UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Aftermarket Hazard Detection for Cyclists

Team 19

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Team Members

- Ozgur Tufekci, CE
  - Software development (networking), physical design
- Adam Snedden, EE
  - Circuit and PCB design, integration, verification, chassis design, logistics
- Erik Ji, CE
  - Circuit design, integration, verification, software development (sensor integration), parts ordering and logistics

Problem & Solution

Problem

Cyclists often have significant blind spots behind them, making them vulnerable to potential dangers on the road, whether from other cyclists or vehicles.

17 percent of personal vehicles have blind spot technology as a standard feature and 57 percent have it as an upgrade option.

Solution

- We designed a LIDAR-based rear collision detection system
- Our product helps solve this problem by alerting the cyclist of hazards approaching from the rear which could otherwise go unnoticed and lead to injuries or fatal accidents.

High-Level Requirements

Sensing/Ranging

- Sensors will remain accurate within ± 5 cm at maximum expectant range of 20 feet / approx. 6 meters

Indication

- LEDs and a buzzer will alert the rider of hazards
- LEDs are bright enough to see clearly in all weather conditions
- Buzzer intensity will increase

Power/Integrity

- System functions on independent power
- Outputs 5V and 3.3 V ± 5 %
- Supplied power lasts 6 hours while running full system

Sensor Choice Considerations

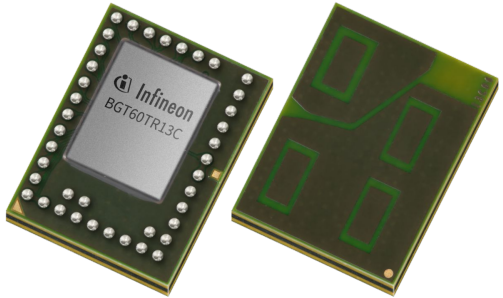
Ultrasonic Sensor

Pros

- Low cost
- Short range

Cons

- Lower reliability



mmWave Radar

Pros

- Medium cost
- Long range

Cons

- BGA soldering

LiDAR

Pros

- High accuracy
- Medium range

Cons

- High cost

Sensor Choice Considerations

Mech. Scanning

Pros

- Good coverage

Cons

- Expensive
- Moving parts (motor)

Solid State

Pros

- Less moving parts (MEMS/OPA)
- Good coverage

Cons

- Expensive

Flash

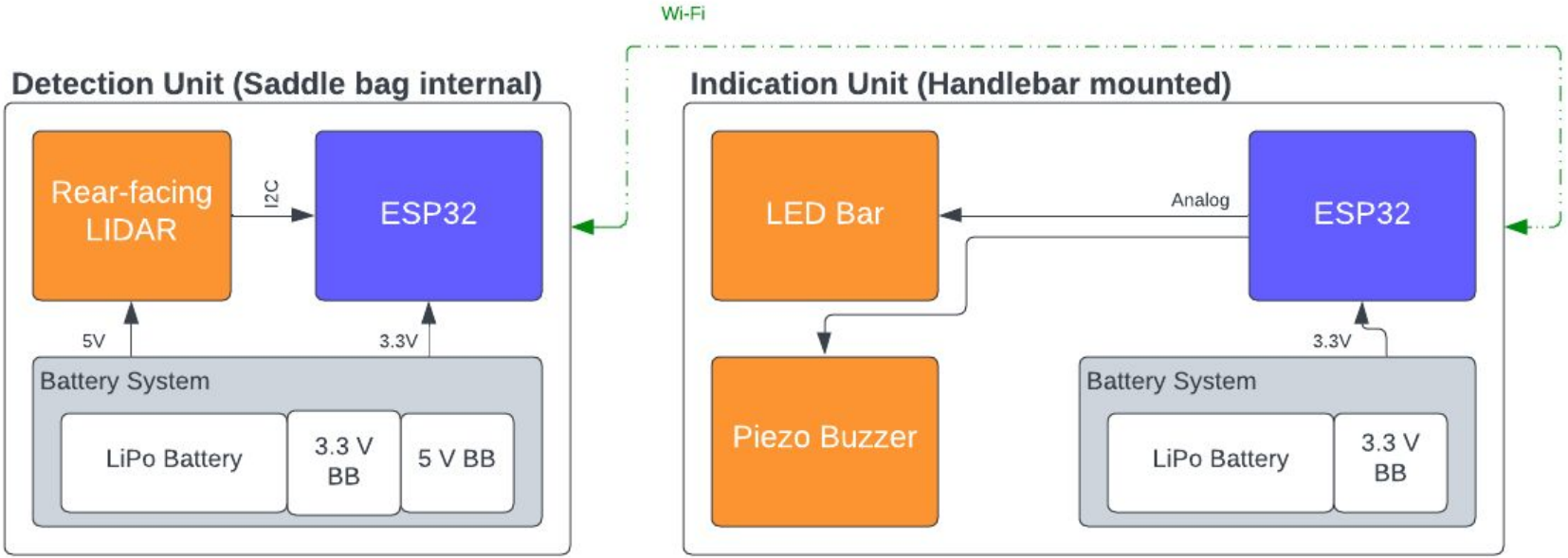
Pros

- Cheap
- Easy to integrated

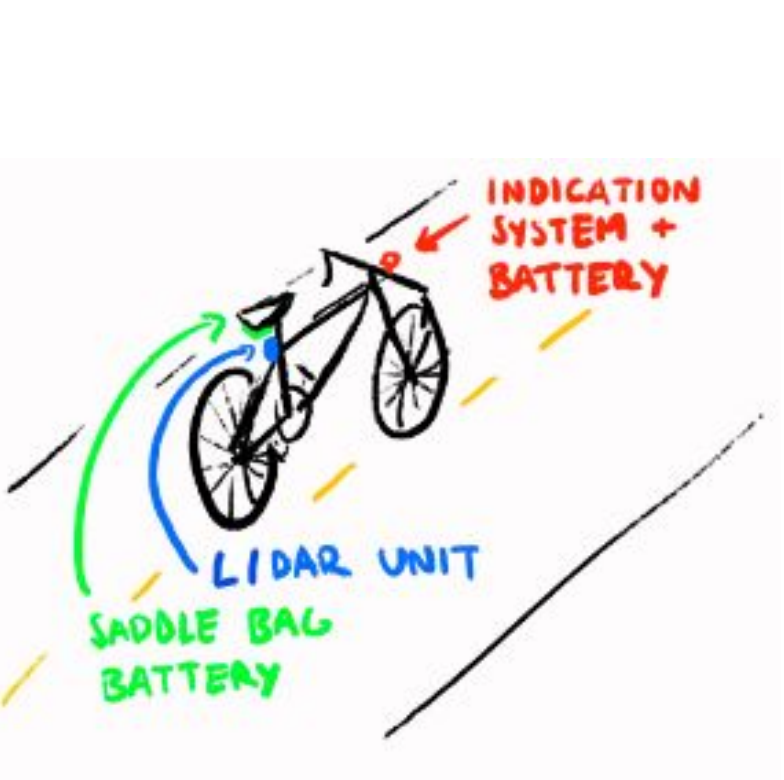
Cons

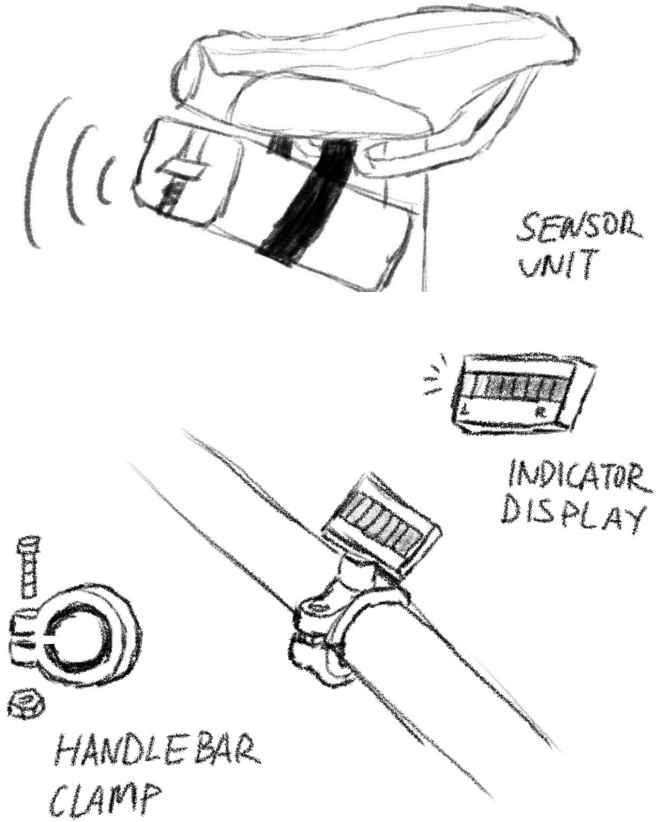
- Poor coverage

Block Diagram



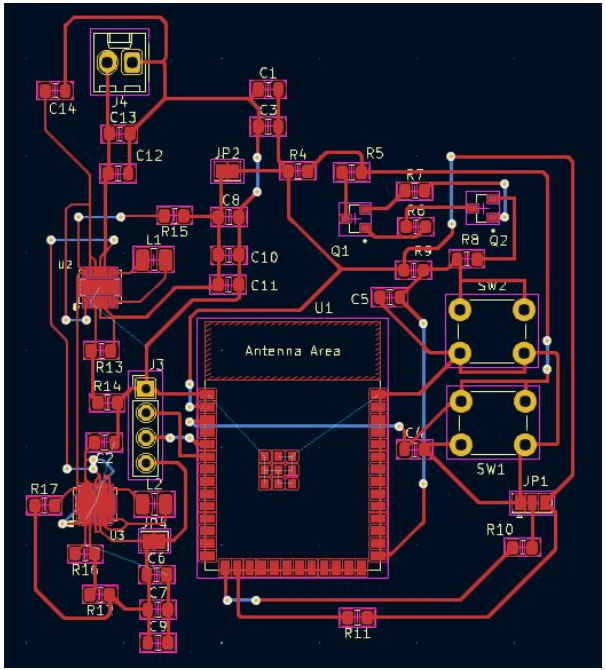
Visual Setup of System



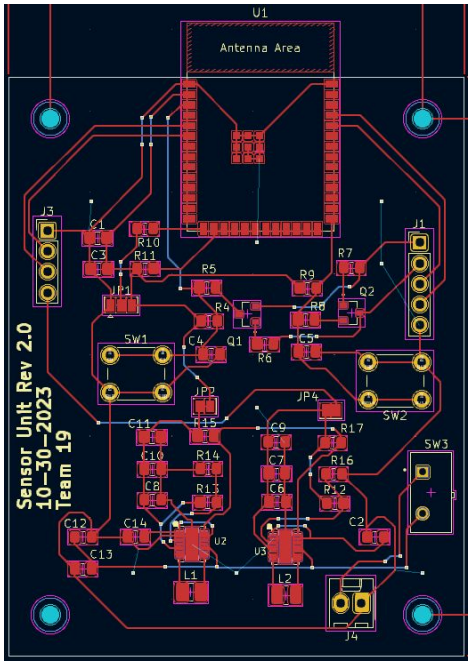


Hardware Design - Sensor Unit

Initial Layout and Routing

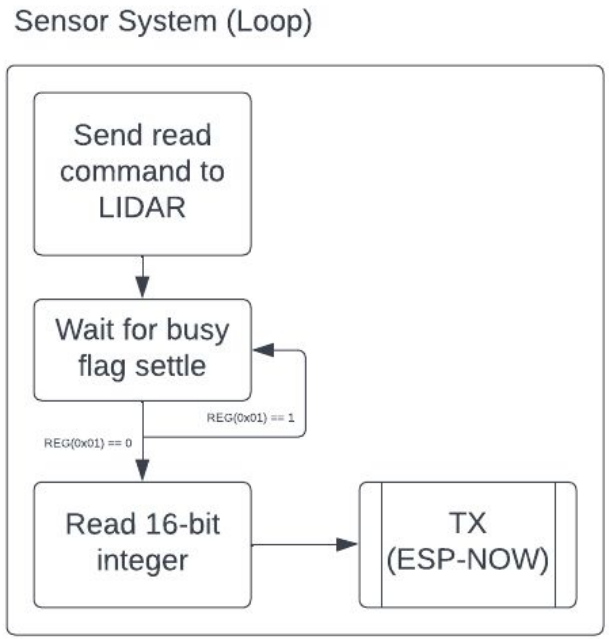


Final PCB Design

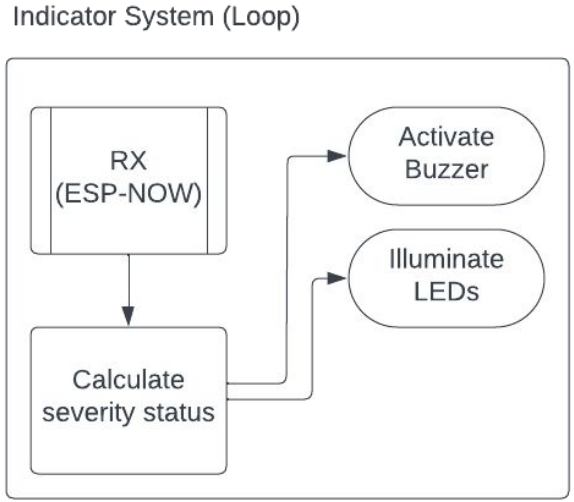


Software Design

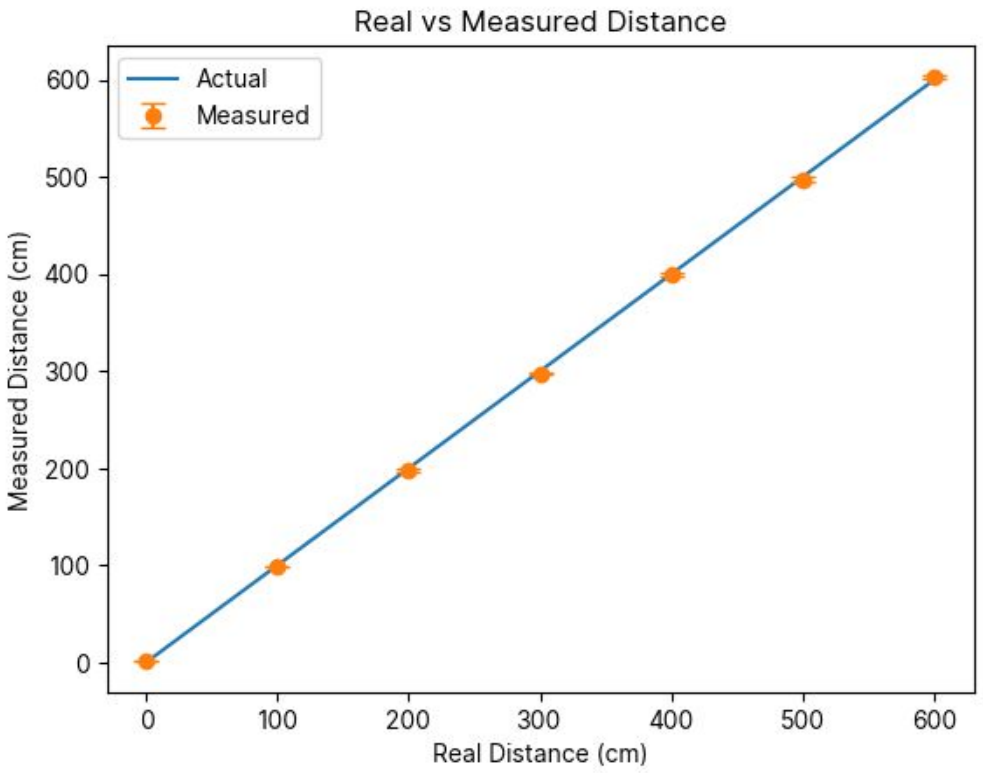
Sensor Unit



Indication Unit



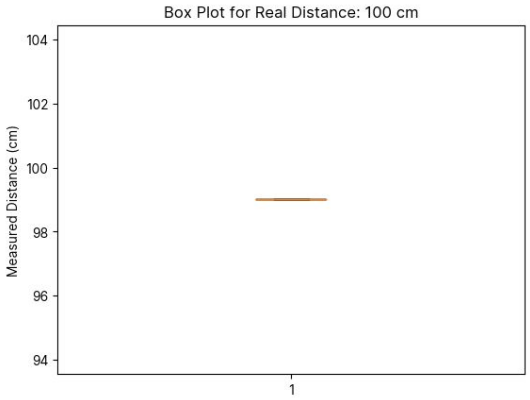
HLR: Sensing/Ranging

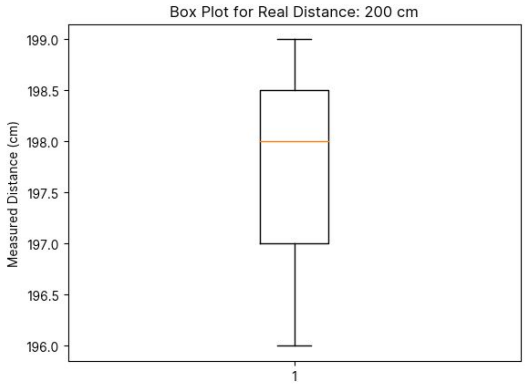


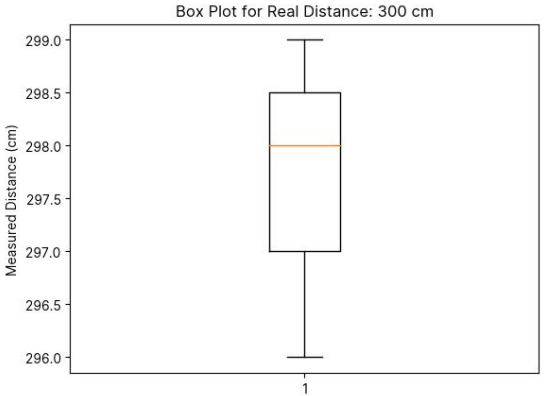
LIDAR Sensor Testing

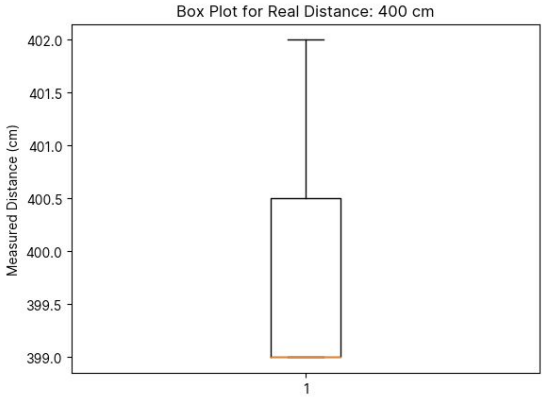
- **Fixed LIDAR ranging against static medium/high reflectivity targets**
  - ~ 80-90% reflectance
- Moved target to specified stop
- Read out measurements from LIDAR sensor via I2C
- Preliminary trials data
  - 3 trials at 7 distances
  - 0-600 cm
- Average Error: 1.66 cm

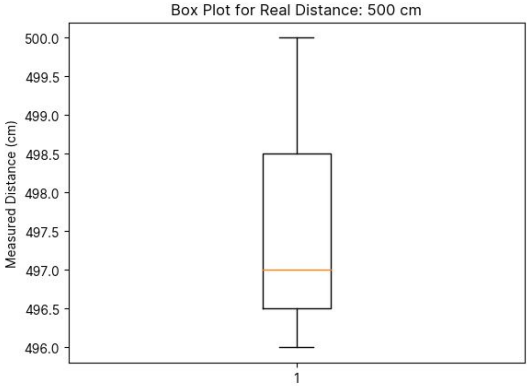
HLR: Sensing/Ranging (cont.)











HLR: Sensing/Ranging (cont.)

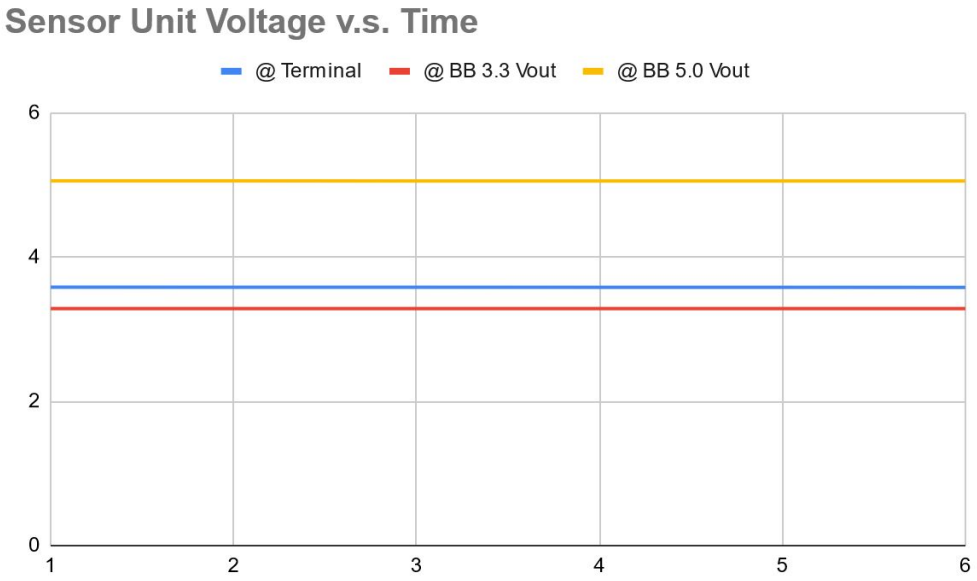
LIDAR Testing Results

- **LIDAR unit is extremely accurate from 0-7 meters**
  - ± 1 cm at all sub-seven meter ranges
- **LIDAR has problems at further distances**
  - Large variation and false positives
  - Up to ± 20 cm variation at 7-10 meter ranges
  - Periodic drops and spikes to high or low

HLR: Indication

Demo indication unit.

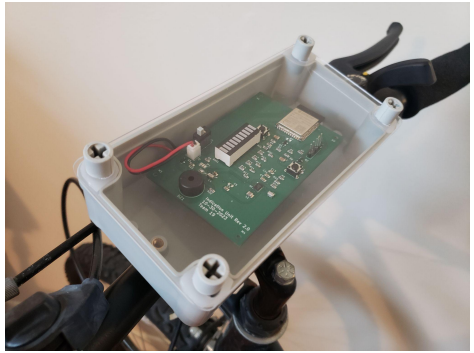
HLR: Power/Integrity

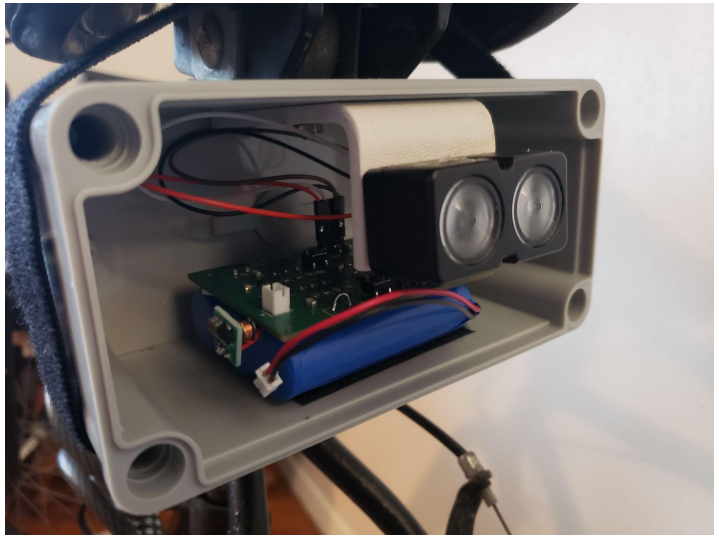


Battery Testing

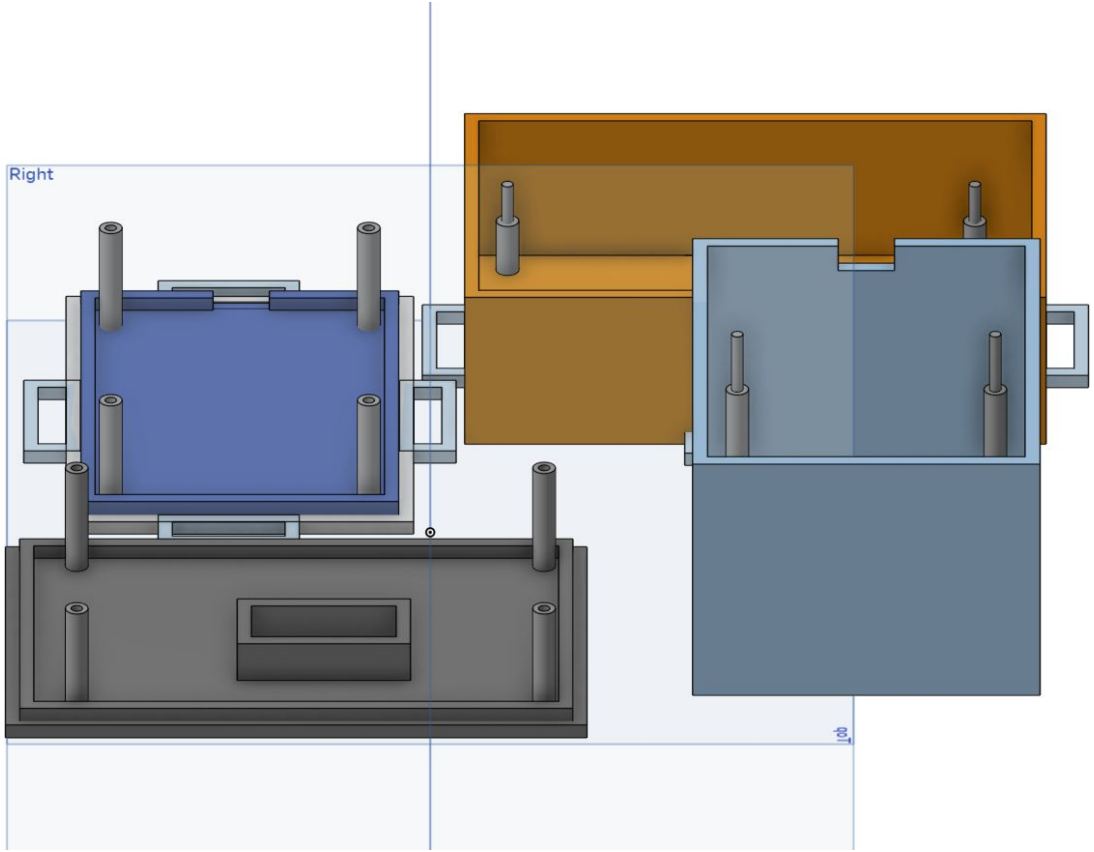
- **Realistic battery and power system testing**
- Ran sensor and indication systems in busy location (to simulate traffic)
- Measured battery and power systems hourly up to expected limit
- Performed in a low humidity, room temperature environment
- Measured using a Fluke 117, last calibrated 12/05/2022

Initial Enclosure Design and Installation





Custom Enclosure Design



Demonstration Video

Recap

Requirements

Sensing/Ranging

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Indication

- ✓ LEDs and a buzzer will alert the rider of hazards
- ✓ LEDs are bright enough to see clearly in all weather conditions
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Power/Integrity

- ✓ System functions on independent power
- — Outputs 5V and 3.3 V ± 5 %
- ✓ Supplied power lasts 6 hours while running full system

Issues

- On-board 5V power is not working
- UART bridge programming circuit has a critical design error

Issues – 5V Power

Issue

On-board 5V power system is dysfunctional.

- TPS630XX-derivative switching buck-boost converter
- Tested on three development boards
- 3/4 units failed immediately upon first power

Solution

Attach an external switching buck-boost converter on the board.

Unsatisfied Requirement(s)

Power/Integrity

- Outputs 5V and 3.3 V ± 5 %

Issues – UART Bridge

Issue

UART RTS/CTS line transistor placed incorrectly.

- SS8050 NPN transistor collector and emitter flipped on schematic
- RTS/CTS signal lines could not trigger ESP32 download mode

Solution

1. **Use manual programming buttons to get ESP32 into download boot mode.**
2. **Flip the transistor when soldering.**

Both solutions were implemented.

Unsatisfied Requirement(s)

None, technically.

Ideas for Improvement

- **More/Better LiDAR units**
  - Widen detection cone
  - Will improve coverage
  - ToF vs FMCW, different types of LiDAR
- **Sensor Fusion**
  - Ultrasonic, radar, camera
  - Can improve accuracy and coverage
- **Reduce indication unit size**
  - Reduced bulk for ergonomics and safety

Q & A

Thank you for listening!