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## MOTIVATION

**1 million** people in America experience blindness or low-vision conditions.

Only **20%** have tried adaptive recreational sports.

This team developed a **prototype ball** to enable people with blindness to play an adapted version of flag football.

Our variable **auditory** and **tactile** approach is a world first for blind sports, designed to signal the ball's location and state.

As the first true adaptation proposed to the NFL for blind participants, this project aims to advance inclusivity and accessibility in sports.

## REQUIREMENTS

### BEEPING

- Airborne state mode-switching
- Multi-module for audibility
- Hearing safety (SPL ≤85 dBA)

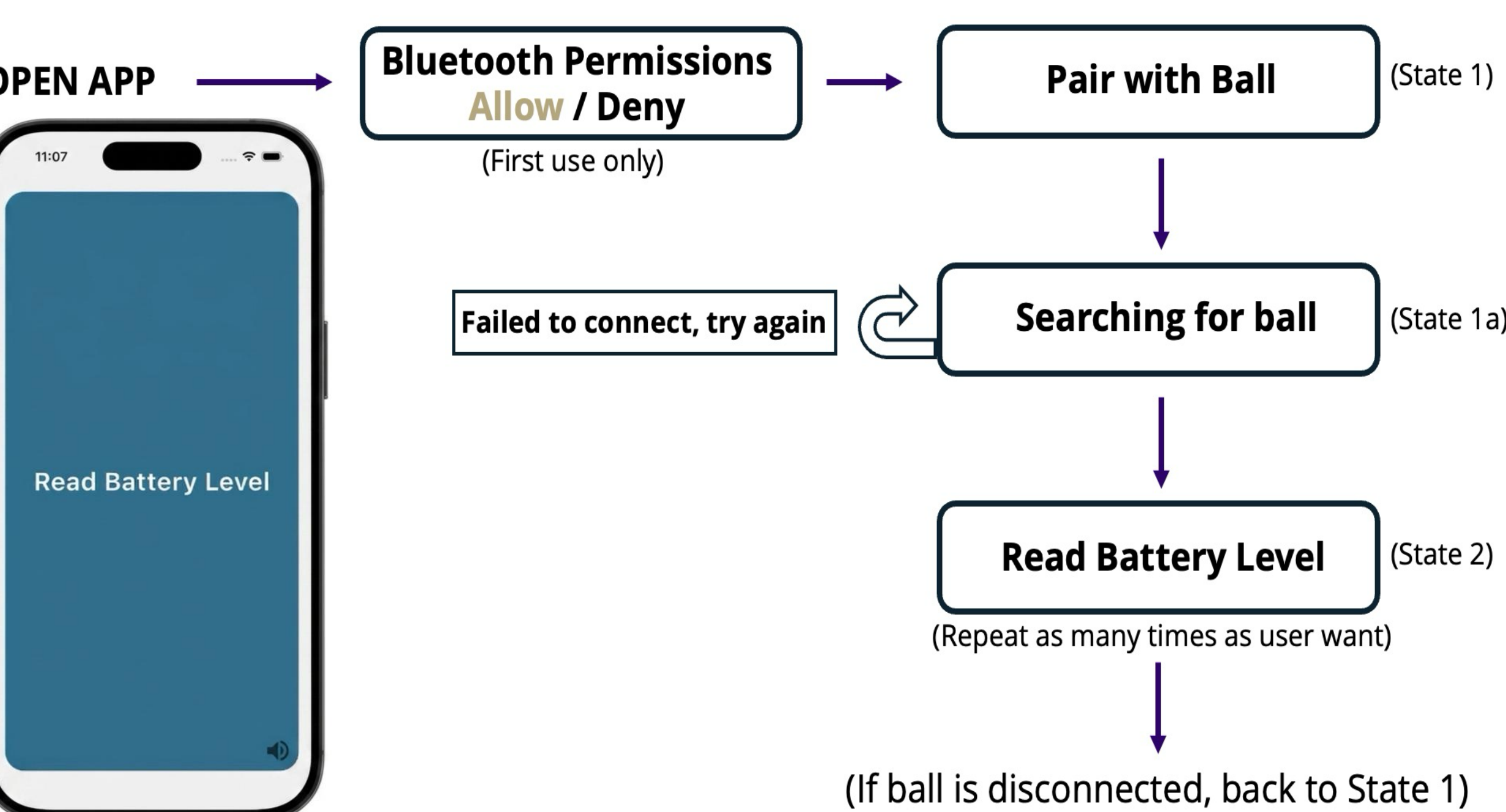
### HAPTICS

- Proximity-activated vibration
- Discernible feedback (150 - 300 Hz)

### CHARGING

- Battery safety
- Accessible on/off switch
- Battery status on mobile device

### BALL CHARGING MOBILE APP



## DESIGN & IMPLEMENTATION

### Integration:

The system components are integrated with the Raspberry Pi Pico 2W and a custom PCB board, enabling programming of complex features

### Airborne Mode-Switching:

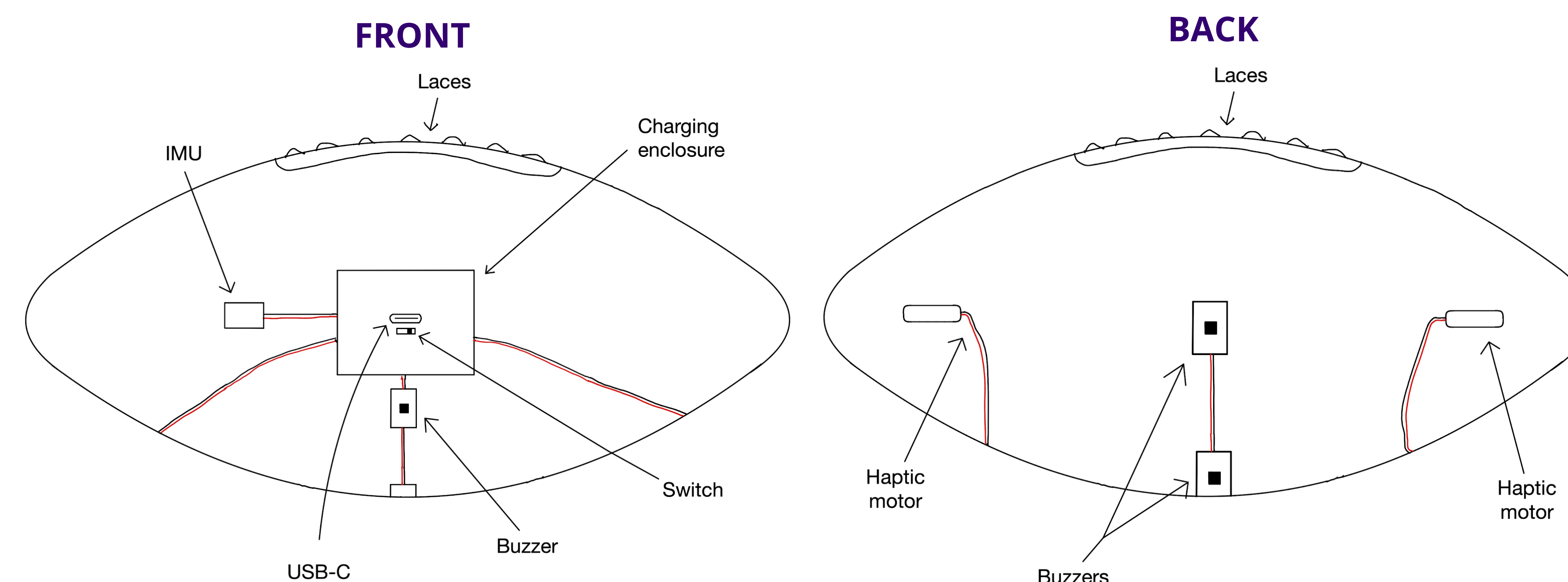
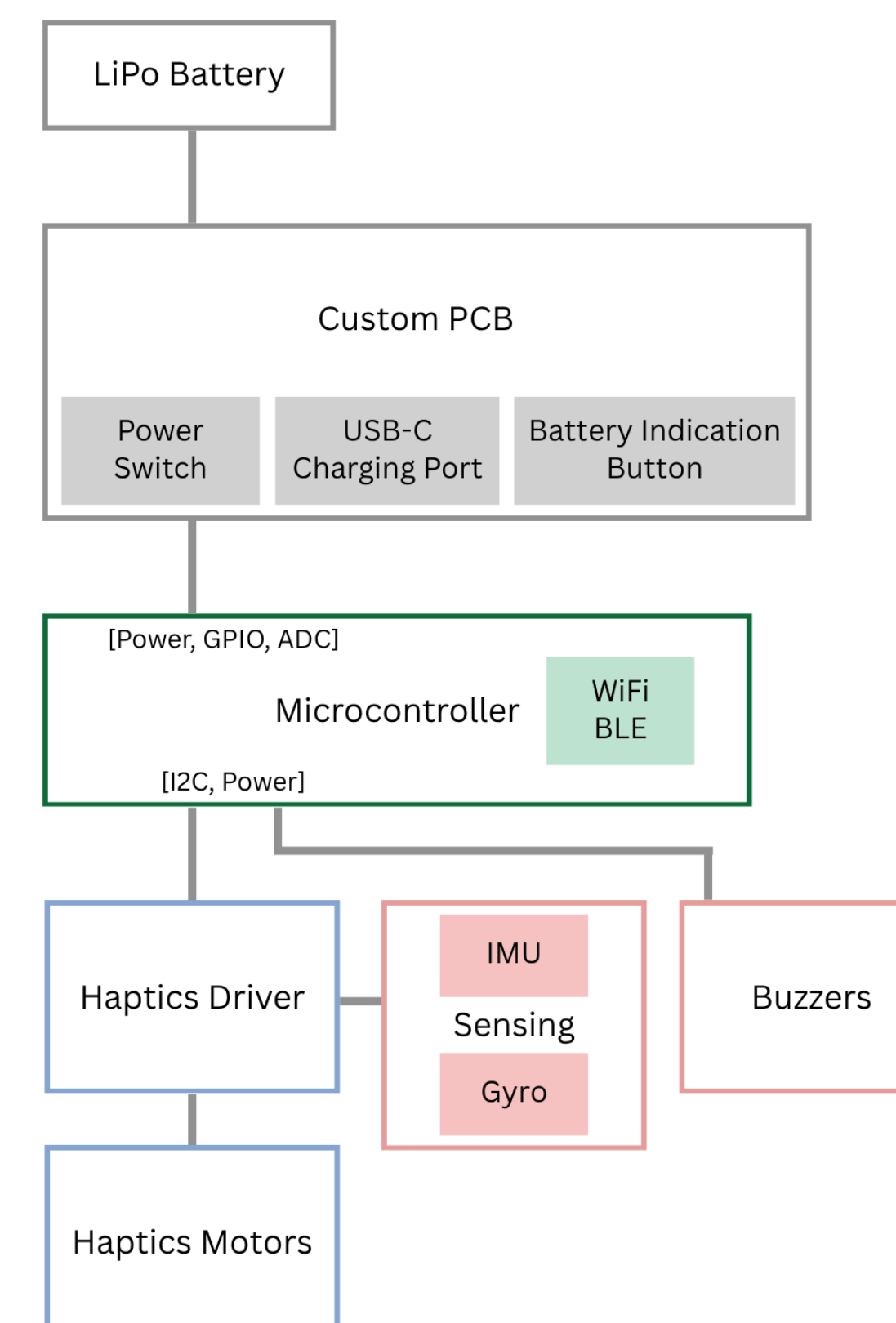
- Emits low-frequency drone when grounded and high-frequency pulse beeping when airborne with the Modulino Buzzer
- Detects airborne state using calibrated transition points for acceleration and angular velocity magnitudes via Modulino Movement

### Proximity Detection:

- Uses blue-tooth signal attenuation (BLE RSSI) to detect distance between ball and field element (end zone, out of bounds, etc.)
- Haptic vibrations begin within 10 meters and frequency increases with proximity

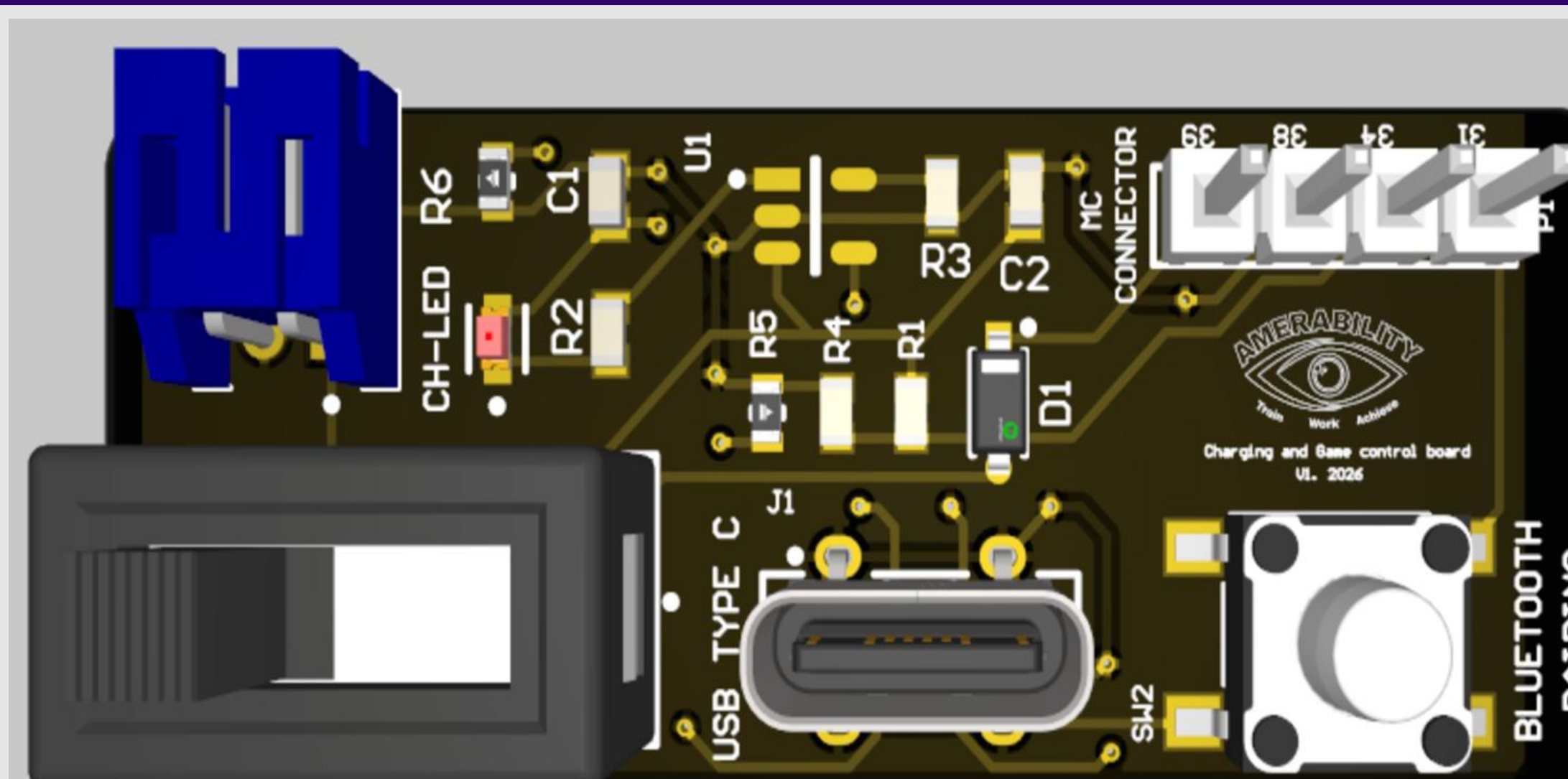
### Battery Indication:

- The battery level of the ball is sampled with ADC measurements and displayed on a paired accessible app interface



### CUSTOM CHARGING CIRCUIT

- POWER SWITCH
- USB-C CONNECTOR
- BLUETOOTH PAIRING BUTTON
- MC CONNECTOR
- LED INDICATOR
- JST CONNECTOR



## RESULTS

- Incorporated user feedback on integral features, haptic & sound thresholds, and switch accessibility



Mode-switching had false-positive and false-negative triggers

Resolved with time-based debouncing and calibrating thresholds for the 6-axis IMU

Trial testing shows **98%** accuracy for airborne mode-switching

Distance sensing options with varying precision and accuracy: Wi-Fi vs. BLE, RSSI vs. ToF

Tested and validated BLE RSSI with time-averaging for precision and calibration for accuracy

Trial testing shows **± 1m** accuracy for distance sensing

## CONCLUSION & FUTURE WORK

Our haptic-enabled football creates a path for blind athletes to play adapted NFL Flag Football. By implementing variable auditory and tactile feedback, this multi-year project lays a scalable foundation for future league and recreational play.

**Year 1** ✓  
**Prototype Ball**

### Year 2

- Field elements: end zone, boundaries
- Work with NFL for deployment
- Manufacture pocket inside the ball

### Year 3

- Player elements: wearables
- App development: Additional features
- Durability Field Testing

