Tracking and Navigation

Global Navigation Satellite System (GNSS)

The Autonomous Vehicle: GNSS Technology Tracking Using Controller

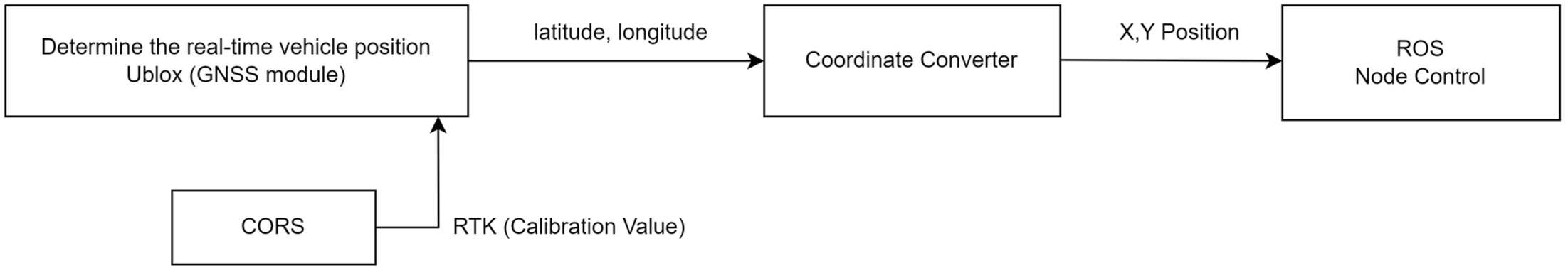
1.Percent fixed and float (RTK and NetworkRTK)

2. Moving Average filter

3. Coordinate converter

Block Diagram

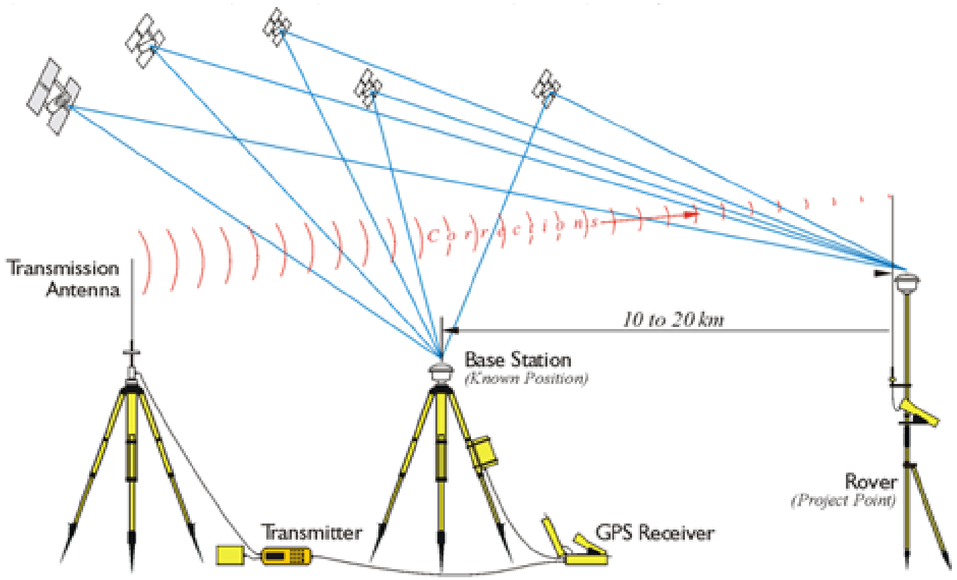
Tracking and Navigation System



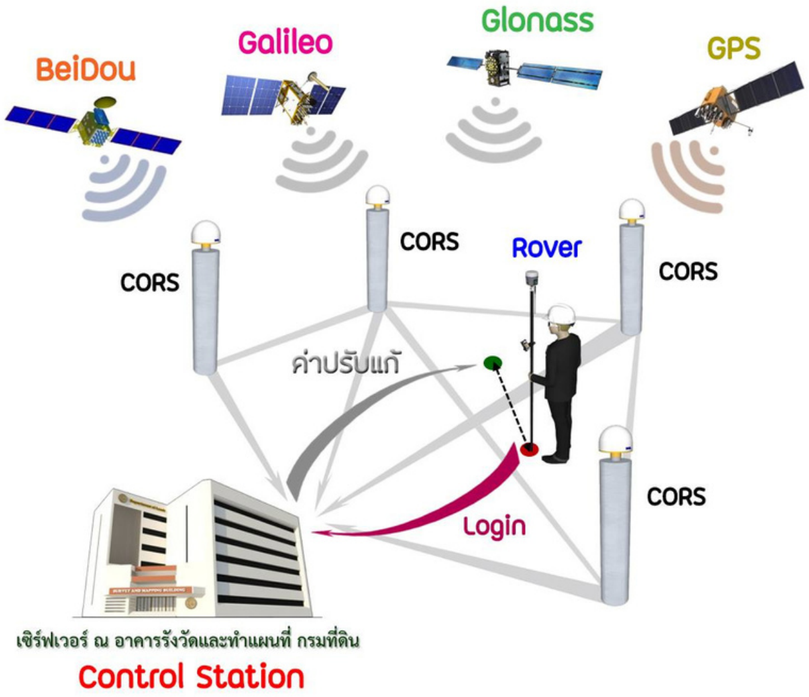
Determine the real-time vehicle position

GNSS Method Surveying

RTK (Real Time Kinematic)

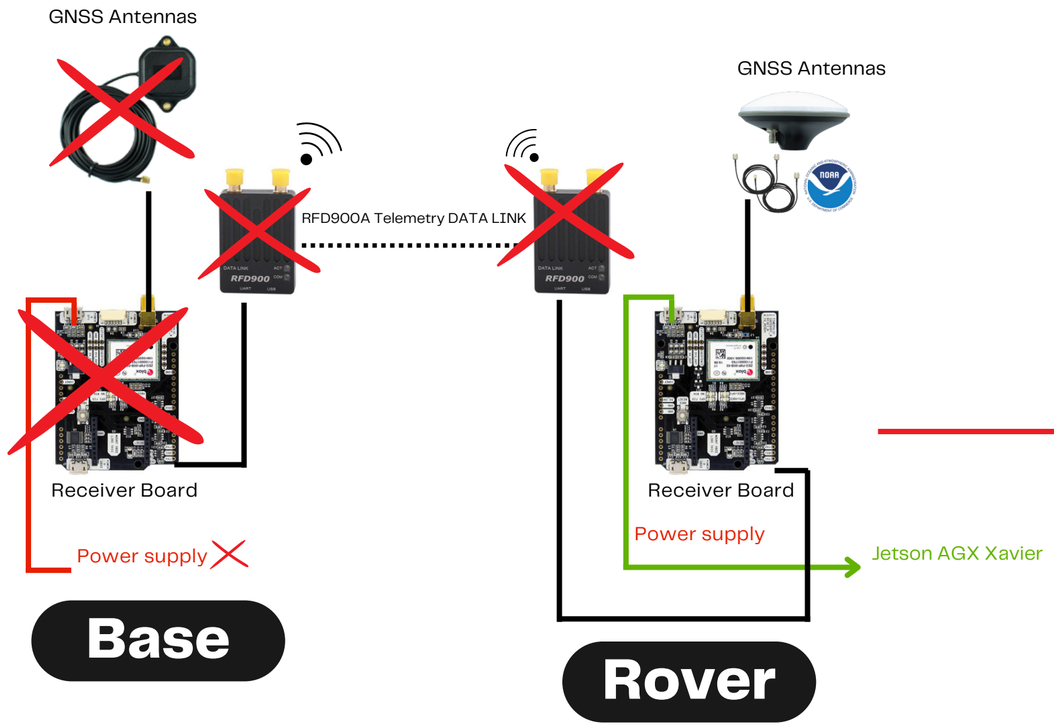


Network RTK

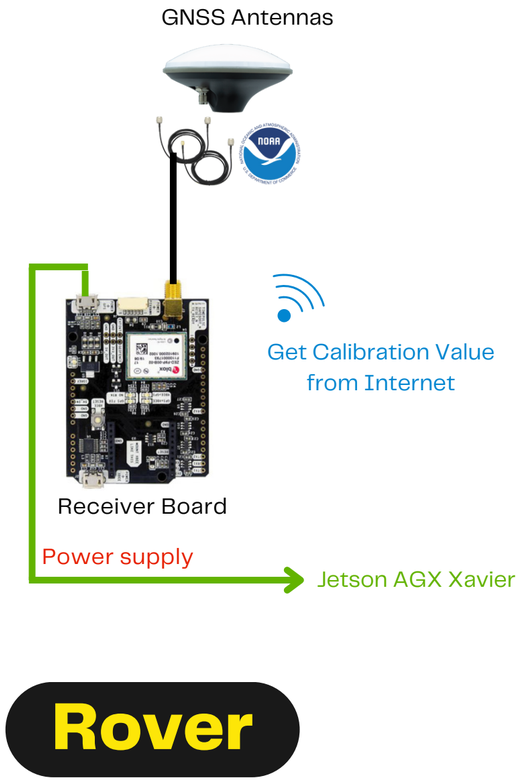


Improvement

RTK (Real Time Kinematic)

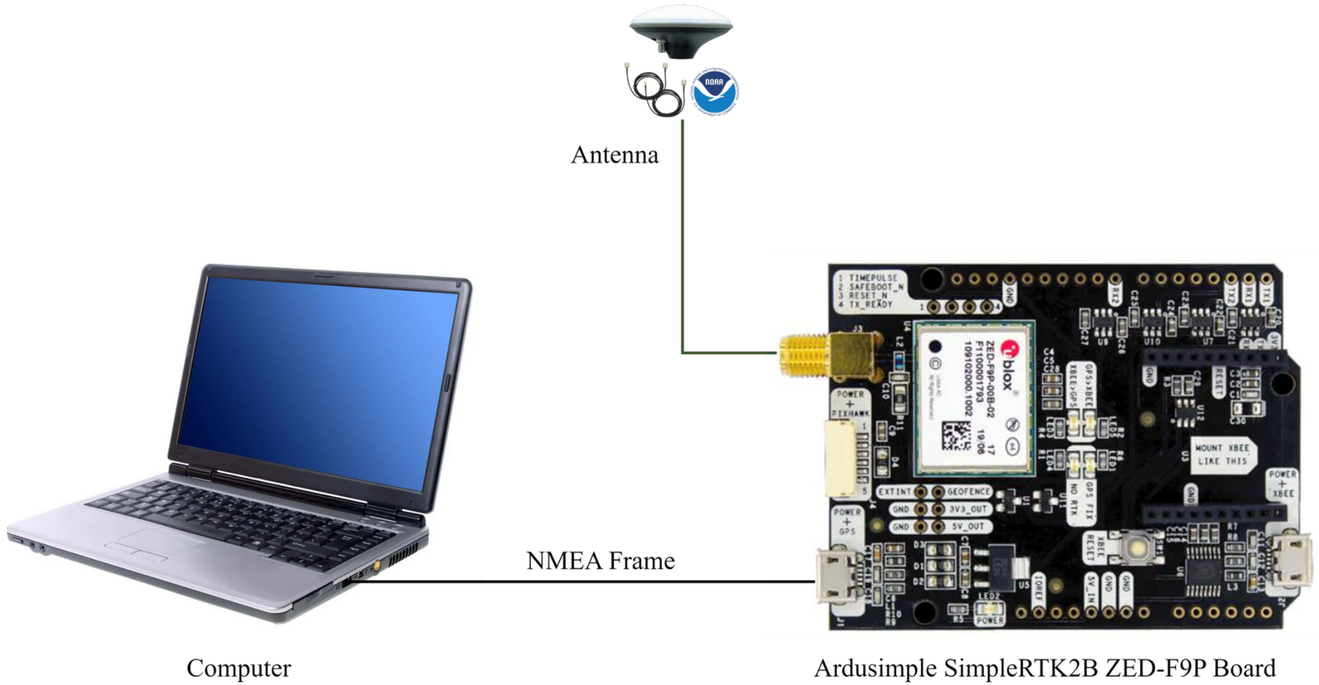


Network RTK

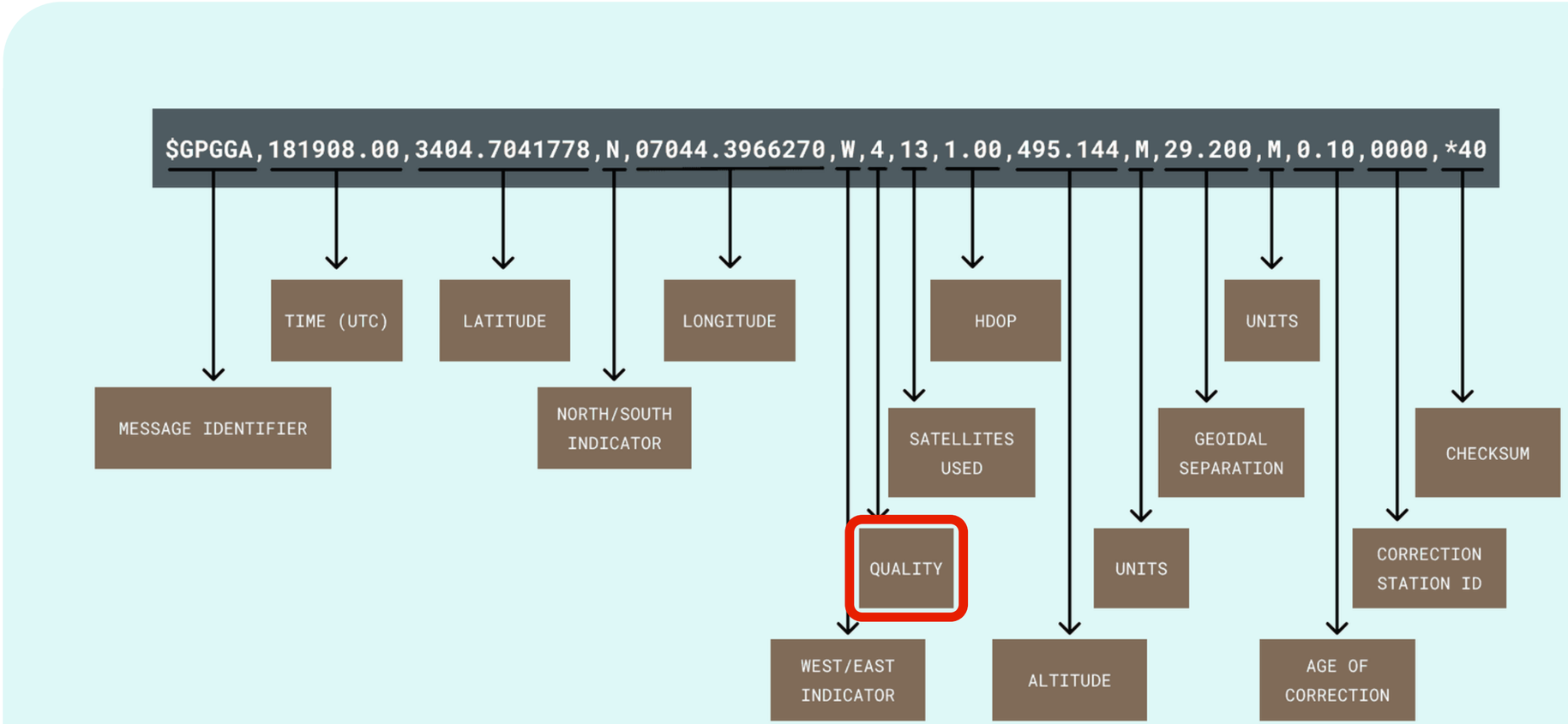


The Autonomous Vehicle: GNSS Technology Tracking Using Controller

Measurement Accuracy



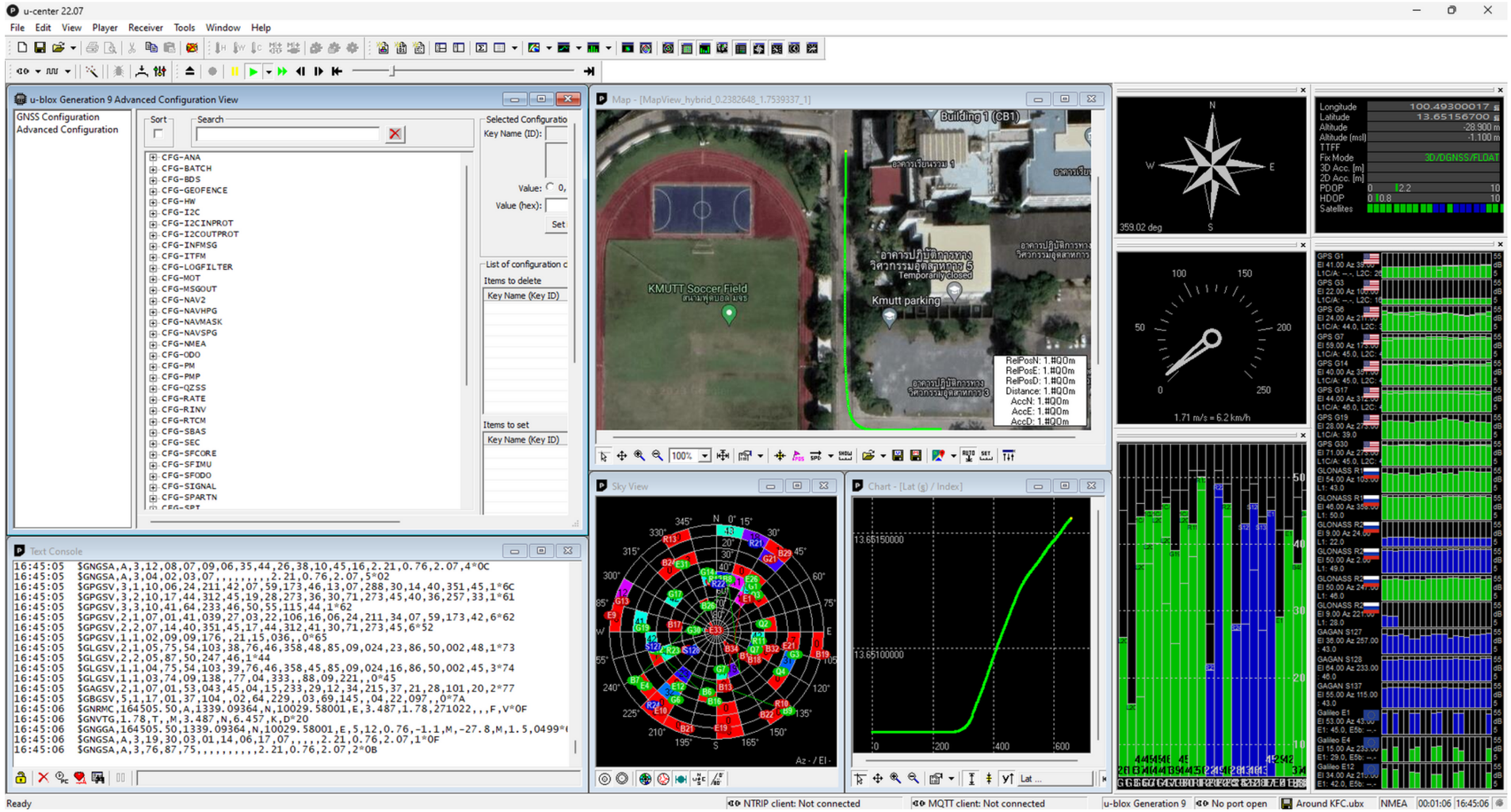
NMEA GGA Frame



Quality Type

Value	Name	Description
0	Invalid	GNSS can't determinate the position (No signal)
1	GPS	Position is gathered only form GPS satellites.
2	DGNSS	Position is gathered from GNSS satellites. The DGNSS accuracy is in the range of 30-50 cm.
4	RTK fixed	Position is gathered and calculated between the satellites and the reference station. The RTK fixed accuracy is in the range of 1-5 cm.
5	RTK float	Very similar to the fixed RTK method. But the calculation has not been solved yet. The RTK fixed accuracy is in the range of 10-20 cm.

U-center


u-center 22.07
File Edit View Player Receiver Tools Window Help
u-blox Generation 9 Advanced Configuration View
GNSS Configuration
Advanced Configuration
Map - [MapView_hybrid_0.2382648_1.7539337_1]
KMUTT Soccer Field
Kmutt parking
Temporarily closed
Sky View
Chart - [Lat (g) / Index]
Text Console
Ready

GGA Frame from U-center

Quality

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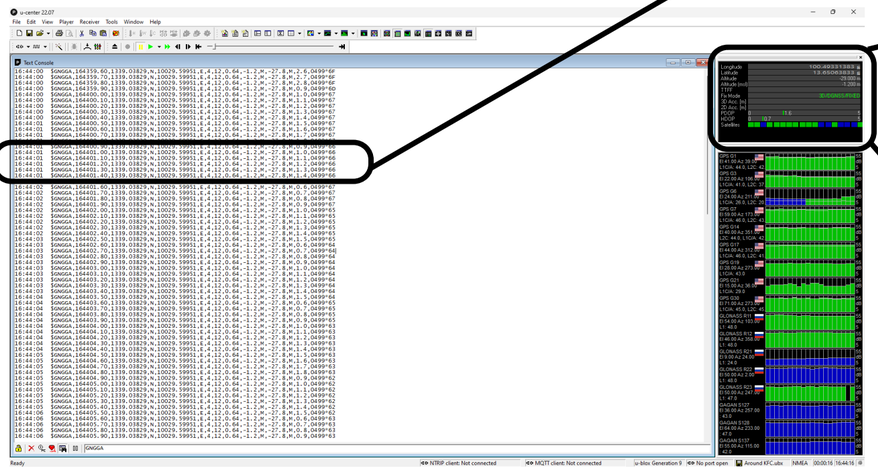
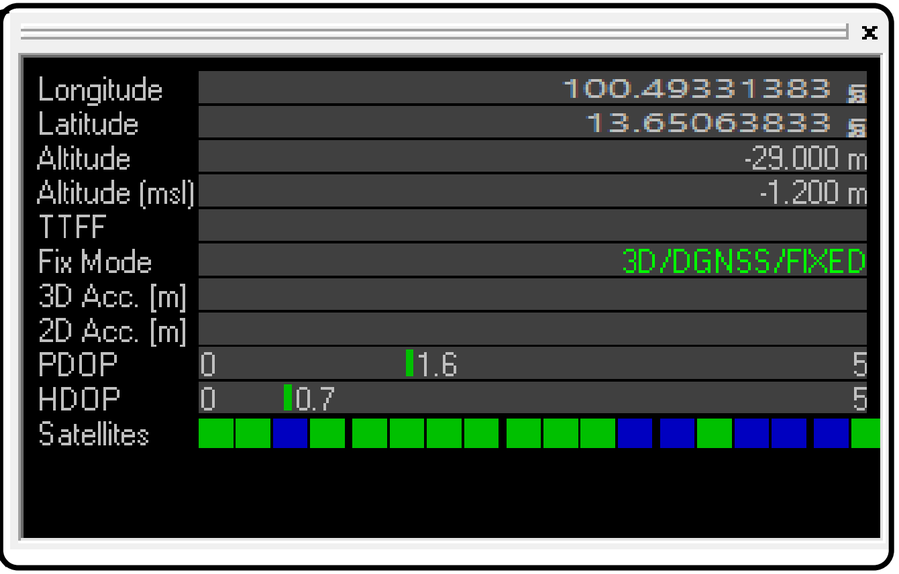
16:44:02  $GNGGA,164401.50,1339.03829,N,10029.59951,E,4,12,0.64,-1.2,M,-27.8,M,0.5,0499*67
```

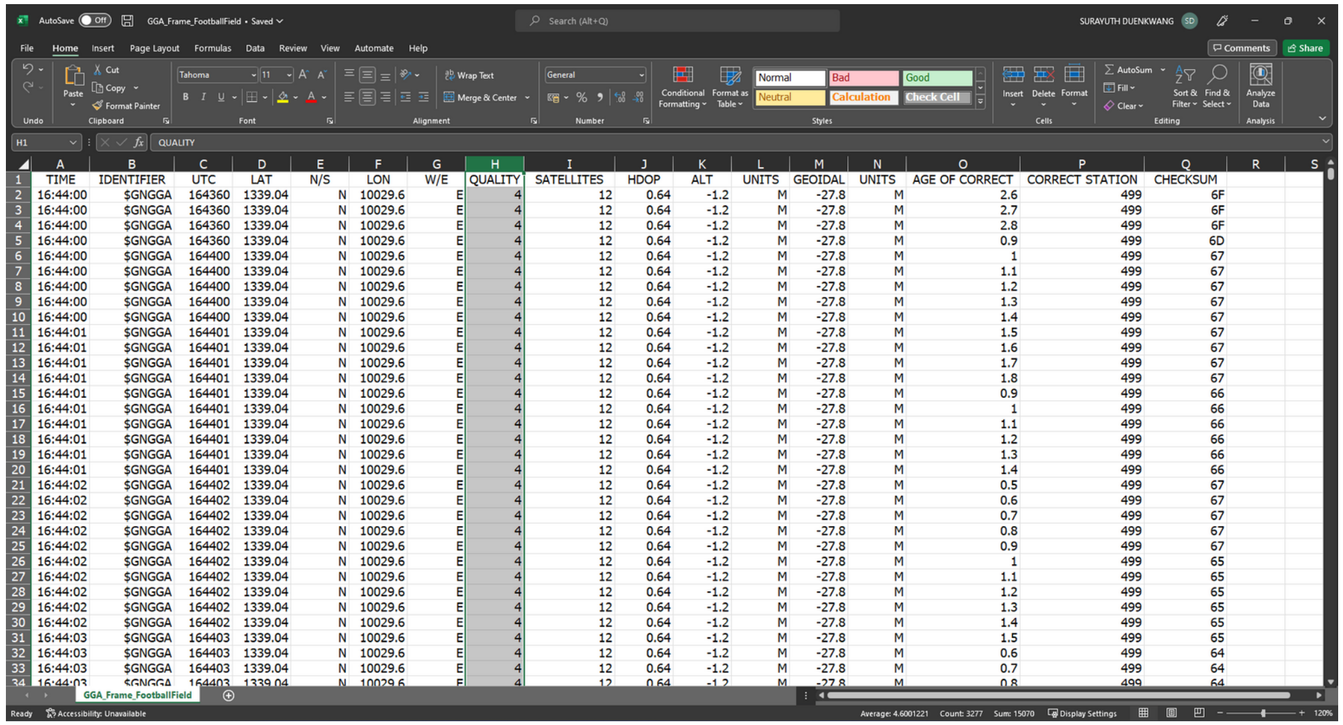




Count The Quality Type

u-center
GNSS, Evaluation Software
u-blox.com

CSV



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3	16:44:00	$GNGGA	164360	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	2.7	499	6F		
4	16:44:00	$GNGGA	164360	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	2.8	499	6F		
5	16:44:00	$GNGGA	164360	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.9	499	6D		
6	16:44:00	$GNGGA	164400	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1	499	67		
7	16:44:00	$GNGGA	164400	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.1	499	67		
8	16:44:00	$GNGGA	164400	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.2	499	67		
9	16:44:00	$GNGGA	164400	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.3	499	67		
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11	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.5	499	67		
12	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.6	499	67		
13	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.7	499	67		
14	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.8	499	67		
15	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.9	499	66		
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17	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.1	499	66		
18	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.2	499	66		
19	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.3	499	66		
20	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.4	499	66		
21	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.5	499	67		
22	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.6	499	67		
23	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.7	499	67		
24	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.8	499	67		
25	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.9	499	67		
26	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1	499	65		
27	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.1	499	65		
28	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.2	499	65		
29	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.3	499	65		
30	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.4	499	65		
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32	16:44:03	$GNGGA	164403	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.6	499	64		
33	16:44:03	$GNGGA	164403	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.7	499	64		
34	16:44:03	$GNGGA	164403	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.8	499	64		

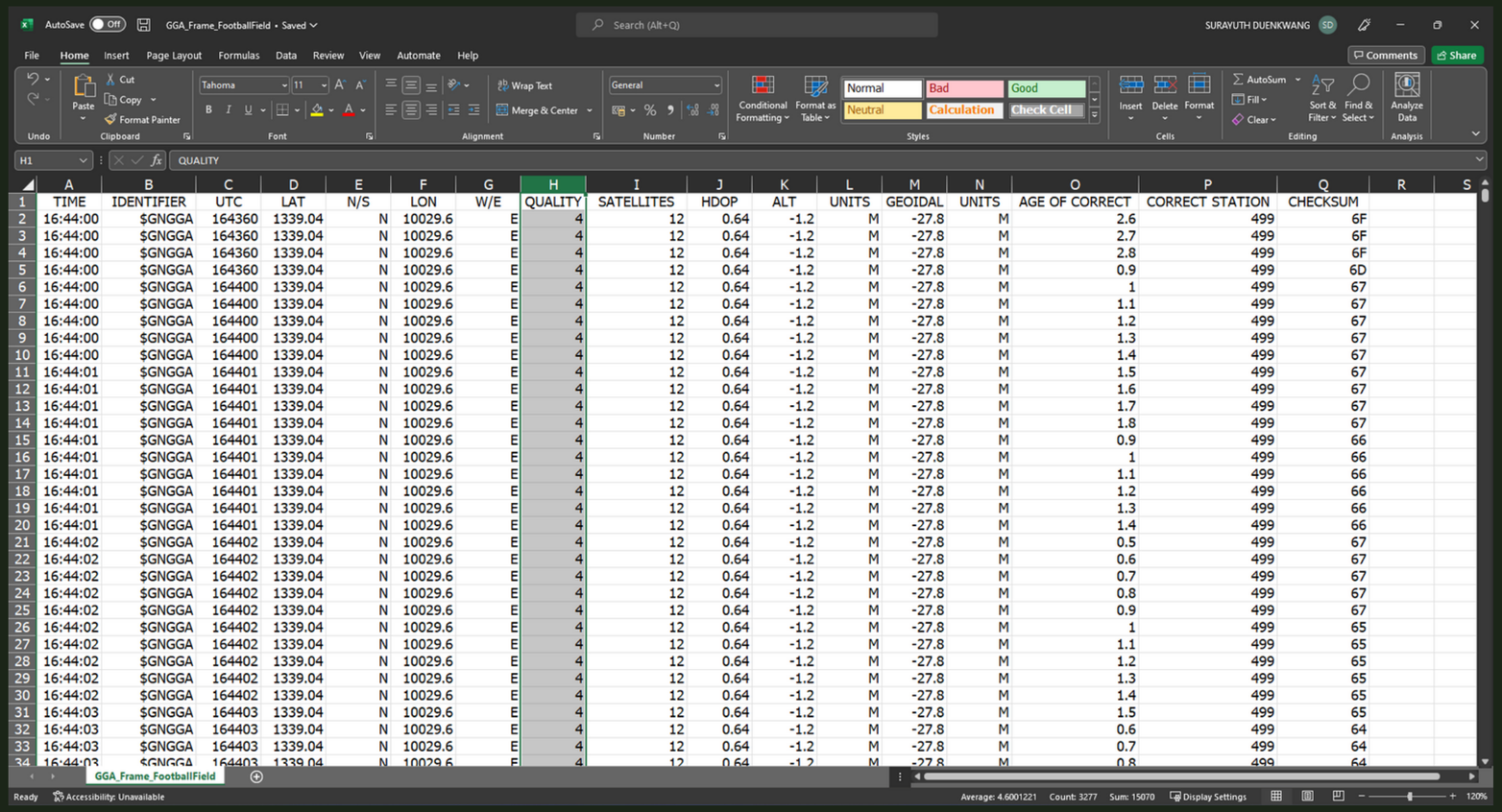
Example Result from Python

```
Sample =  3276
RTK FIXED Quality =  1004  Sample
RTK FLOAT Quality =  2170  Sample
RTK DGNSS Quality =  102  Sample
Total Quality =  3276  Sample
RTK FIXED Quality =  30.65 %
RTK float Quality =  66.24 %
RTK DGNSS Quality =  3.11 %
```

Count The Quality Type

Example Result from Python

```
Sample =  3583
RTK FIXED Quality =  1727  Sample
RTK FLOAT Quality =  1803  Sample
RTK DGNSS Quality =  53  Sample
Total Quality =  3583  Sample
RTK FIXED Quality =  48.2 %
RTK float Quality =  50.32 %
RTK DGNSS Quality =  1.48 %
```



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3	16:44:00	$GNGGA	164360	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	2.7	499	6F
4	16:44:00	$GNGGA	164360	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	2.8	499	6F
5	16:44:00	$GNGGA	164360	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.9	499	6D
6	16:44:00	$GNGGA	164400	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1	499	67
7	16:44:00	$GNGGA	164400	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.1	499	67
8	16:44:00	$GNGGA	164400	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.2	499	67
9	16:44:00	$GNGGA	164400	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.3	499	67
10	16:44:00	$GNGGA	164400	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.4	499	67
11	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.5	499	67
12	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.6	499	67
13	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.7	499	67
14	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.8	499	67
15	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.9	499	66
16	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1	499	66
17	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.1	499	66
18	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.2	499	66
19	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.3	499	66
20	16:44:01	$GNGGA	164401	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.4	499	66
21	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.5	499	67
22	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.6	499	67
23	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.7	499	67
24	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.8	499	67
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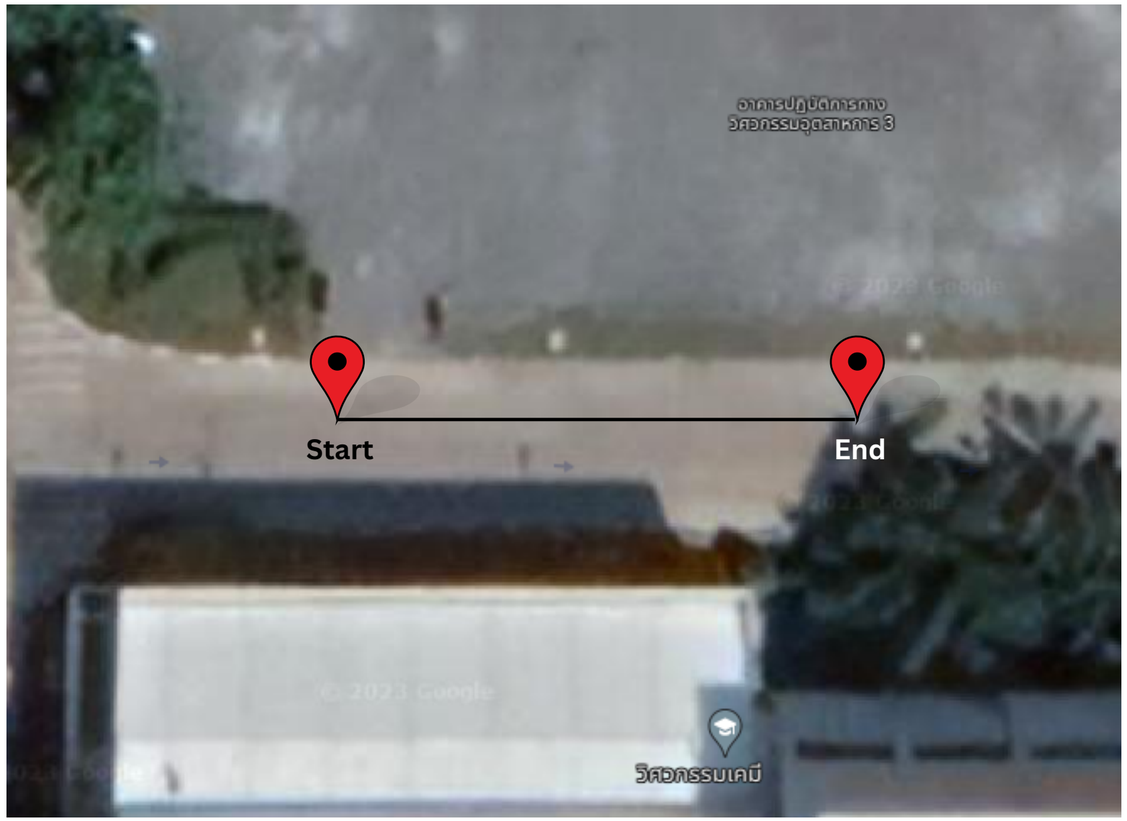
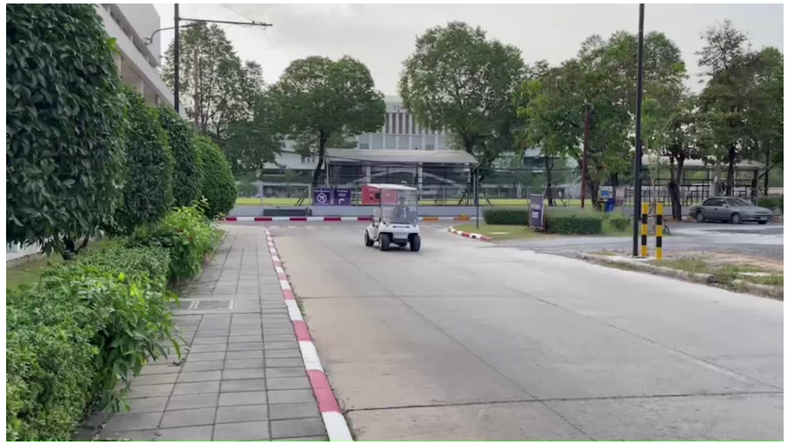
26	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1	499	65
27	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.1	499	65
28	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.2	499	65
29	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.3	499	65
30	16:44:02	$GNGGA	164402	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.4	499	65
31	16:44:03	$GNGGA	164403	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	1.5	499	65
32	16:44:03	$GNGGA	164403	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.6	499	64
33	16:44:03	$GNGGA	164403	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.7	499	64
34	16:44:03	$GNGGA	164403	1339.04	N	10029.6	E	4	12	0.64	-1.2	M	-27.8	M	0.8	499	64

Experiment 1 :

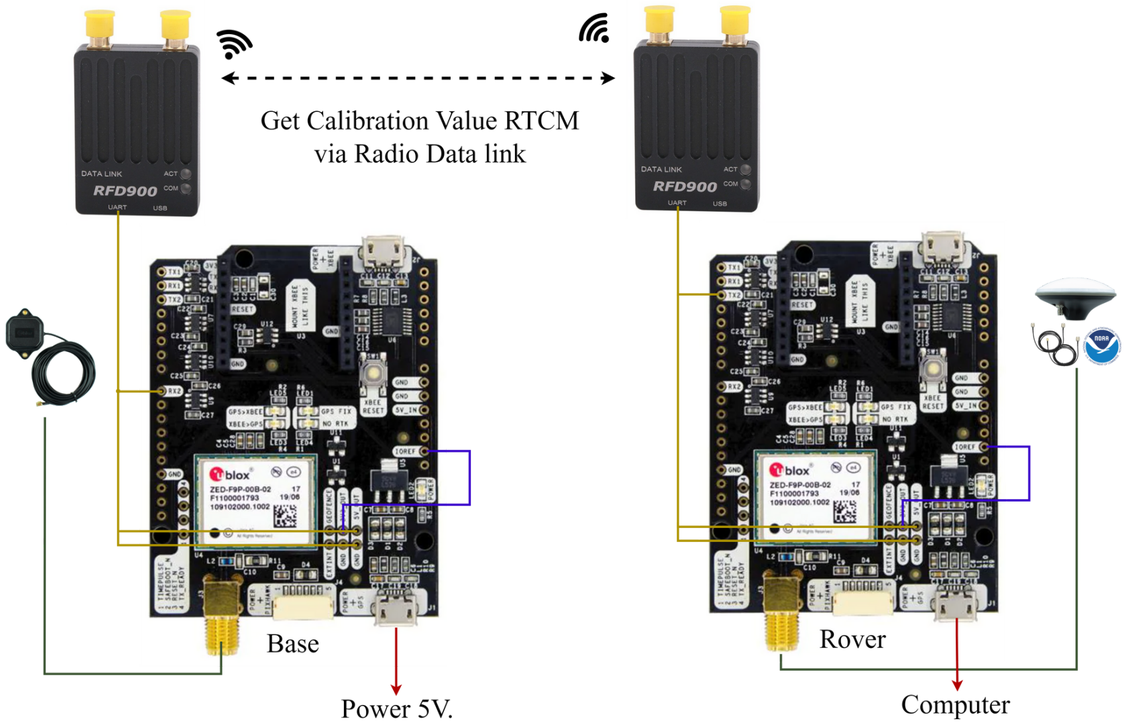
Short Distance





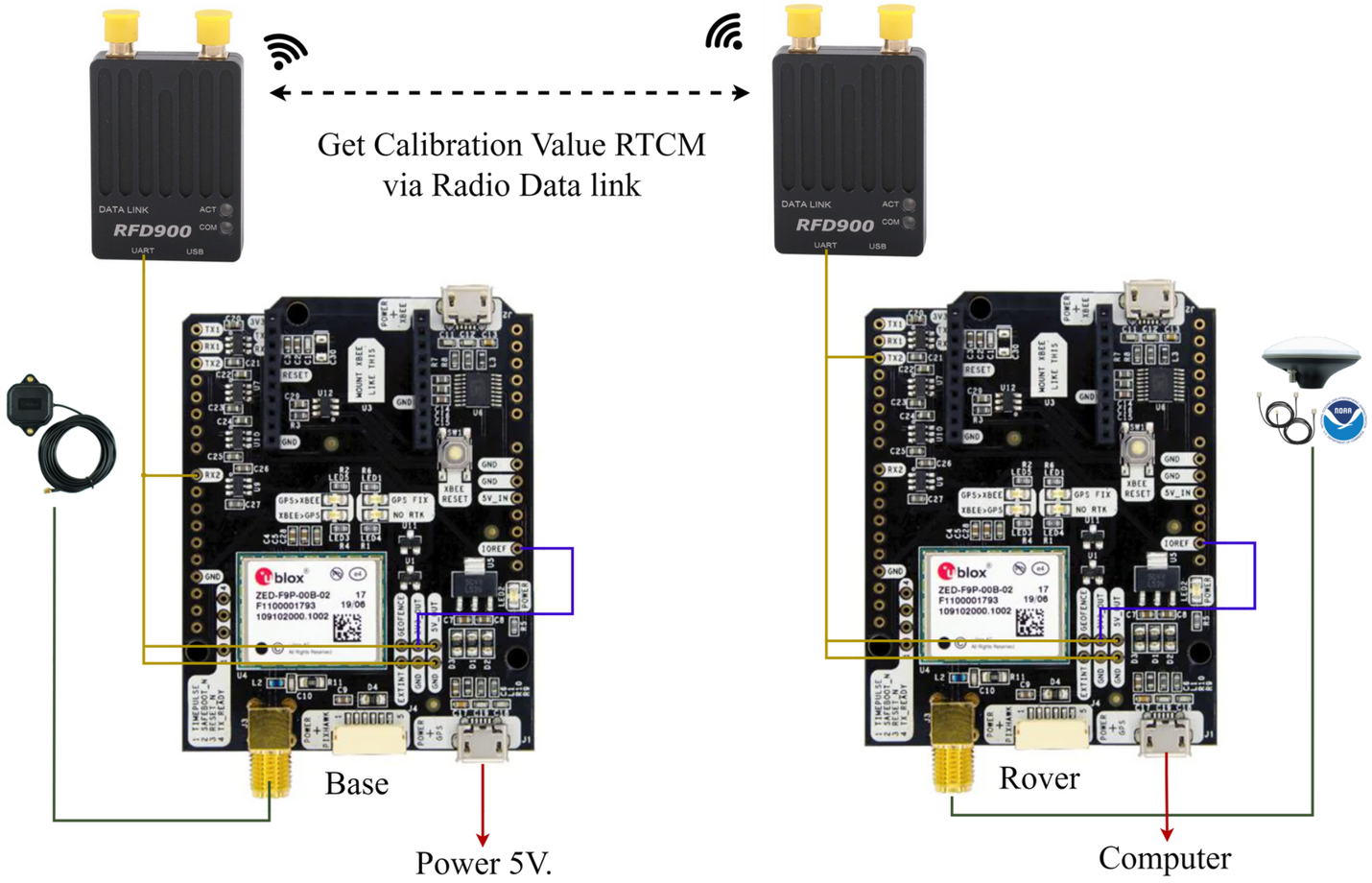
Set-up

Real Time Kinematic Method (2 Boards)



Base Station

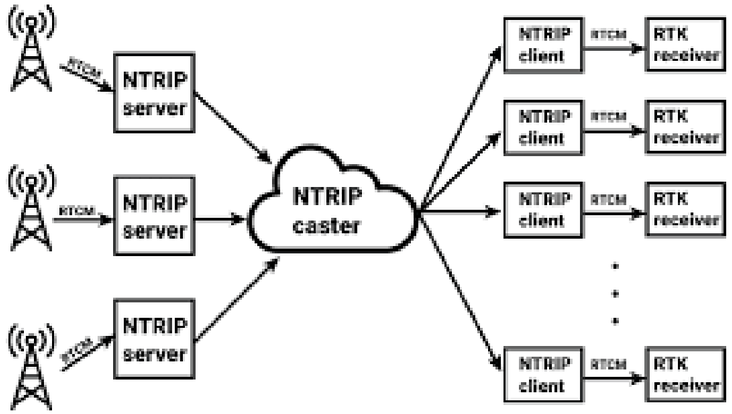
Rover Station


DATA LINK
ACT
RFD900
COM
UART
USB
Get Calibration Value RTCM
via Radio Data link
DATA LINK
ACT
RFD900
COM
UART
USB
Base
Power 5V.
Rover
Computer


GNSS Antennas
Receiver Board
Get Calibration Value
RTCM via Internet
Power supply
Computer

Set-up

Network RTK (1 Boards)

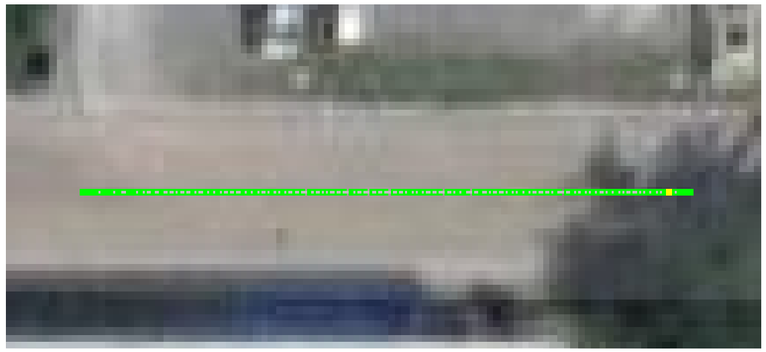


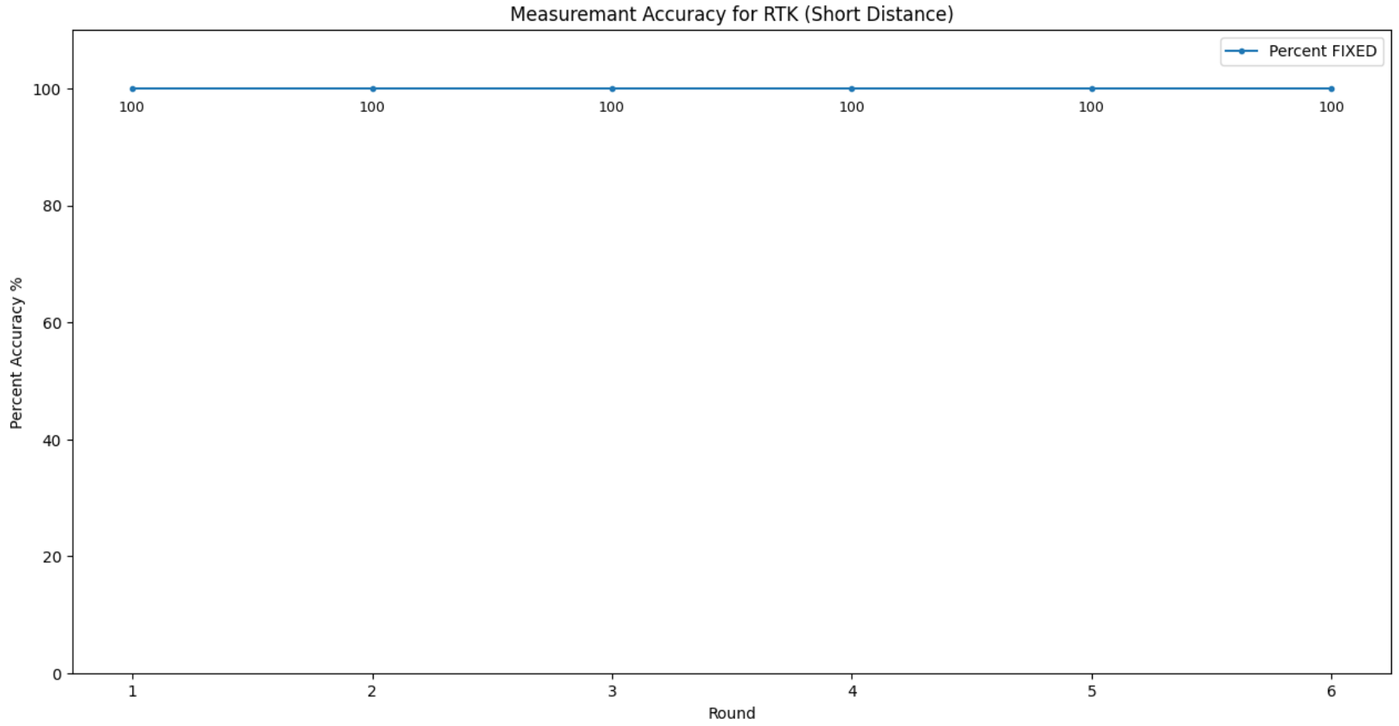
system architecture

Rover Station

Experiment 1 : Short Distance

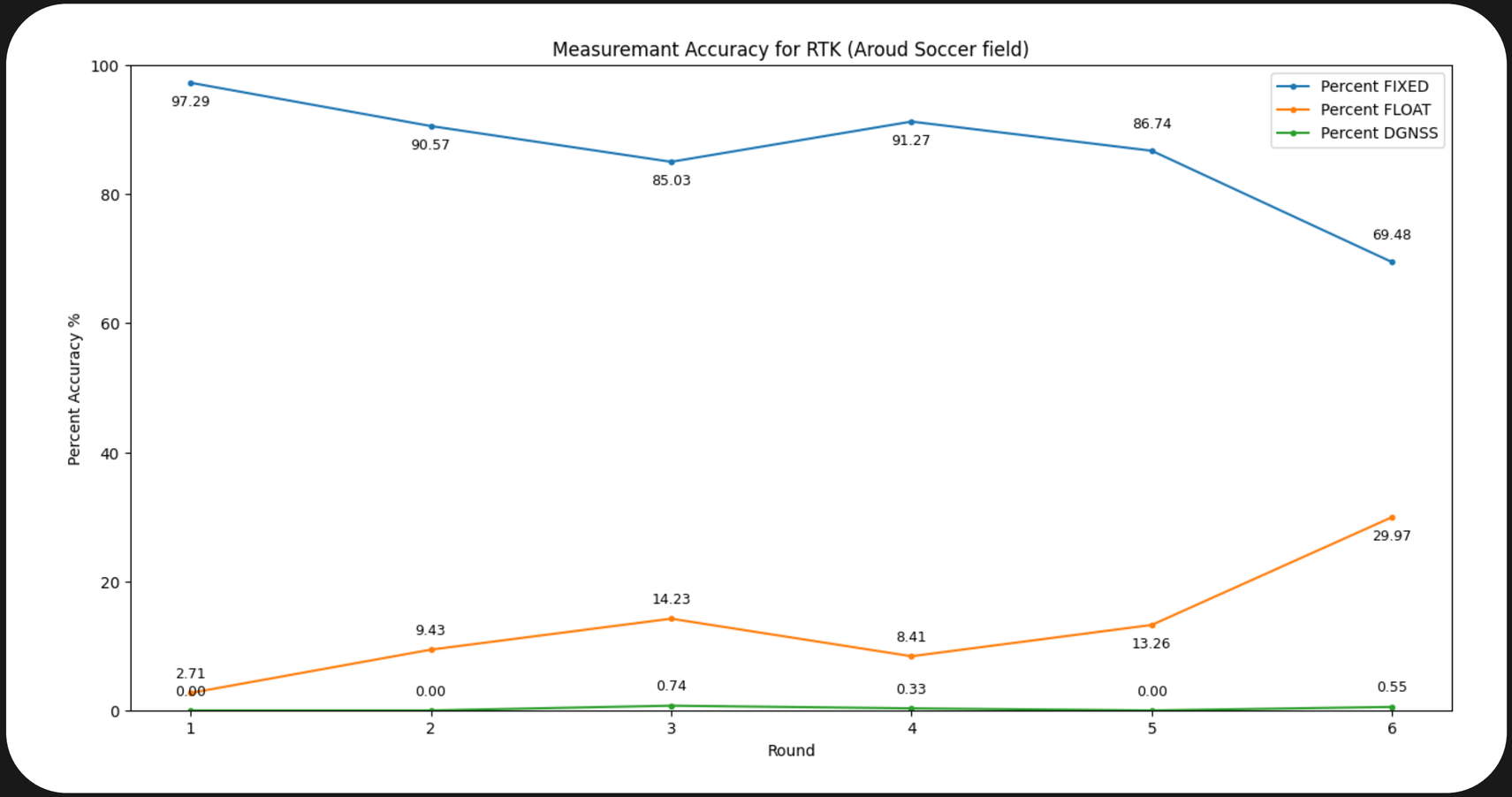
Real Time Kinematic Method (2 Boards)





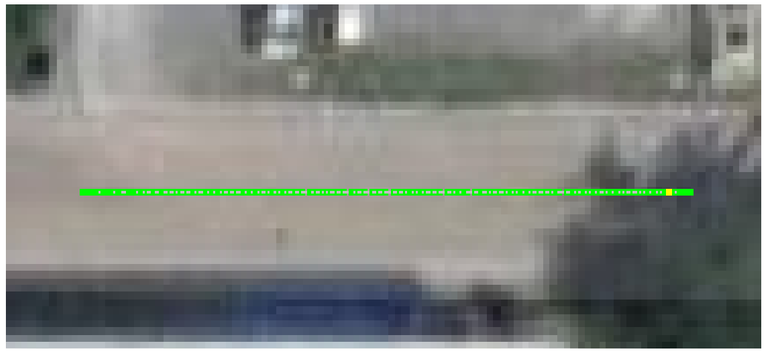
Experiment 2 : Around KMUTT Soccer Field

Real Time Kinematic Method (2 Boards)



Experiment 1 : Short Distance

Real Time Kinematic Method (2 Boards)



```
Sample =  58
RTK FIXED Quality =  58  Sample
RTK FLOAT Quality =  0  Sample
RTK DGNSS Quality =  0  Sample
Total Quality =  58  Sample
RTK FIXED Quality =  100.0 %
RTK float Quality =  0.0 %
RTK DGNSS Quality =  0.0 %
```

```
Sample =  100
RTK FIXED Quality =  100  Sample
RTK FLOAT Quality =  0  Sample
RTK DGNSS Quality =  0  Sample
Total Quality =  100  Sample
RTK FIXED Quality =  100.0 %
RTK float Quality =  0.0 %
RTK DGNSS Quality =  0.0 %
```

```
Sample =  129
RTK FIXED Quality =  129  Sample
RTK FLOAT Quality =  0  Sample
RTK DGNSS Quality =  0  Sample
Total Quality =  129  Sample
RTK FIXED Quality =  100.0 %
RTK float Quality =  0.0 %
RTK DGNSS Quality =  0.0 %
```

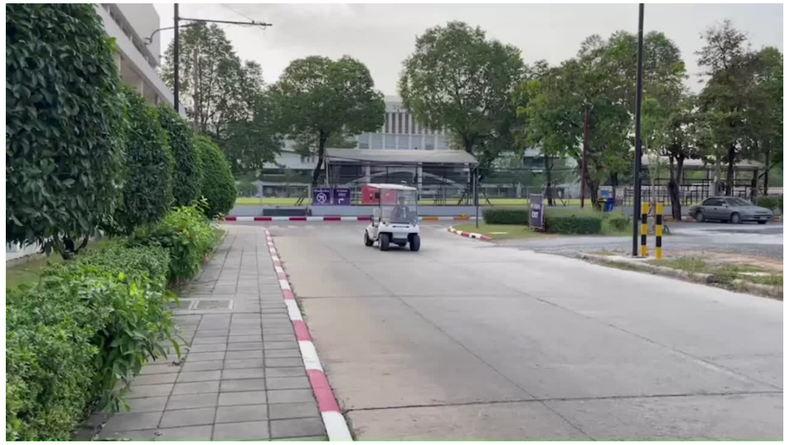
```
Sample =  90
RTK FIXED Quality =  90  Sample
RTK FLOAT Quality =  0  Sample
RTK DGNSS Quality =  0  Sample
Total Quality =  90  Sample
RTK FIXED Quality =  100.0 %
RTK float Quality =  0.0 %
RTK DGNSS Quality =  0.0 %
```

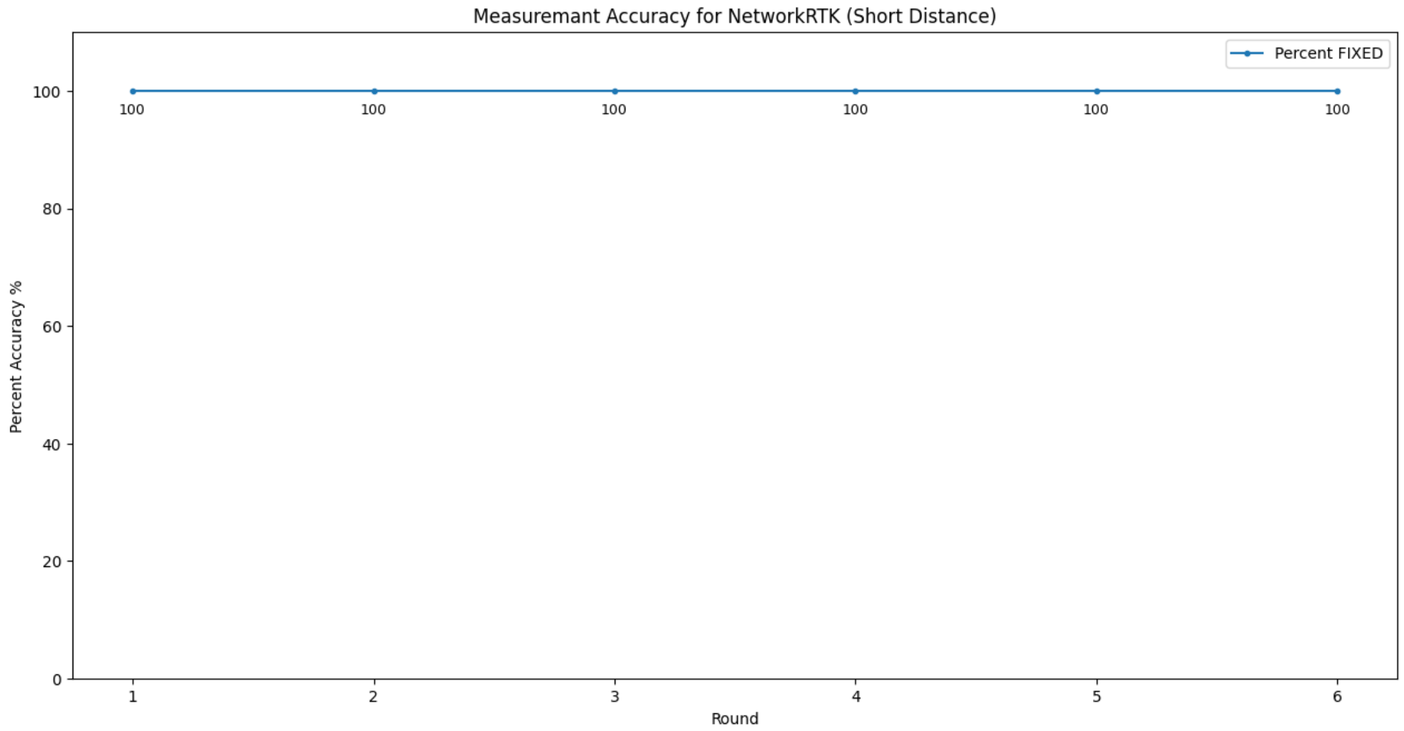
```
Sample =  84
RTK FIXED Quality =  84  Sample
RTK FLOAT Quality =  0  Sample
RTK DGNSS Quality =  0  Sample
Total Quality =  84  Sample
RTK FIXED Quality =  100.0 %
RTK float Quality =  0.0 %
RTK DGNSS Quality =  0.0 %
```

```
Sample =  87
RTK FIXED Quality =  87  Sample
RTK FLOAT Quality =  0  Sample
RTK DGNSS Quality =  0  Sample
Total Quality =  87  Sample
RTK FIXED Quality =  100.0 %
RTK float Quality =  0.0 %
RTK DGNSS Quality =  0.0 %
```

Experiment 1 : Short Distance

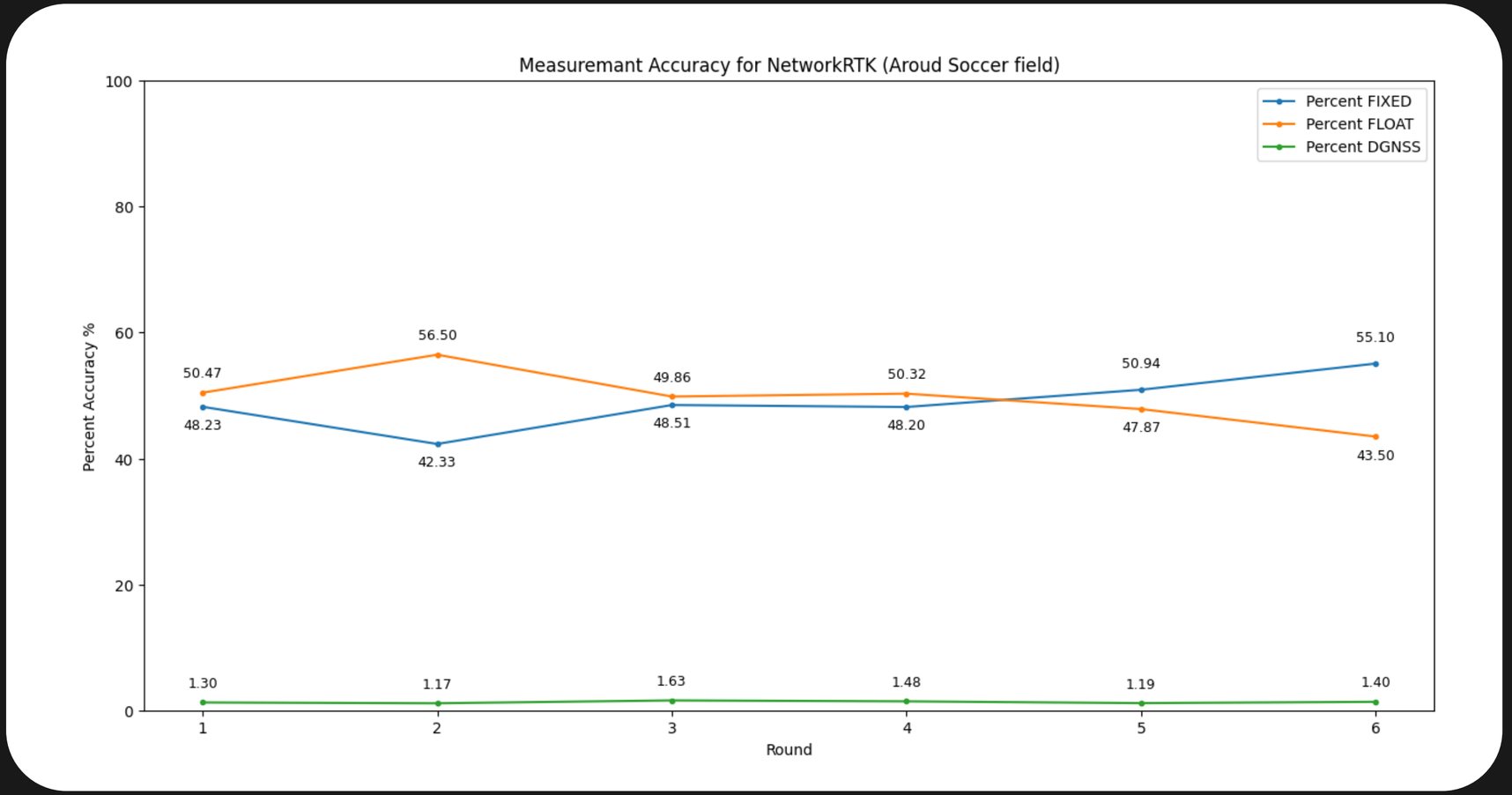
Network RTK (1 Boards)





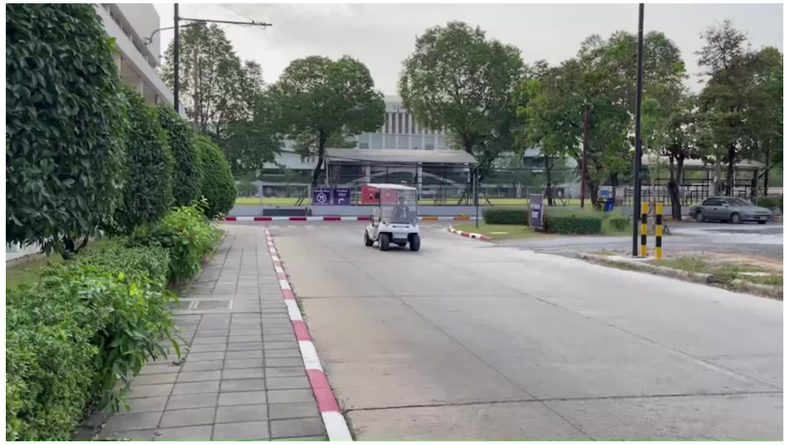
Experiment 2 : Around KMUTT Soccer Field

Network RTK (1 Boards)



Experiment 1 : Short Distance

Network RTK (1 Boards)



```
Sample =  326
RTK FIXED Quality =  326  Sample
RTK FLOAT Quality =  0  Sample
RTK DGNSS Quality =  0  Sample
Total Quality =  326  Sample
RTK FIXED Quality =  100.0 %
RTK float Quality =  0.0 %
RTK DGNSS Quality =  0.0 %
```

```
Sample =  309
RTK FIXED Quality =  309  Sample
RTK FLOAT Quality =  0  Sample
RTK DGNSS Quality =  0  Sample
Total Quality =  309  Sample
RTK FIXED Quality =  100.0 %
RTK float Quality =  0.0 %
RTK DGNSS Quality =  0.0 %
```

```
Sample =  347
RTK FIXED Quality =  347  Sample
RTK FLOAT Quality =  0  Sample
RTK DGNSS Quality =  0  Sample
Total Quality =  347  Sample
RTK FIXED Quality =  100.0 %
RTK float Quality =  0.0 %
RTK DGNSS Quality =  0.0 %
```

```
Sample =  306
RTK FIXED Quality =  306  Sample
RTK FLOAT Quality =  0  Sample
RTK DGNSS Quality =  0  Sample
Total Quality =  306  Sample
RTK FIXED Quality =  100.0 %
RTK float Quality =  0.0 %
RTK DGNSS Quality =  0.0 %
```

```
Sample =  273
RTK FIXED Quality =  273  Sample
RTK FLOAT Quality =  0  Sample
RTK DGNSS Quality =  0  Sample
Total Quality =  273  Sample
RTK FIXED Quality =  100.0 %
RTK float Quality =  0.0 %
RTK DGNSS Quality =  0.0 %
```

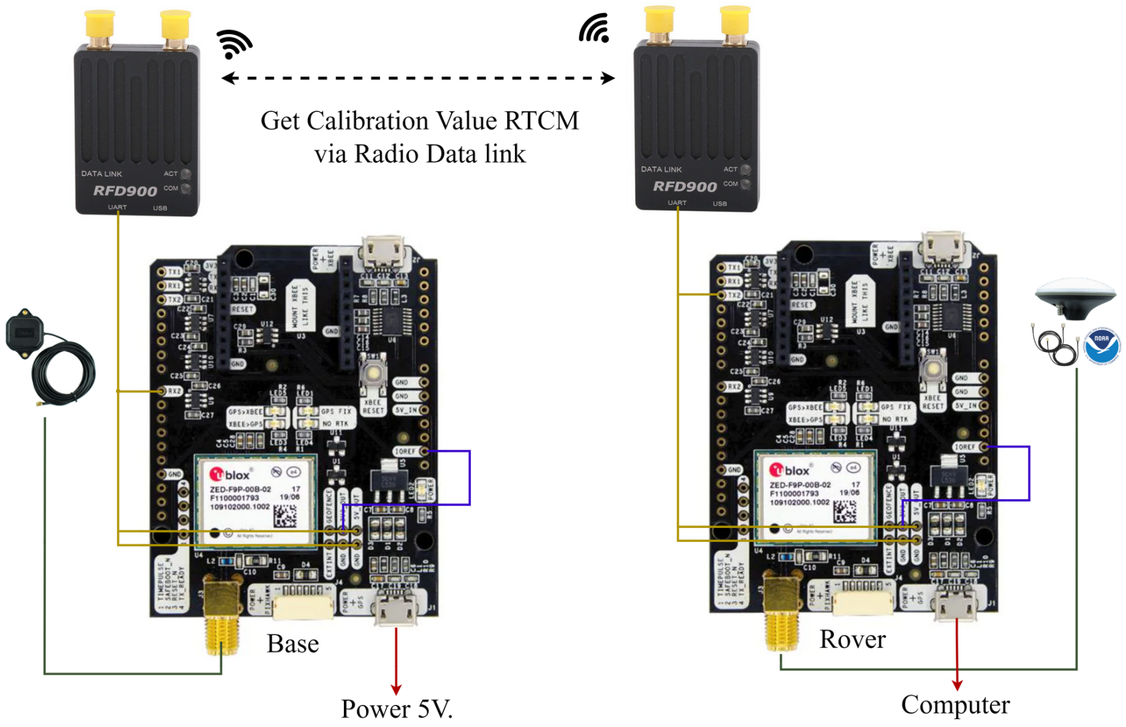
```
Sample =  253
RTK FIXED Quality =  253  Sample
RTK FLOAT Quality =  0  Sample
RTK DGNSS Quality =  0  Sample
Total Quality =  253  Sample
RTK FIXED Quality =  100.0 %
RTK float Quality =  0.0 %
RTK DGNSS Quality =  0.0 %
```

Experiment 2 :

Around KMUTT Soccer Field

Set-up

Real Time Kinematic Method (2 Boards)

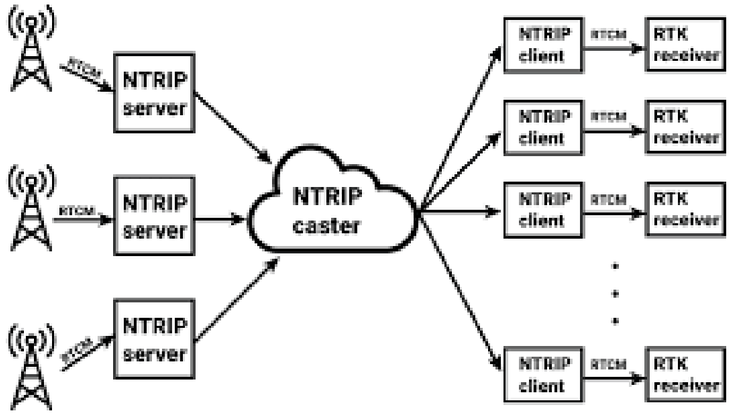


Base Station

Rover Station

Set-up

Network RTK (1 Boards)

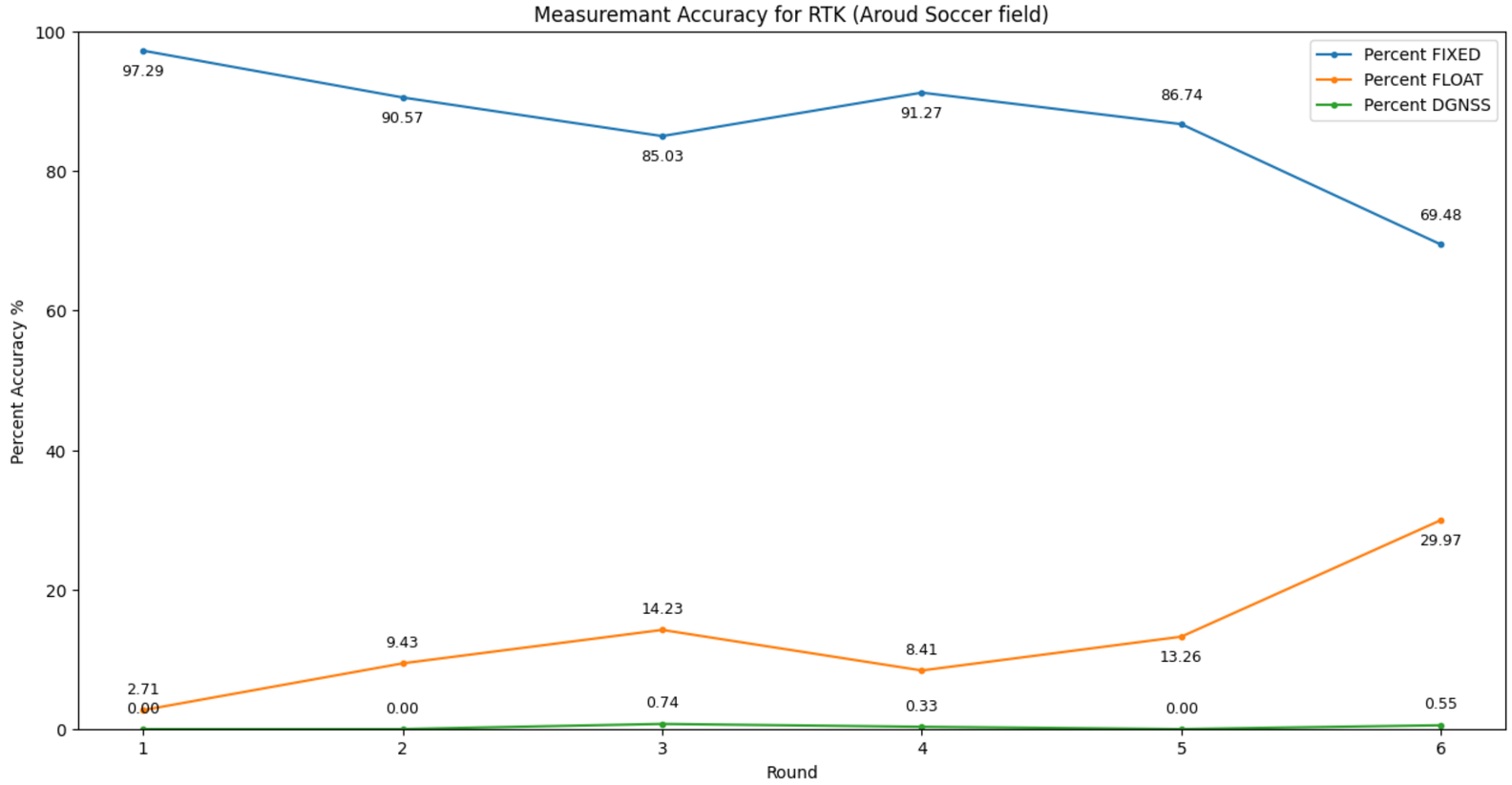


system architecture

Rover Station

Experiment 2 : Around KMUTT Soccer Field

Real Time Kinematic Method (2 Boards)



Experiment 2 : Around KMUTT Soccer Field

Real Time Kinematic Method (2 Boards)


```
Sample =  737
RTK FIXED Quality =  717  Sample
RTK FLOAT Quality =  20  Sample
RTK DGNSS Quality =  0  Sample
Total Quality =  737  Sample
RTK FIXED Quality =  97.29 %
RTK float Quality =  2.71 %
RTK DGNSS Quality =  0.0 %
```

```
Sample =  942
RTK FIXED Quality =  801  Sample
RTK FLOAT Quality =  134  Sample
RTK DGNSS Quality =  7  Sample
Total Quality =  942  Sample
RTK FIXED Quality =  85.03 %
RTK float Quality =  14.23 %
RTK DGNSS Quality =  0.74 %
```

```
Sample =  916
RTK FIXED Quality =  836  Sample
RTK FLOAT Quality =  77  Sample
RTK DGNSS Quality =  3  Sample
Total Quality =  916  Sample
RTK FIXED Quality =  91.27 %
RTK float Quality =  8.41 %
RTK DGNSS Quality =  0.33 %
```

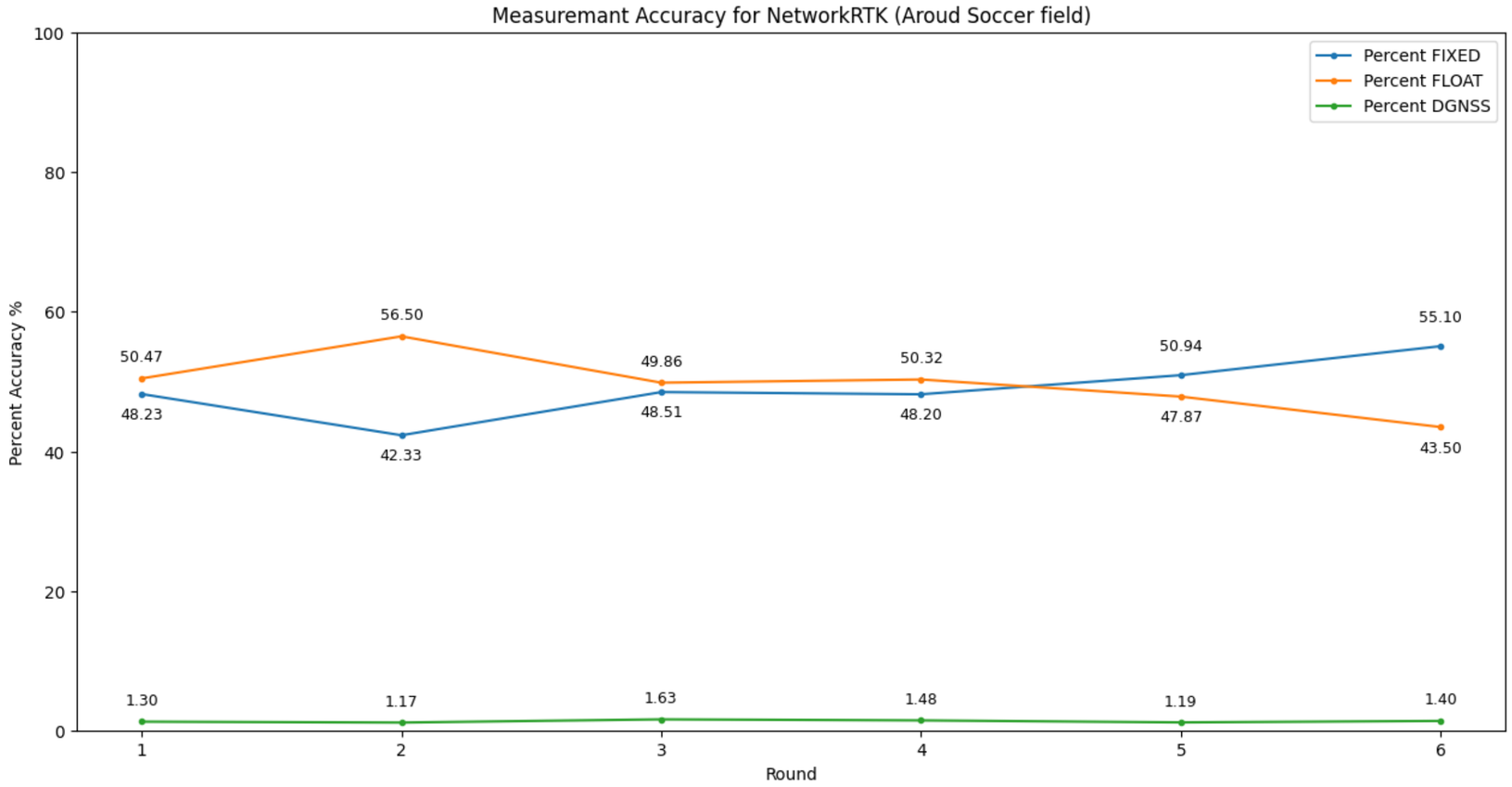
```
Sample =  911
RTK FIXED Quality =  633  Sample
RTK FLOAT Quality =  273  Sample
RTK DGNSS Quality =  5  Sample
Total Quality =  911  Sample
RTK FIXED Quality =  69.48 %
RTK float Quality =  29.97 %
RTK DGNSS Quality =  0.55 %
```

```
Sample =  891
RTK FIXED Quality =  807  Sample
RTK FLOAT Quality =  84  Sample
RTK DGNSS Quality =  0  Sample
Total Quality =  891  Sample
RTK FIXED Quality =  90.57 %
RTK float Quality =  9.43 %
RTK DGNSS Quality =  0.0 %
```

```
Sample =  860
RTK FIXED Quality =  746  Sample
RTK FLOAT Quality =  114  Sample
RTK DGNSS Quality =  0  Sample
Total Quality =  860  Sample
RTK FIXED Quality =  86.74 %
RTK float Quality =  13.26 %
RTK DGNSS Quality =  0.0 %
```

Experiment 2 : Around KMUTT Soccer Field

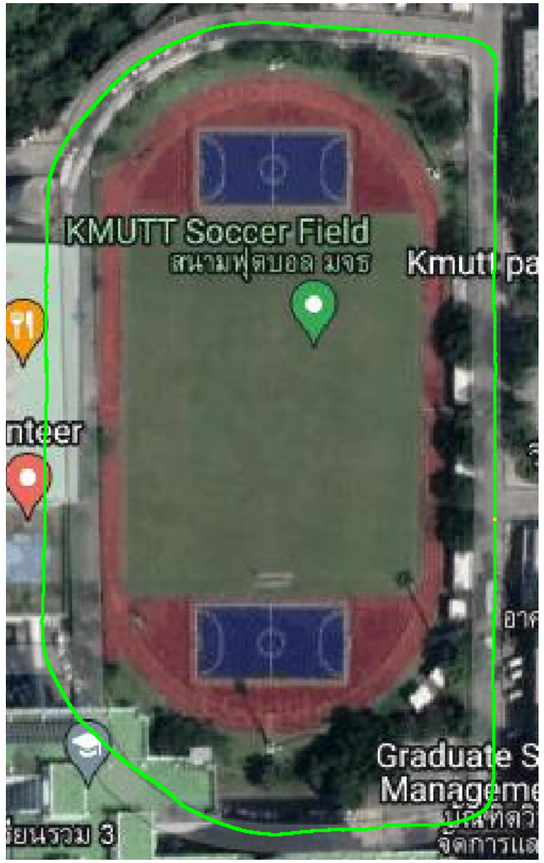
Network RTK (1 Boards)



Experiment 2

Network RTK (1 Boards)

#วิ่งระยะทางไกล รอบสนามฟุตบอล




```
Sample =  3583
RTK FIXED Quality =  1727  Sample
RTK FLOAT Quality =  1803  Sample
RTK DGNSS Quality =  53  Sample
Total Quality =  3583  Sample
RTK FIXED Quality =  48.2 %
RTK float Quality =  50.32 %
RTK DGNSS Quality =  1.48 %
```

```
Sample =  3338
RTK FIXED Quality =  1413  Sample
RTK FLOAT Quality =  1886  Sample
RTK DGNSS Quality =  39  Sample
Total Quality =  3338  Sample
RTK FIXED Quality =  42.33 %
RTK float Quality =  56.5 %
RTK DGNSS Quality =  1.17 %
```

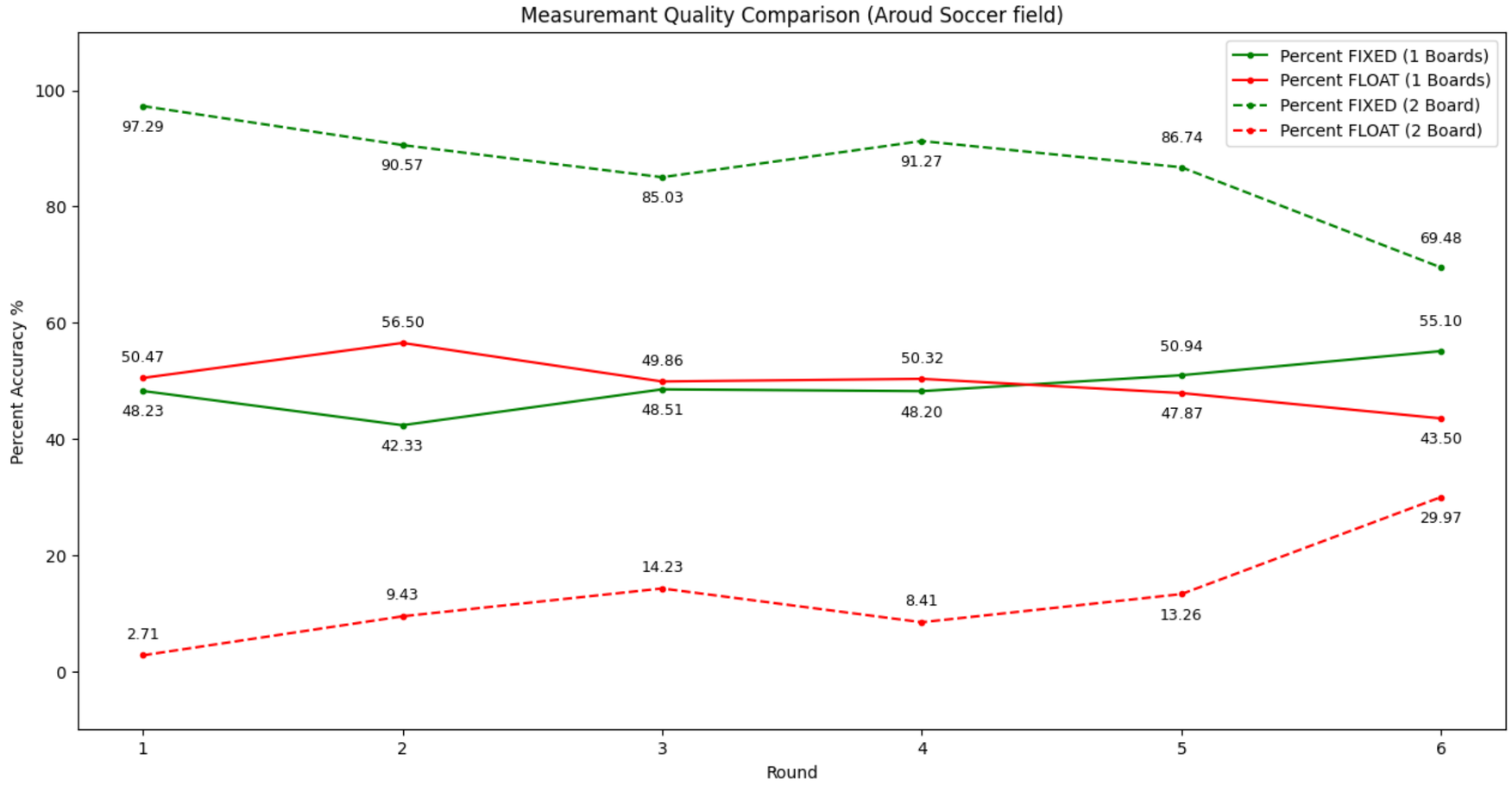
```
Sample =  3566
RTK FIXED Quality =  1730  Sample
RTK FLOAT Quality =  1778  Sample
RTK DGNSS Quality =  58  Sample
Total Quality =  3566  Sample
RTK FIXED Quality =  48.51 %
RTK float Quality =  49.86 %
RTK DGNSS Quality =  1.63 %
```

```
Sample =  3313
RTK FIXED Quality =  1598  Sample
RTK FLOAT Quality =  1672  Sample
RTK DGNSS Quality =  43  Sample
Total Quality =  3313  Sample
RTK FIXED Quality =  48.23 %
RTK float Quality =  50.47 %
RTK DGNSS Quality =  1.3 %
```

```
Sample =  3355
RTK FIXED Quality =  1709  Sample
RTK FLOAT Quality =  1606  Sample
RTK DGNSS Quality =  40  Sample
Total Quality =  3355  Sample
RTK FIXED Quality =  50.94 %
RTK float Quality =  47.87 %
RTK DGNSS Quality =  1.19 %
```

```
Sample =  3356
RTK FIXED Quality =  1849  Sample
RTK FLOAT Quality =  1460  Sample
RTK DGNSS Quality =  47  Sample
Total Quality =  3356  Sample
RTK FIXED Quality =  55.1 %
RTK float Quality =  43.5 %
RTK DGNSS Quality =  1.4 %
```

Comparison

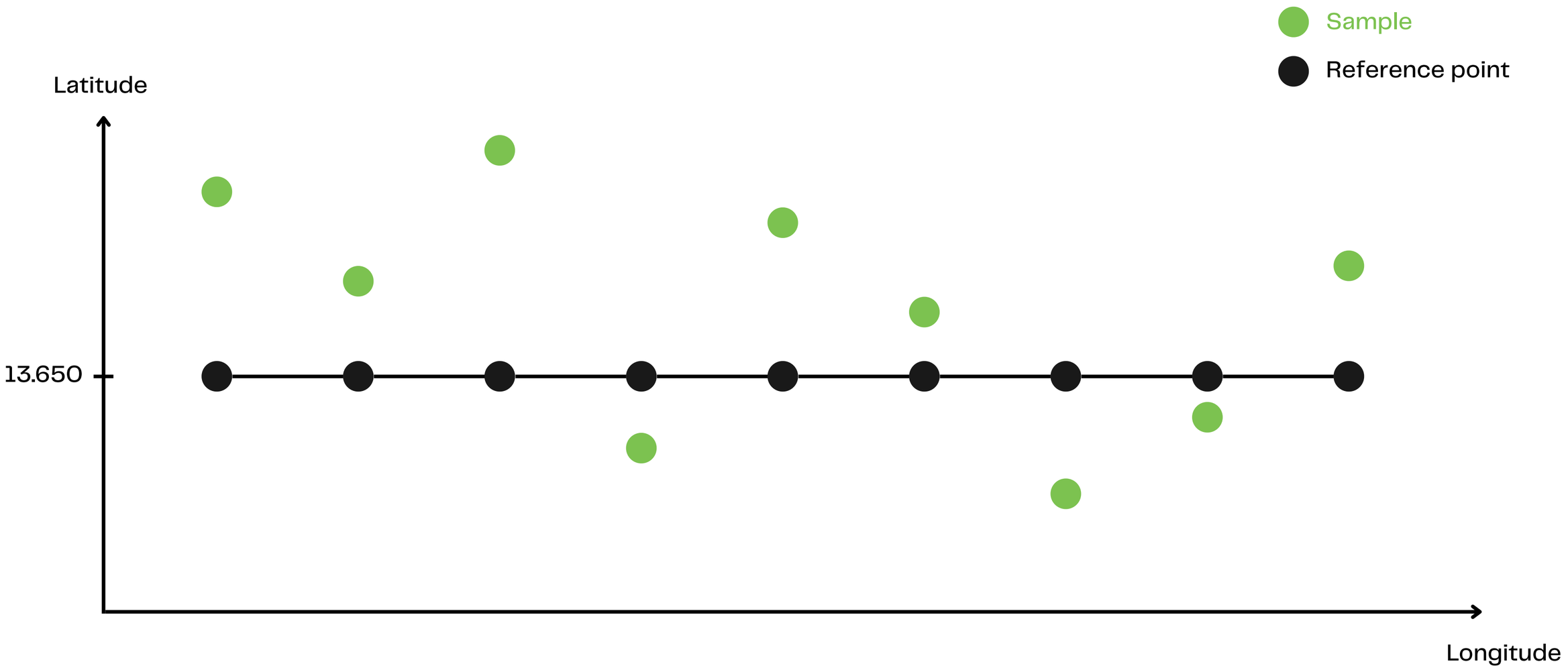

Measuremant Quality Comparison (Aroud Soccer field)
Percent FIXED (1 Boards)
Percent FLOAT (1 Boards)
Percent FIXED (2 Board)
Percent FLOAT (2 Board)
Percent Accuracy %
Round
100
80
60
40
20
0
1
2
3
4
5
6
97.29
90.57
85.03
91.27
86.74
69.48
50.47
56.50
49.86
50.32
50.94
55.10
48.23
42.33
48.51
48.20
47.87
43.50
2.71
9.43
14.23
8.41
13.26
29.97

Measurement Accuracy Visualization

1. Create the reference points (Const lat or lon)

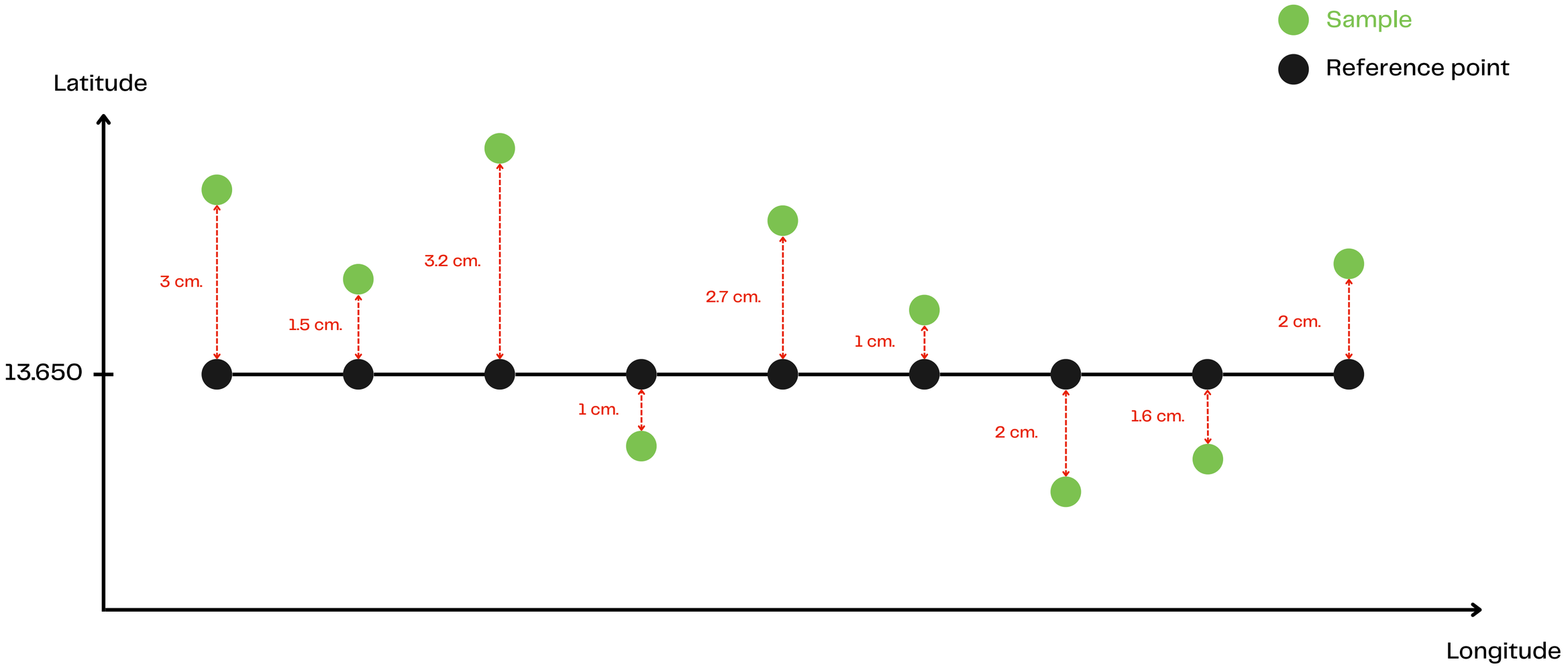
Measurement Accuracy Visualization

2.Comparison Sample and Reference point



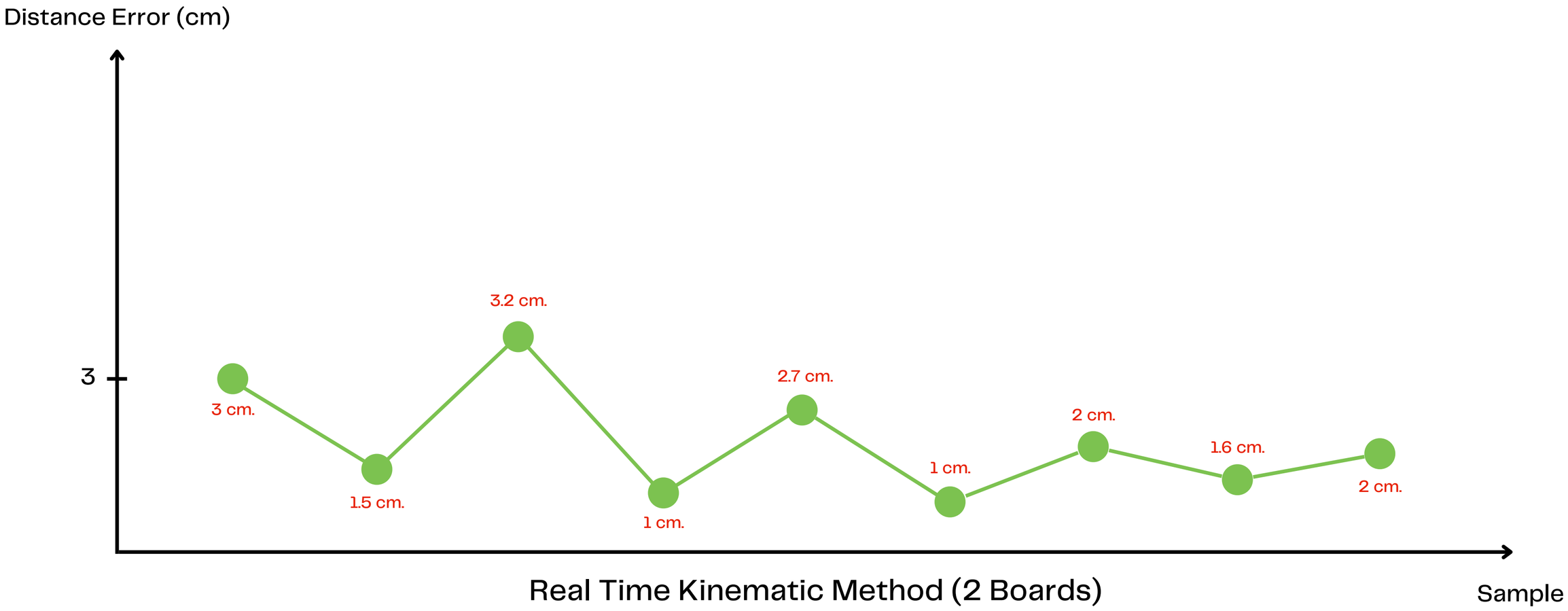
Measurement Accuracy Visualization

3. Find distance error



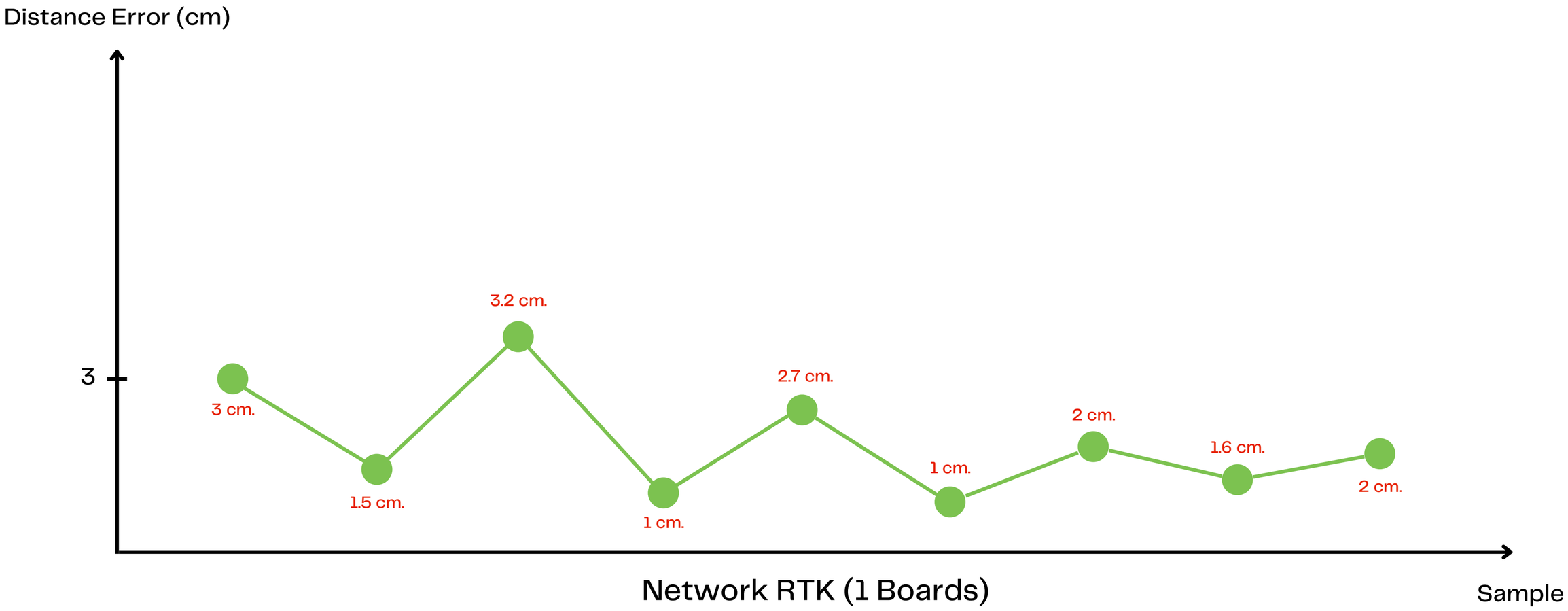
Measurement Accuracy Visualization

4.plot graph



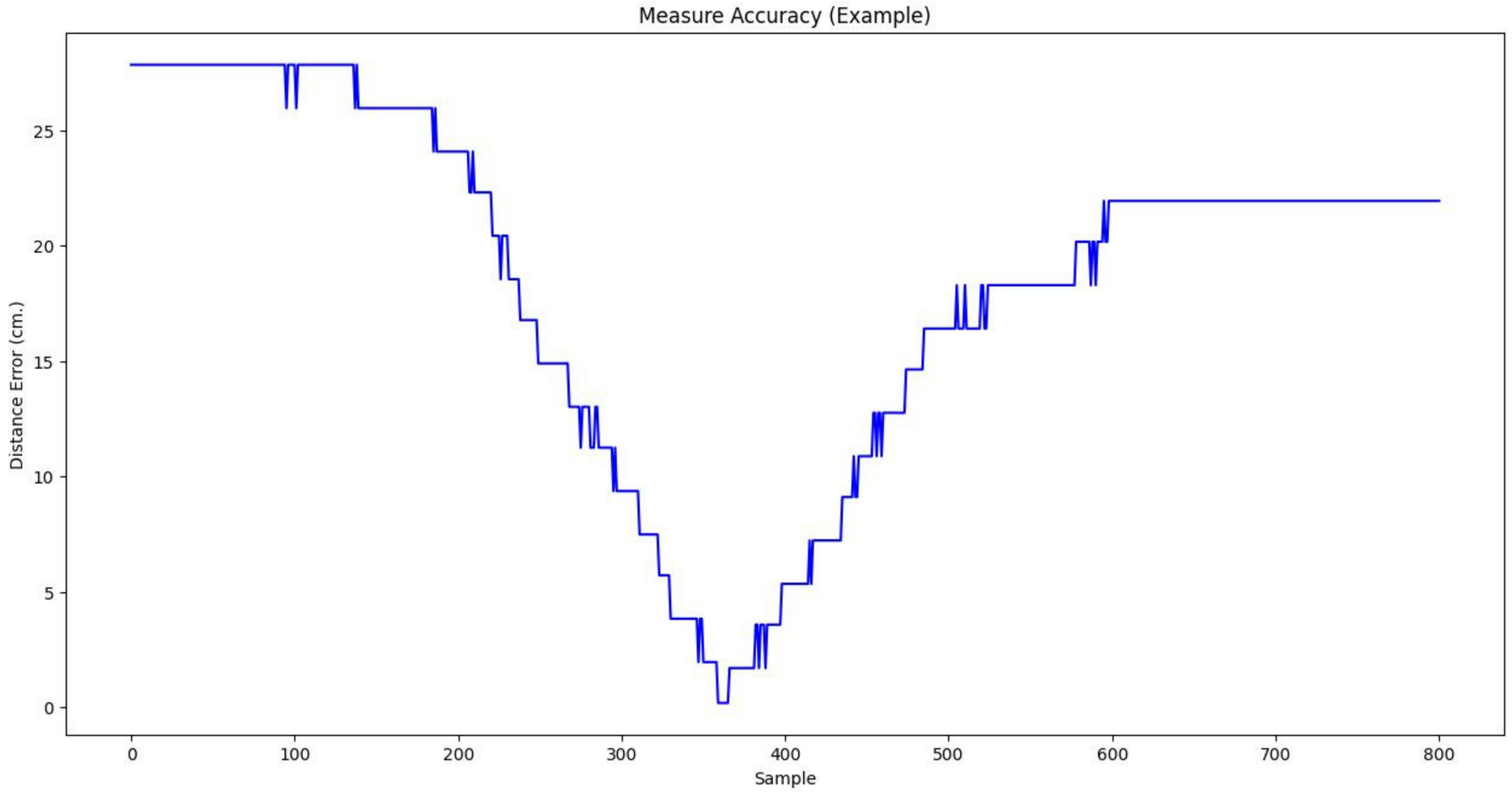
Measurement Accuracy Visualization

4.plot graph



Measurement Accuracy Visualization

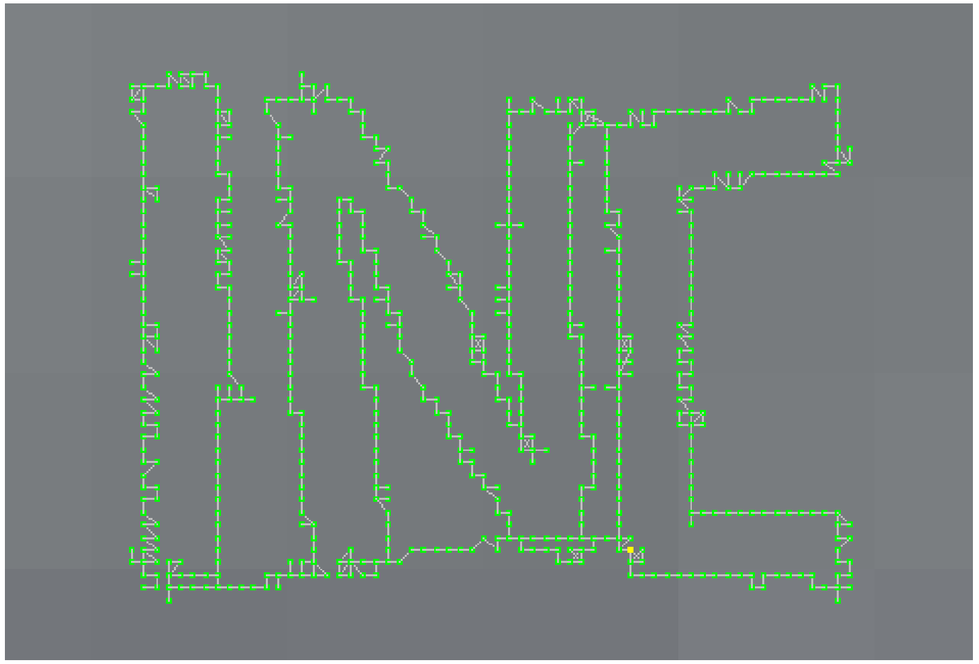
4.plot graph



Result

Real Time Kinematic Method (2 Boards)

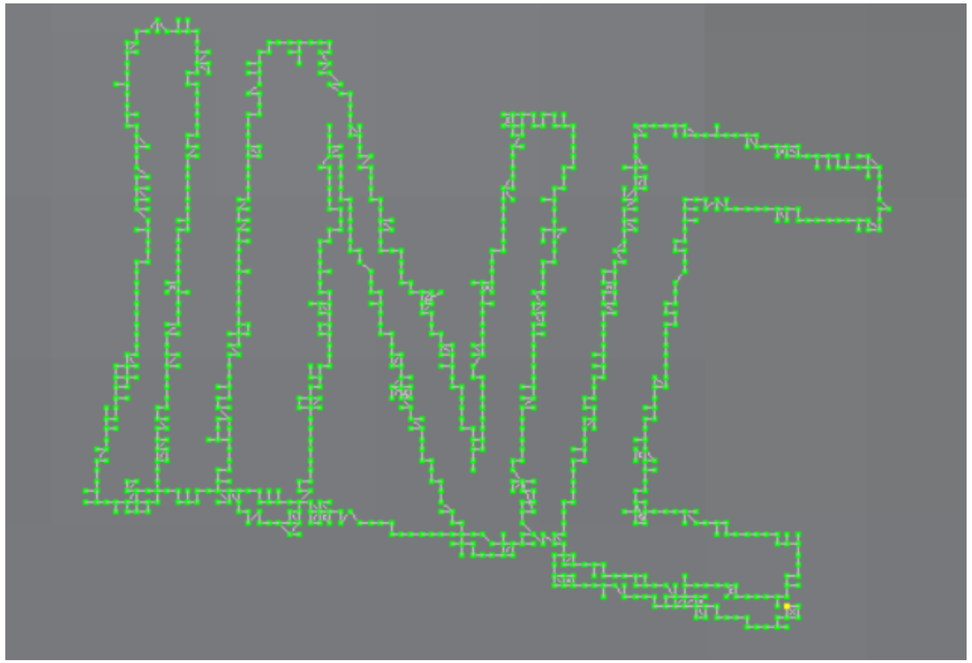
Centimeter Accuracy



Result

Network RTK (1 Boards)

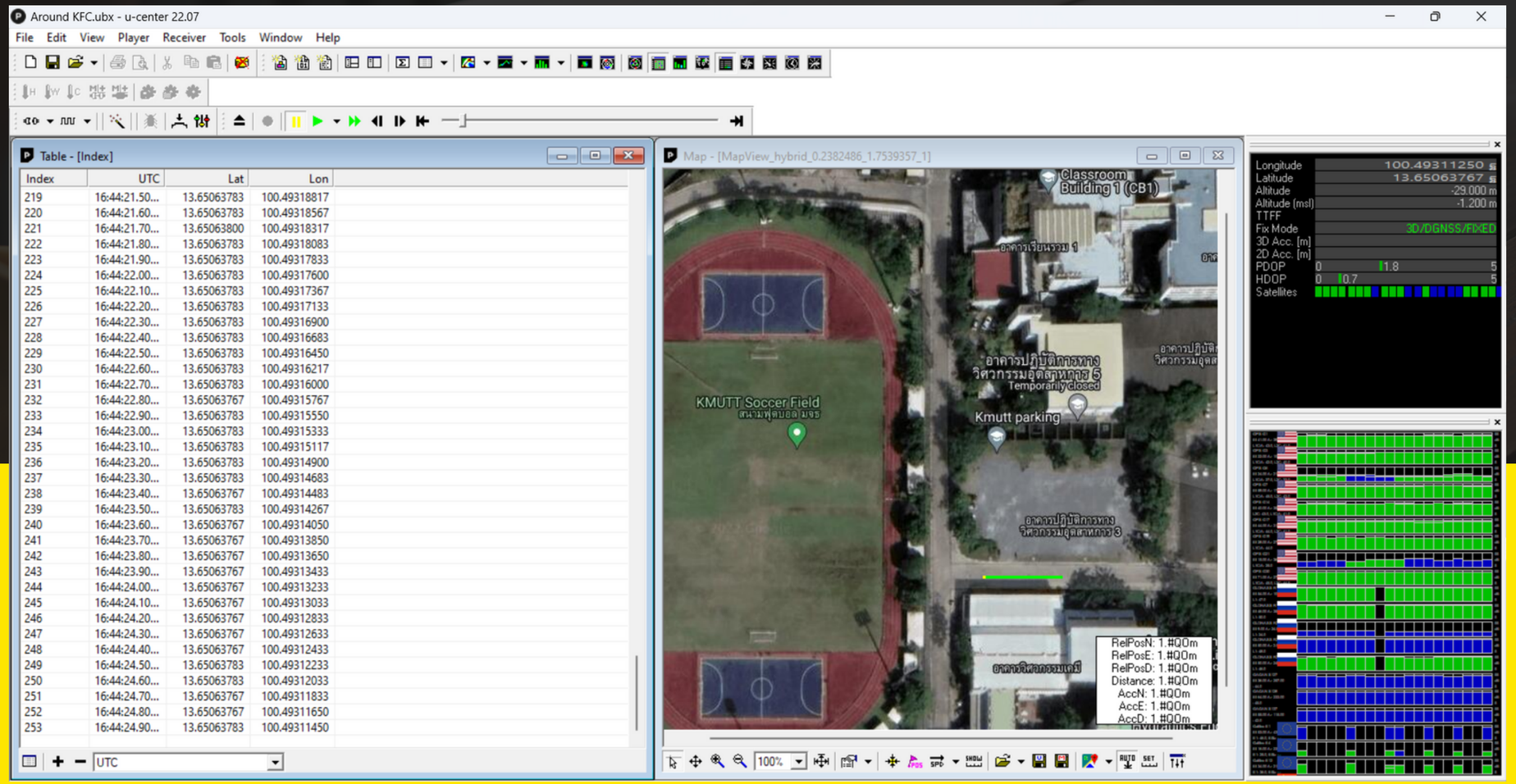
Centimeter Accuracy



Coordinate Converter

Experiment

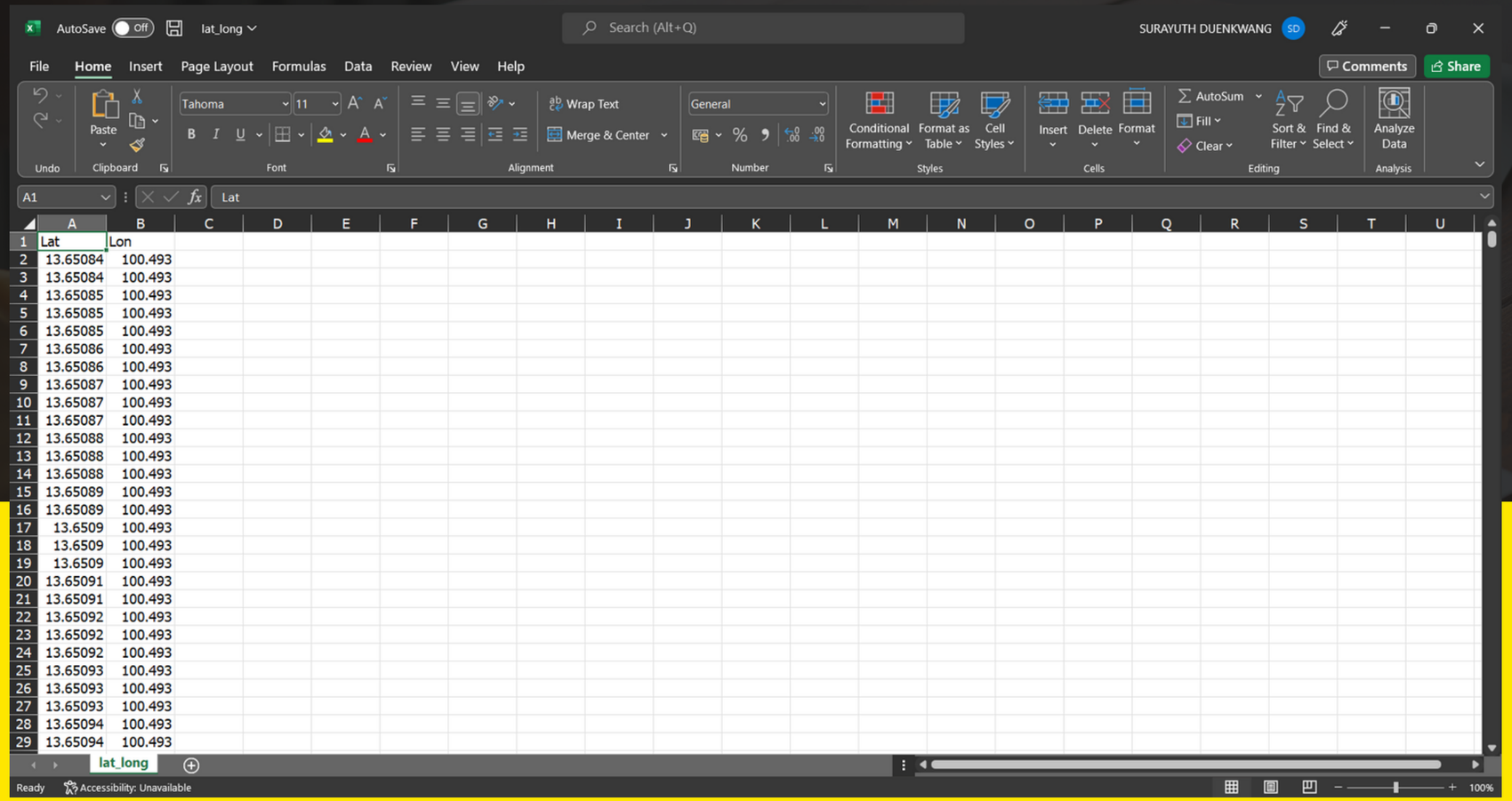
Convert Lat-Lng to X Y Coordinate from Reference route (CSV File)



The Autonomous Vehicle: GNSS Technology Tracking Using Controller

Experiment

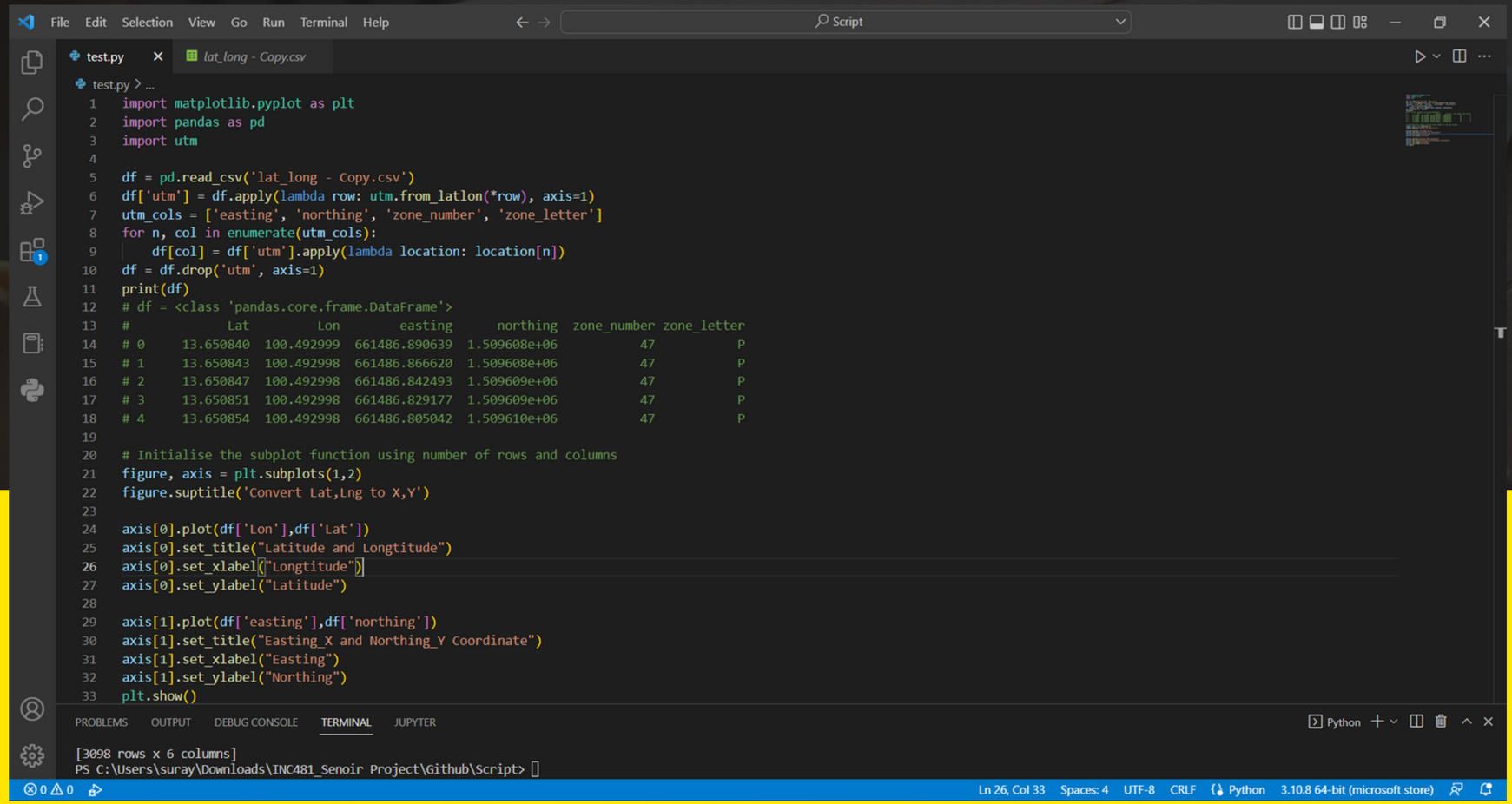
Convert Lat-Lng to X Y Coordinate from Reference route (CSV File)



	A	B
1	Lat	Lon
2	13.65084	100.493
3	13.65084	100.493
4	13.65085	100.493
5	13.65085	100.493
6	13.65085	100.493
7	13.65086	100.493
8	13.65086	100.493
9	13.65087	100.493
10	13.65087	100.493
11	13.65087	100.493
12	13.65088	100.493
13	13.65088	100.493
14	13.65088	100.493
15	13.65089	100.493
16	13.65089	100.493
17	13.6509	100.493
18	13.6509	100.493
19	13.6509	100.493
20	13.65091	100.493
21	13.65091	100.493
22	13.65092	100.493
23	13.65092	100.493
24	13.65092	100.493
25	13.65093	100.493
26	13.65093	100.493
27	13.65093	100.493
28	13.65094	100.493
29	13.65094	100.493

Experiment

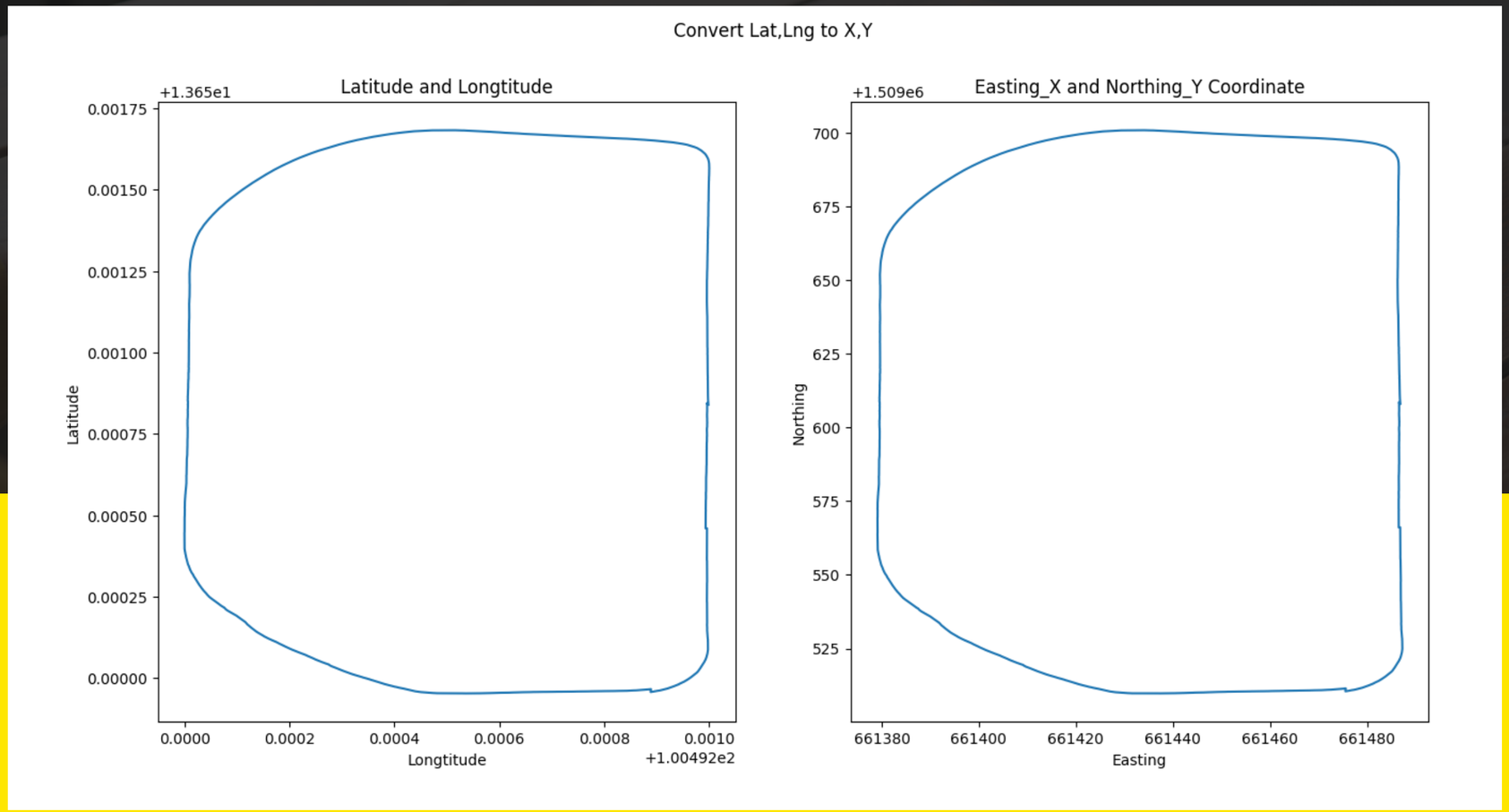
Convert Lat-Lng to X Y Coordinate from Reference route (CSV File)



The Autonomous Vehicle: GNSS Technology Tracking Using Controller

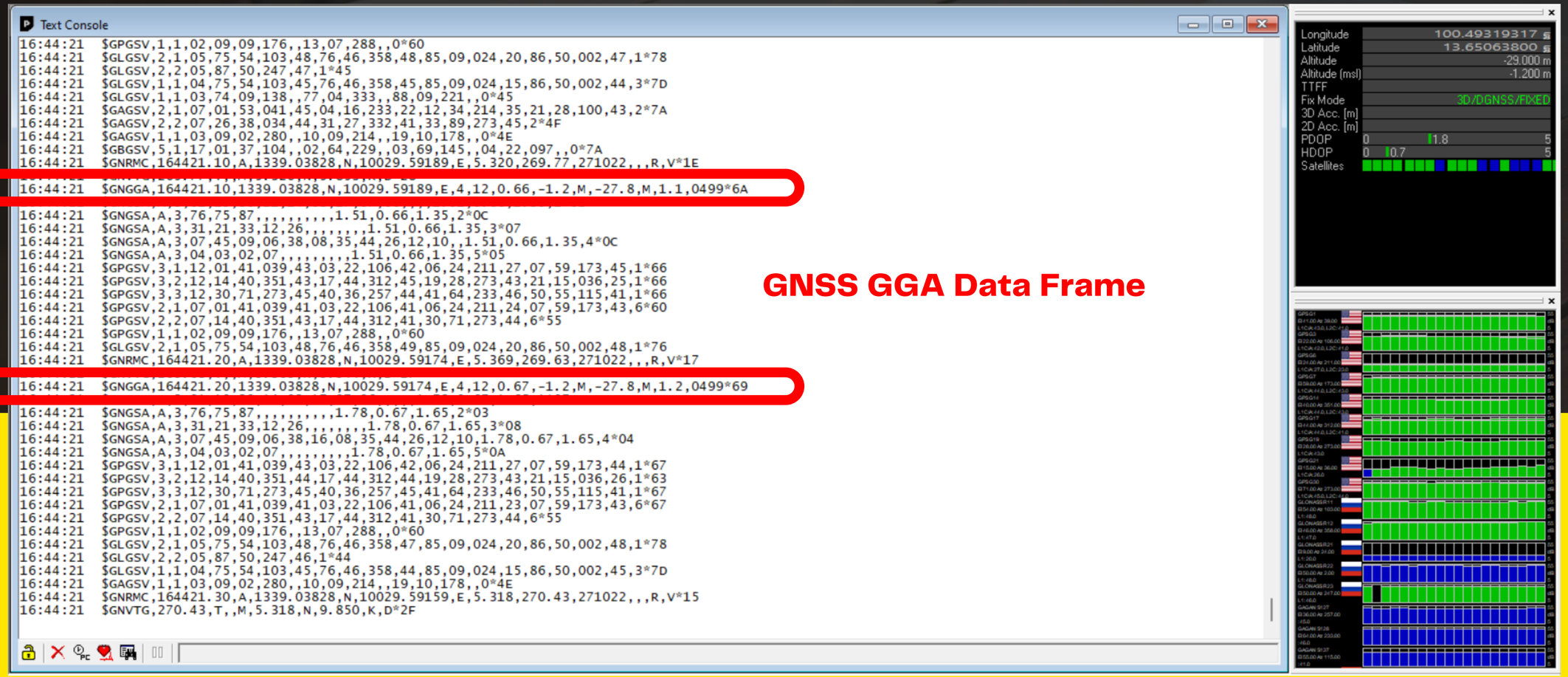
Experiment

Comparison Between Latitude-Longtitude and X-Y UTM Coordinate



Coordinate Converter

GNSS GGA Frame

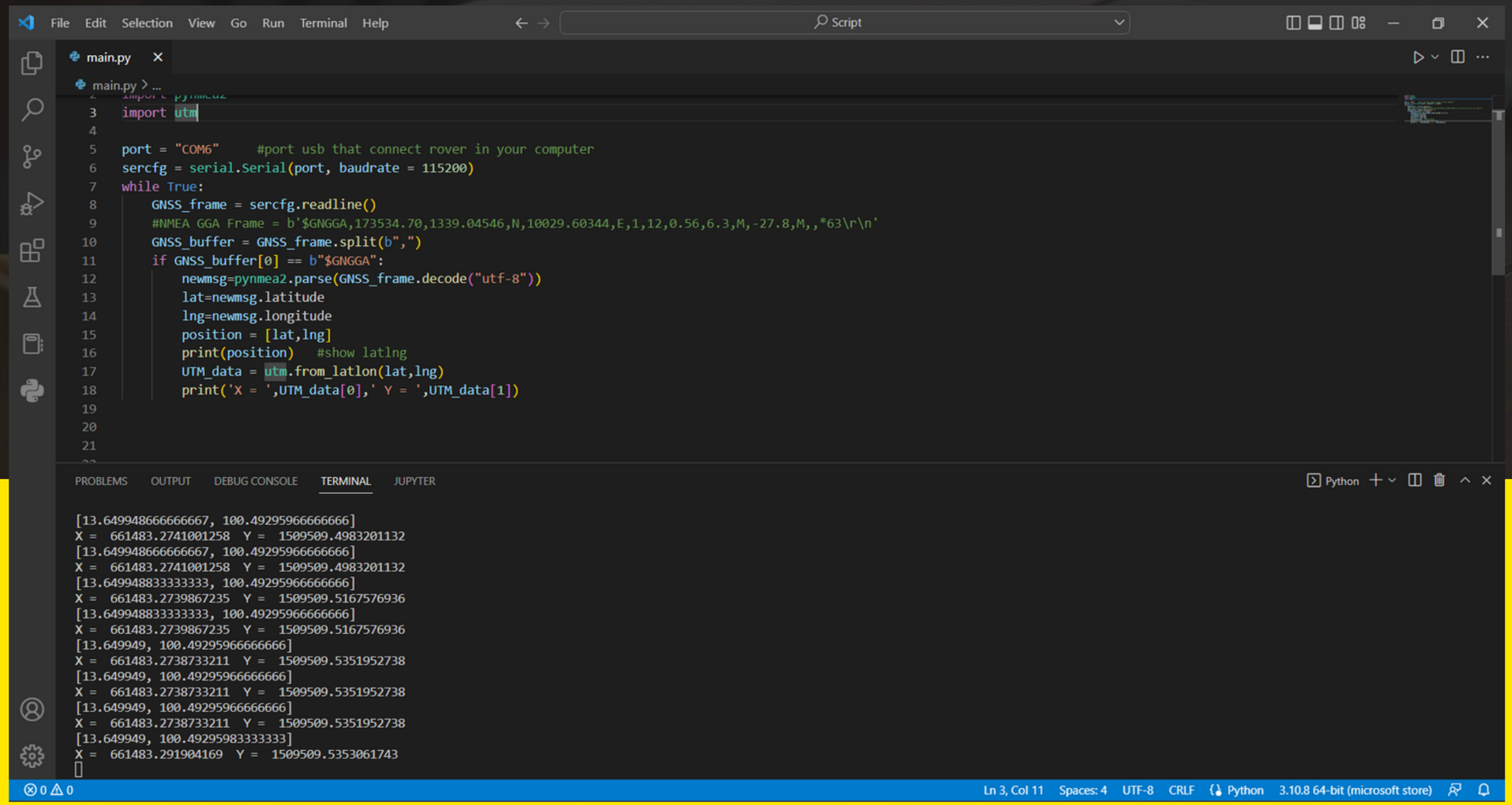


GNSS GGA Data Frame

The Autonomous Vehicle: GNSS Technology Tracking Using Controller

Coordinate Converter

Read Real Time Data from GNSS Module and Convert to X Y



The Autonomous Vehicle: GNSS Technology Tracking Using Controller

Coordinate Converter

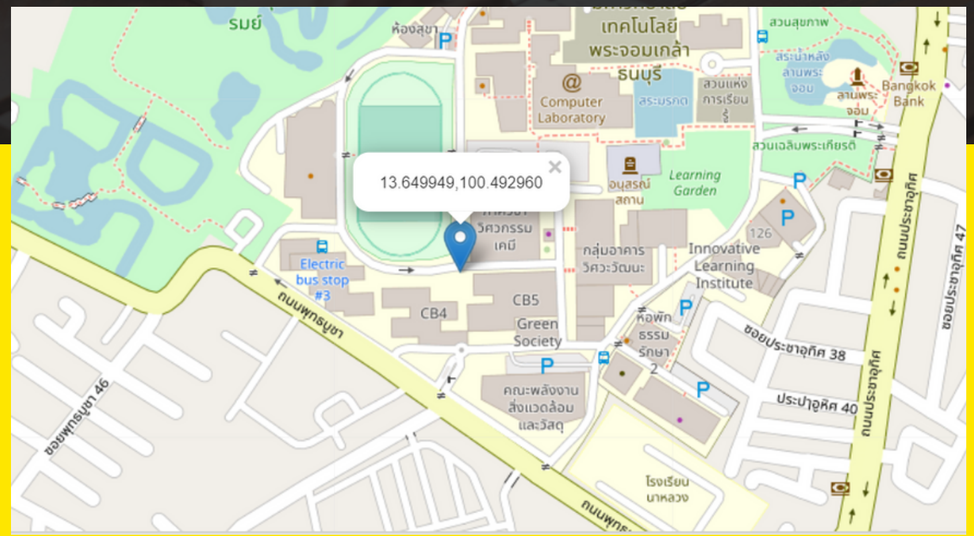
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL JUPYTER

```
[13.649948666666667, 100.49295966666666]
X =  661483.2741001258  Y =  1509509.4983201132
[13.649948666666667, 100.49295966666666]
X =  661483.2741001258  Y =  1509509.4983201132
[13.649948833333333, 100.49295966666666]
X =  661483.2739867235  Y =  1509509.5167576936
[13.649948833333333, 100.49295966666666]
X =  661483.2739867235  Y =  1509509.5167576936
[13.649949, 100.49295966666666]
X =  661483.2738733211  Y =  1509509.5351952738
[13.649949, 100.49295966666666]
[13.649949, 100.49295966666666]
X =  661483.2738733211  Y =  1509509.5351952738
X =  661483.291904169  Y =  1509509.5353061743
```

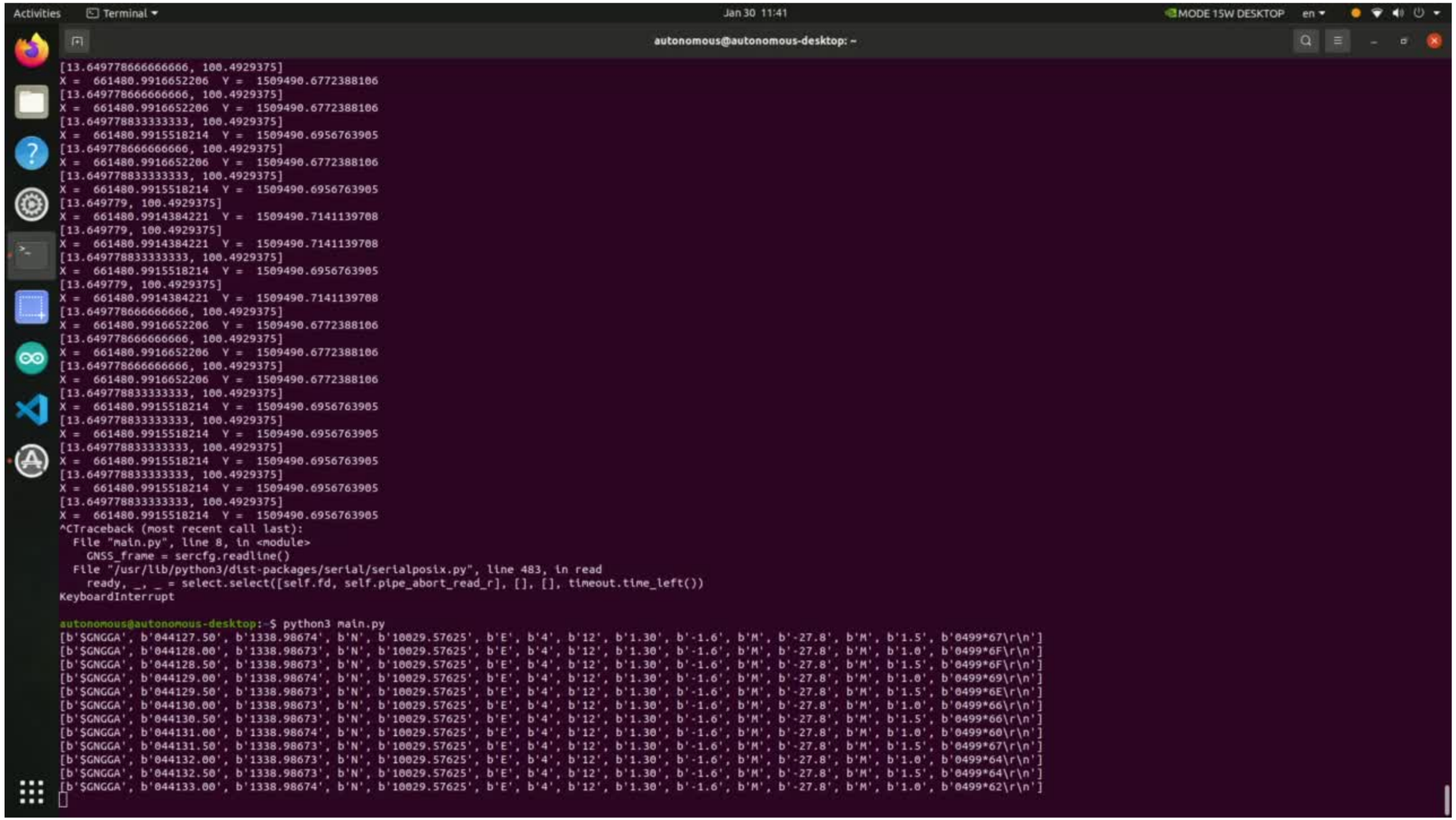
Type the latitude and longitude values to convert into **UTM** (Universal Transverse Mercator) coordinate system.

Latitude	Longitude	
13.649949	100.492960	**Convert**

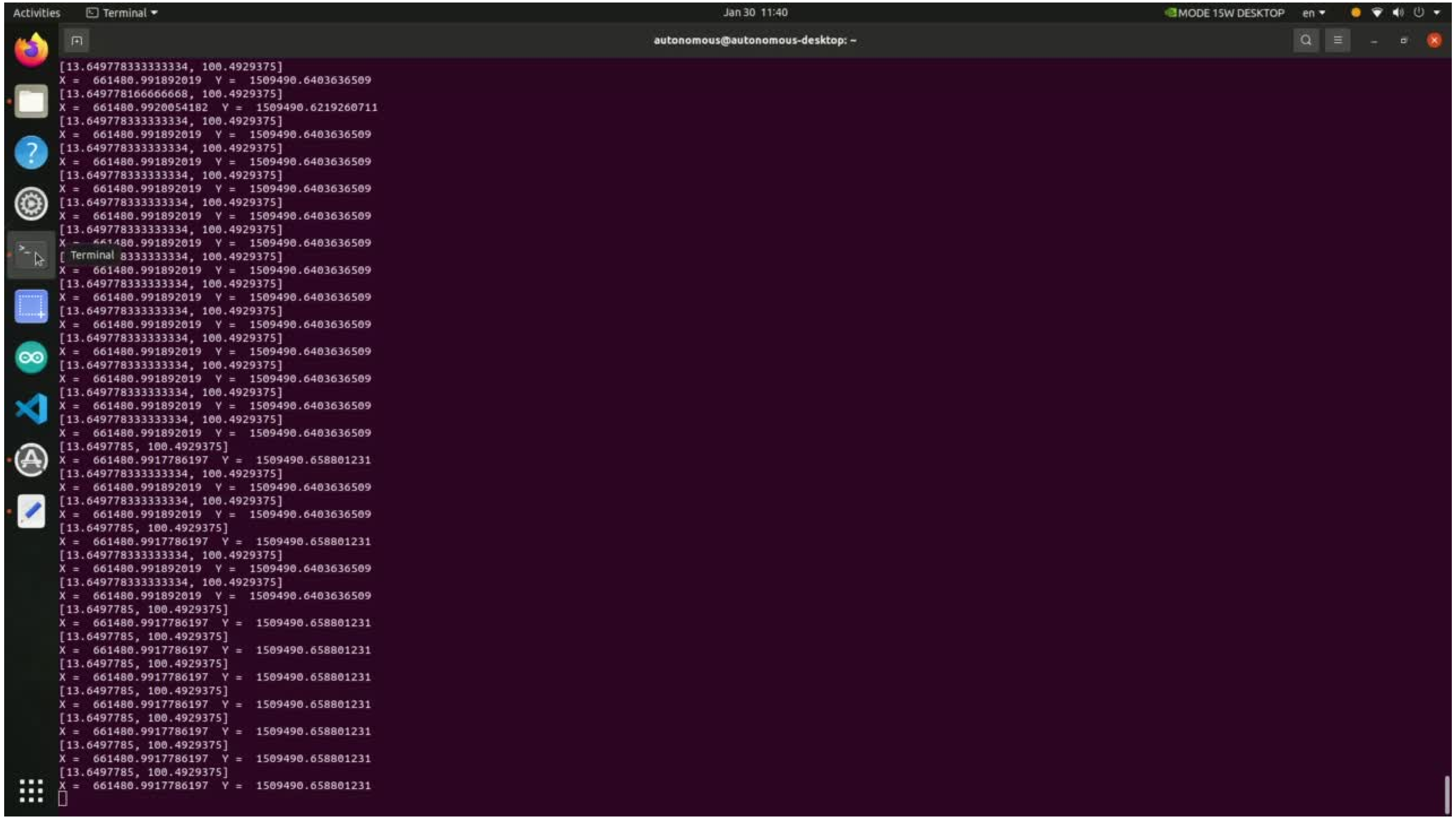
UTM Easting	UTM Northing	UTM Zone
661483.31	1509509.54	47P

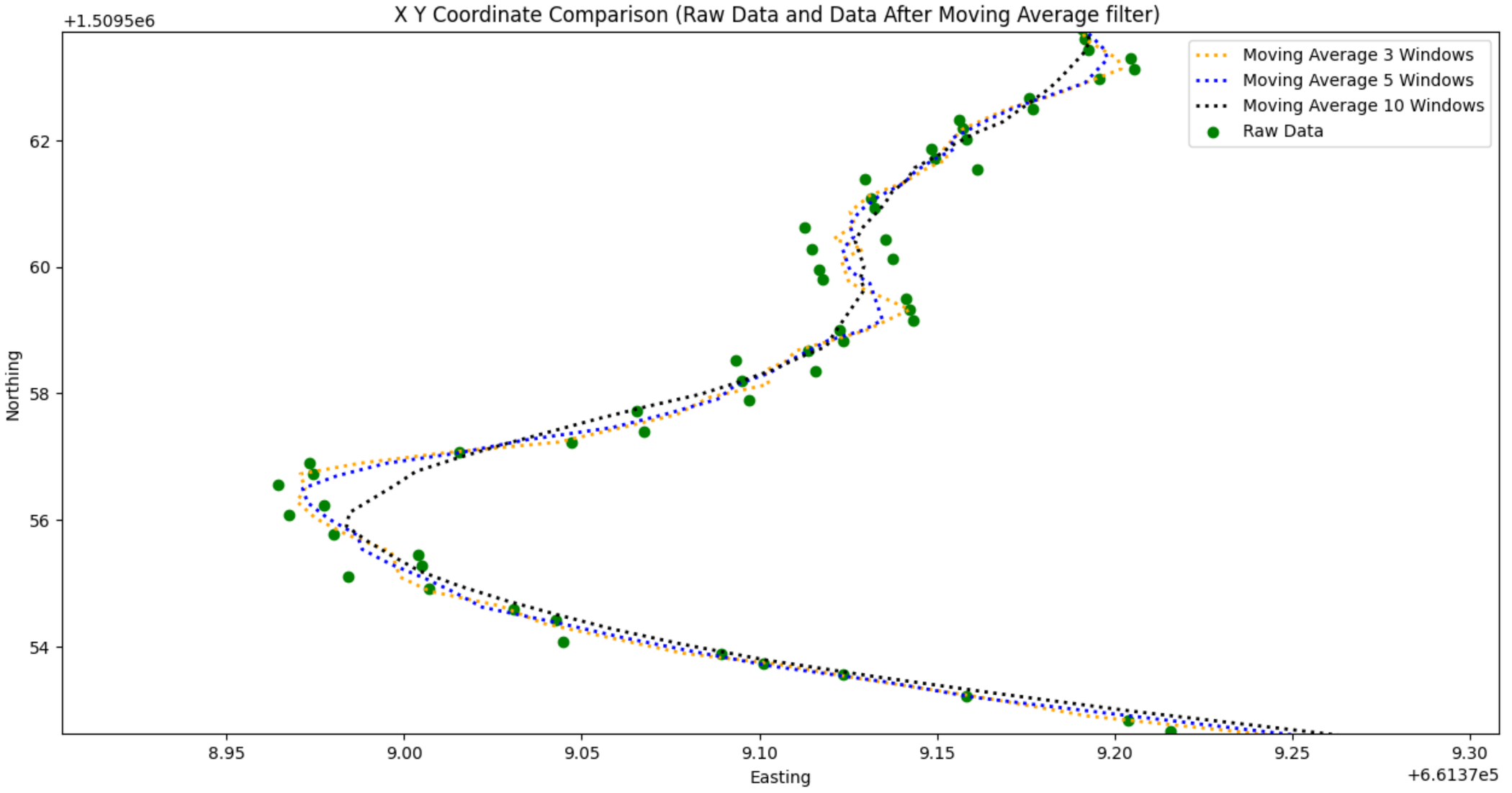


Send GGA frame to Ubuntu



Convert Lat Lon to X Y (Ubuntu)




X Y Coordinate Comparison (Raw Data and Data After Moving Average filter)
+1.5095e6
62
60
58
56
54
Northing
8.95
9.00
9.05
9.10
9.15
9.20
9.25
9.30
+6.6137e5
Easting
Moving Average 3 Windows
Moving Average 5 Windows
Moving Average 10 Windows
Raw Data