BASE STATION SYSTEM FOR TRACKING POWDER VALLEY NATURE CENTER COPPERHEAD SNAKES

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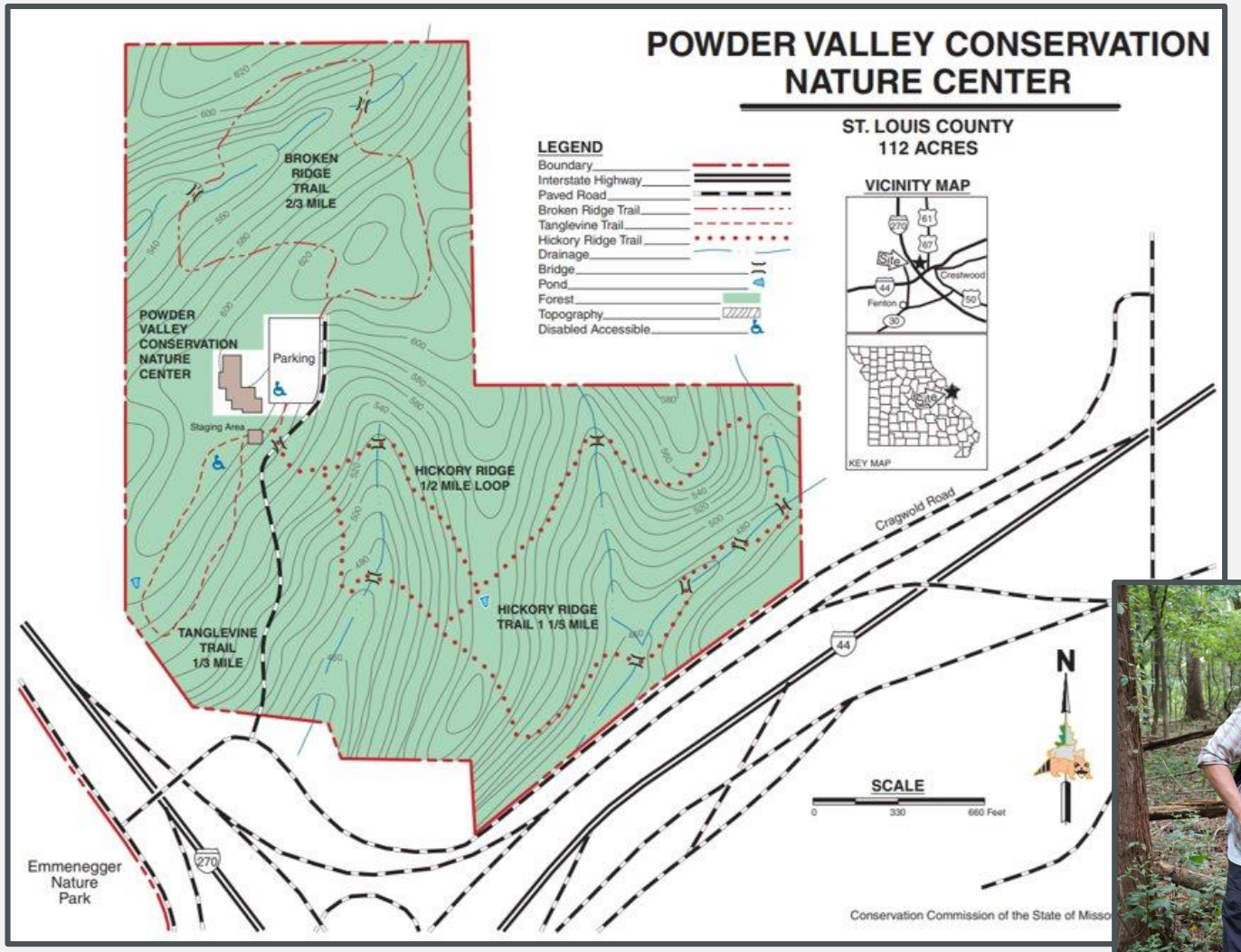
PRESENTATION OUTLINE

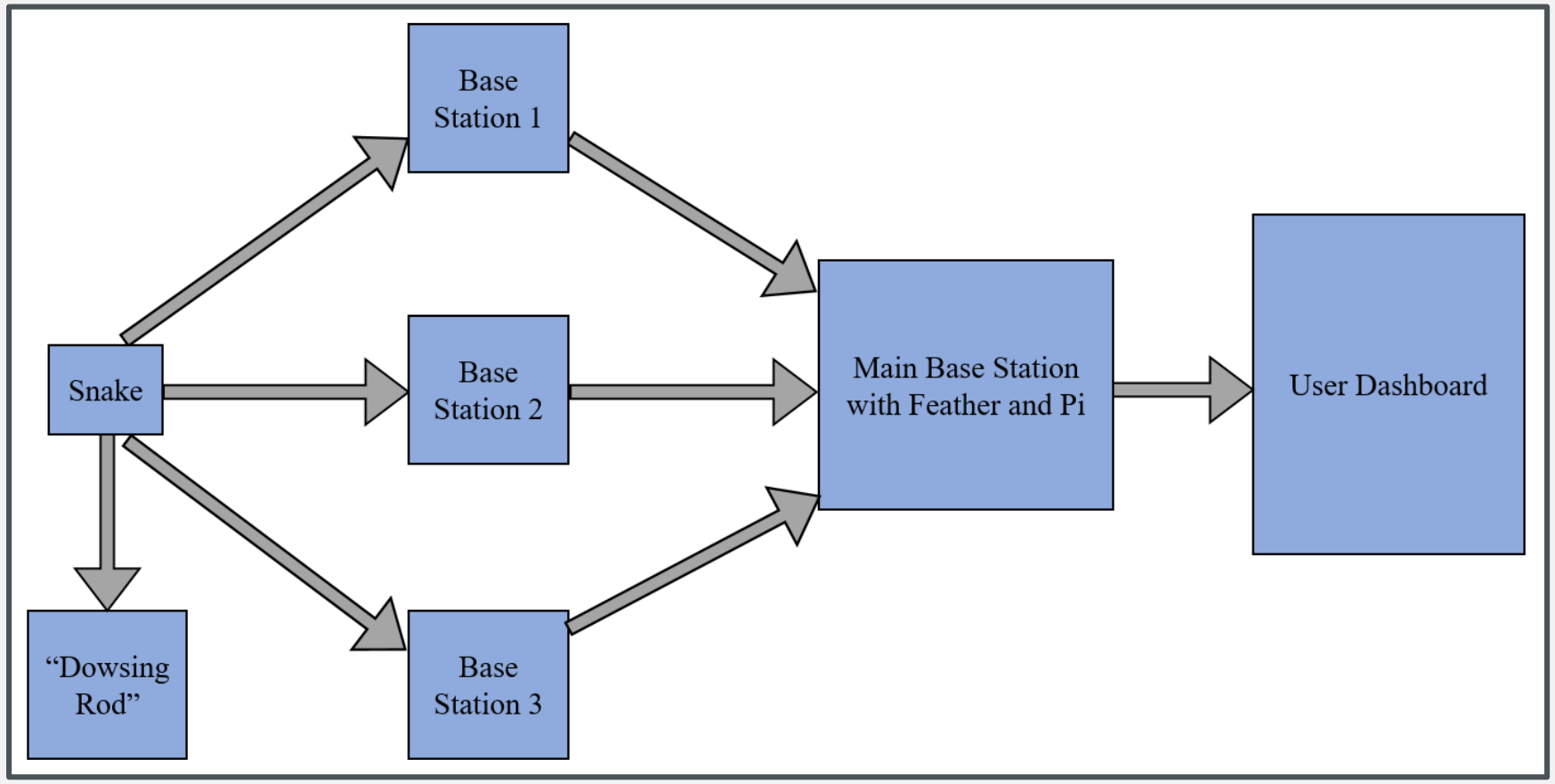
- Background Information
- Project Objectives
- Technical Approach
- Code Logic
- Testing
- Results
- Future Studies

Background Information

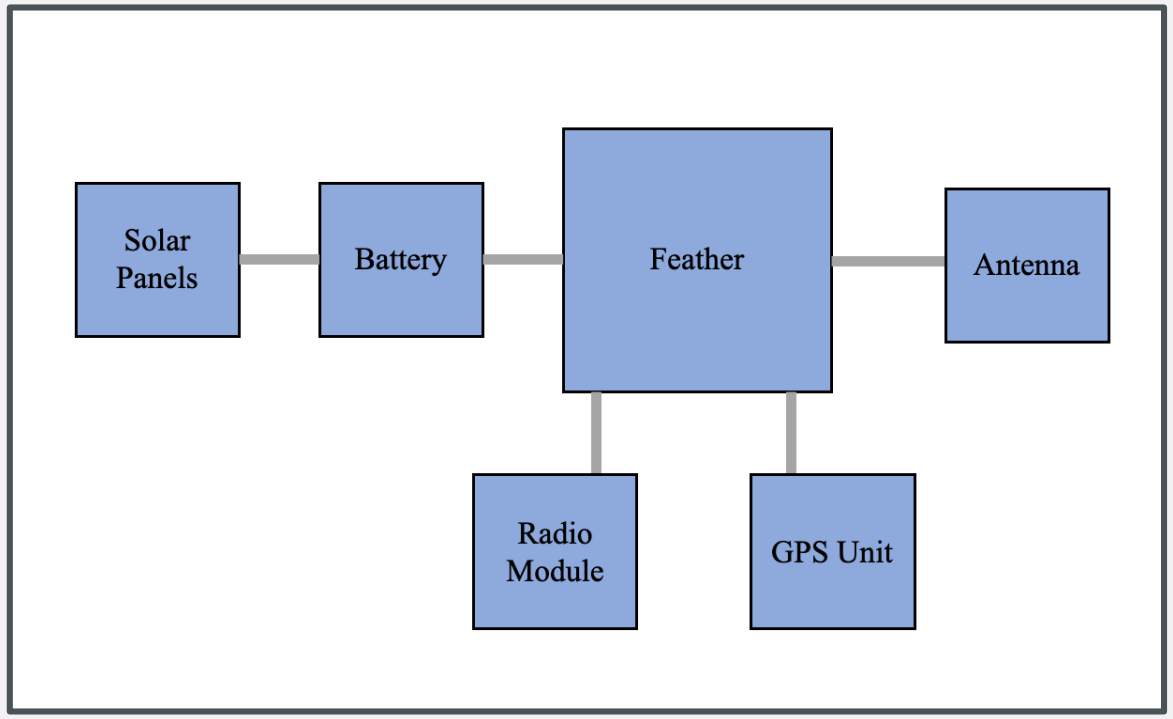


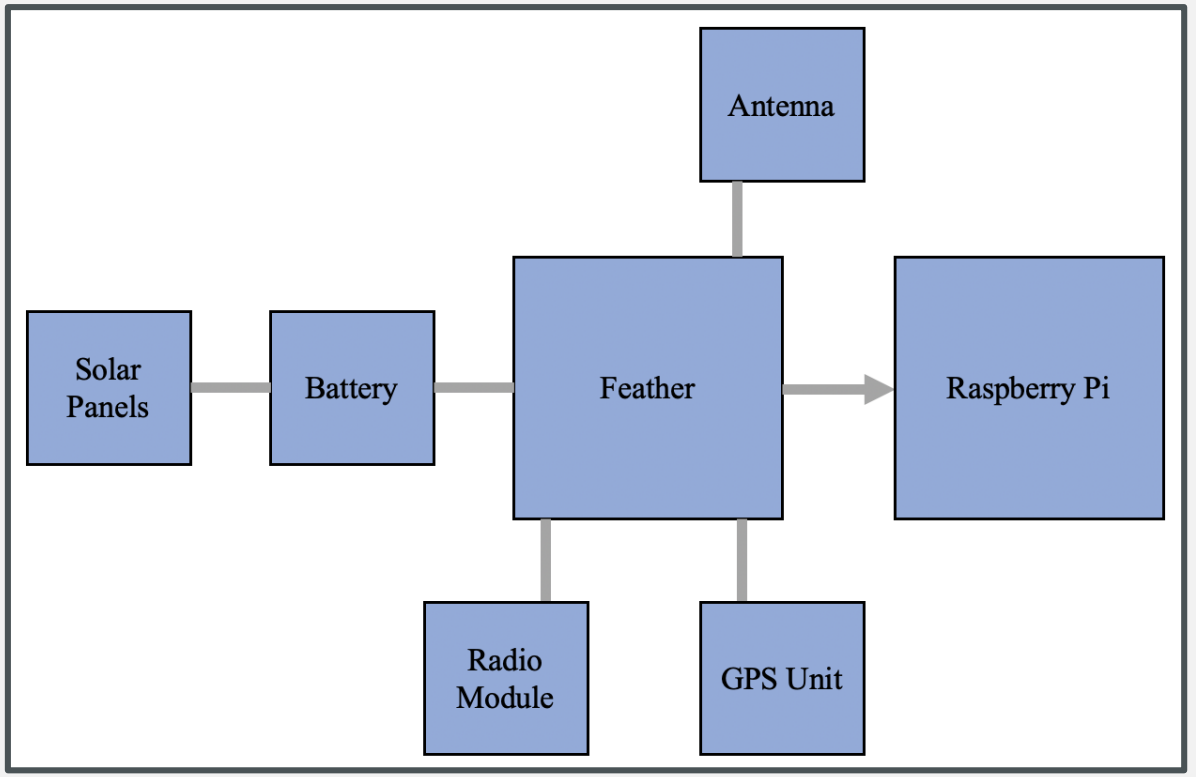
Project Objectives and Overall Technical Approach

Our goal was to design and implement a system that calculates the coordinates of an implantable tracking device. Specifically, we aimed to track an implant that does not contain a GPS unit.



Base Station Block Diagrams





Base Station Code Logic (Arduino Level)

General Operation

- Transmitter Data
  - Snake ID, Sequence ID, Ping ID, Temperature, Voltage
- Base station Receives Message (passive listening)
- Base station appends GPS data (location, timestamp)
- Base station forwards complete packet to main station
- Results are sent via serial to Raspberry Pi
- Raspberry Pi runs algorithm

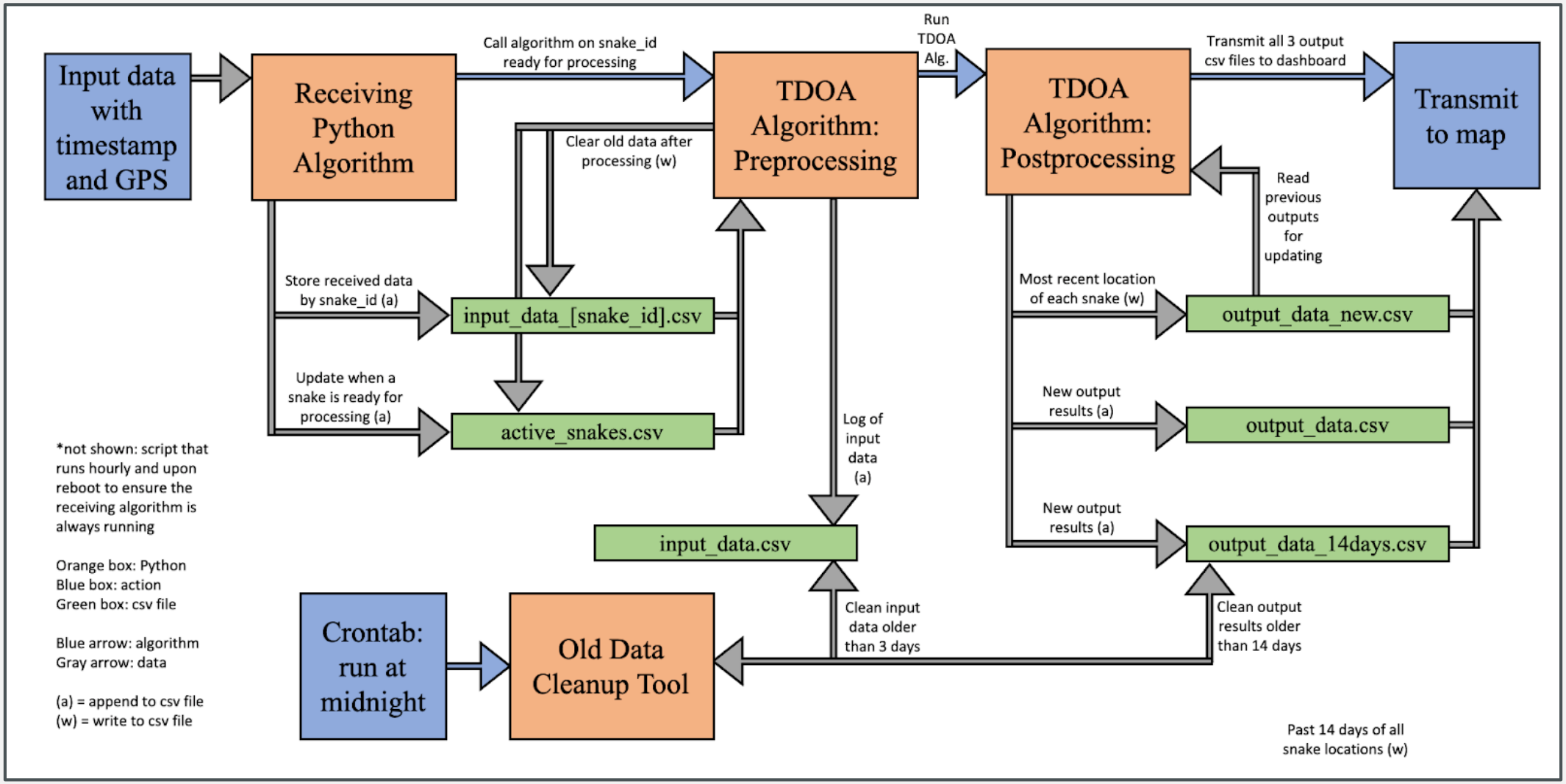
Timing and Locating

- GPS data acquisition (10 Hz)
- Storage of most recent data
- Extrapolating milliseconds (last received GPS time and Arduino clock)

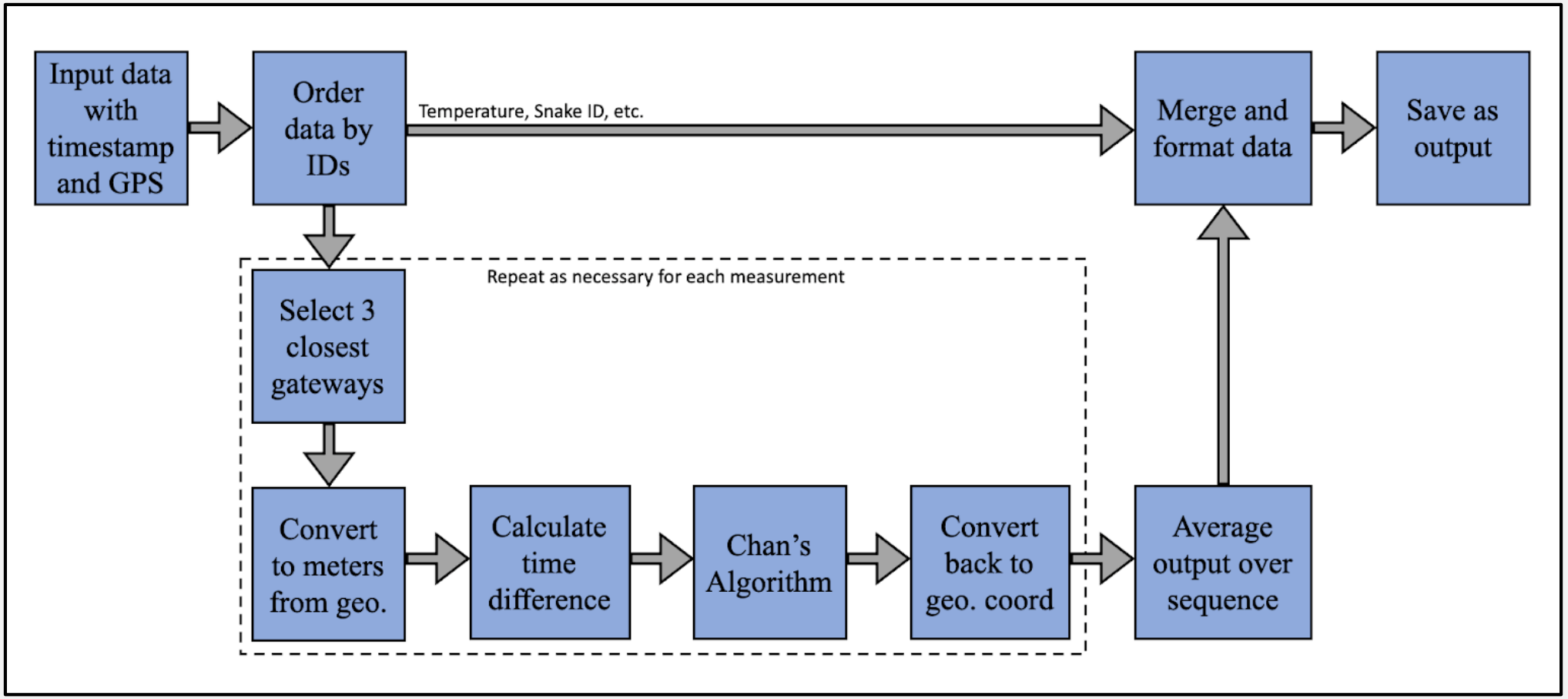
Addressability

- All secondary stations share address
- Main Base Station and controller each have unique address
- All snake addresses sequentially increase

Algorithm Logic and Data Flow



TDoA Algorithm Block Diagram



Indoor Testing

Round 1
- GPS accuracy of single station
- Communication between Feathers
- Power consumption calculations

Round 2
- Addressability between stations
- Control panel menu options
- Enclosure prototyping

Round 3
- Power consumption live testing
- "Dowsing Rod" efficacy

```
DATA,20,3,0,71,10,2021-04-21 01:22:15.828, 3836.1394,N, 9014.3252,W
LDATA,20,3,0,71,10,2021-04-21 01:22:15.534, 3836.1394,N, 9014.3369,W
DATA,20,3,1,71,10,2021-04-21 01:22:19.660, 3836.1389,N, 9014.3252,W
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DATA,20,3,2,71,10,2021-04-21 01:22:22.536, 3836.1389,N, 9014.3262,W
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DATA,20,3,5,71,10,2021-04-21 01:22:35.687, 3836.1394,N, 9014.3252,W
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```
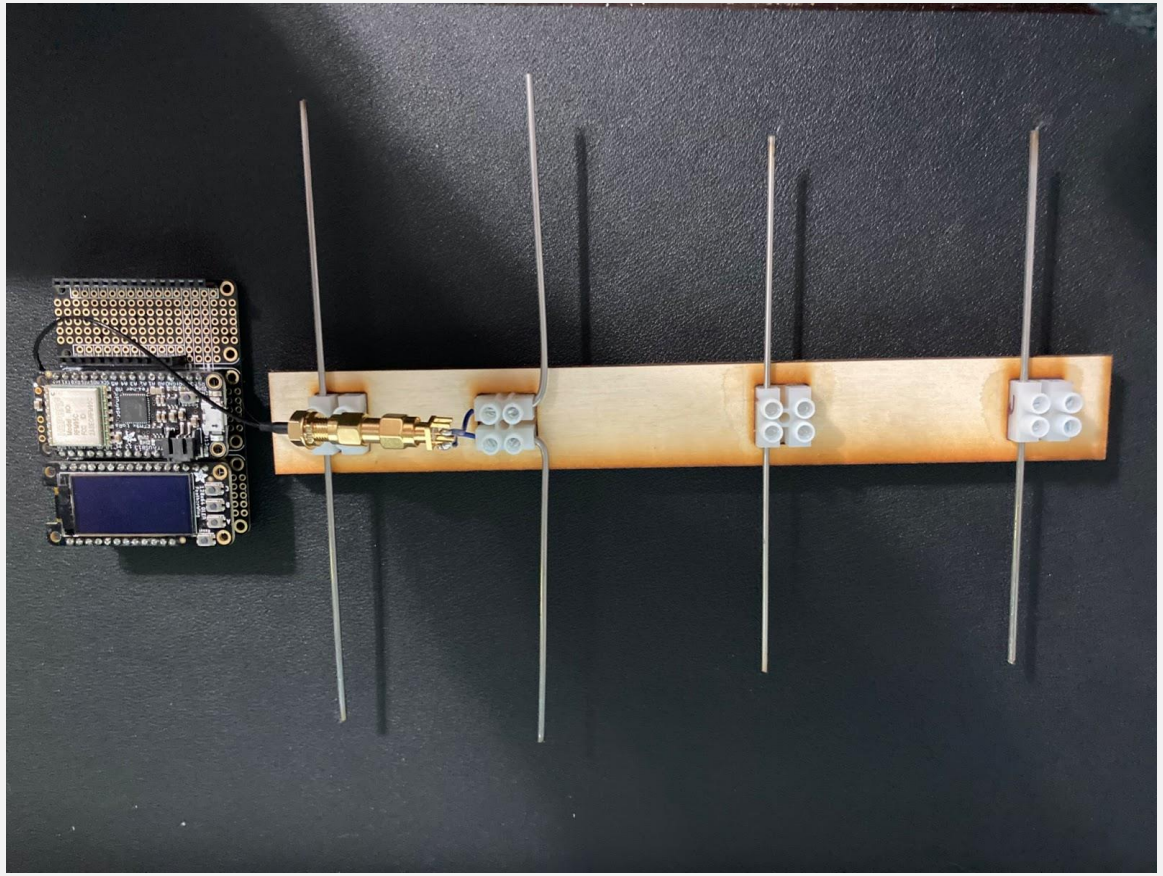
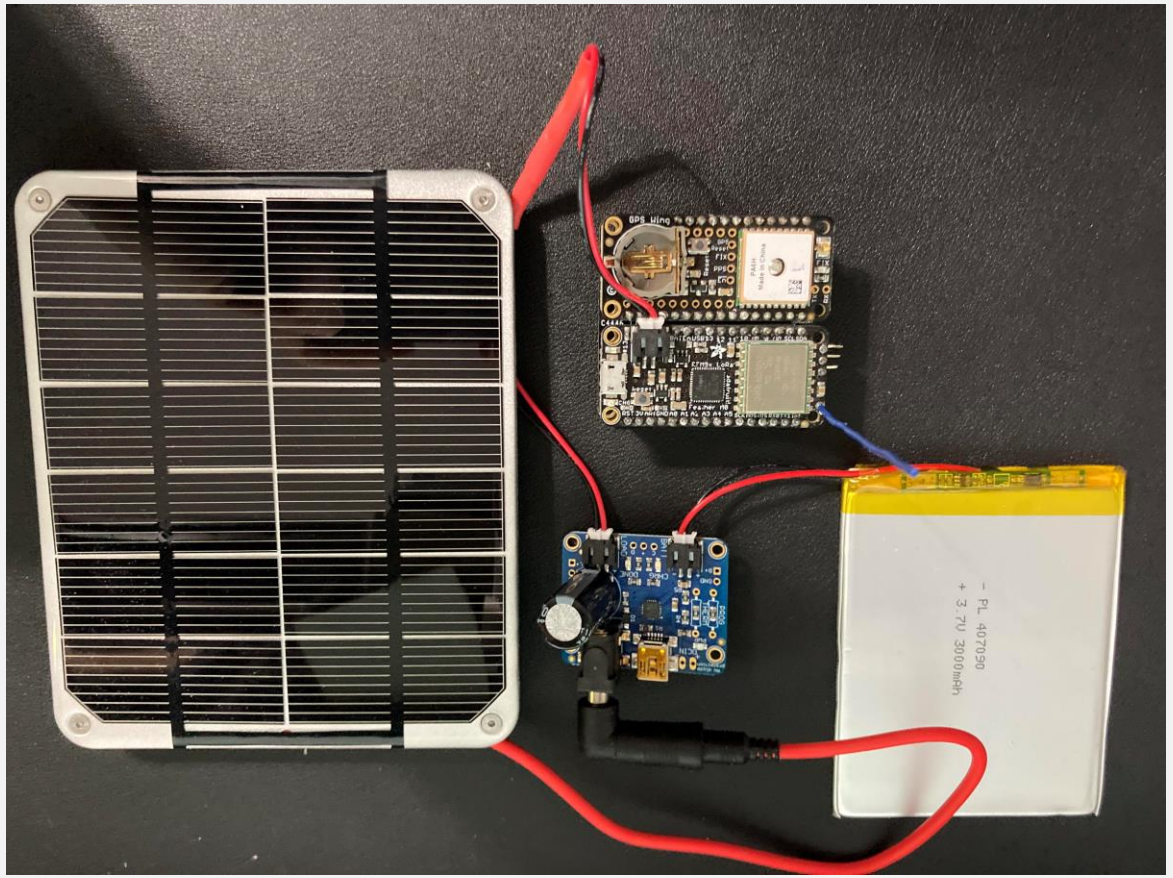
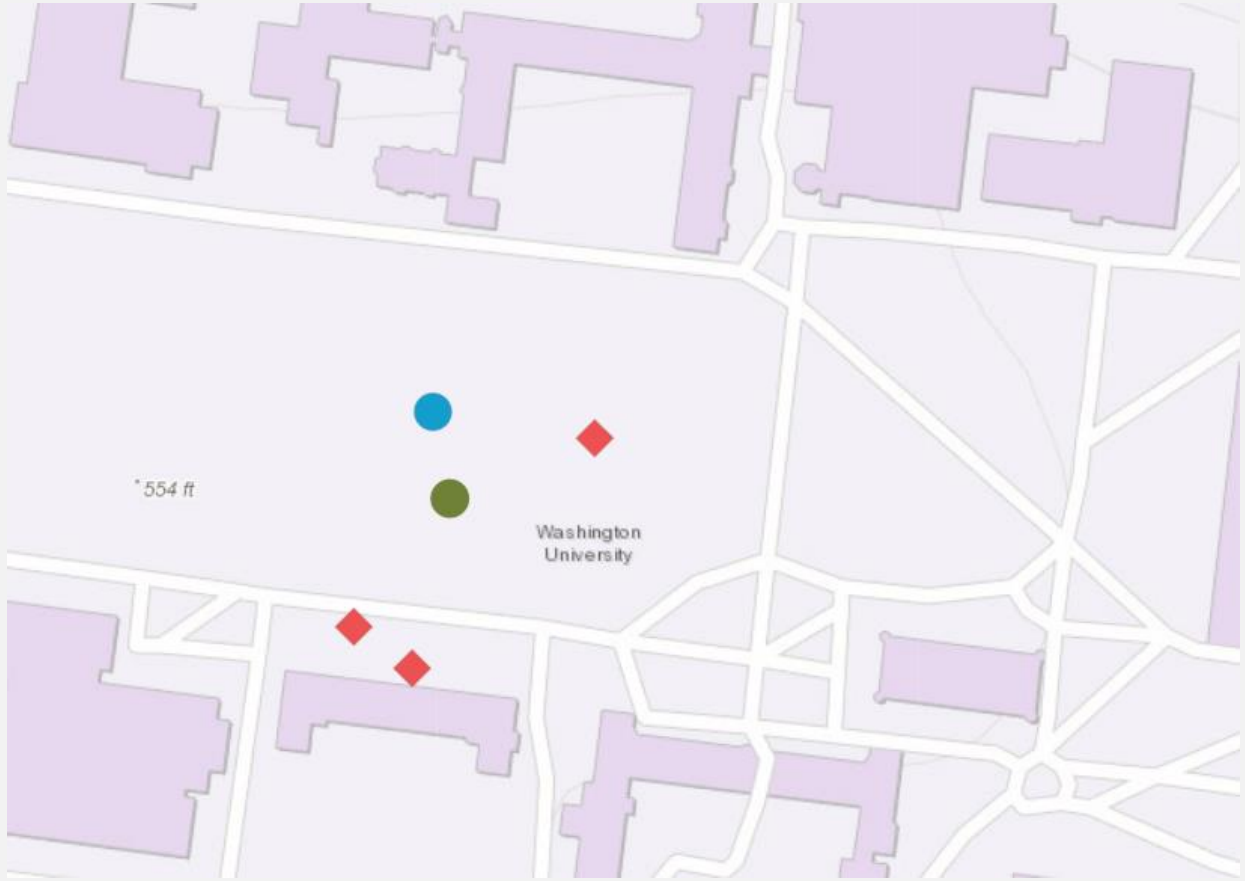

Power Consumption and RSSI Results





Mudd Field Testing



Signal Bouncing

Sample input data from our testing

```
2021-04-25 17:39:53.393,20,11,0,71,10,38.648755,-090.309912
2021-04-25 17:39:55.091,20,11,0,71,10,38.64834,-090.310595
2021-04-25 17:39:53.393,20,11,0,71,10,38.648755,-090.309912
2021-04-25 17:39:55.091,20,11,0,71,10,38.64834,-090.310595
2021-04-25 17:39:53.393,20,11,0,71,10,38.648755,-090.309912
2021-04-25 17:39:55.091,20,11,0,71,10,38.64834,-090.310595
2021-04-25 17:39:56.514,20,11,0,71,10,38.64825,-090.310433
2021-04-25 17:39:57.233,20,11,1,71,10,38.64834,-090.310595
2021-04-25 17:39:57.233,20,11,1,71,10,38.64834,-090.310595
2021-04-25 17:39:56.887,20,11,1,71,10,38.648758,-090.309912
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```
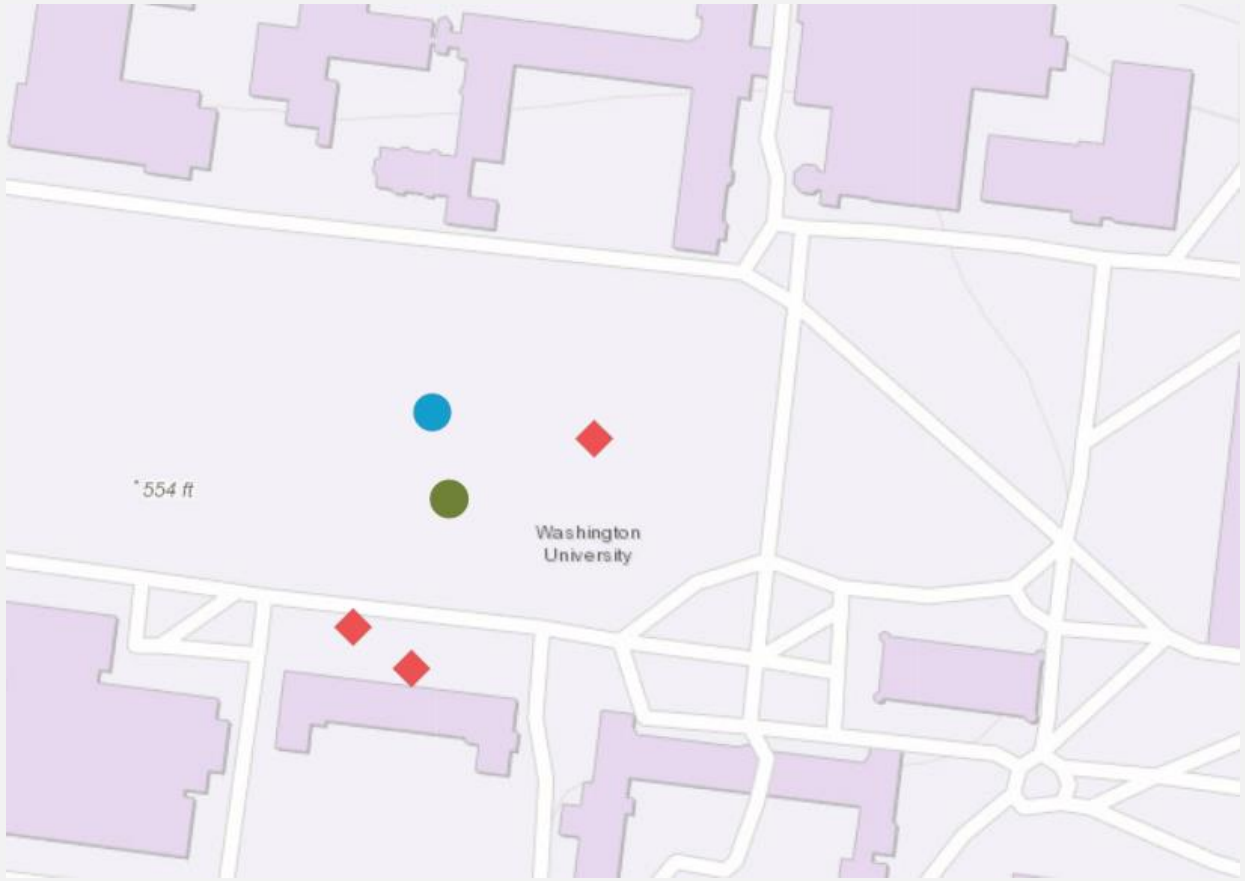

Timing Discrepancy

Results

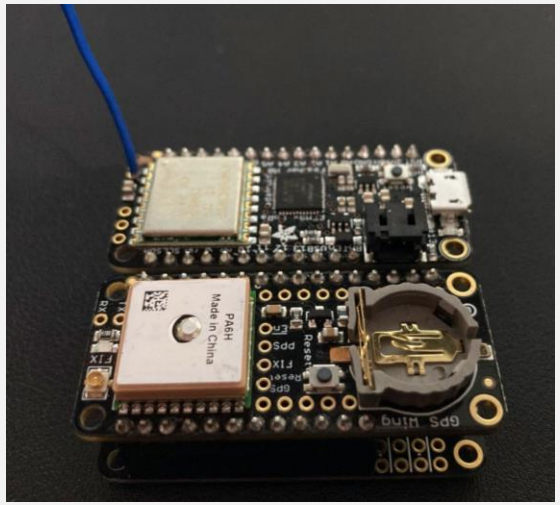


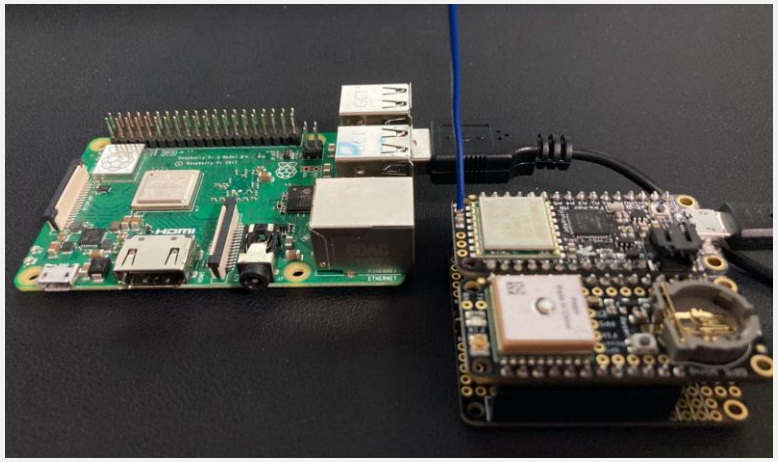
Mudd Field Testing of Locating the Transmitter

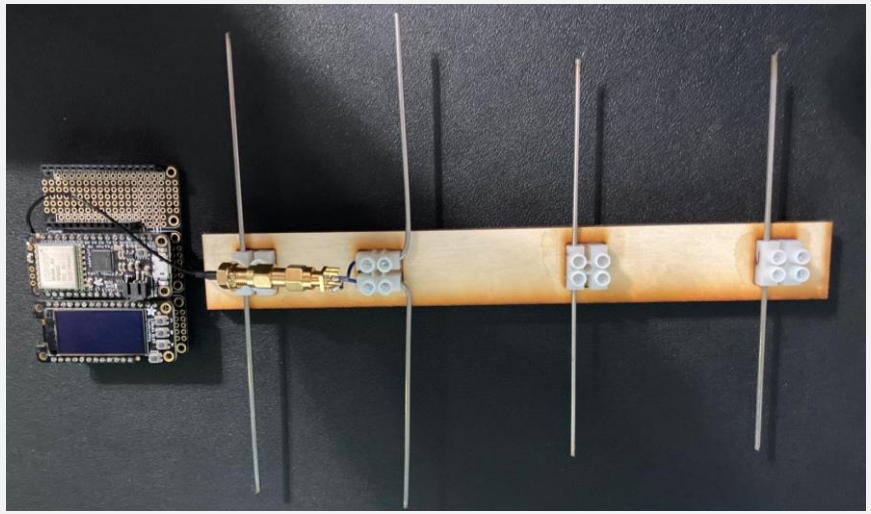
Point	Latitude	Longitude
Actual Location (blue dot)	38.648823 (N)	-90.310377 (W)
Calculated Location (green dot)	38.648899 (N)	-90.305587 (W)
Base Station 1 (closest to the DUC)	38.648254 (N)	-90.310425 (W)
Base Station 2 (closest to Simon Hall)	38.648342 (N)	-90.310597 (W)
Base Station 3 (closest to Olin Library)	38.648756 (N)	-90.30991 (W)

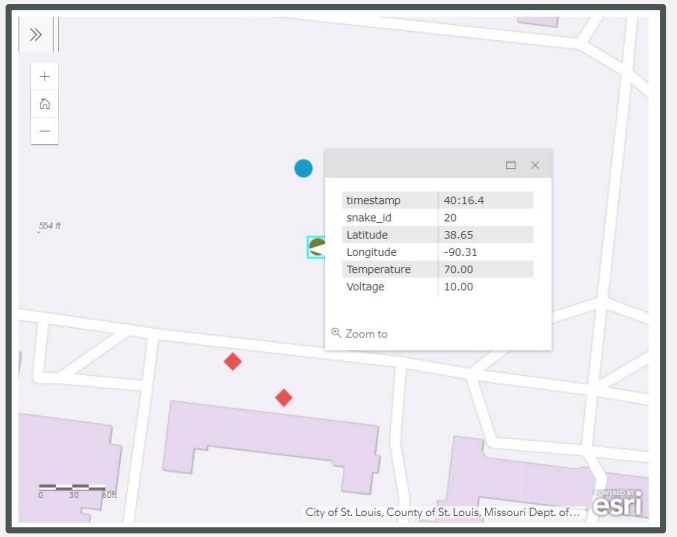
Overall Accomplishments

Trilateration TDoA Algorithm









Future Endeavors

Timing Accuracy

Signal Bouncing

Upgrade User Dashboard

Questions

References

Chan, Y, T., et al,, "A simple and efficient estimator for Hyperbolic Location," *IEEE Transactions on Signal Processing, vol. 42, No. 8,* **August 1994**

Choi, W., *et. al.*, "Low-Power LoRa Signal-Based Outdoor Positioning Using Fingerprint Algorithm," *International Journal of Geo-Information,* **2018** (11), https://doi.org/10.3390/ijgi7110440

Fargas, B. C., *et. al.*, "GPS-free Geolocation using LoRa in Low-Power WANs," *Proceedings of 2017 Global Internet of Things Summit,* **2017**, https://doi.org/10.1109/GIOTS.2017.8016251

Kays, R., *et. al.*, "Tracking Animal Location and Activity with an Automated Radio Telemetry System in a Tropical Rainforest," *The Computer Journal,* **2011**, https://doi.org/10.1093/comjnl/bxr072

Podevijn, N., *et. al.*, "TDoA-Based Outdoor Positioning with Tracking Algorithm in a Public LoRa Network," *Wireless Communications and Mobile Computing,* **2018**, https://doi.org/10.1155/2018/1864209

Pospisil, J., *et. al.*, "Investigation of the Performance of TDoA-Based Localization Over LoRaWAN in Theory and Practice," *Sensors,* **2020** (20), https://doi.org/10.3390/s20195464

Zarlenga, Dan. "Powder Valley Nature Center Reveals Results of Ongoing Snake Study at a Special Program Aug. 23." *Missouri Department of Conservation*, 12 Aug. 2019, https://mdc.mo.gov/newsroom/powder-valley-nature-center-reveals-results-ongoing-
snake-study-special-program-aug-23