Report on RTK GNSS Analysis

Introduction:

RTK Global Navigation Satellite System (GNSS) is a precise and highly accurate navigation technology that combines numerous GNSS satellites to give centimeter-level positioning precision. The purpose of this report is to analyze RTK GNSS data gathered during a stationary and walking experiment and compare it to standalone GNSS without RTK. We'll also look into the origins of errors in RTK GNSS.

Differences between RTN GNSS and GNSS:

RTK GNSS, sometimes known as Network RTK GNSS (RTN GNSS), is an improved version of traditional GNSS. While both systems rely on satellite signals for locating, RTK GNSS provides greater accuracy. It accomplishes this by employing a fixed reference station and a mobile receiver. The known position of the reference station aids in real-time signal correction for the mobile receiver, resulting in centimeter-level accuracy. Standalone GNSS, on the other hand, does not use a fixed reference station and gives lesser precision, often in the meter-level range.

Sources of Error in RTK GNSS:

Several reasons can contribute to RTK GNSS navigation errors:

1. Atmospheric Conditions
2. Multipath Effects
3. Satellite Geometry
4. Obstructions
5. Interference

Analysis:

Ranges and Shapes of Position in Easting and Northing

From RTK GNSS data, 2D histograms are generated for the Easting and Northing positions. Easting and Northing are geographical coordinates that indicate places in a Cartesian coordinate system along the east-west and north-south axes, respectively. The histograms indicated a concentrated cluster of data points, indicating that the position was as close to the genuine position as possible. The RTK GNSS system provides highly accurate and consistent location information. The narrow range in the histogram provides an indicator of precision. When comparing RTK GNSS to standalone GNSS, the range of positions in Easting and Northing was substantially narrower in RTK GNSS. This demonstrates RTK GNSS's ability to give highly precise and reliable positioning. The RTK GNSS offers much higher accuracy, resulting in a smaller range of positions. The fig 1.1 indicates the stationary closed utm easting and northing histogram where the density is low whereas in the fig 1.2 the stationary open utm easting and northing histogram indicates that the density is little higher than the closed. The fig 1.3 indicates the walking closed utm easting and northing histogram whereas the fig 1.4 indicates the walking open utm easting and northing. In the closed the data is scattered whereas in the open it is uniform.

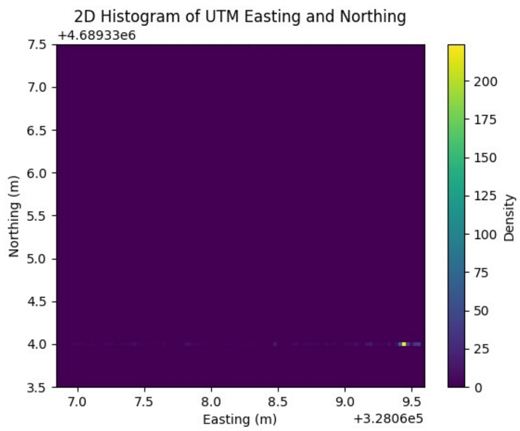

Fig 1.1: Stationary Closed UTM

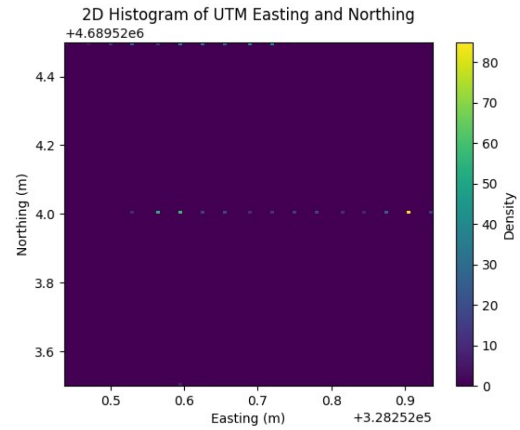

Fig 1.2: Stationary Open UTM

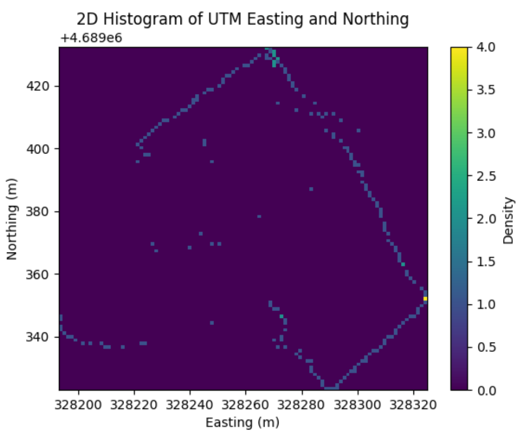

Fig 1.3: Walking Closed UTM

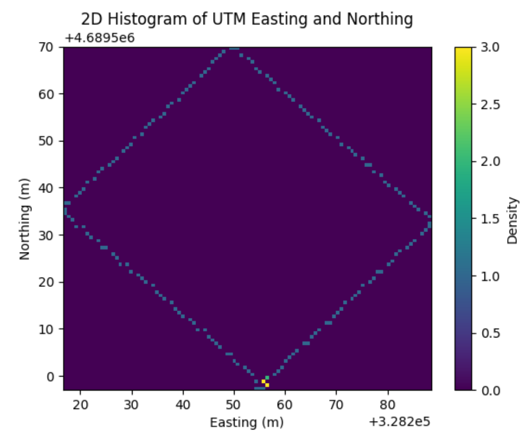

Fig 1.4: Walking Open UTM

Comparison with Lab 1 Dataset

From the Lab 1 there is a wider spread of positions due to a potential reduction in the number of satellites used for positioning which lead to a larger deviation from the true position. The RTK GNSS system are more versatile and can work with multiple GNSS systems, due to multiple GNSS the positioning is more accurate and it reduces the error which results in a narrower distribution of positions and a smaller range. Since the histogram between the Lab 1 shows a difference in data distribution and accuracy. The RTK GNSS systems leads to more precise and consistent positioning system. It results to a more narrower data distribution and reduced error compared to the standalone GNSS system which was used in Lab 1.

Accuracy of RTK GNSS and Standalone GNSS

The error which was observed in the RTK GNSS data, when it is compared to a “true” position, which was significantly smaller than the standalone GNSS. The RTK GNSS achieved centimeter-level accuracy whereas the standalone GNSS achieved meter-level accuracy. This indicates that the precision and positioning of the RTK GNSS is superior than the standalone GNSS system. The RTK GNSS provide highly precise and consistent positioning.

Walking Data in Open and Occluded Cases

For both the open and occluded cases the moving data revealed in the RTK GNSS provided lower errors. The difference in the error can be regard to the GNSS fix quality. In the open field, where satellite signals are less interfered so that the RTK GNSS delivers better accuracy compared to occluded environments which have more signal interference.

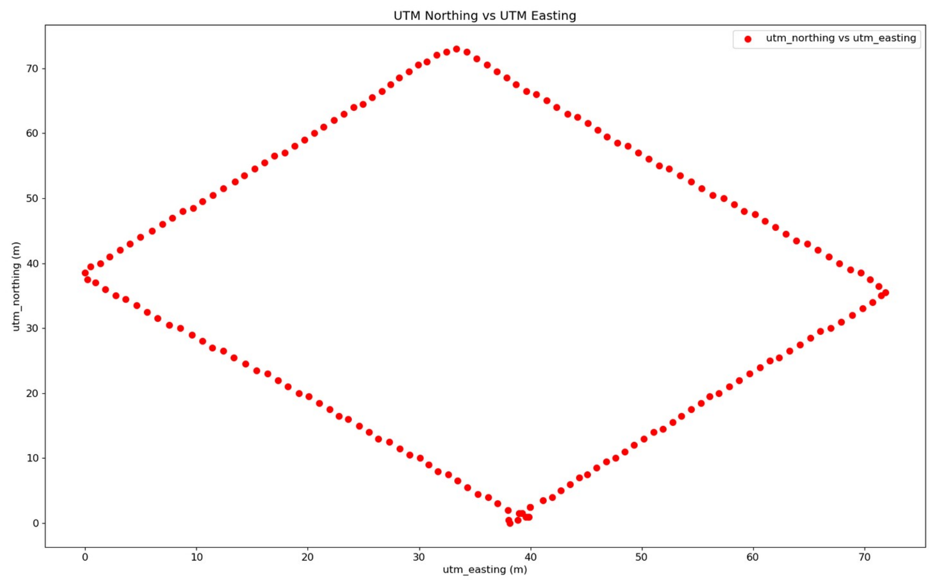

Fig 2.1: Walking open - utm northing vs utm easting

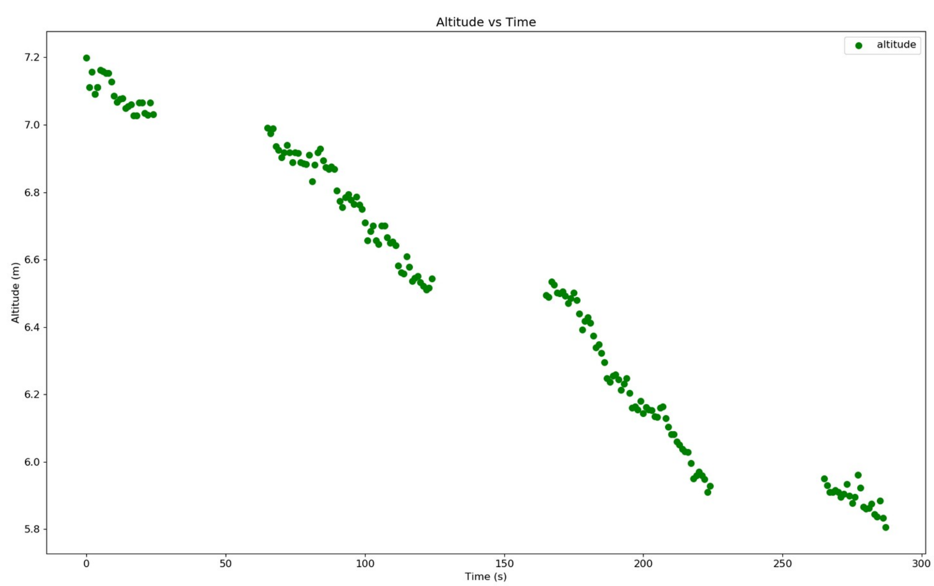

Fig 2.2: Walking open – altitude vs time

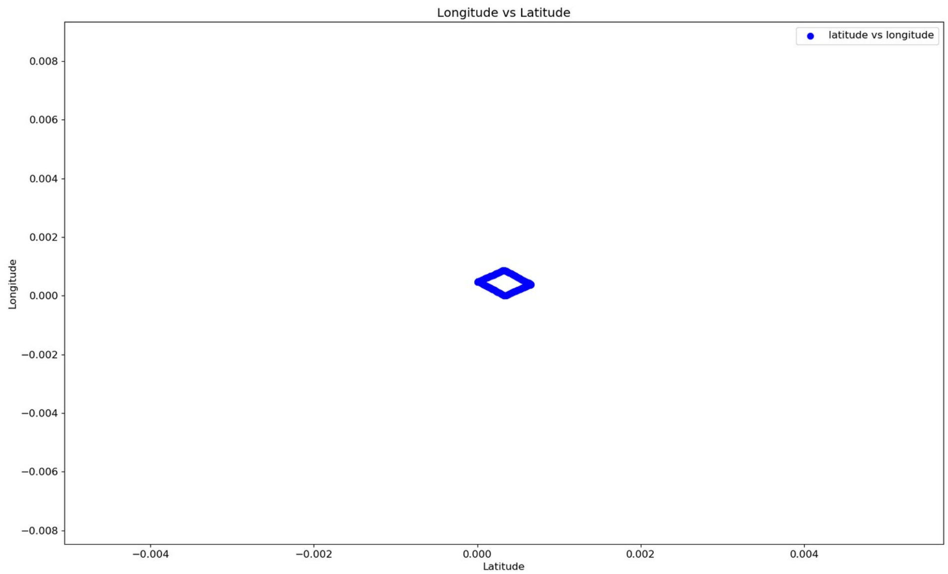

Fig 2.3: Walking open – longitude vs latitude

From the graph fig 2.1 which shows the walking open – utm easting vs utm northing where the data points are closely packed, which shows accurate and reliable positioning. The narrow distribution of the data points shows that there is less error from the "true" position. The clusters of data point in the graph shows that the RTK GNSS system data for walking in an open field is highly precise and consistent. There is a slightly scatter plots which shows a tightly clustered of data points. The fig 2.2 which shows graph of walking open – altitude vs time, there is a variation in the altitude over time. The variations in the data points occurred due to the following factors such as changes in terrain or atmospheric conditions. The scatter plots of data points shows the variations in altitude over time. There are fluctuations in altitude as there are receiver's accuracy which limit in determining altitude. The graph shown in fig 2.3 shows walking open – longitude vs latitude which displays a scatter plot of data points distribution. The data points are closely packed in the graph which indicates that the RTK GNSS system consistently provides accurate longitude and latitude coordinates. There is a narrow range of data points due to precise positioning.

The calculation for statistical measures such as mean and standard deviation for walking data for open field is:

1. UTM Northing - Mean: 4689532.1823529415
2. UTM Northing - Standard Deviation: 21.838895018753547
3. UTM Easting - Mean: 328252.7818014706
4. UTM Easting – Standard Deviation: 20.354075797738183
5. Latitude - Mean: 42.33909891913919
6. Latitude - Standard Deviation: 0.00019601538599811703
7. Longitude - Mean: -71.08486251831054
8. Longitude - Standard Deviation: 0.000247719631116342
9. Altitude - Mean: 6.509388216804056
10. Altitude - Standard Deviation: 0.41823038836926574

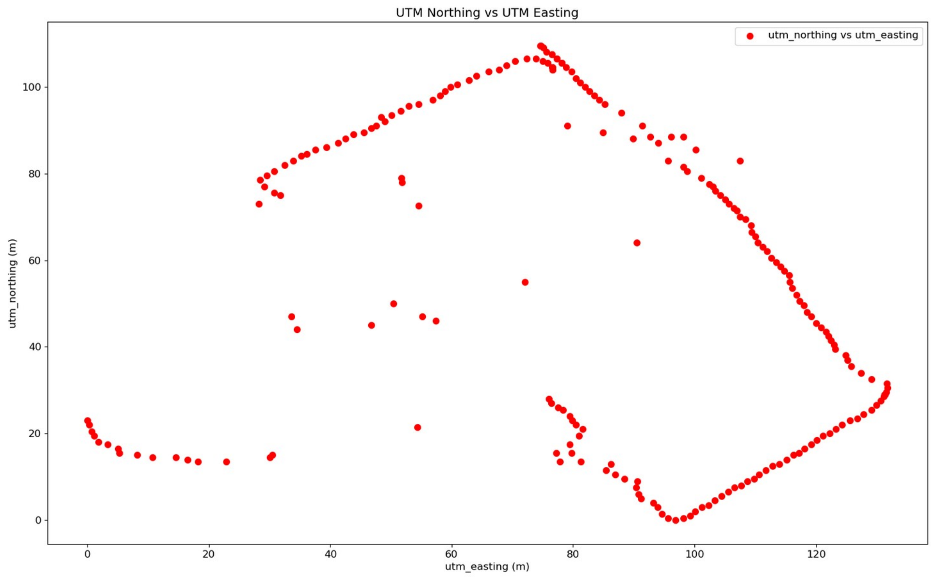

Fig 2.4: Walking Closed – utm northing vs utm easting

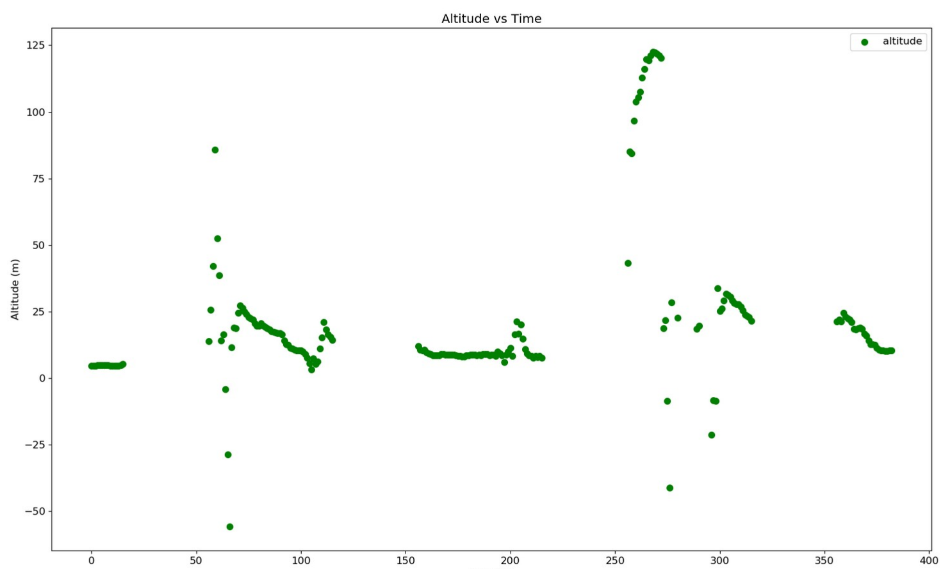

Fig 2.5: Walking Closed - altitude vs time

From the graph fig 2.4 which shows the walking closed – utm easting vs utm northing where the data points are scattered, which is not closely packed and there is minor cluster of data points which shows that the data is not much accurate and reliable positioning than the walking open. The distribution of data points shows that there is error from the "true" position and it is slightly more than the open field data because of the obstructions and interference. The fig 2.5 which shows graph of walking closed – altitude vs time, where there is a variation in the altitude over time. The variations in the data points happens due to atmospheric conditions or terrain. The fluctuations in the altitude happens due to accuracy of receiver which limit in determining altitude. There is a huge variation as time passes but the data points are clustered in specific areas.

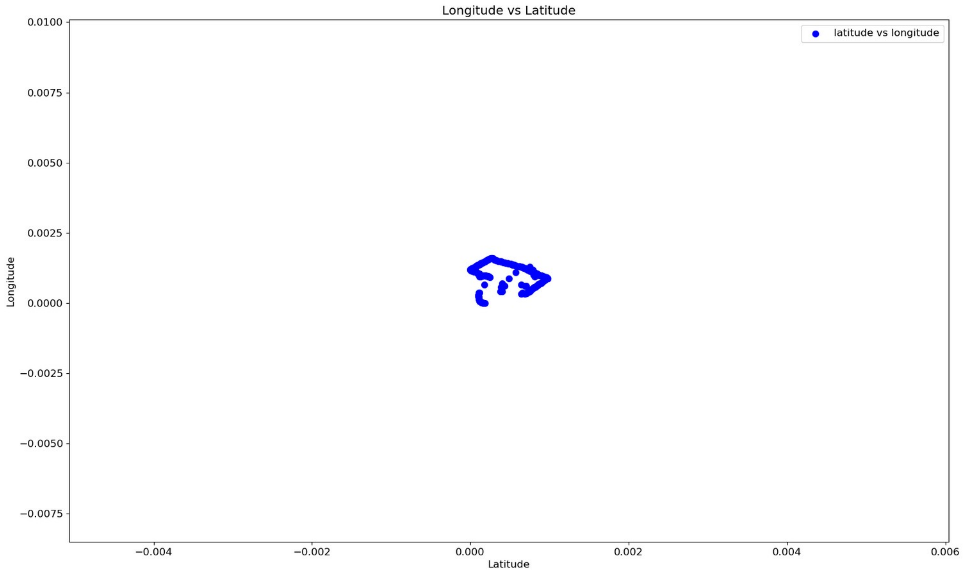

Fig 2.6: Walking Closed – longitude vs latitude

The graph shown in fig 2.6 shows walking closed – longitude vs latitude which displays a scatter plot of data points distribution. The data points are closely packed but there is a slight variations in the graph which shows that there is consistently accurate longitude and latitude coordinates. There is narrow range of data points and the data is disturbed in the precise positioning.
The calculation for statistical measures such as mean and standard deviation for walking data for closed is:

1. UTM Northing - Mean: 4689377.63507109
2. UTM Northing - Standard Deviation: 35.93344957633015
3. UTM Easting - Mean: 328275.4182464455
4. UTM Easting - Standard Deviation: 34.22165426937669
5. Latitude - Mean: 42.33771319637931
6. Latitude - Standard Deviation: 0.00032185587318952444
7. Longitude - Mean: -71.08454222475748
8. Longitude - Standard Deviation: 0.00041734937957369243
9. Altitude - Mean: 20.894805700293084
10. Altitude - Standard Deviation: 28.806837659136196

Stationary Data in Open and Occluded Cases

The stationary data also showed error reduction in open field areas as compared to occluded areas. The difference is associated with the GNSS fix quality, which is similar to the moving data. In the open field, the RTK GNSS system has a better line of sight to the satellites, resulting in improved accuracy. The reduced error and narrower data distributions shows superiority over standalone GNSS in varrious environmental conditions.

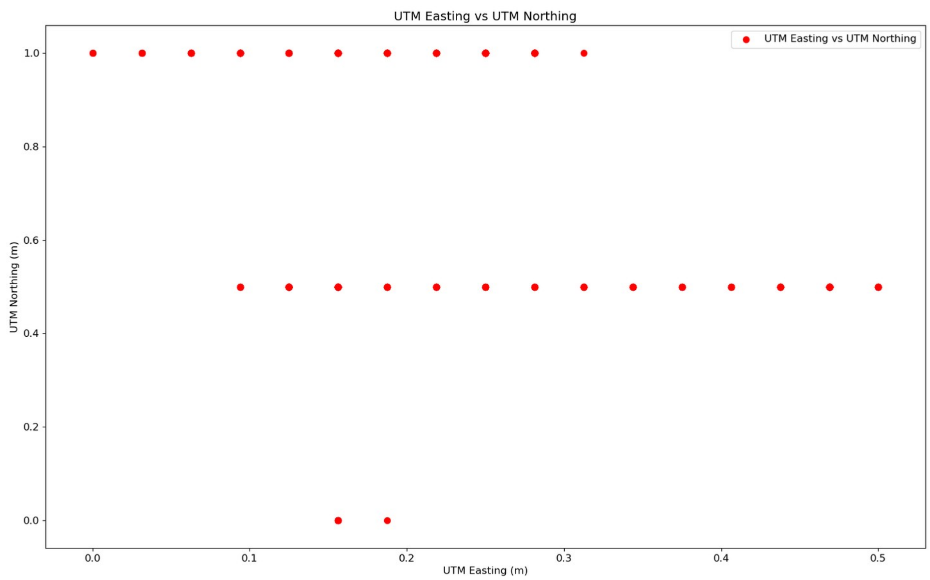

Fig 3.1: Stationary Open – utm easting vs utm northing

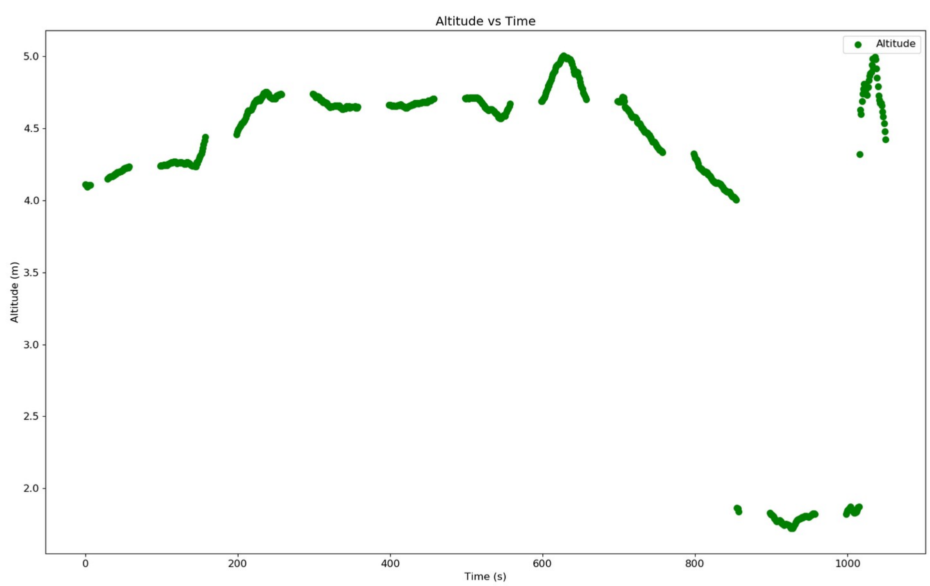

Fig 3.2: Stationary Open – altitude vs time

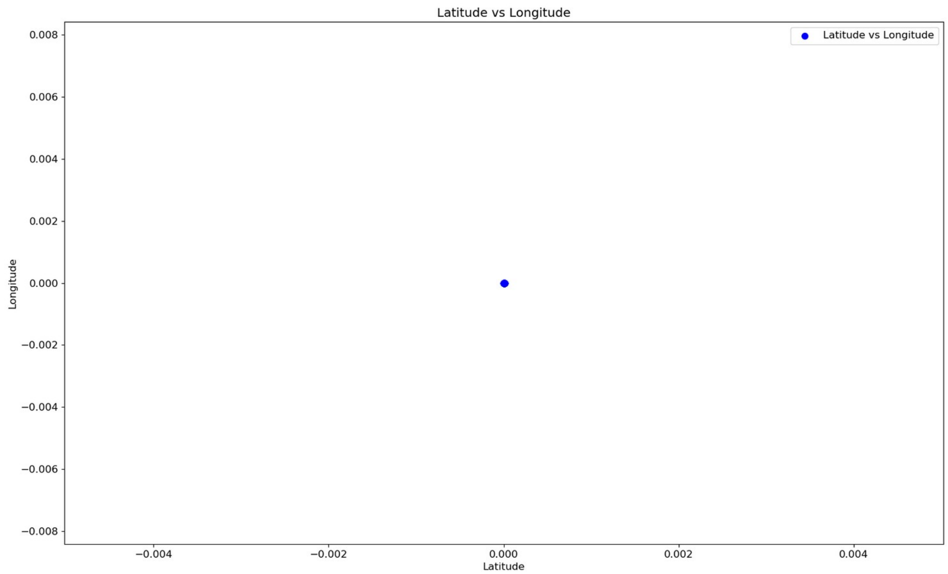

Fig 3.3: Stationary Open – longitude vs latitude

Figure 3.1 depicts a stationary open - utm easting vs utm northing graph with scattered data points, which may indicate precise and stable positioning. The data point distribution suggests that there may be less deviation from the "true" position. The graph demonstrates that the RTK GNSS system data for stationary in an open field is less exact, yet consistent. There are straight graphs that show data points. In Fig. 3.2, which depicts a graph of stationary open - altitude versus time, the altitude varies over time. Variations in data points were caused by variables such as changes in topography or atmospheric conditions. The scatter plots of data points depict changes in height over time. There are changes in altitude due to receiver accuracy, which limits the ability to determine altitude. Figure 3.3 depicts a stationary open - longitude versus latitude graph with a scatter plot of data point distribution. The data dots in the graph are densely packed, indicating that the RTK GNSS system consistently gives precise longitude and latitude coordinates. Because of the precise placement, the data points are limited.

The calculation for statistical measures such as mean and standard deviation for stationary data for open field is:

1. UTM Northing - Mean: 4689524.199356914
2. UTM Northing - Standard Deviation: 0.25917176629752137
3. UTM Easting - Mean: 328252.6876004823
4. UTM Easting - Standard Deviation: 0.13114177880936745
5. Latitude - Mean: 42.339026944813654
6. Latitude - Standard Deviation: 2.30935640252378e-06
7. Longitude - Mean: -71.0848617553711
8. Longitude - Standard Deviation: 0.0
9. Altitude - Mean: 4.193934086051401
10. Altitude - Standard Deviation: 0.9547581943700374

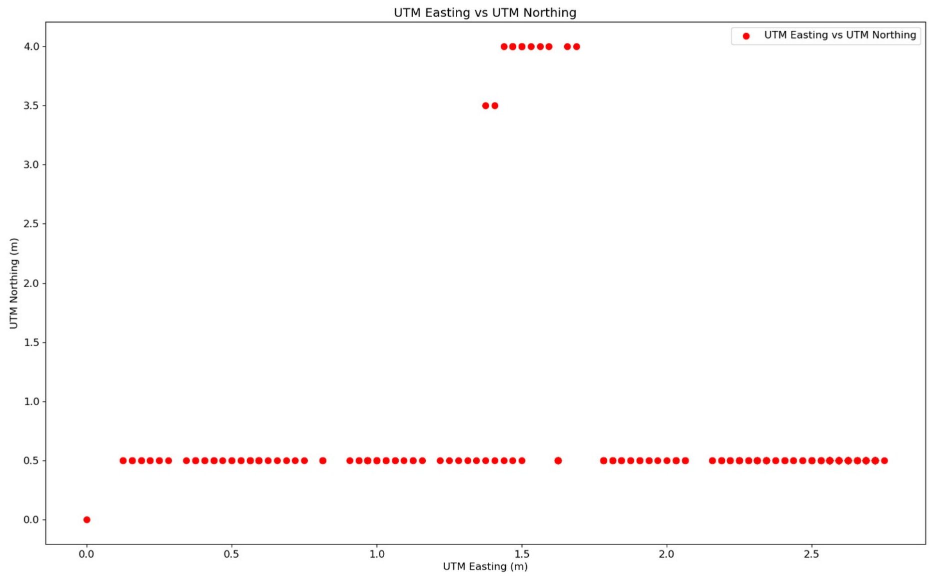

Fig 3.4: Stationary Closed – utm easting vs utm northing

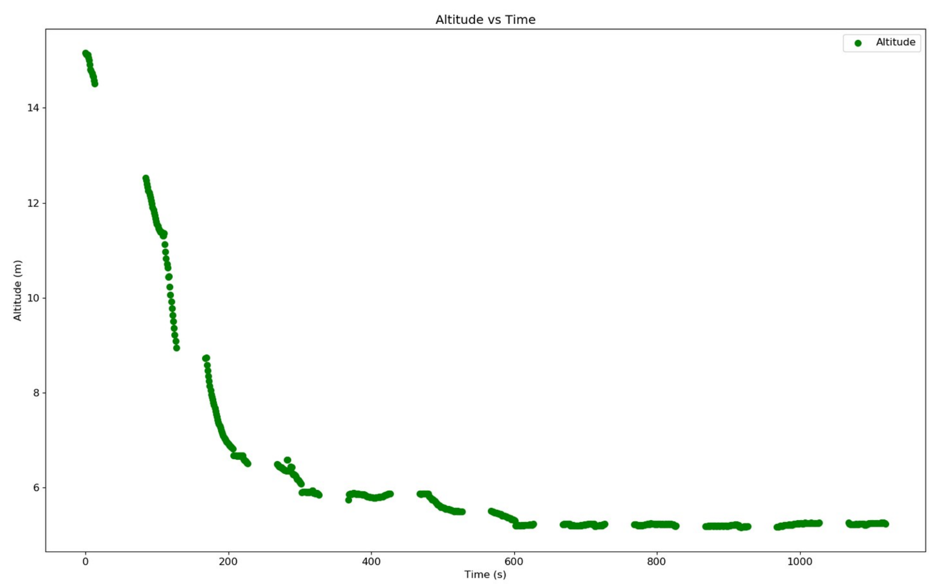

Fig 3.5: Stationary Closed – altitude vs time

Figure 3.4 depicts the stationary closed - utm easting vs utm northing graph, where the data points are scattered, not densely packed, and there is no cluster of data points. Because of the barriers and interference, the distribution of data points shows that there is error from the "true" position, which is slightly greater than the open field data. Figure 3.5 depicts a graph of stationary closed - altitude vs time, where the altitude varies with time. Variations in data points occur as a result of atmospheric conditions or geography. The changes in height are caused by the receiver's precision, which limits the ability to determine altitude. There is a significant variance throughout time, however they are clustered in distinct places.

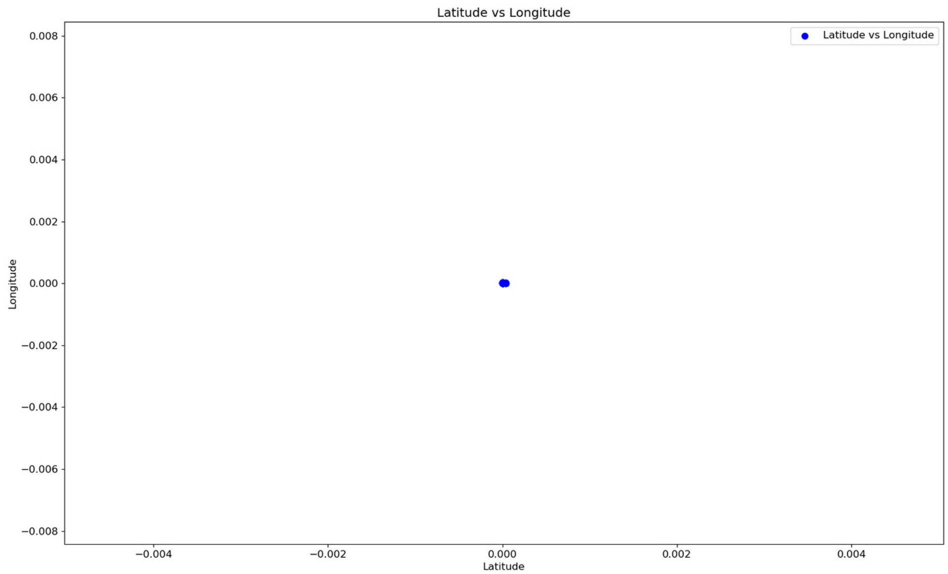

Fig 3.6: Stationary Closed – longitude vs latitude

Figure 3.6 depicts a stationary closed - longitude vs latitude graph with a scatter plot of data point distribution. The data points are closely packed, yet there are tiny changes in the graph, indicating that the longitude and latitude coordinates are constantly accurate. The data is affected in the precise location due to the limited range of data points.

For stationary closed data, the calculation for statistical measures such as mean and standard deviation is:

1. TM Northing - Mean: 4689334.07296467
2. UTM Northing - Standard Deviation: 0.49851419512951517
3. UTM Easting - Mean: 328069.11251920124
4. UTM Easting - Standard Deviation: 0.6532109517164977
5. Latitude - Mean: 42.33727557977773
6. Latitude - Standard Deviation: 4.866394509382762e-06
7. Longitude - Mean: -71.08703218334098
8. Longitude - Standard Deviation: 7.673489764055432e-06
9. Altitude - Mean: 6.204900150474865
10. Altitude - Standard Deviation: 1.9990475531868805