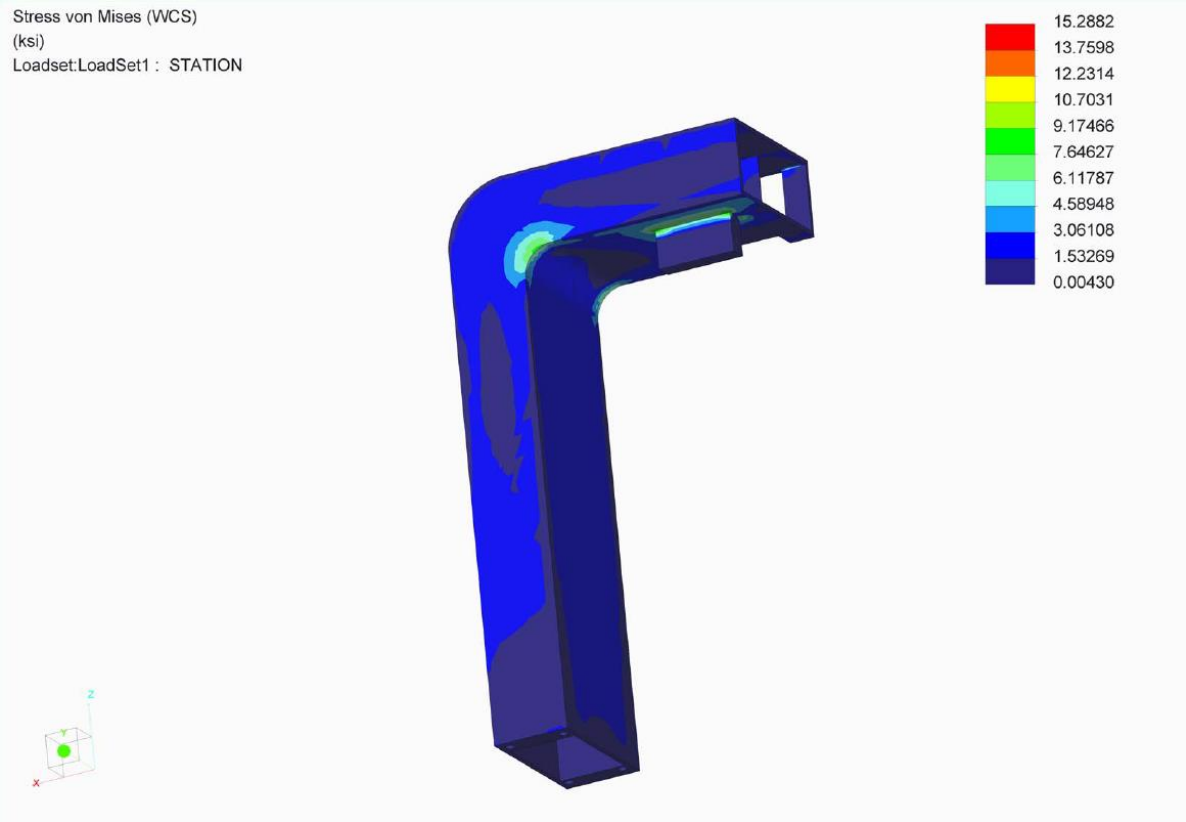


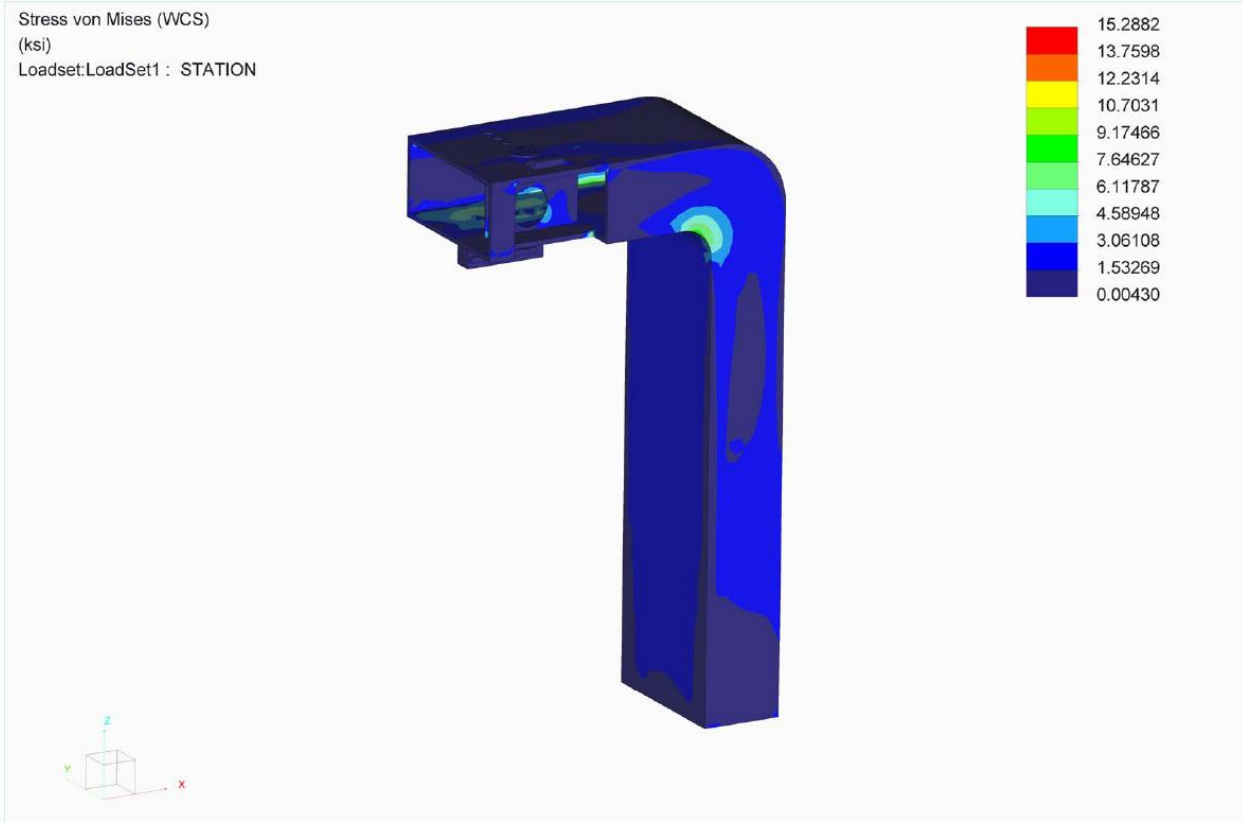
MODULAR DESIGN

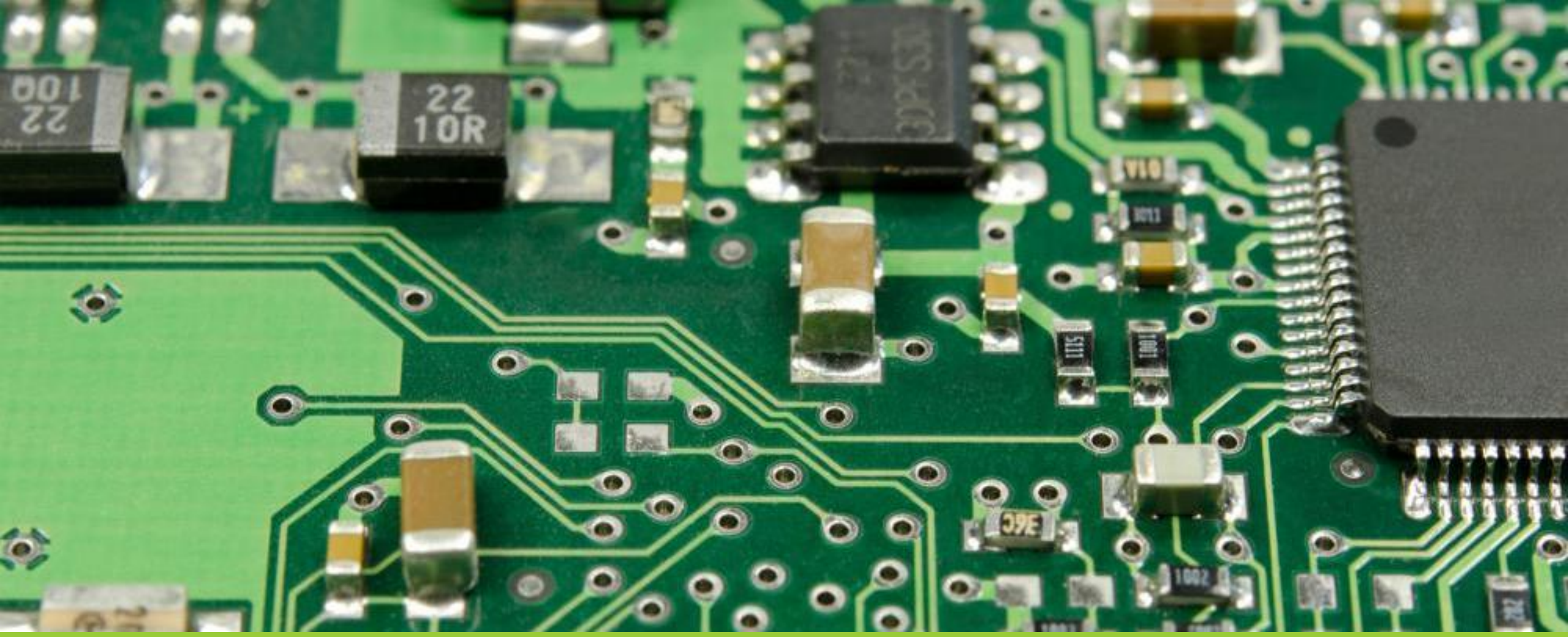


- Compact and can be re-oriented to suit spacing needs
- Total surface area 9.375 ft^2

TESTS AND RESULTS

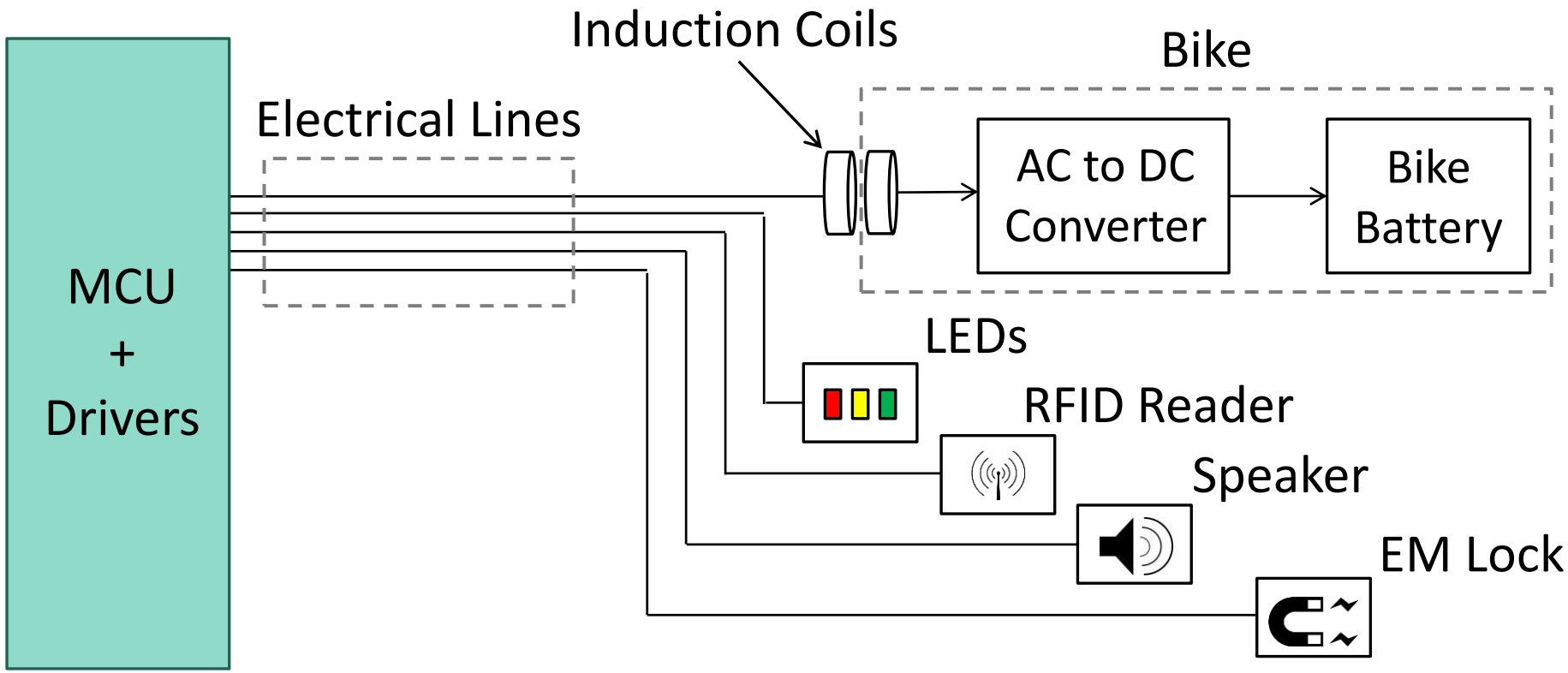






ELECTRICAL COMPONENT

ELECTRICAL OVERVIEW



INDUCTION CORES

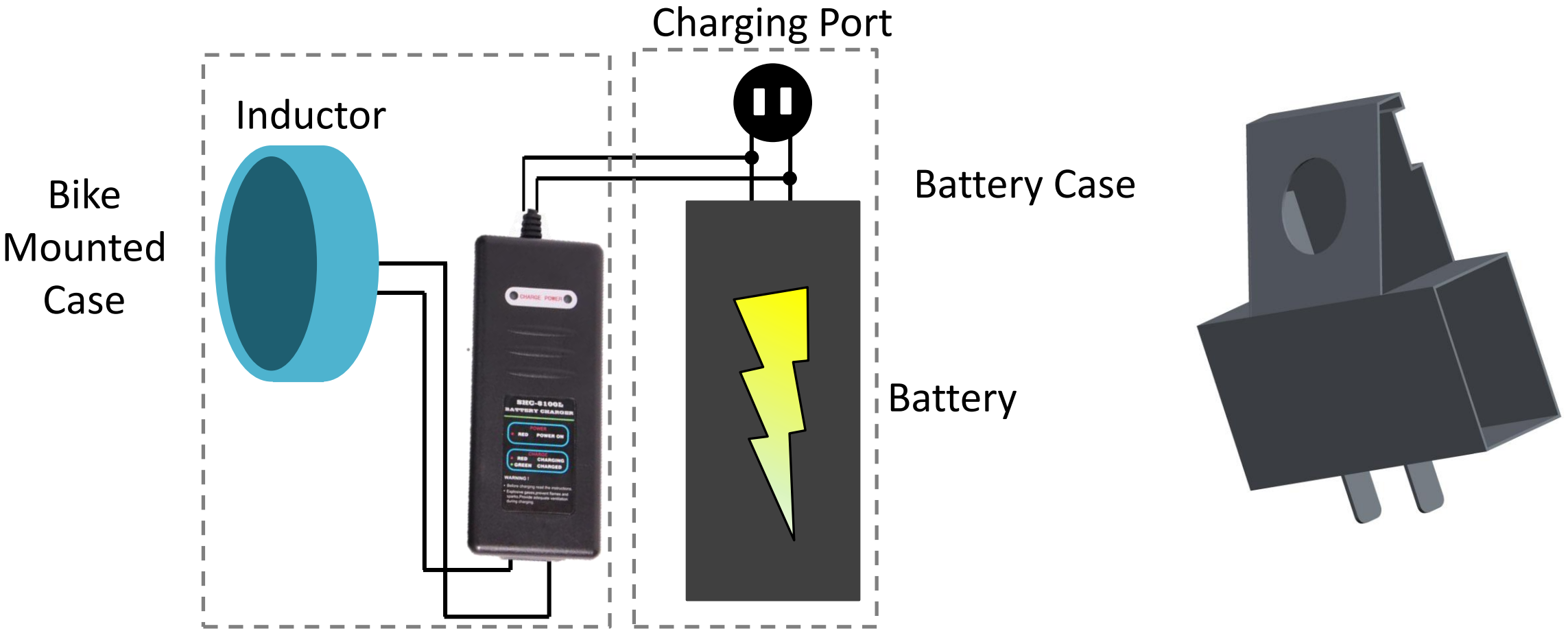
- New U-I core design
- ~300 primary turns, ~900 secondary turns
- Gain of up to 2.4
- Realistic gain with air gap: 0.5 to 1

Gap Size	Vin (V)	Vout (V)	Voltage Gain	Needed Gain
“resting”	7.0625	5.122	0.725	0.91
Small		8.183	1.159	
None		16.9	2.39	

AC/DC CONVERTER

- Input to be converted from 110V 60Hz AC to 36V DC
- Best option for simplicity is to have converter within bike adapter
  - Seamlessly go from AC input to DC output

AC/DC CONVERTER



USER'S TAG
S50 Key Fob

E-BIKE
S50 Sticker Tag

READING TAG
. . .

RFID READER
Read Tag

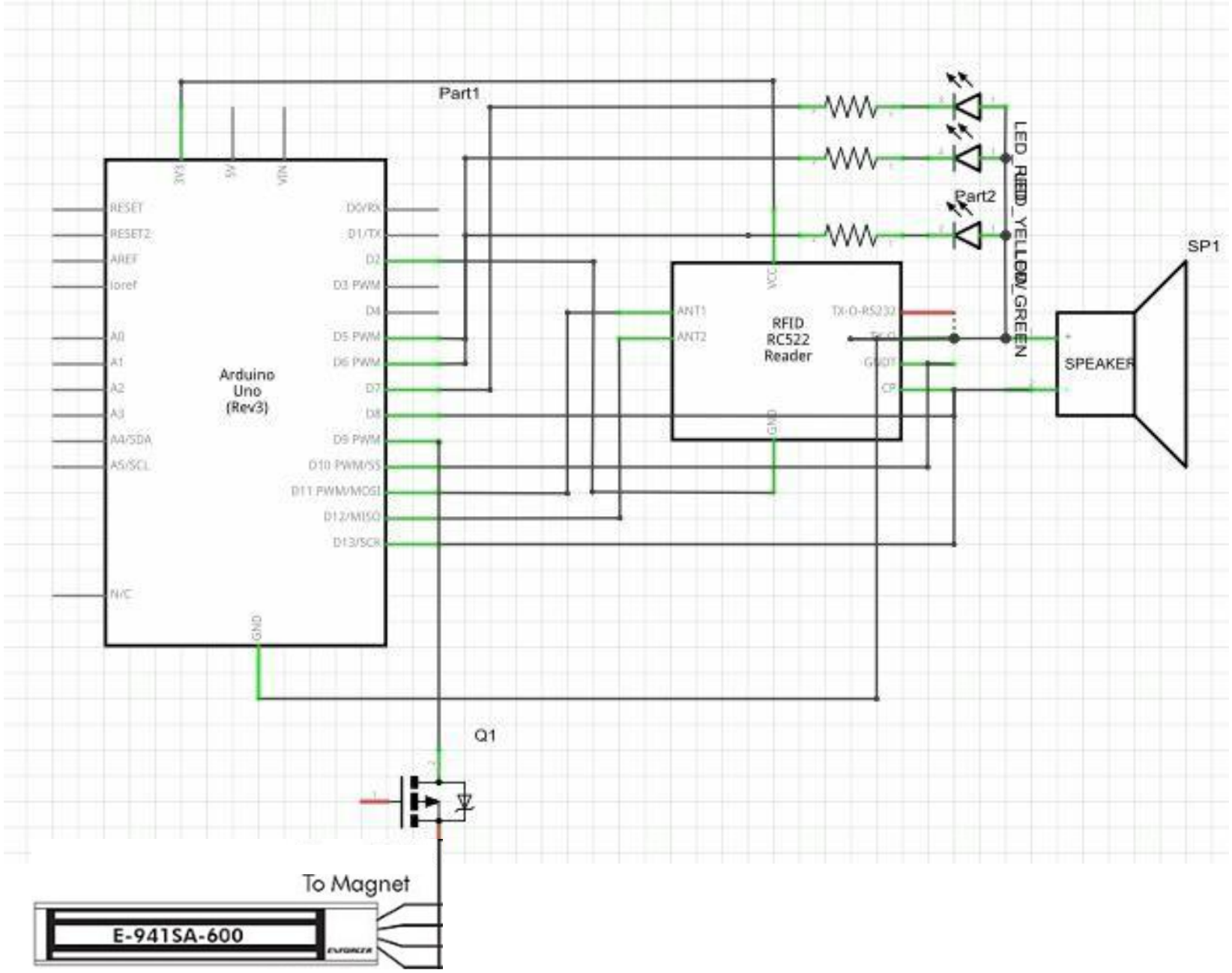
READING TAG
. . .

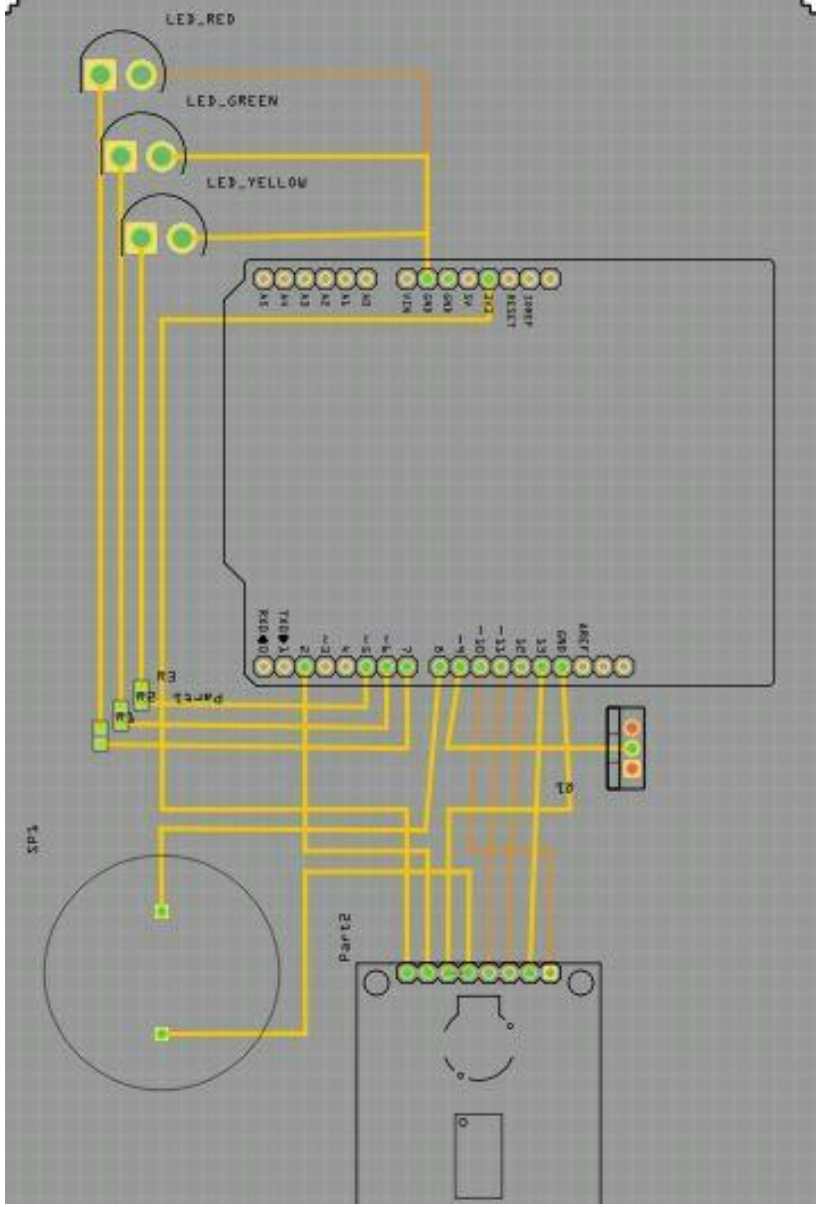
TAG IDENTIFIED
Access Granted

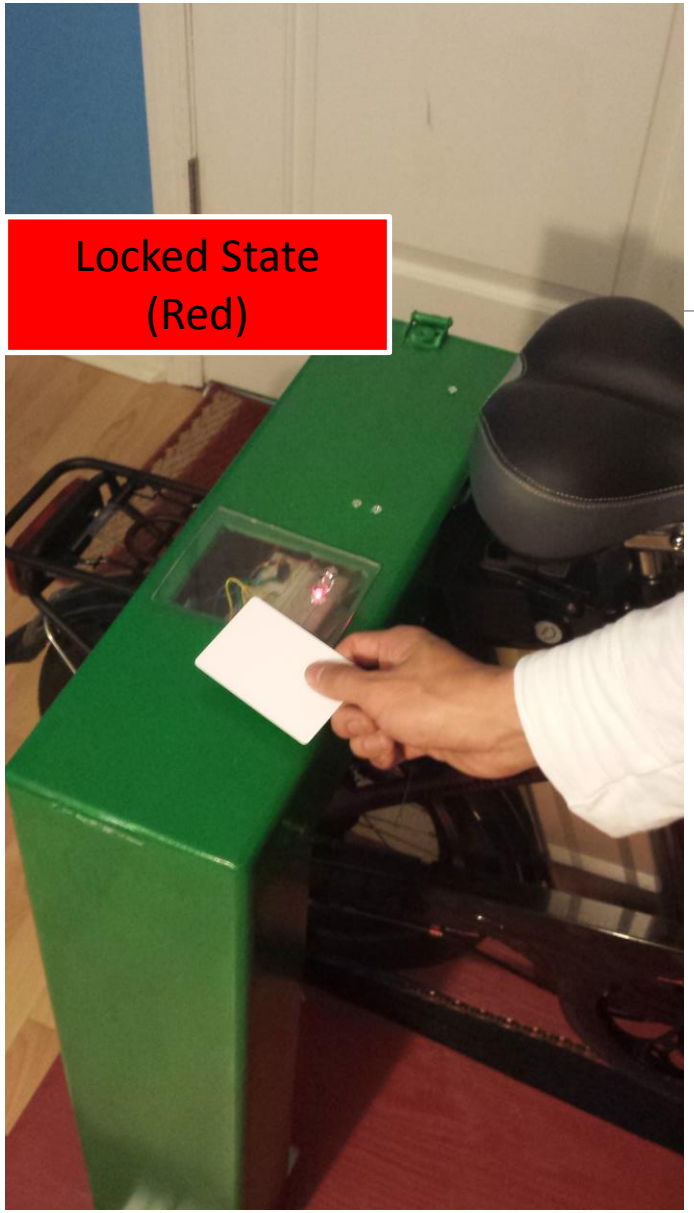
TAG UNIDENTIFIED
Access Denied

BIKE IDENTIFIED
Secure Lock

BIKE UNIDENTIFIED
Remain Unlocked


Part1
Part2
Arduino
Uno
(Rev3)
RFID
RC522
Reader
SPEAKER
SP1
LED_RED
LED_YELLOW
LED_GREEN
Q1
To Magnet
E-941SA-600


LED_RED
LED_GREEN
LED_YELLOW
Part2
SP1
Q1


Locked State
(Red)


Standby State
(Yellow)


Unlocked State
(Green)

User Interface

Requirements

- Microcontroller sends correct signals
- R/Y/G LEDs light up for each state
- Speaker plays 500-1000 Hz tones to notify user the status of bike

Performance

- Microcontroller sends signals to both components
- R/Y/G LEDs light up for corresponding state
- Speaker plays two different tones when locked and unlocked

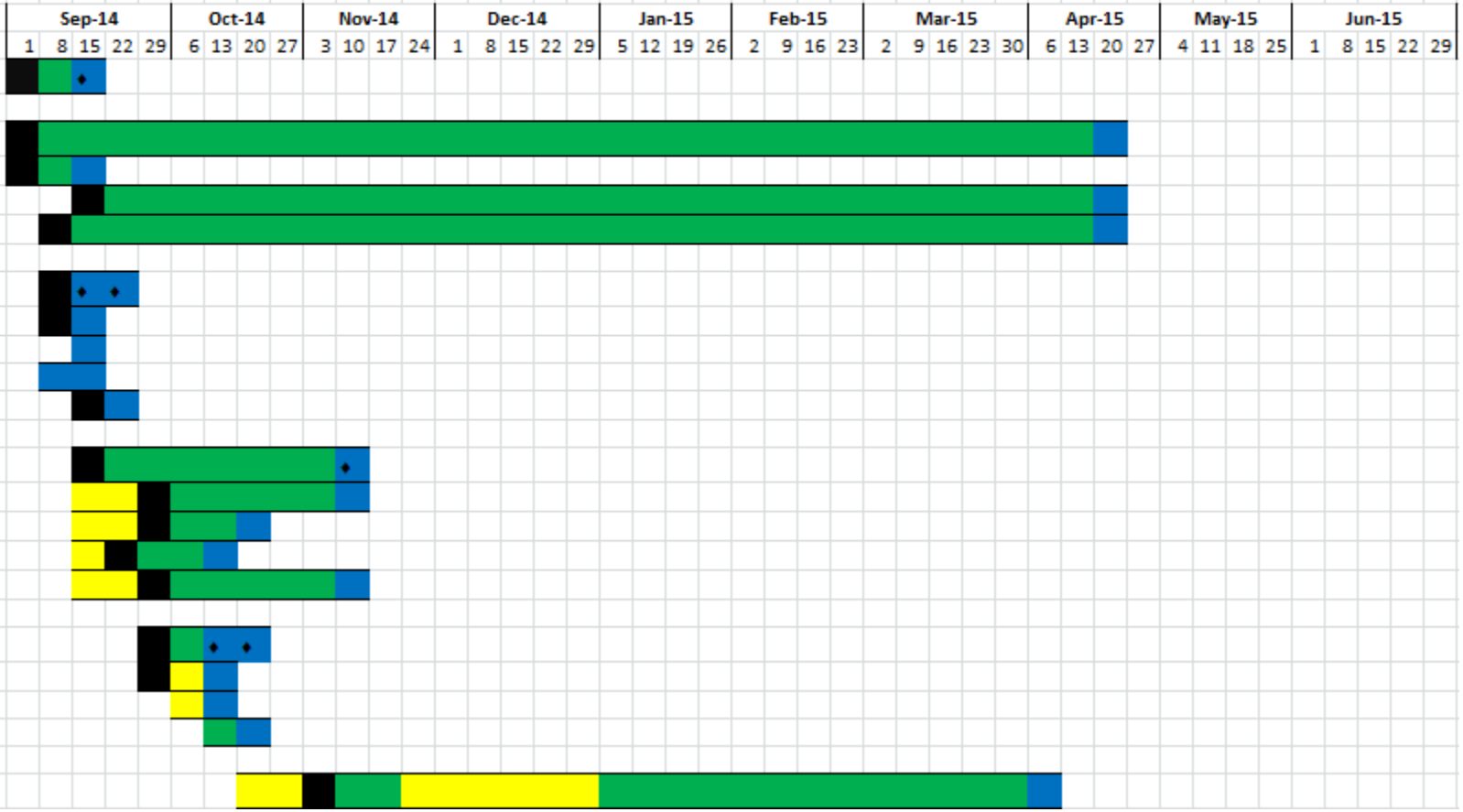
Schedule

E-Bike Charging and Docking Station Project Schedule

Castro, Kim, Johnson, Knoblauch, Rafiq

Completed | Started | To be Completed | On Track | Not On Track | Late | Milestone

Task Name	Duration	Start	End
1. Code of Conduct Agreement	7 days	9/5/14	9/12/14
2. Project Management	7 months	9/5/14	4/17/15
2.1 Duty Assignments			
2.2 Sponsor Meetings			
2.3 Advisor Meetings			
3. Needs Analysis and Req. Specifications	15 days	9/11/14	9/26/24
3.1 Written Report	7 days	9/11/14	9/18/14
3.1.1 Sponsor needs/wants			
3.1.2 Prepare Document			
3.2 Group Presentation	5 days	9/21/14	9/26/14
4. Components Research/Selection	56 days	9/15/14	11/13/14
4.1 Induction Charging			
4.2 Locking Mechanism			
4.3 Housing			
4.4 Microcontrollers			
5. Project Proposal	22 days	10/2/14	10/23/14
5.1 Written Report	15 days	10/2/14	10/17/14
5.1.1 Design Proposal			
5.2 Group Presentation	5 days	10/18/14	10/23/14
6. Order Components	82 days	10/22/14	3/30/15



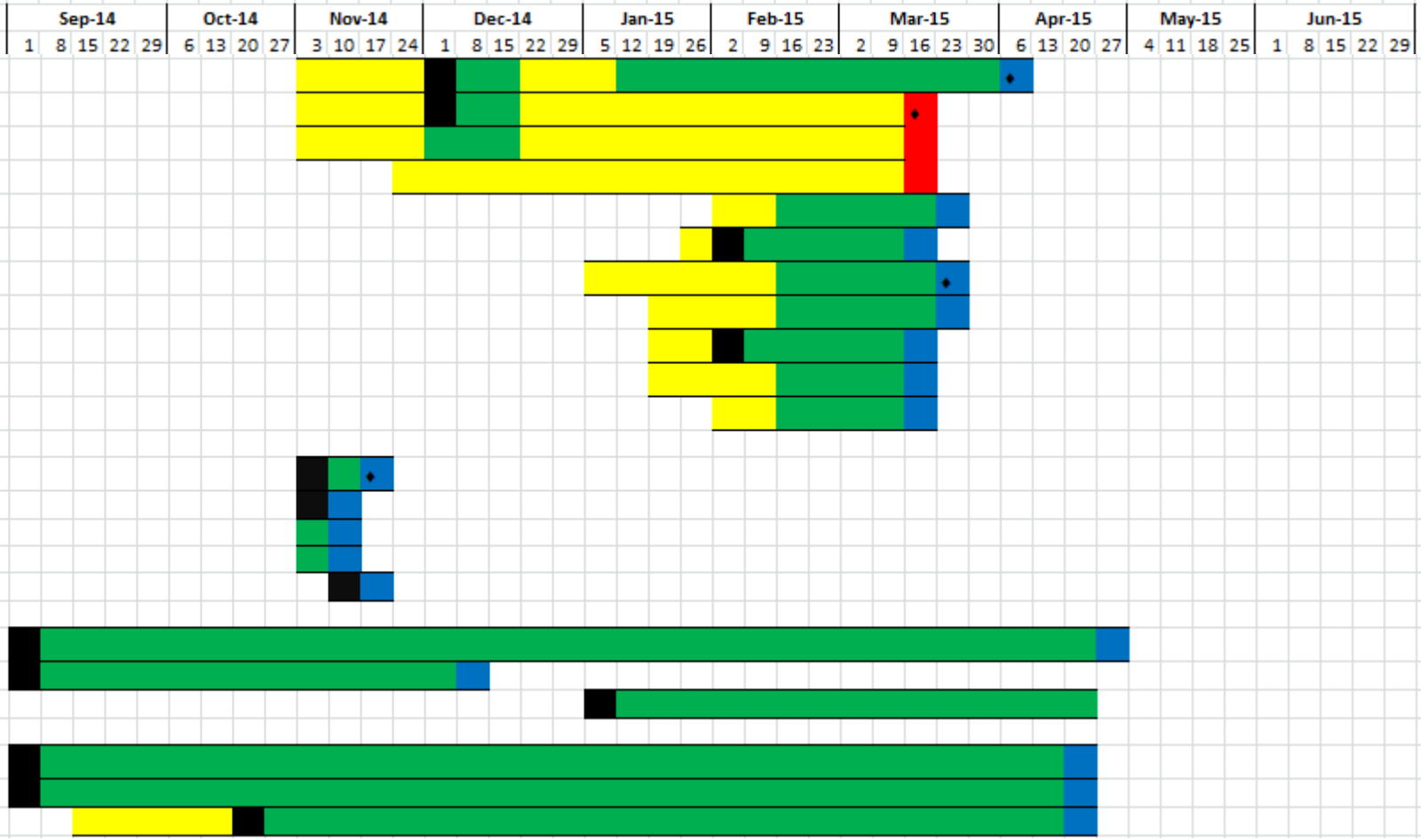
Schedule

E-Bike Charging and Docking Station Project Schedule

Castro, Kim, Johnson, Knoblauch, Rafiq

Completed | Started | To be Completed | On Track | Not On Track | Late | Milestone

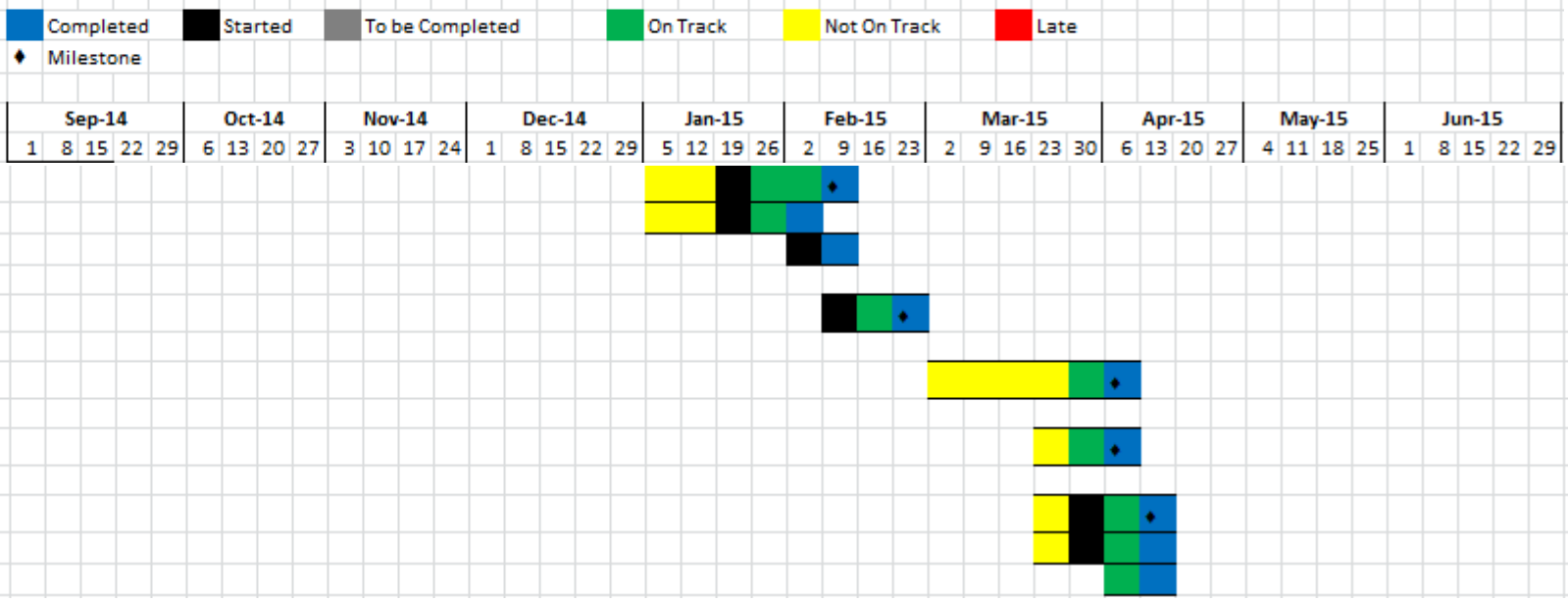
Task Name	Duration	Start	End
7. Test/Implement Components	5 months	11/3/14	4/6/15
7.1 Test and Implement Induction charging			
7.1.1 Test Induction Coils			
7.1.2 Test charging circuit			
7.2 Test and Implement Station Structure			
7.3 Test and Implement Microcontrollers			
7.4 Test and Implement Locking Mechanism			
7.5 Test and Implement RFID Module			
7.6 Test and Implement LEDs			
7.7 Test and Implement Speaker			
7.8 Test and Implement Housing			
8. System-Level Design Review	15 days	11/6/14	11/21/14
8.1 Written Report			
8.1.1 Create detailed system designs			
8.1.2 Update designs			
8.2 Group Presentation			
9. Self & Peer Evaluation	7 months	9/5/14	4/24/15
9.1 Fall Semester			
9.2 Spring Semester			
10. Project Documentation	7 months	9/5/14	4/17/15
10.1 Meeting Minutes			
10.2 Team's Website			



Schedule

E-Bike Charging and Docking Station Project Schedule

Castro, Kim, Johnson, Knoblauch, Rafiq

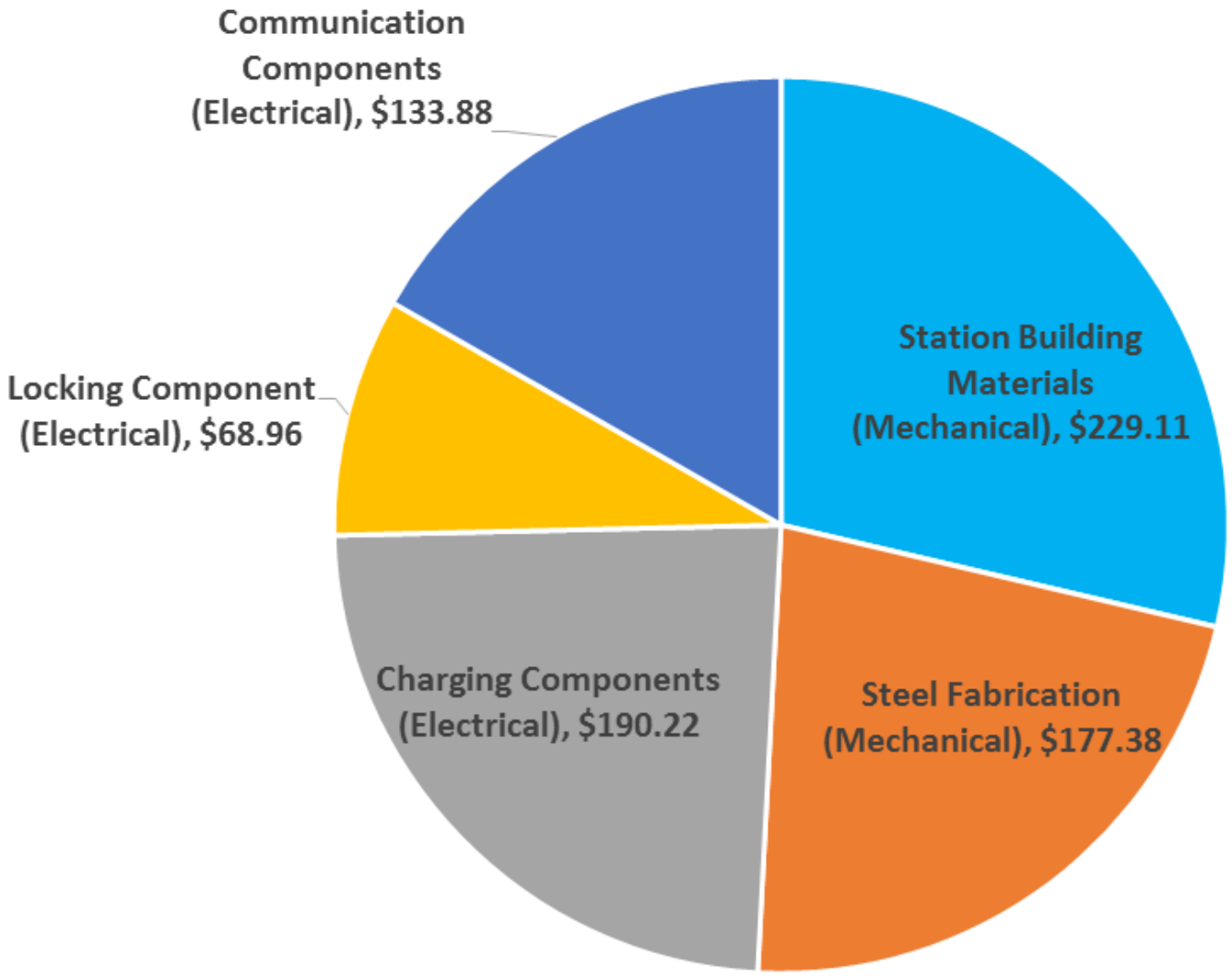


Task Name	Duration	Start	End
11. Detailed Design Review and Test Plan	39 days	1/5/15	2/13/15
11.1 Written Report			
11.2 Group Presentation			
12. Midterm Hardware/Software Reviews	13 days	2/14/15	2/27/15
13. Test Prototype	35 days	3/2/15	4/6/15
14. Final System Demonstrations	18 days	3/23/15	4/10/15
15. Project Final Report	25 days	3/23/15	4/17/15
15.1 Written Report			
15.2 Group Presentation			

Project Responsibilities

Team Member	Project Tasks Responsible For
Bilal Rafiq (ME - Team Leader)	• Building and Installation of all Mechanical Components • CAD Drawings • Involved in all Aspects of the Project
Justin Johnson (ME)	• Virtual Modeling • Design of Various Mechanical Components
Bryan Castro (EE)	• Electromagnetic Lock • Inductance Charging • Microcontroller/Speaker Integration
Seve Kim (CpE)	• Microcontroller/Locking Integration • Microcontroller/RFID Integration • Microcontroller/Speaker Integration • Microcontroller/LEDs Integration
Jacob Knoblauch (CpE – ECE Team Leader)	• Microcontroller/Speaker Integration • Inductance Charging • Electromagnetic Lock

Project Final Budget



Final Budget	
Allocated Project Costs	$1,000
Total Project Costs	$799.55
Remaining Balance	**$200.45**

FUTURE IMPROVEMENTS

- Unique code for each bike that will track and identify it in a database
- Data structure to hold and then communicate with website via a touch screen device or a mobile app
- Further research and development on high power transfer induction charging
- Improve charge time of Li-Ion batteries

CONCLUSIONS

Accomplished 3 out of 4 requirements

- Completed
  - Station design
  - Locking device
  - User friendly unlocking and locking feature
- Un-complete
  - Charging component
  - Bike-User RFID interface