EECE 5554 – Lab 1
Name: Phillip Muvadi
Date: February 7, 2026

1. Purpose of the Lab

The primary objective of this lab was to design and evaluate a complete GPS data acquisition and analysis workflow within the ROS 2 environment. This process included developing a Python-based GPS driver capable of parsing GPGGA messages, converting latitude and longitude measurements into UTM coordinates, and publishing the processed information using a custom ROS message. Additionally, rosbag was used to record real GPS data, which was later analyzed to quantify positional accuracy under both stationary and moving conditions. Overall, the lab aimed to assess the accuracy of standalone GPS measurements and identify the main sources of positioning error.

2. Experimental Procedure

Three separate datasets were collected using a USB-based GNSS receiver:

- **Open-sky stationary data (5 minutes):** recorded in an unobstructed outdoor environment.
- **Occluded stationary data (5 minutes):** recorded near buildings or trees that partially blocked satellite signals.
- **Walking data (approximately 200–300 m):** collected while moving in a roughly straight path.

The GPS driver continuously published UTM easting, northing, altitude, HDOP, and timestamp information on the **/gps** topic. Each dataset was recorded into a ROS 2 bag file and later analyzed using Python.

For stationary datasets, positional error was calculated as the **Euclidean distance** between measured UTM coordinates and a known reference position.
For the walking dataset, deviation from a straight trajectory was determined using the **perpendicular distance to a least-squares best-fit line**.

3. Results

3.1 Stationary Position Error – Occluded Environment

- Number of samples: **142**
- Mean error: **7.135 m**
- Standard deviation: **4.215 m**
- Median: **7.651 m**
- 95th percentile: **13.705 m**
- Maximum error: **13.890 m**

3.2 Stationary Position Error – Open-Sky Environment

- Number of samples: **320**
- Mean error: **3.249 m**
- Standard deviation: **1.754 m**
- Median: **3.004 m**
- 95th percentile: **5.248 m**
- Maximum error: **11.205 m**

3.3 Walking Line-Fit Error

- Number of samples: **39**
- Mean perpendicular error: **0.544 m**
- Standard deviation: **0.447 m**
- Median: **0.514 m**
- 95th percentile: **1.539 m**
- Maximum error: **1.703 m**

4. Discussion

The results demonstrate that **open-sky conditions provide significantly better positional accuracy** than occluded environments. This observation is consistent with typical civilian GPS performance, where unobstructed satellite visibility leads to lower measurement error. In contrast, nearby buildings and trees introduce **multipath reflections and signal blockage**, which increase uncertainty in the estimated position.

During the walking experiment, the GPS trajectory remained close to a straight line, with **sub-meter average deviation** from the best-fit path. This indicates that even when absolute position accuracy is limited, GPS can still provide relatively smooth **relative motion tracking**. However, the small number of recorded samples while walking suggests a lower update rate, which may reduce confidence in trajectory estimation.

5. Conclusion

This lab successfully demonstrated the complete workflow of **GPS data acquisition, ROS 2 message publishing, rosbag recording, and statistical analysis**. The results confirm that:

- Open-sky GPS accuracy is typically within a few meters.
- Environmental obstruction significantly increases positional error.
- Relative motion tracking while walking can remain smooth despite sparse sampling.

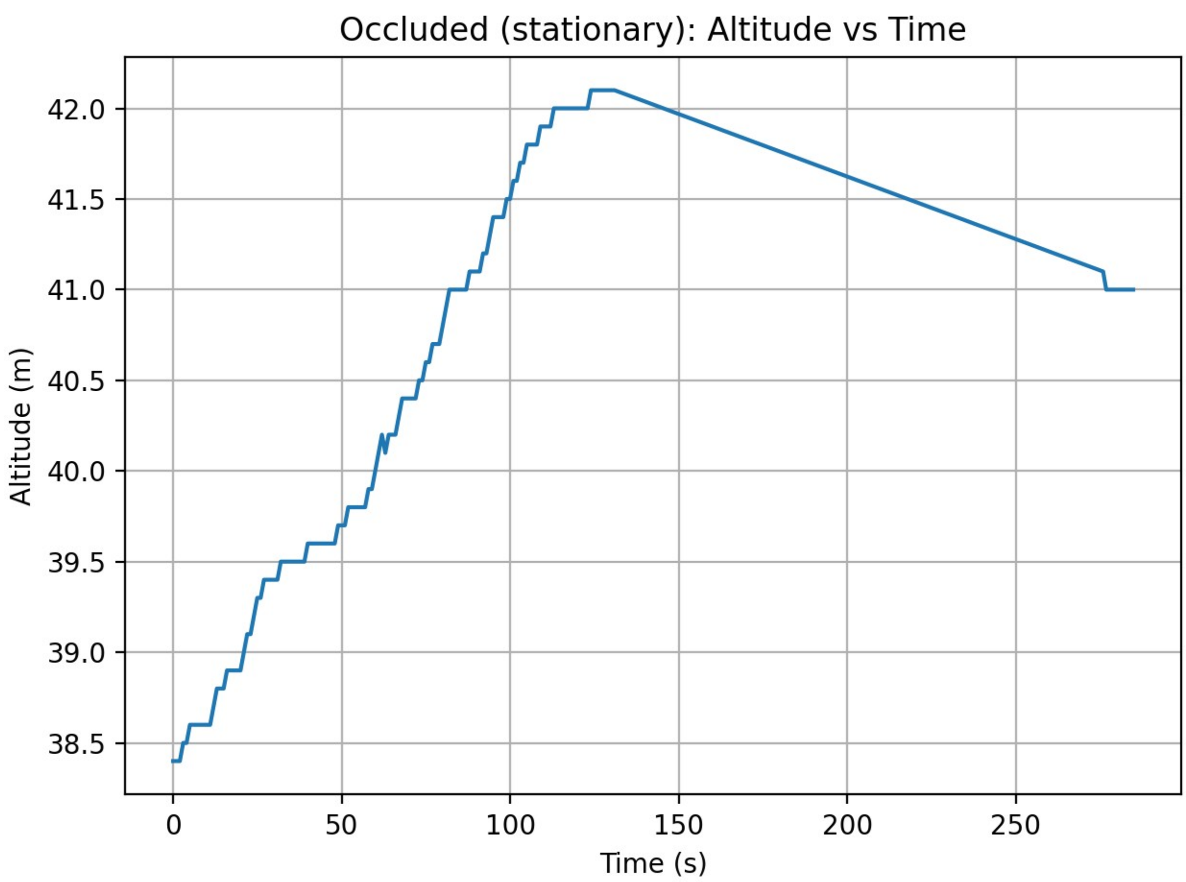
These findings highlight both the **capabilities and limitations of standalone GPS navigation** and emphasize the importance of **sensor fusion and improved satellite visibility** for reliable robotic localization.

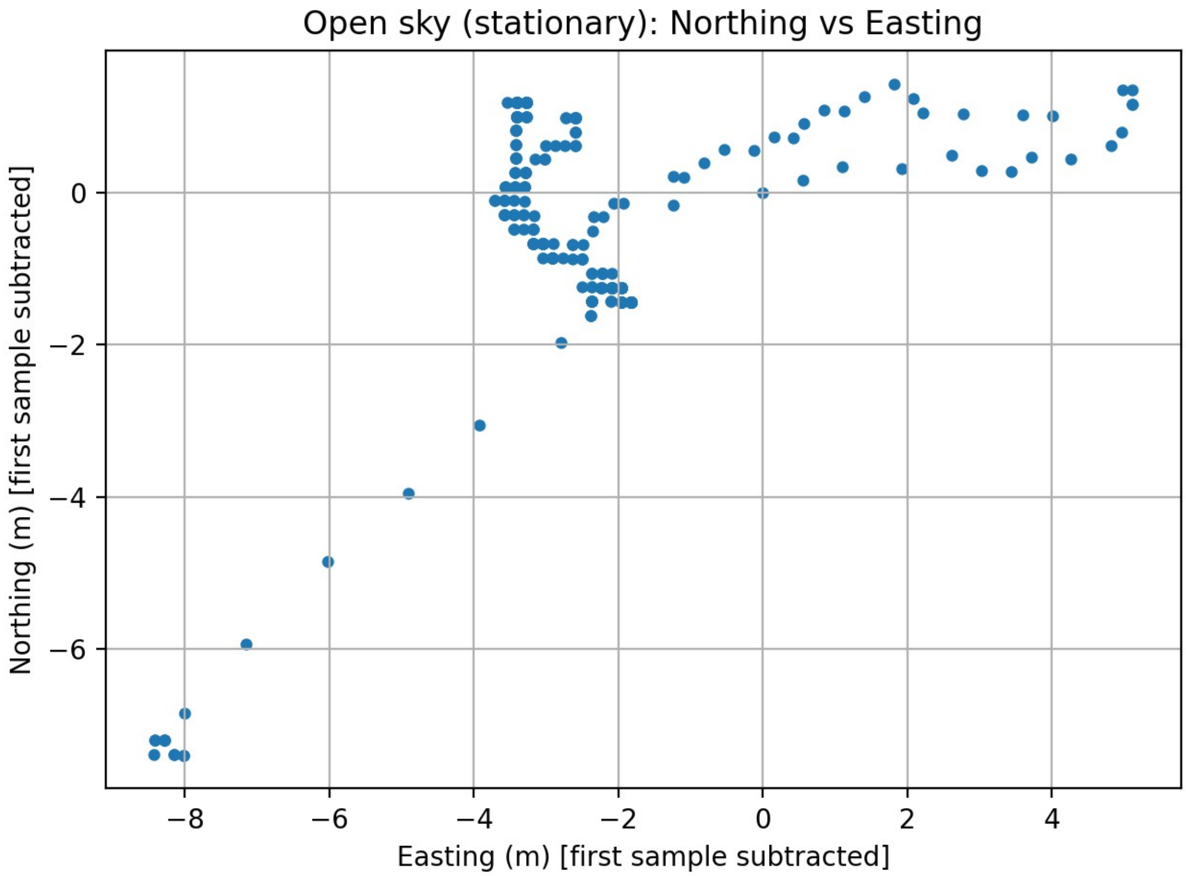
---

6. Included Figures

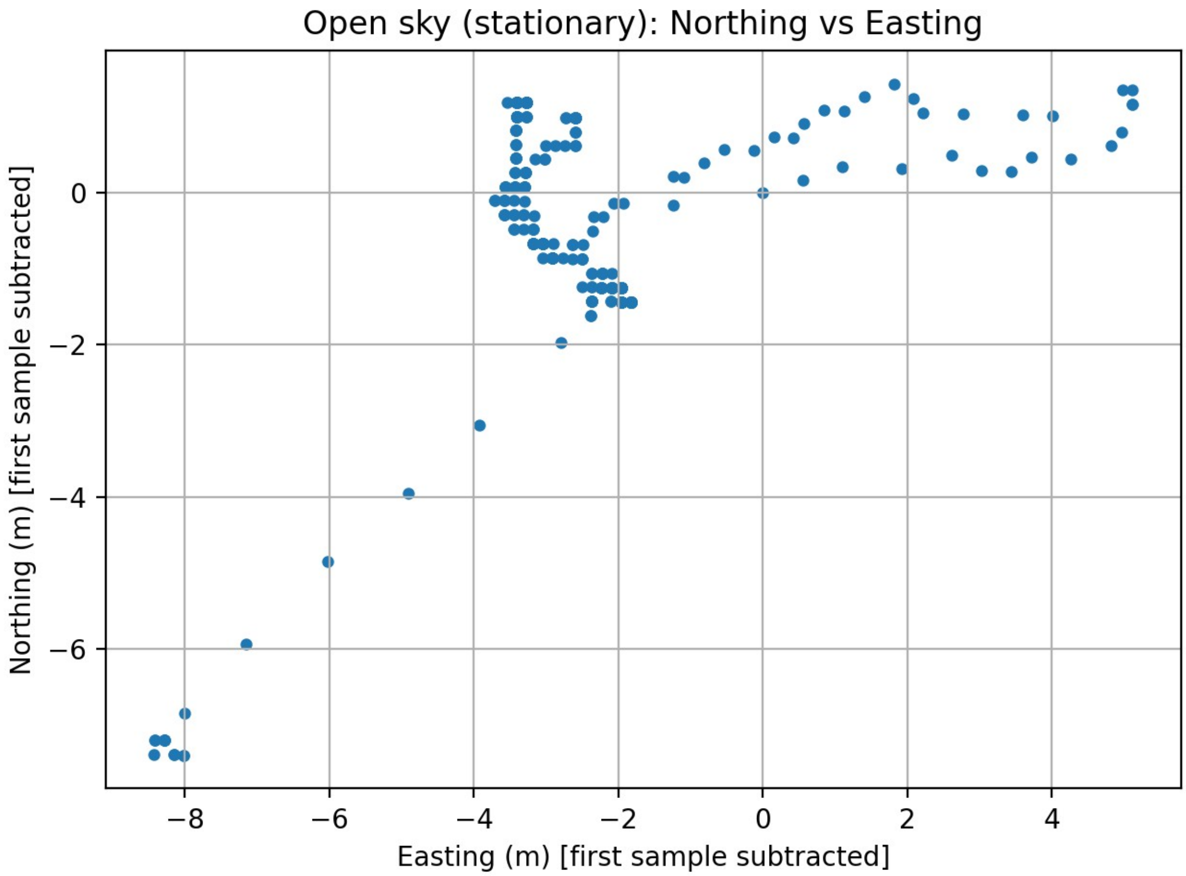
The report includes the following plots generated during analysis:

- Stationary northing-versus-easting scatterplots (open sky and occluded)
- Histograms of stationary position error
- Altitude-versus-time plots for stationary and walking datasets
- Walking trajectory scatterplot
- Histogram of walking line-fit perpendicular error

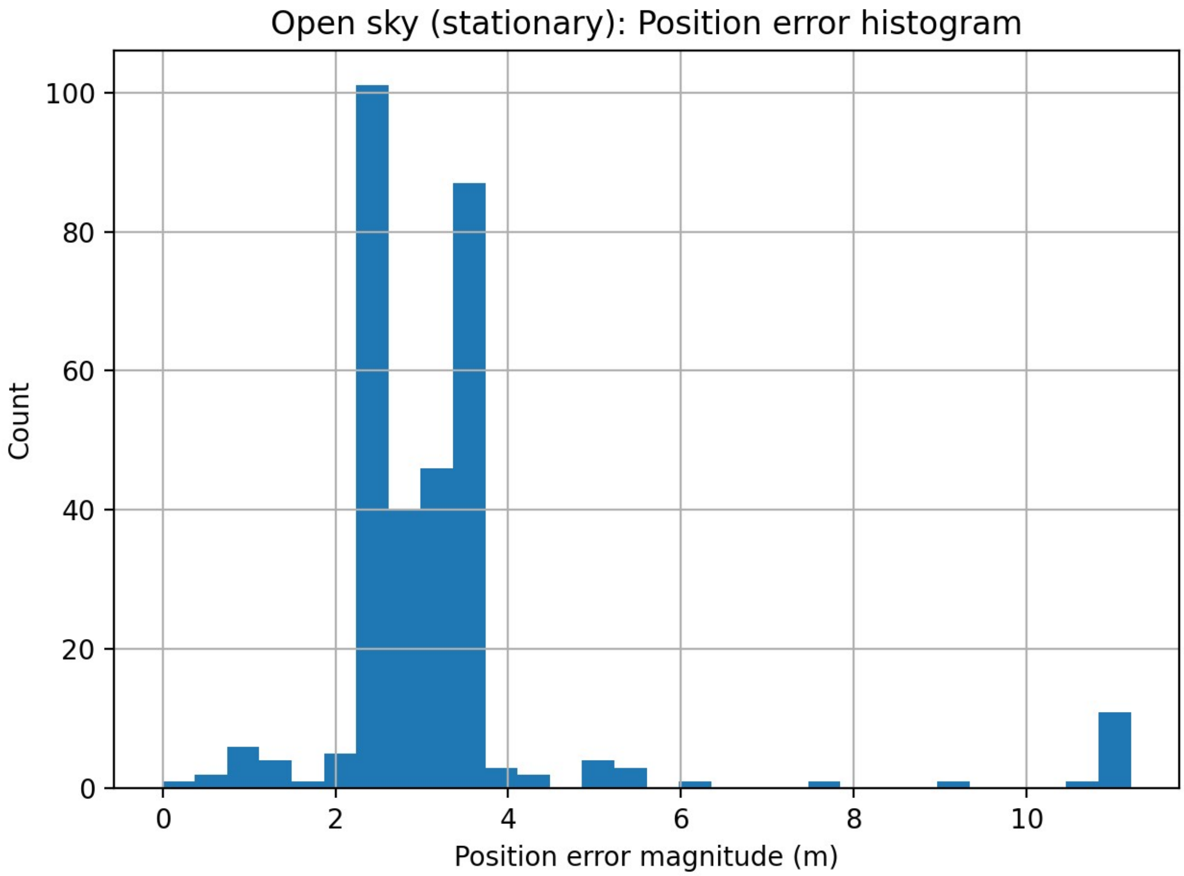




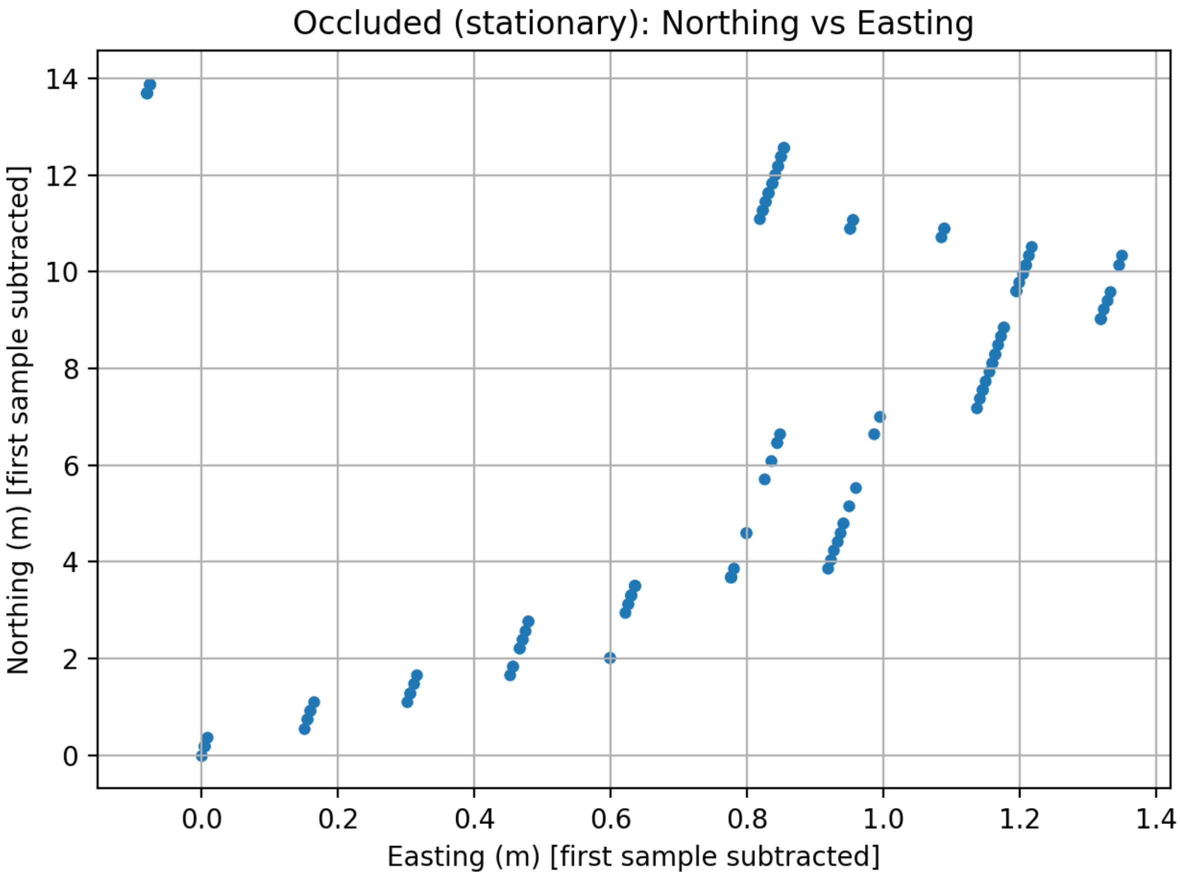
Open sky (stationary): Northing vs Easting
Northing (m) [first sample subtracted]
Easting (m) [first sample subtracted]
0
−2
−4
−6
−8
−6
−4
−2
0
2
4

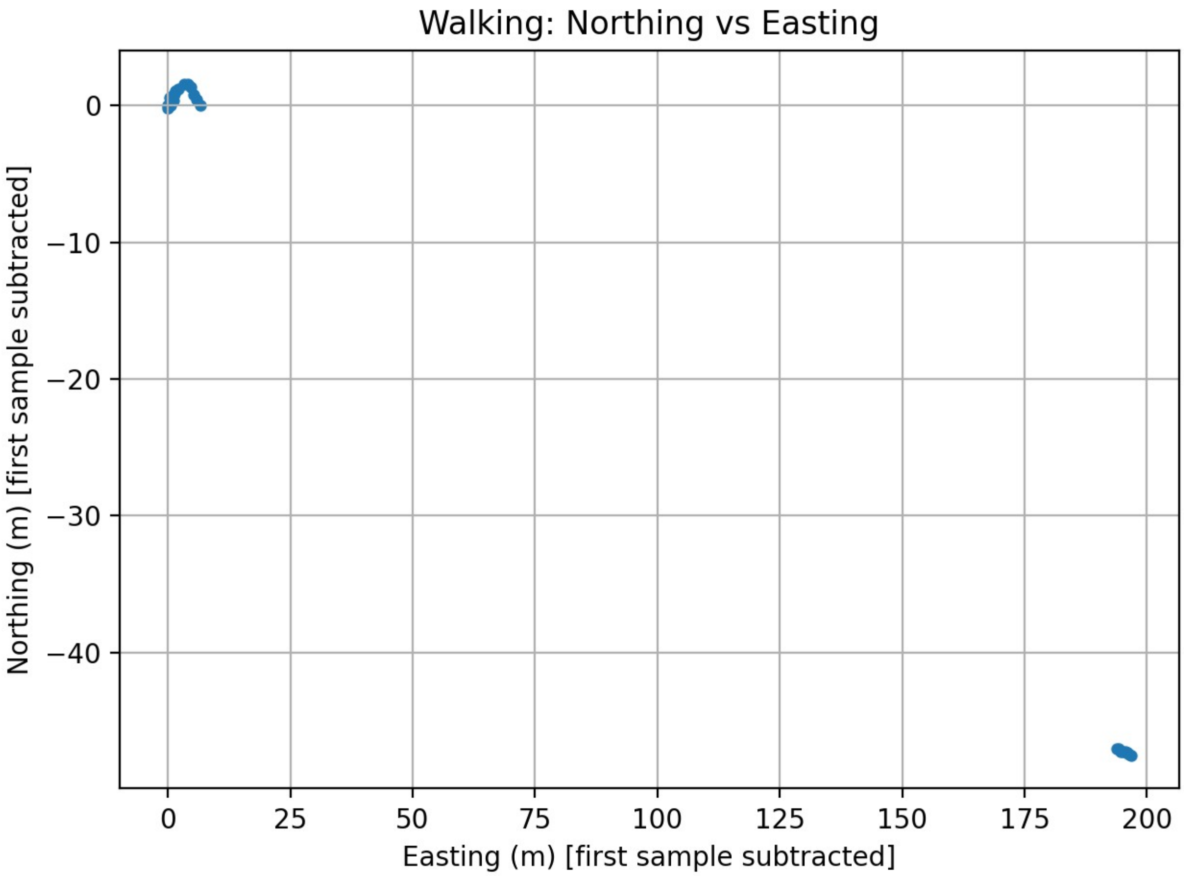


Open sky (stationary): Northing vs Easting
Northing (m) [first sample subtracted]
Easting (m) [first sample subtracted]
0
−2
−4
−6
−8
2
4

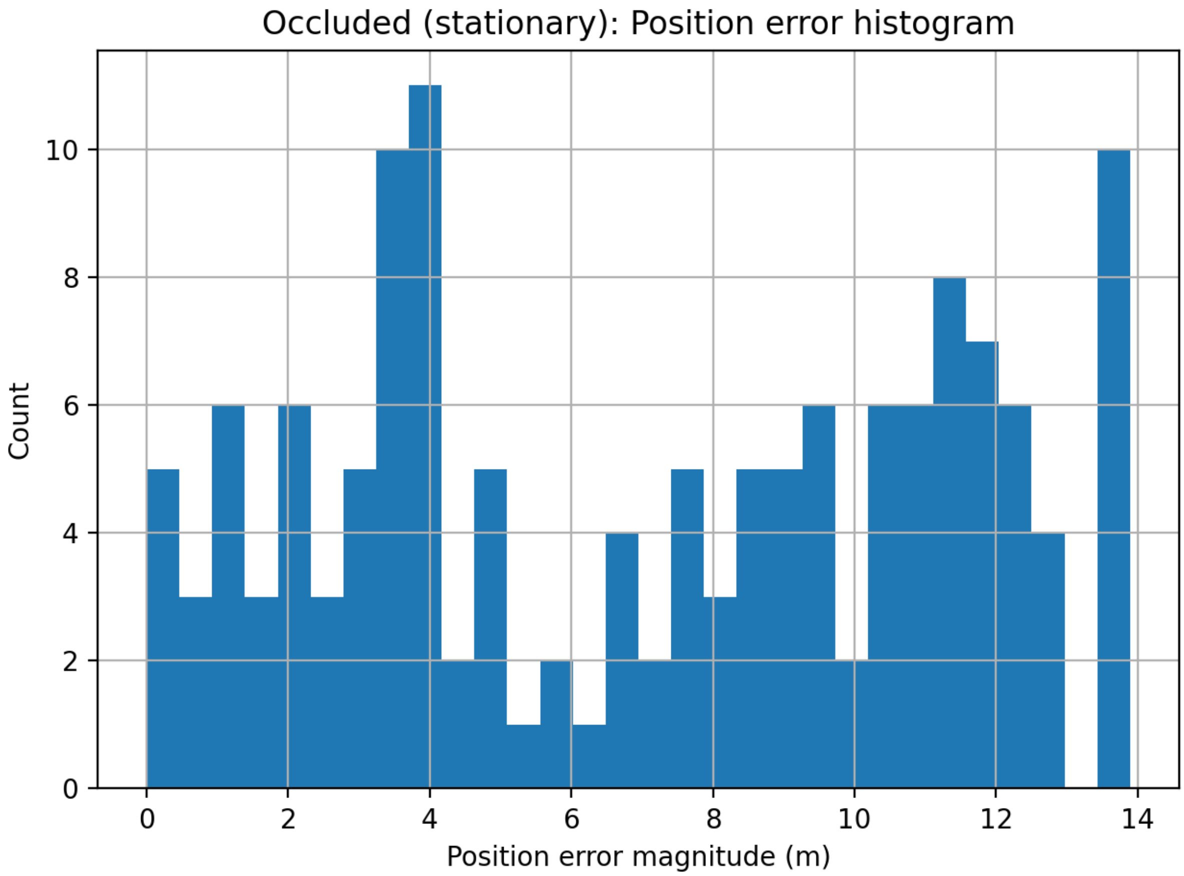


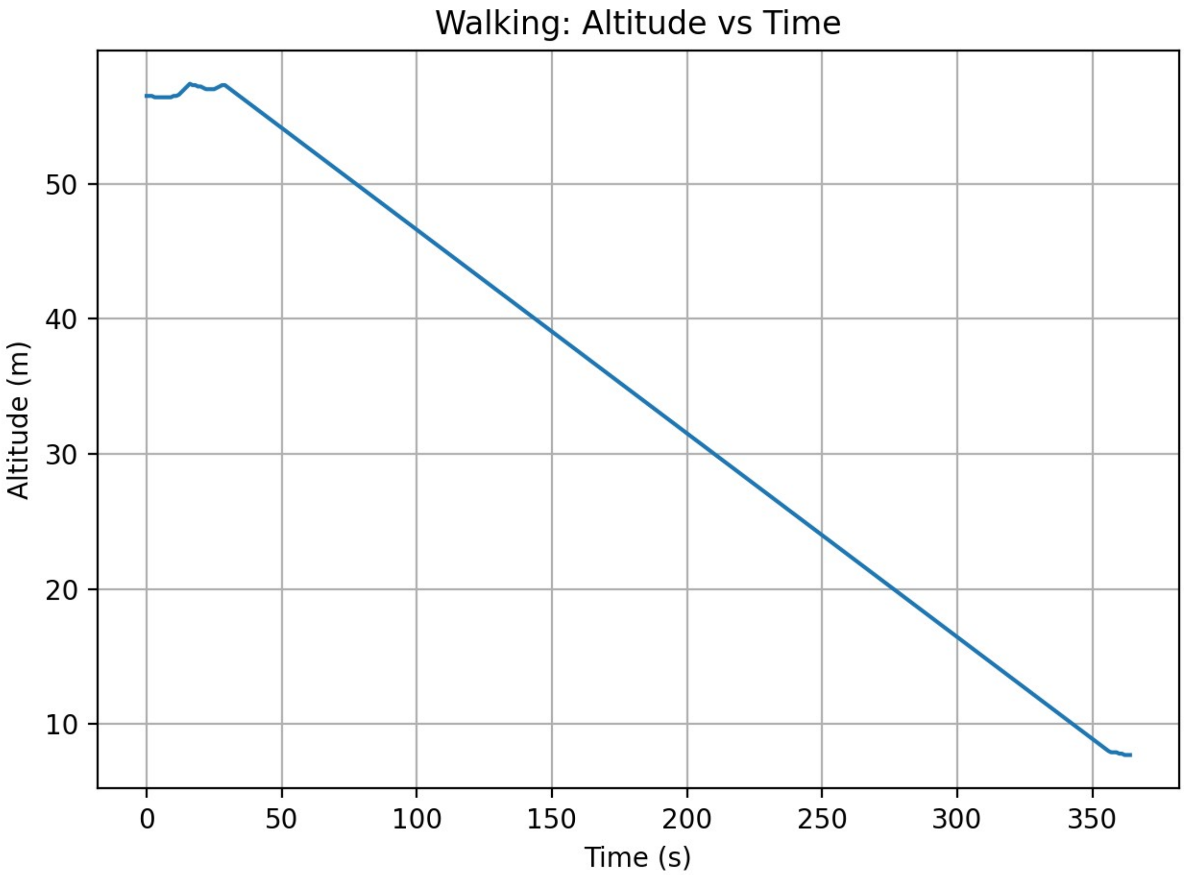
Open sky (stationary): Position error histogram
Count
0
20
40
60
80
100
0
2
4
6
8
10
Position error magnitude (m)

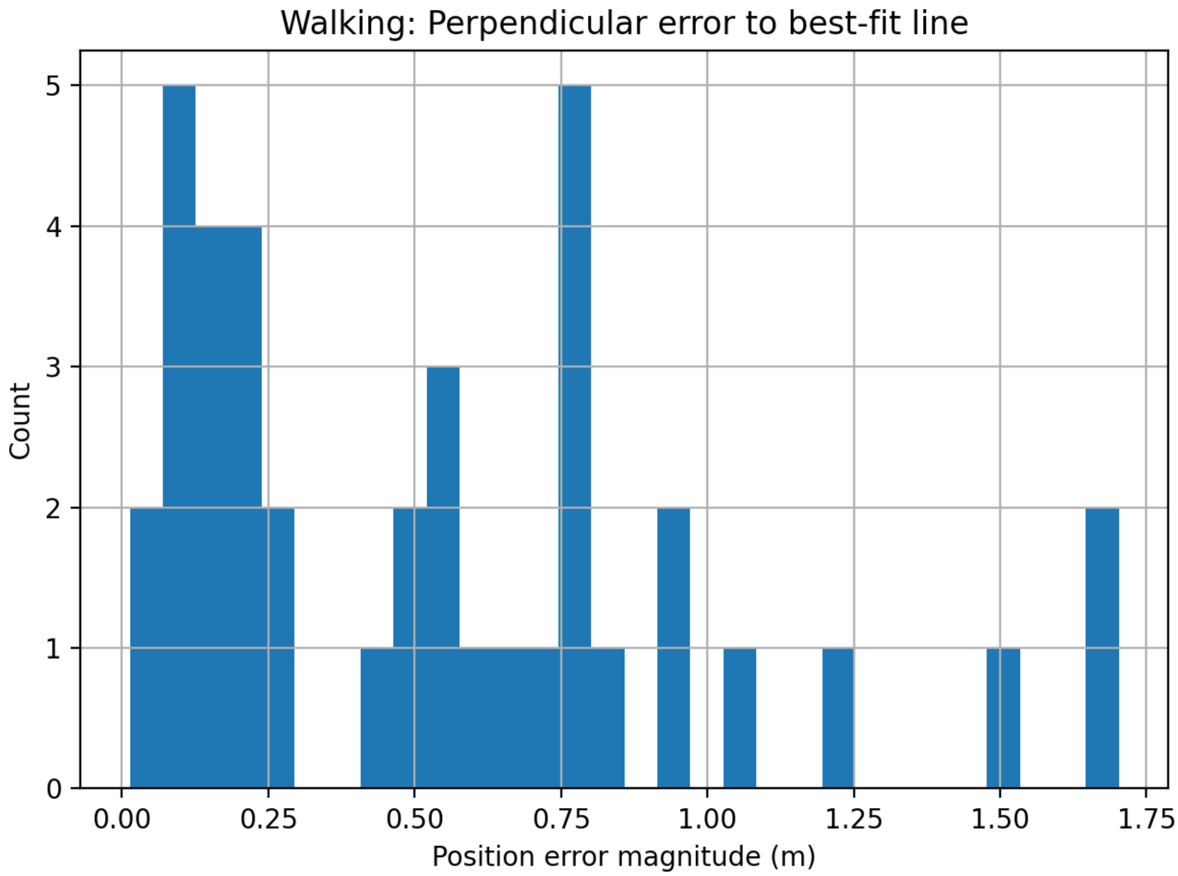

Occluded (stationary): Northing vs Easting
Northing (m) [first sample subtracted]
Easting (m) [first sample subtracted]
0
2
4
6
8
10
12
14
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4



Walking: Northing vs Easting
Northing (m) [first sample subtracted]
Easting (m) [first sample subtracted]
0
−10
−20
−30
−40
0
25
50
75
100
125
150
175
200


Occluded (stationary): Position error histogram
Count
Position error magnitude (m)
0
2
4
6
8
10
12
14
0
2
4
6
8
10


Walking: Altitude vs Time
Altitude (m)
Time (s)
10
20
30
40
50
0
50
100
150
200
250
300
350


Walking: Perpendicular error to best-fit line
Count
Position error magnitude (m)
0
1
2
3
4
5
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75