Introduction

RTK (Real-Time Kinematic) is a GNSS-based technology that uses a fixed base station to correct drift errors, providing centimeter-level positioning accuracy. This experiment compares RTK GNSS with standalone GNSS and explores key error sources affecting RTK accuracy. Standalone GNSS calculates positions by receiving signals from satellites but typically achieves only meter-level accuracy due to atmospheric conditions and signal delays. RTK improves accuracy by using a reference base station, applying phase measurements, and making real-time differential corrections, reducing these errors for more precise positioning.

Data Analysis

1. Altitude vs Time Comparison (Open and Occluded)

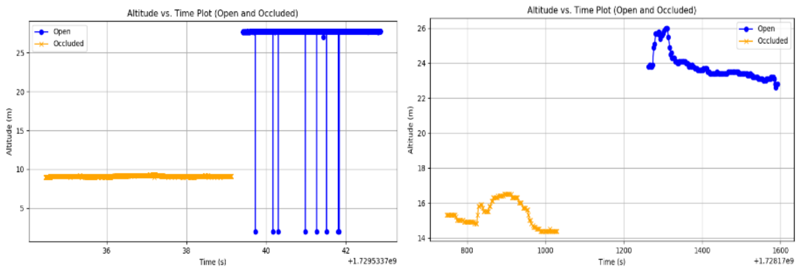

Figure 1. RTK vs GNSS (Scatter Plot)

The first plot shows altitude changes under open and occluded conditions for **stationary data**. As seen, the altitude remains almost unchanged under both open and occluded conditions, while the same situation of GNSS shows more significant variations and outliers. These results demonstrate that RTK has higher accuracy than GNSS by comparing both plots.

2. Histogram Comparison (Open and Occluded)

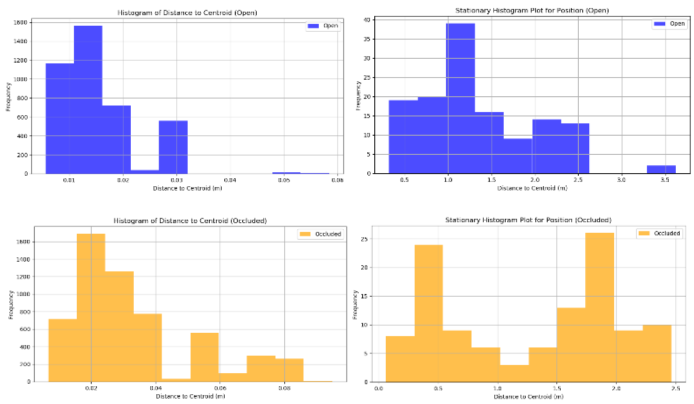

Figure 2. RTK vs GNSS (Histogram)

For **RTK**, as shown in the first two histograms (first column):

1. **Occluded condition (RTK)**:
   - The distance to centroid ranges between 0.02 to 0.08 meters. The majority of data points are clustered between 0.02 and 0.05 meters, with a peak around 0.03 meters.
   - The histogram shows that even under occluded conditions, the RTK system keeps deviations relatively small, with most data tightly packed in the lower range.

2. **Open condition (RTK)**:
   - The distance to centroid ranges between 0.01 and 0.05 meters. The largest cluster is around 0.015 to 0.02 meters, with a sharp drop after 0.02 meters.
   - This tight distribution indicates that under open sky conditions, RTK achieves excellent precision, with minimal deviation in the position.

For **GNSS**, the last two histograms:

1. **Occluded condition (GNSS)**:
   - The distance to centroid ranges between 0 to 2.5 meters. The data shows two distinct peaks, one around 0.5 meters and another around 2 meters, indicating that the positioning accuracy is significantly affected by occlusion.
   - The wide distribution and the large range of deviations suggest that GNSS without RTK performs poorly under occluded conditions, leading to significant positioning errors.
2. **Open condition (GNSS)**:
   - The distance to centroid ranges from 0.5 to 3.5 meters. The largest cluster is around 1 meter, with smaller peaks around 2 and 3 meters, showing that even in open conditions, standalone GNSS exhibits large deviations in positioning.
   - This indicates that the standalone GNSS system is more prone to inaccuracies and deviations, even in favorable environments.

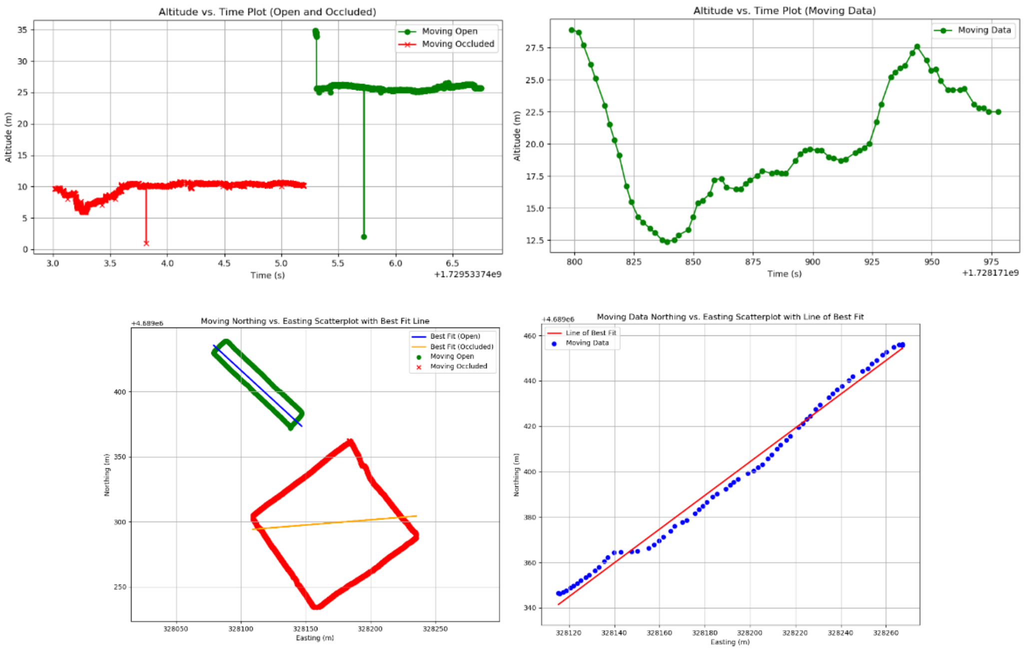

Figure 2. RTK vs GNSS (Histogram)

Impact of GNSS Fix Quality:

In occluded environments, reduced signal quality severely affects GNSS fix quality, leading to lower positioning accuracy and increased errors. Although RTK is also affected under occlusion, its performance remains superior to standalone GNSS without RTK corrections.

In summary, GNSS fix quality greatly impacts positioning accuracy, especially in occluded environments, where the decline in fix quality leads to increased errors. RTK mitigates some of these errors through differential corrections.