Skier's Help Information Tracker

ECE 445

Team 52

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Introduction

- Jack Bay: Electrical Engineer – Hardware
  - Responsibilities: PCB Design, Power Subsystem

- Ryder Heit: Computer Engineer - Firmware
  - Responsibilities: Collection and Storage Subsystems

- Sam Knight: Computer Engineer – Software
  - Responsibilities: Processing Subsystem

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Problem Description

- Slalom skiing is broken up into "passes"
- A skier typically takes 6 passes in a practice
- The skier needs to go through the entrance and exit gates, and around each outside buoy for a pass to count
- To earn a higher score, skier can shorten the rope from the standard 75ft, or speed up the boat to a maximum of 36mph
- The pass is always the same and looks like the diagram on the right

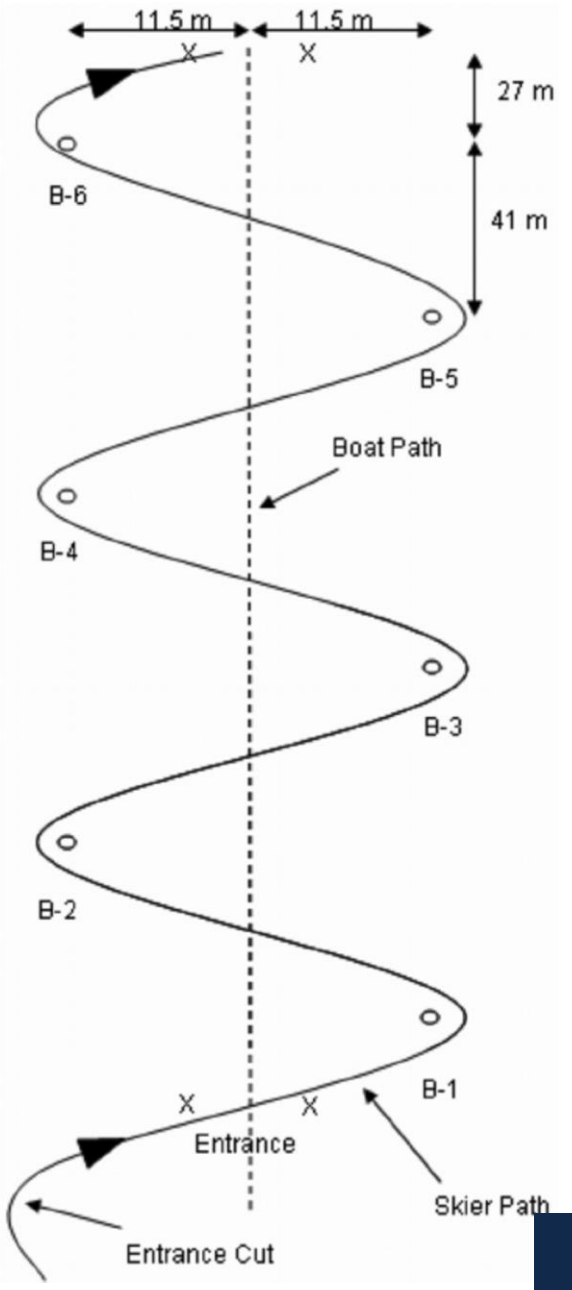

Figure 1: Slalom Course

Problem Statement

- Slalom skiers require precise feedback to improve their skiing technique

- The most common way to get this feedback is via video playback, but this does not supply a detailed analysis

- Waterski coaches are both hard to find and expensive

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Solution Statement

- Utilize sensors to acquire quantitative data
- Analyze the data on an external computer
- This device will be:
    - Easy to attach
    - Easy to use
    - Low cost – much more affordable than ski coaching

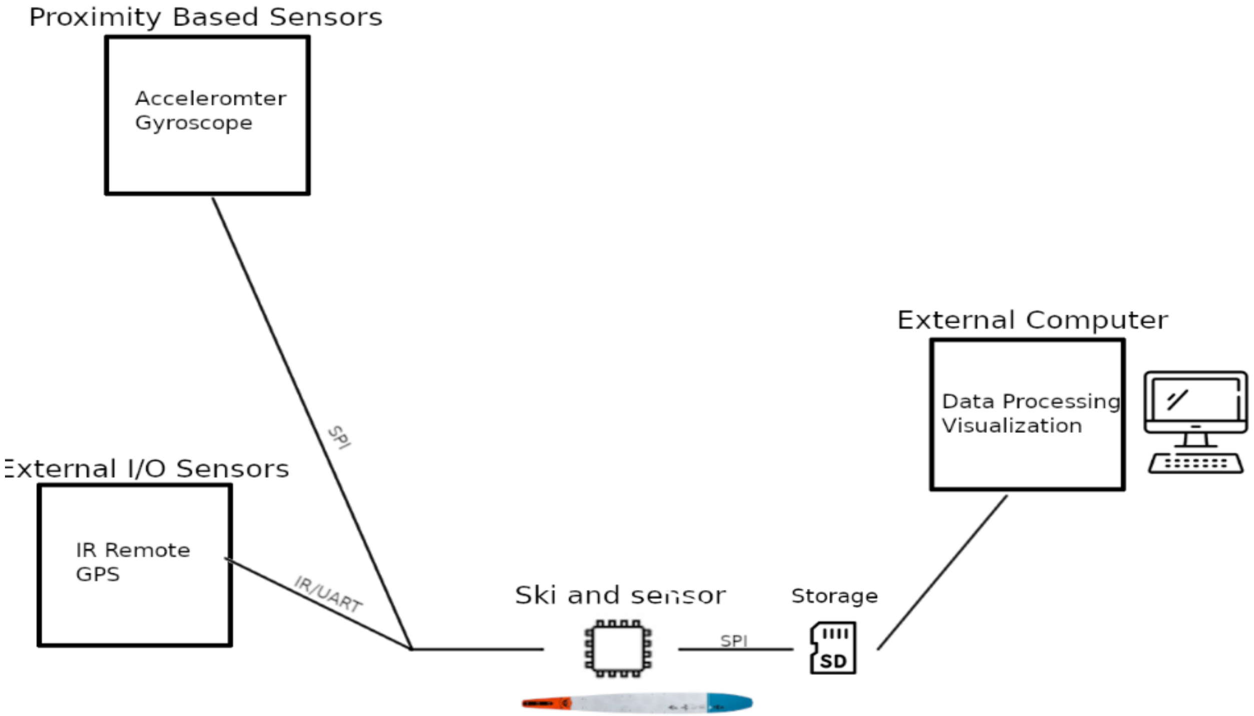

Figure 2: High Level Design

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Brief Review of Original Design

- Power, Storage, and Collection all on PCB
- Processing done on separate computer

Figure 3: Slalom Ski

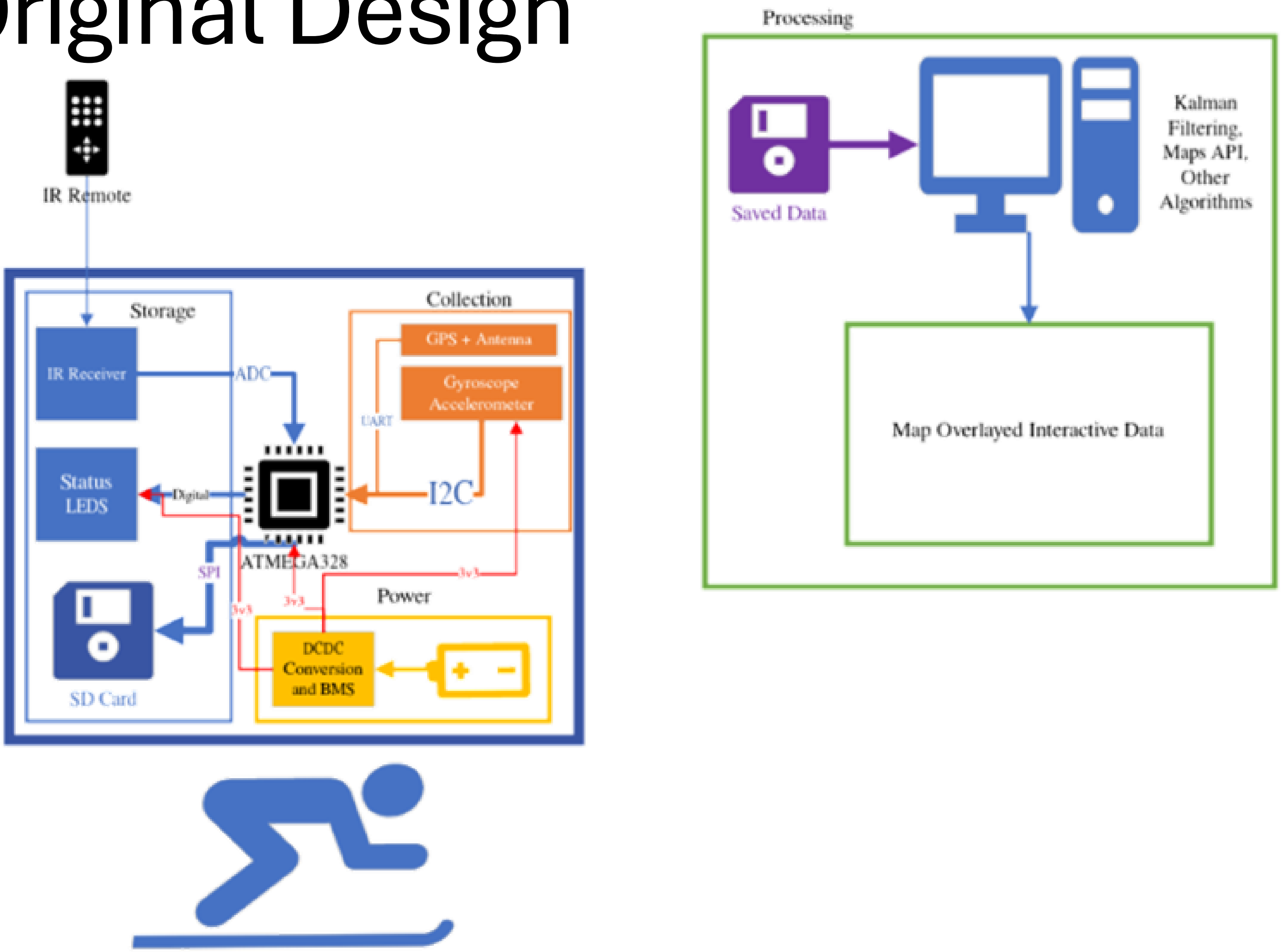

Figure 4: Device Block Diagram

Power Subsystem

- Requirements:
  - Battery will last for at least 2 hours
  - All components be supplied with 3.3 VDC (+/- 0.1 V) and a maximum of 1.5 A of current
- Verification:
  - Monitor status LEDs over 2 hours of device usage (PASSED)
  - Confirm that correct voltage is supplied across test loads using multimeter (PASSED)
- Changes Made:
  - Battery voltage changed from 3.7V to 6V to account for regulator head-room

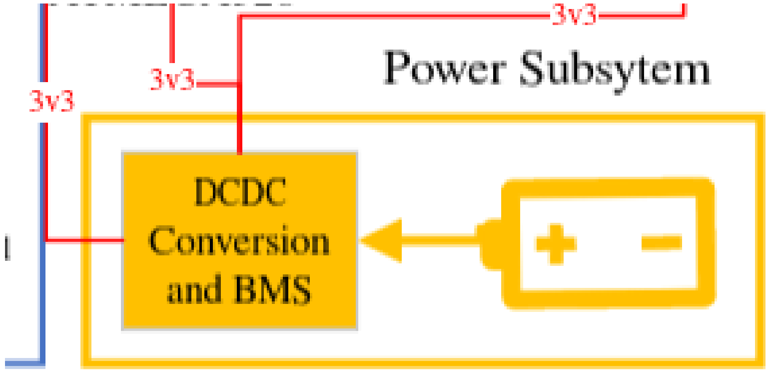

Figure 5: Power Subsystem Blocks

Collection Subsystem

- Requirements:
  - MCU must process data at 10Hz to match sensors
  - Ability to save ‘calibration data’
- Verification:
  - GPS clock and system timer verify data is being correctly polled (PASSED)
  - SD card correctly populated after multiple runs (PASSED)
- Changes Made:
  - Changed to STM32 chip from ATMEGA for better performance and more pins

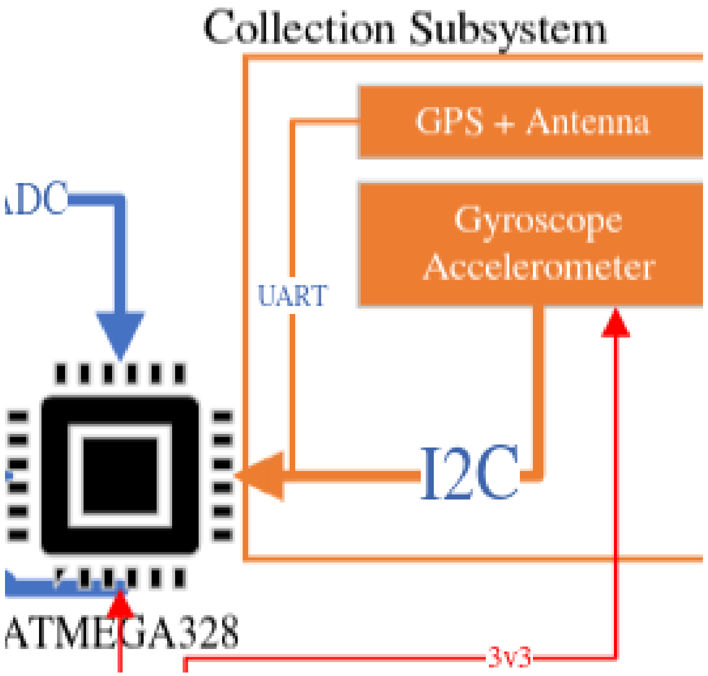

Figure 6: Collection Subsystem Blocks

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Storage Subsystem

- Requirements:
  - IR receiver and remote will have multiple functions
  - SD Card will store up to 10 full passes
  - Status LEDs will show all device states
- Verification:
  - The IR remote will be used to cycle through all modes of operation (FAILED)
  - 10 full passes will be recorded during test runs (PASSED)
- Changes Made:
  - Switched to button for starting and stopping passes

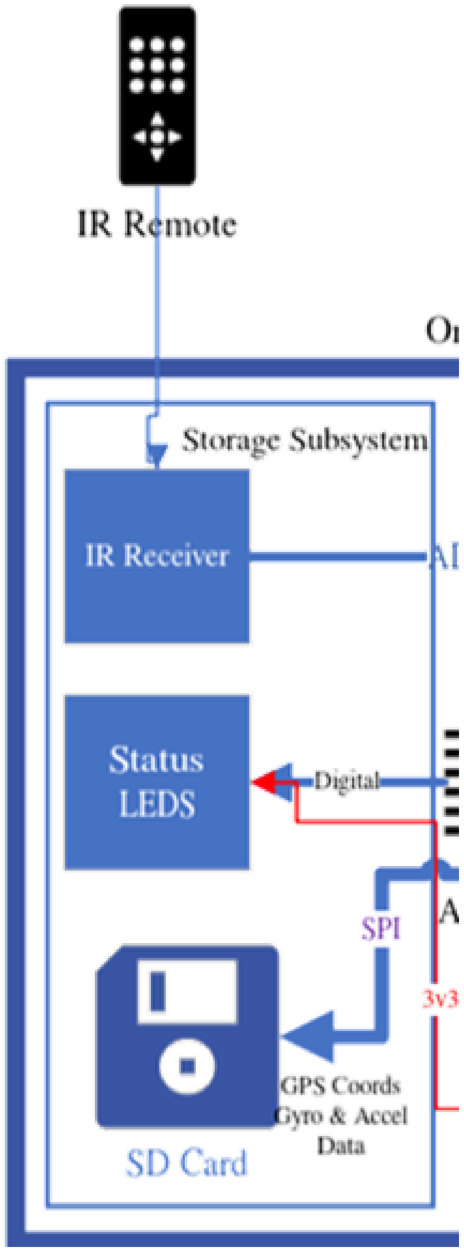

Figure 7: Storage Subsystem Blocks

Processing Subsystem

- Requirements:
  - Reduce data noise and improve accuracy using filtering
  - Create live satellite map display of skier location during the run
  - Display all data side-by-side for comparison
- Verification:
  - Compare data accuracy pre and post filtering (PASSED)
  - Display all collected data points on a map (PASSED)
  - Display imported data on GUI tool (PASSED)
- Changes Made:
  - Moved from OpenCV and Pillow writers to FFmpeg for all animations
  - Swapped small box car window for large Hamming window

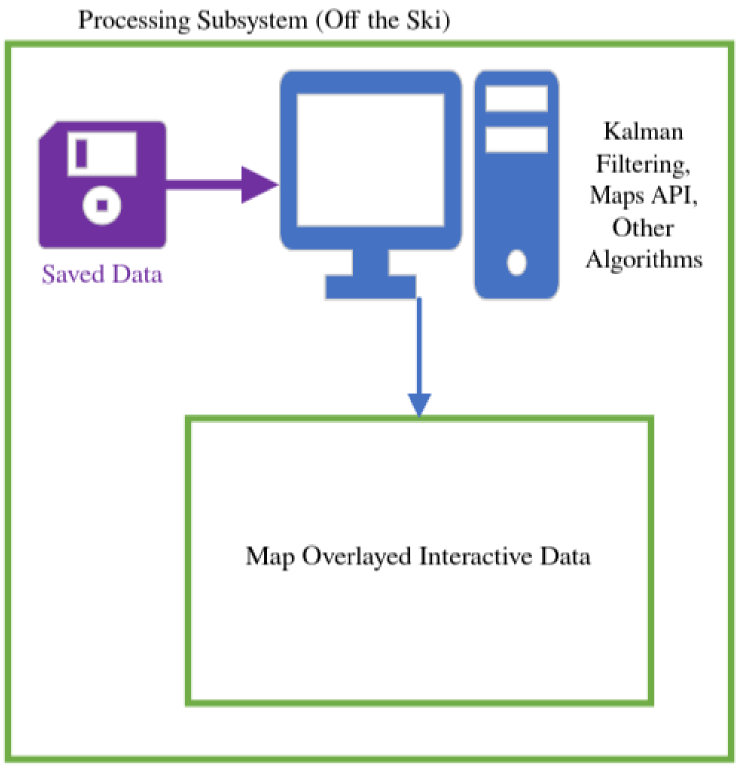

Figure 8: Processing Subsystem Blocks

PCB Schematic

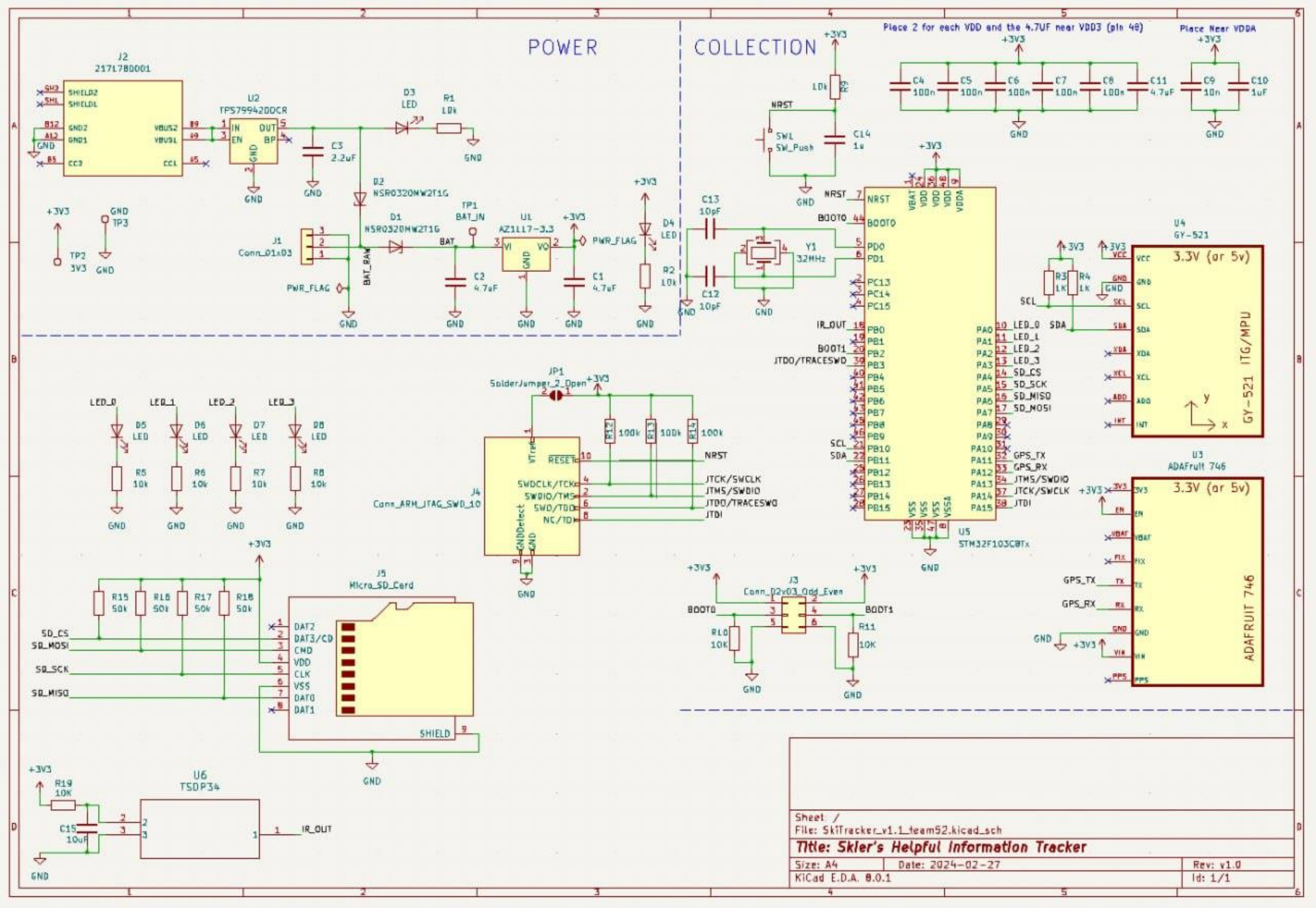

Figure 9: PCB Schematic

PCB Layout

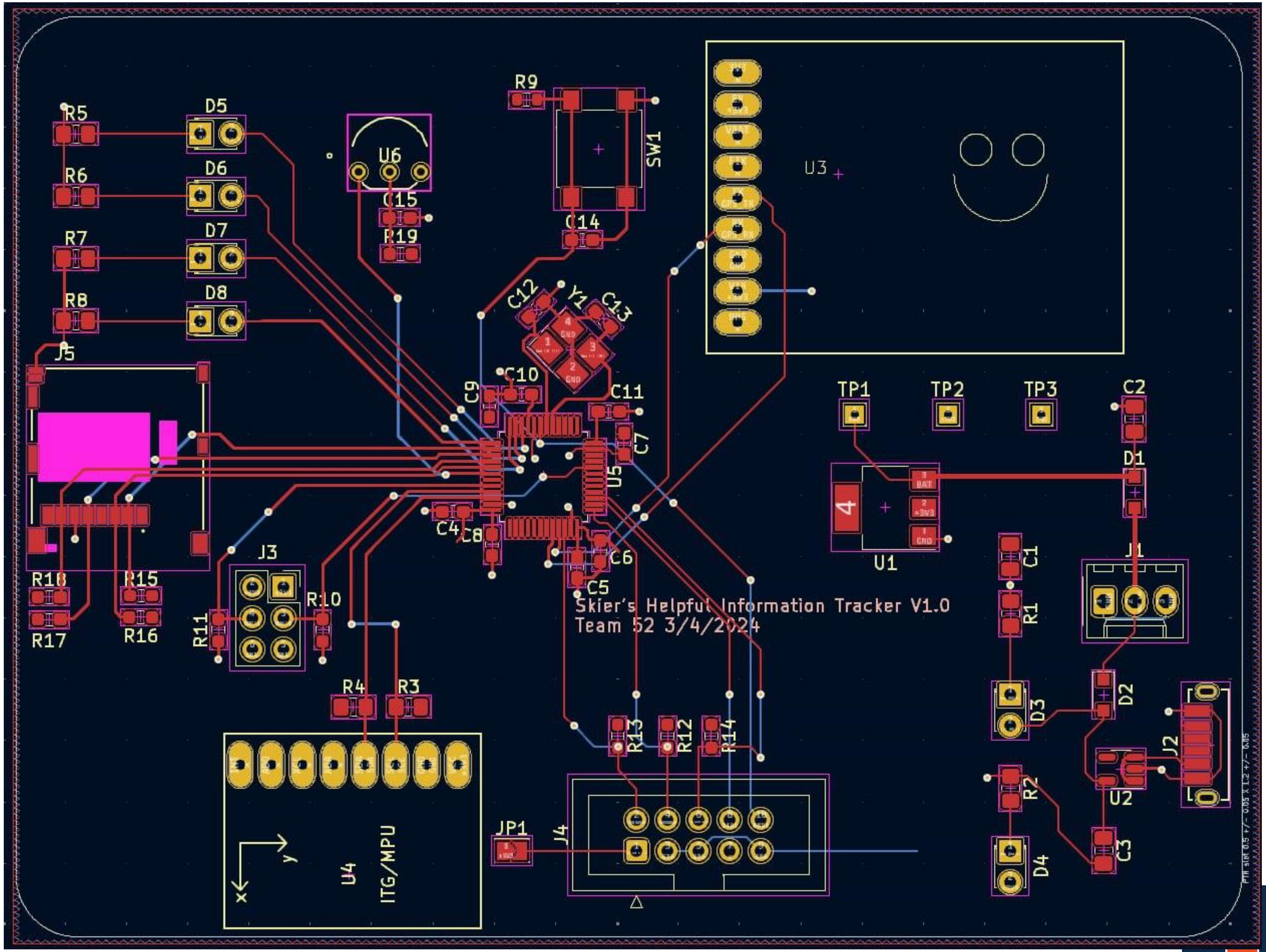

Figure 10: PCB Layout

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Firmware

- Programmed using the HAL library for the STM32 MCU family
- Used i2c to gather data from Gyroscope and UART Interrupts for GPS data
- Data was then written to the SD Card using the SPI protocol

Figure 11: STM family MCU

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Waterproofing

- Waterproof box provided by machine shop
- Utilizes silicon buffer and screws to keep box water-tight
- Passed initial waterproofness tests

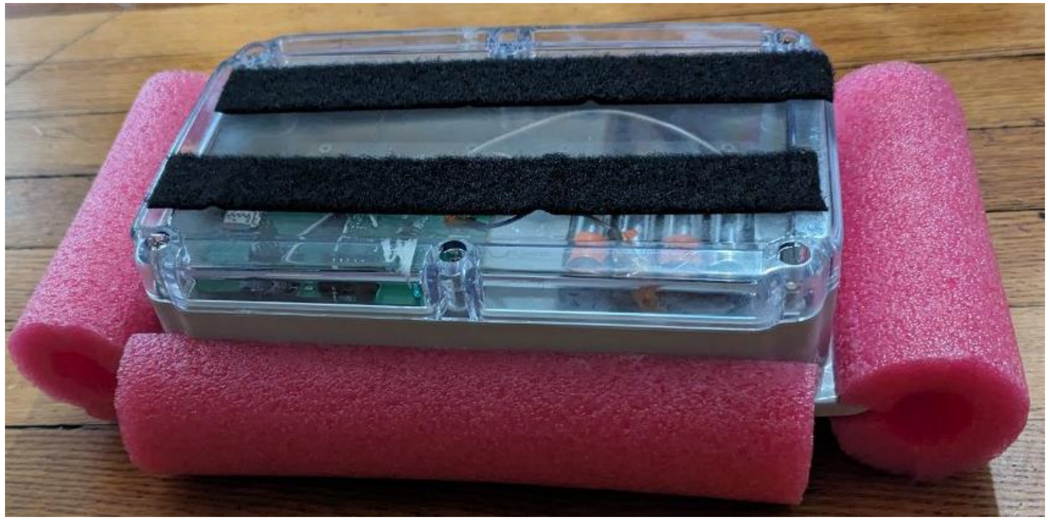

Figure 12: Waterproof Box Side View

Figure 13: Waterproofness Validation

Figure 14: Waterproof Box Top Down

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Project Build

Figure 15: Top-Down Mount on Ski

Figure 16: Side View Box and Ski

Figure 17: Completed Open Box Build

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Device Operation

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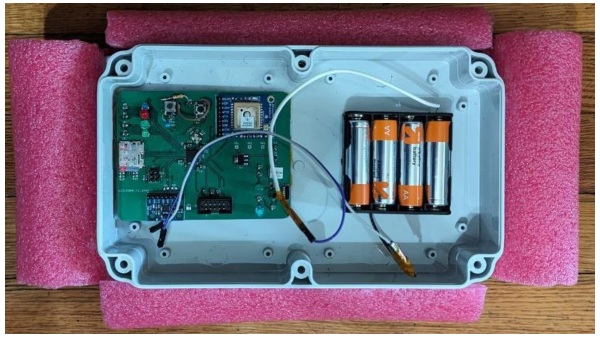

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Functional Test

- Weather was not fit for skiing (too cold), so we had to improvise
- Bicycle acts as ski
- State Farm Center parking lot acts as lake
- Marked out course and ‘slalomed’ around it on the bicycle with device attached to front handlebars

Figure 18: Bicycle "Slalom Run"

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Functional Test Results

- Device powers on and runs through states of operation
- Successfully recorded data on SD card
- Successfullv visualized data in GUI

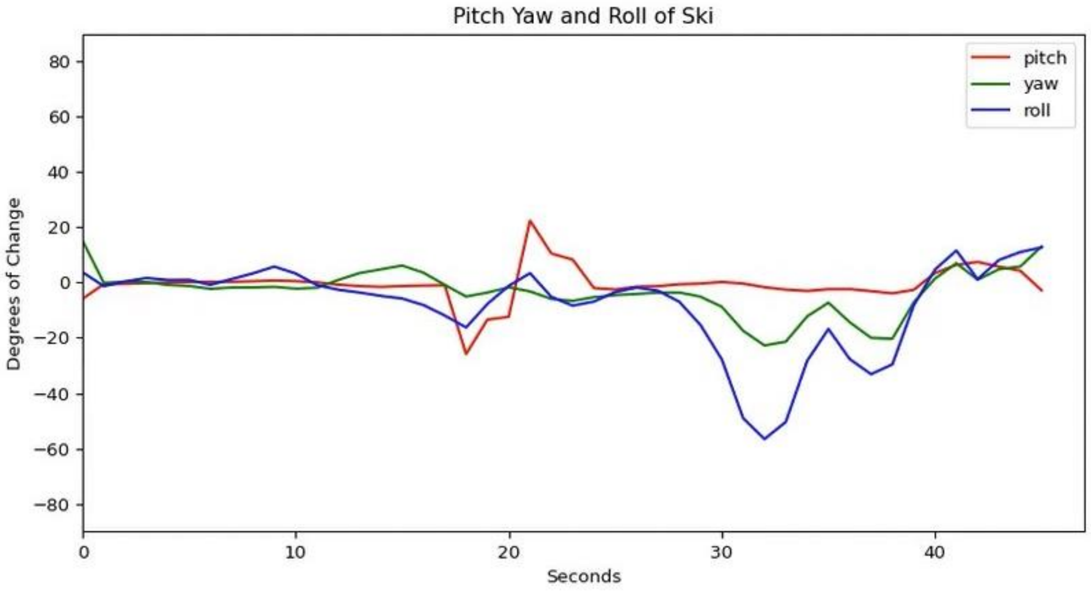

Figure 19: Mock Run Pitch/Yaw/Roll

Figure 20: Bicycle "Slalom Run" Map

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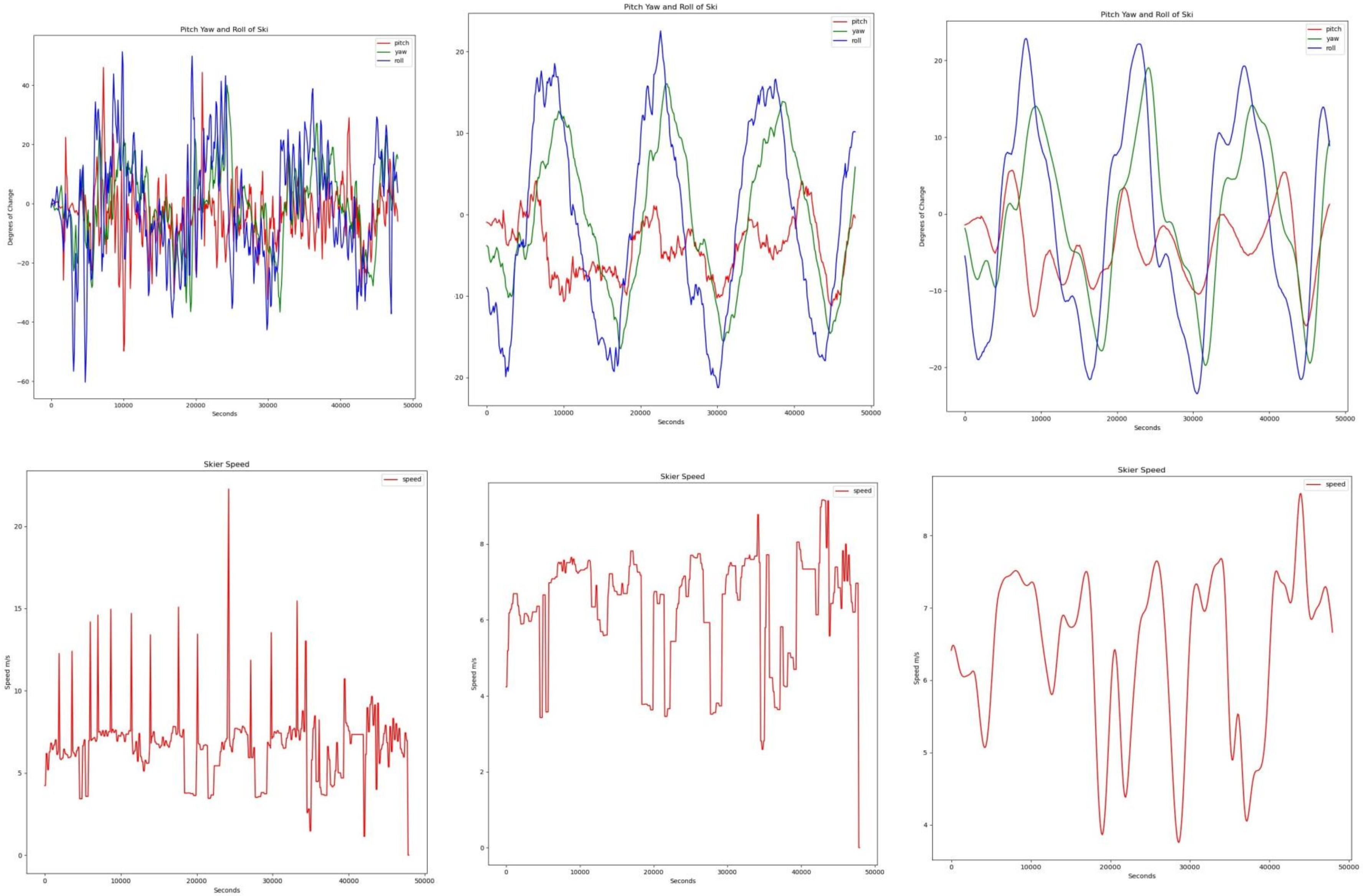
Data Processing

Figure 21: Data Smoothing Progression



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Data Visualization

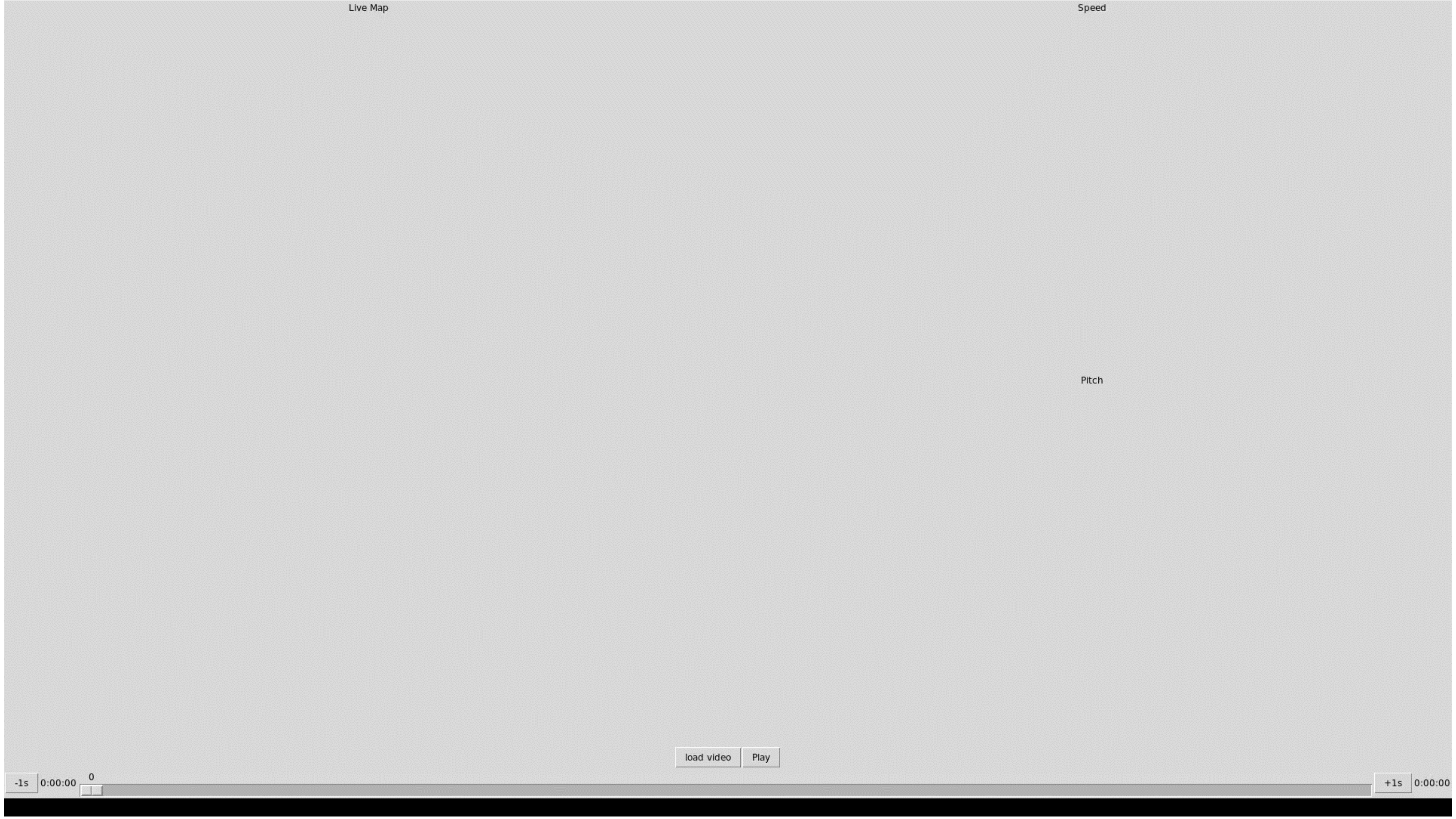

Figure 22: GUI Tool Showing Data in Sync

Data Visualization Smoothed

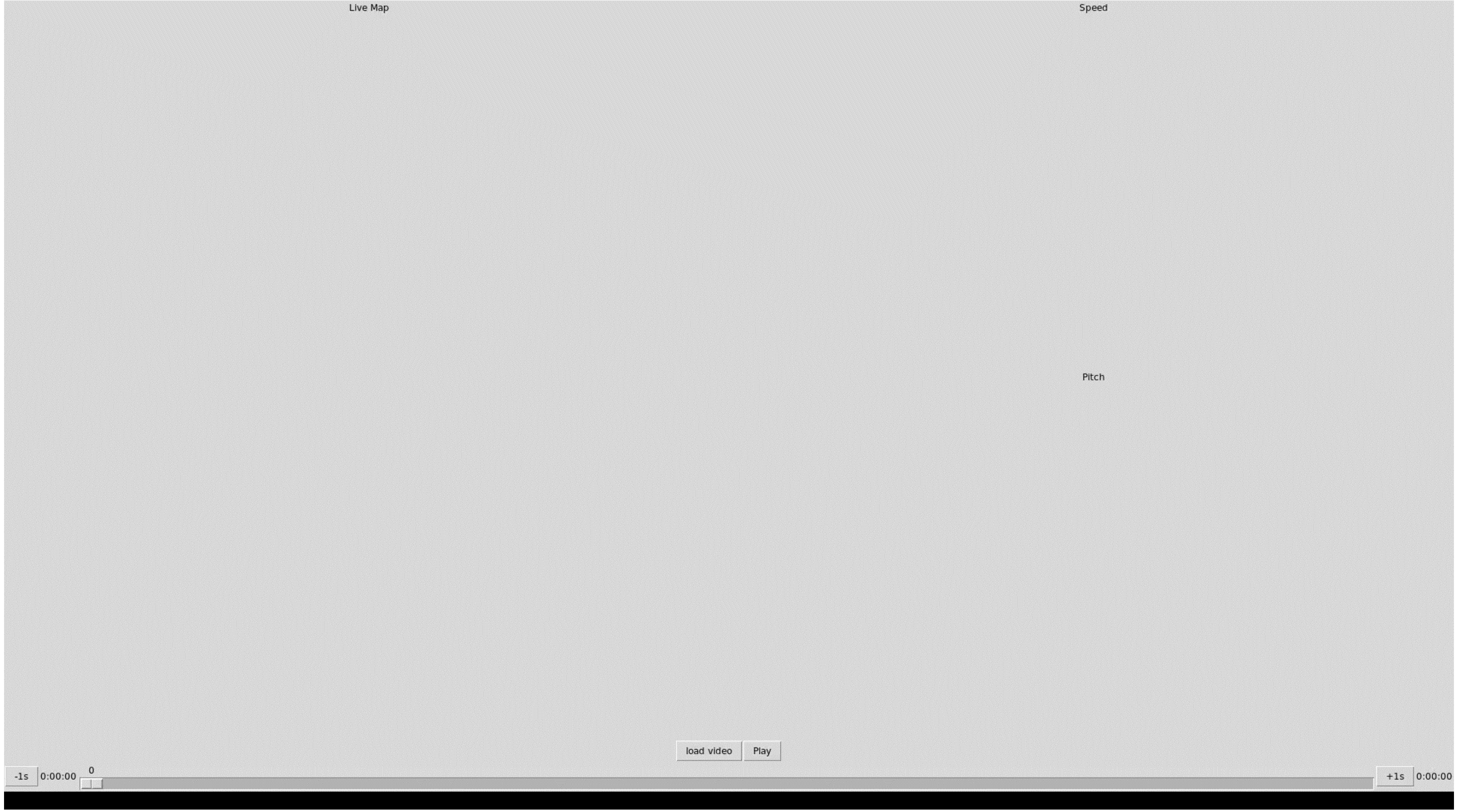

Figure 23: GUI Tool Showing Smoothed Data in Sync

Successes

- Waterproof case is incredibly waterproof and securely mounts to ski without any issues
- Power subsystem delivers power past desired usage duration
- Collection subsystem links together relevant data before passing to storage system
- Storage subsystem writes data streams in real-time
- Processing subsystem accurately displays taken data
  - GUI plays videos in sync and provide valuable feedback on the run

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Challenges

- Board orders came in late
- Data was initially very noisy
- GPS is not very accurate
- Mounting security was difficult due to the high turbulence of skiing

Failed Verifications

- IR Receiver did not work the way we intended
  - Polling rate was too high for the MCU
    - Not enough time remaining to order a replacement part
  - Instead, used a button on the PCB

Conclusions

- Results, while having accuracy concerns, are useful
- Data collection operates smoothly
- Visualization process integrates collected data seamlessly
- Overall, the cost and usefulness of the device renders it a success!

Further Study

- Replace GPS with RTK system
  - Improves location accuracy
  - RTK already used at many tournament water ski courses
- Increase Polling Rate
  - Greatly increases smoothness of data
  - Gather more data
  - Use external oscillator correctly
- Add screen for better visibility

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Questions?