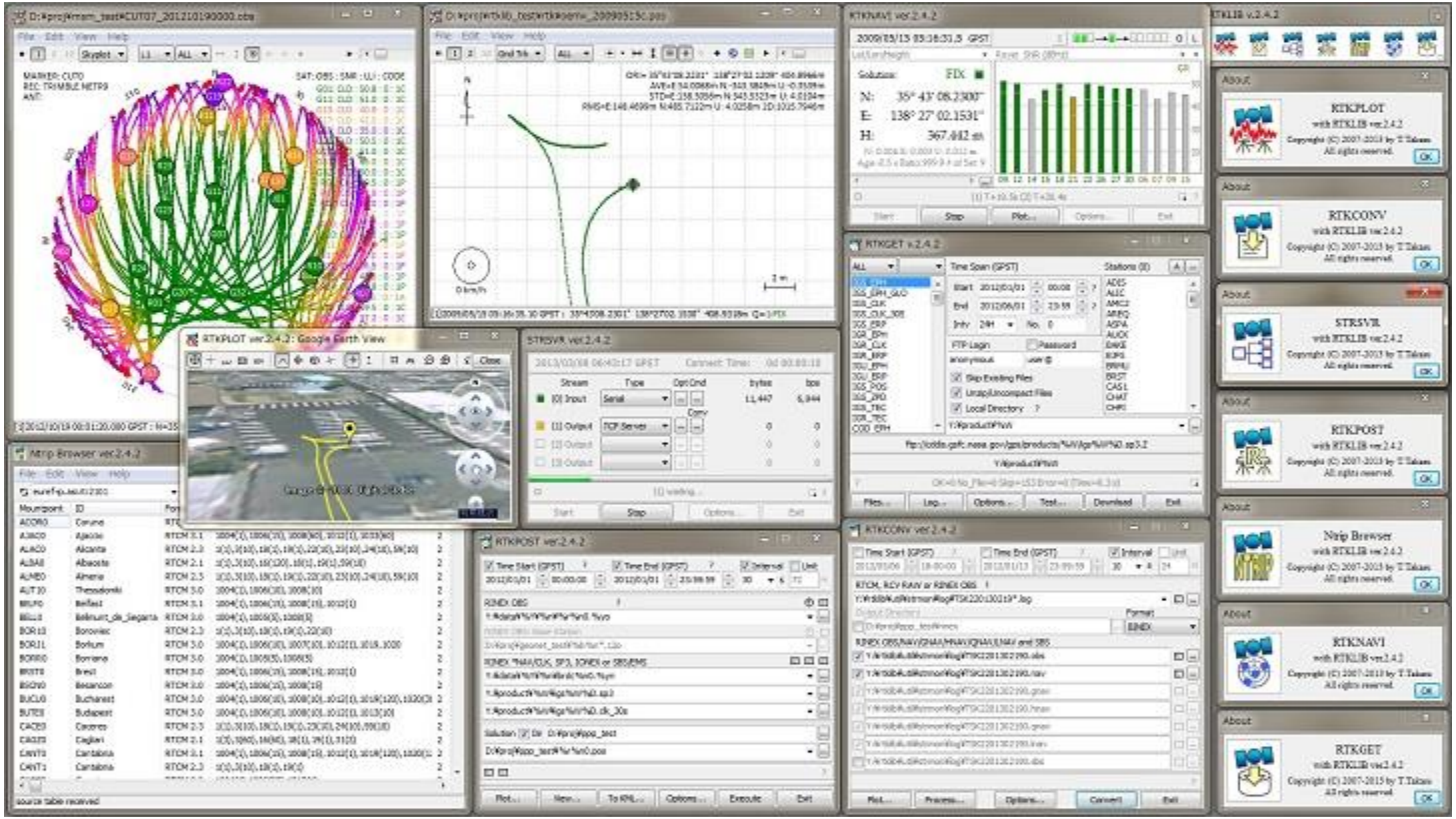
# 高精度測位チャレンジ
# 東京データ簡易分析結果

# RTKLIB（2006~）

The developer is
Mr. Tomoji Takasu.



# Motivation

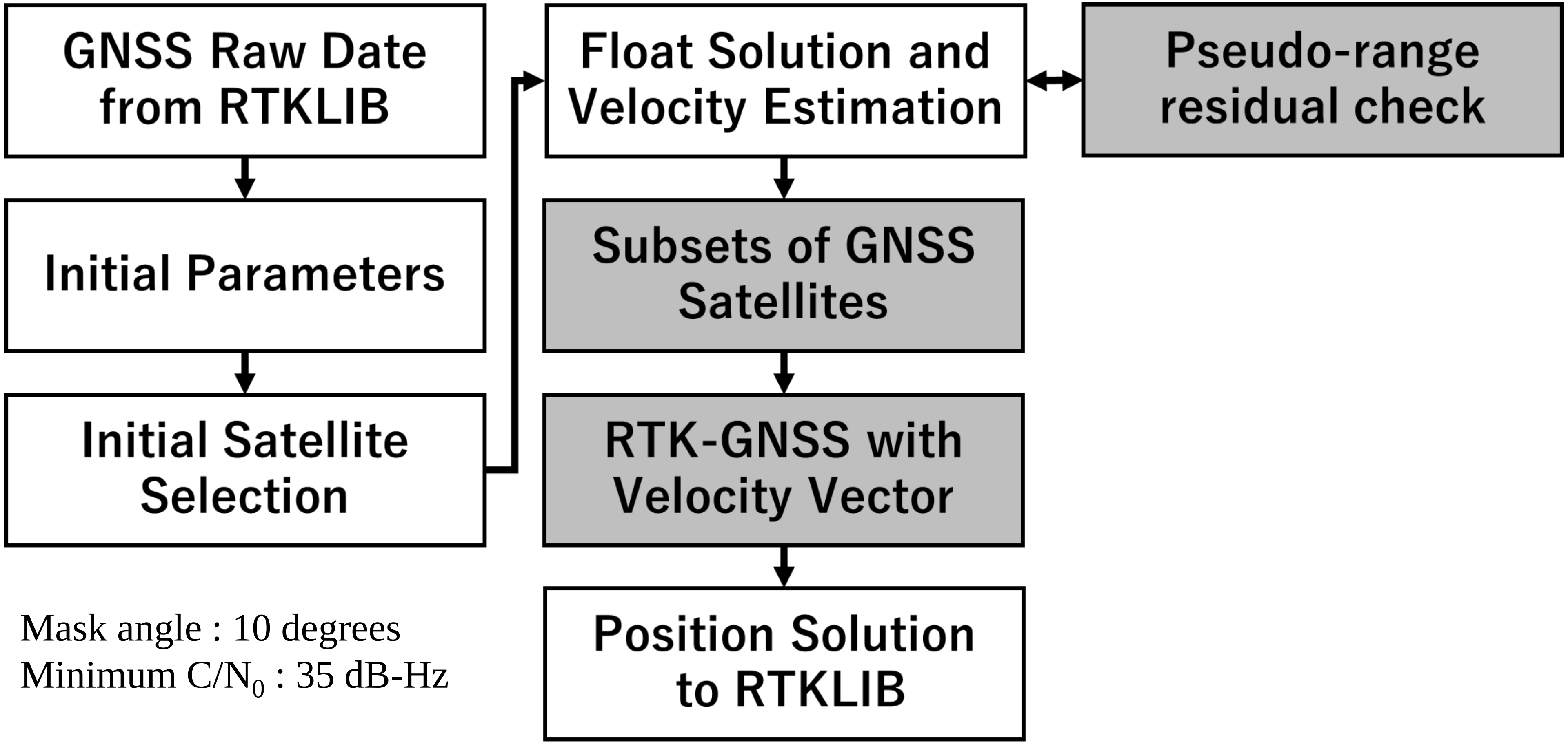
- The RTK performance of **commercial receivers** has improved owing to the commercial availability of low-cost dual-frequency receivers since around 2018.
- Little by little, differences in performance are being seen especially in the case of **urban areas**.
- **rtklibexplorer** has contributed to fill in the gaps in this situation.
- Here, we describe an improved algorithm for RTK, particularly for vehicles in urban areas, and present the experimental results by comparing the RTKs of RTKLIB, rtklibexplorer, and a typical low-cost RTK receiver

# Three methods for the improvement

1. Satellite selection based on Pseudo-range residuals
2. Use of GNSS velocity for float solutions
3. Subsets of GNSS satellites

- These are **conventional methods**, but it is effective to improve the RTK performance.

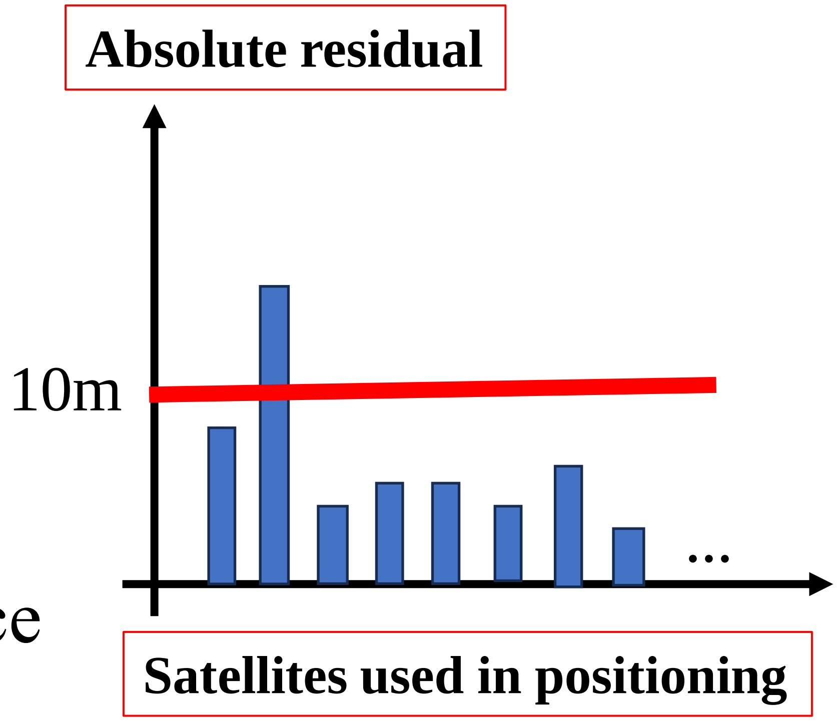
# Flowchart of methodology




Mask angle : 10 degrees
Minimum $C/N_0$ : 35 dB-Hz

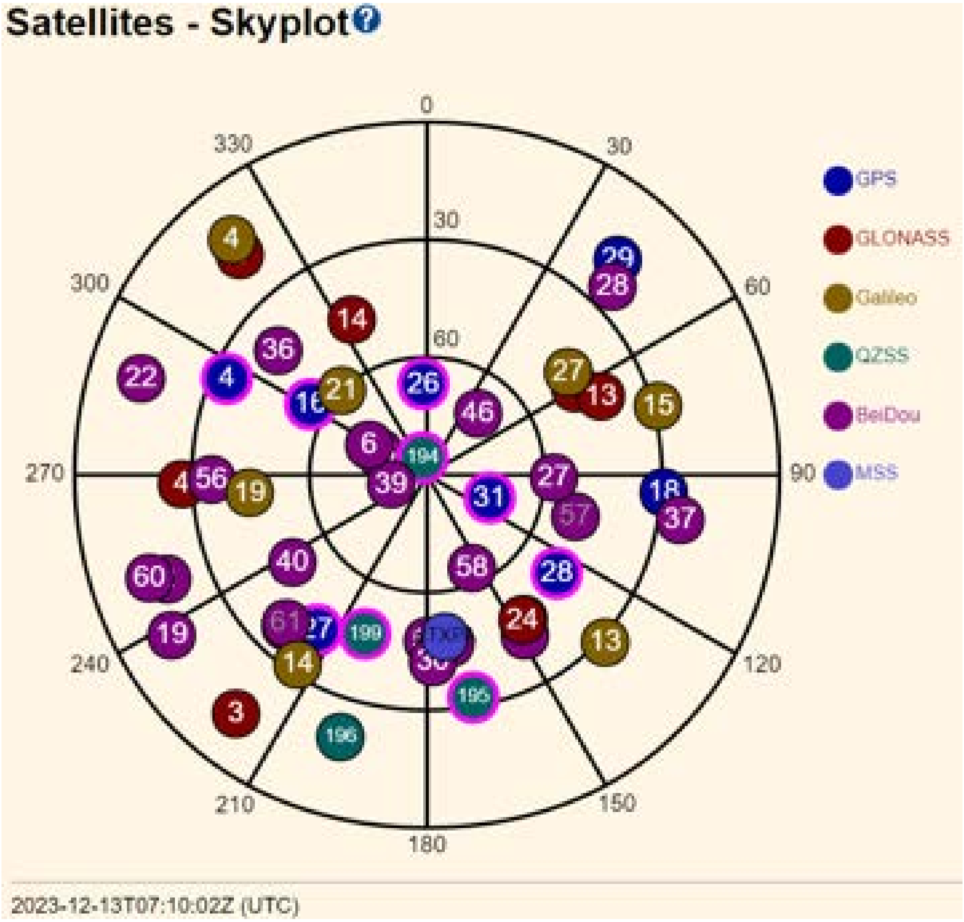
# Pseudo-range residual check

- The residuals of the satellites were checked using the least squares method.
- If the absolute residual of the satellite was at its maximum and was over approximately **10 m**, the satellite was repeatedly removed from positioning, provided that the HDOP was lower than 10.
- The maximum iteration number is set 5.
- If you don't want to remove the satellite, we can reduce the weight the satellite in positioning.
- **Doppler frequency residual** in velocity estimation can also be used for this purpose (future task).



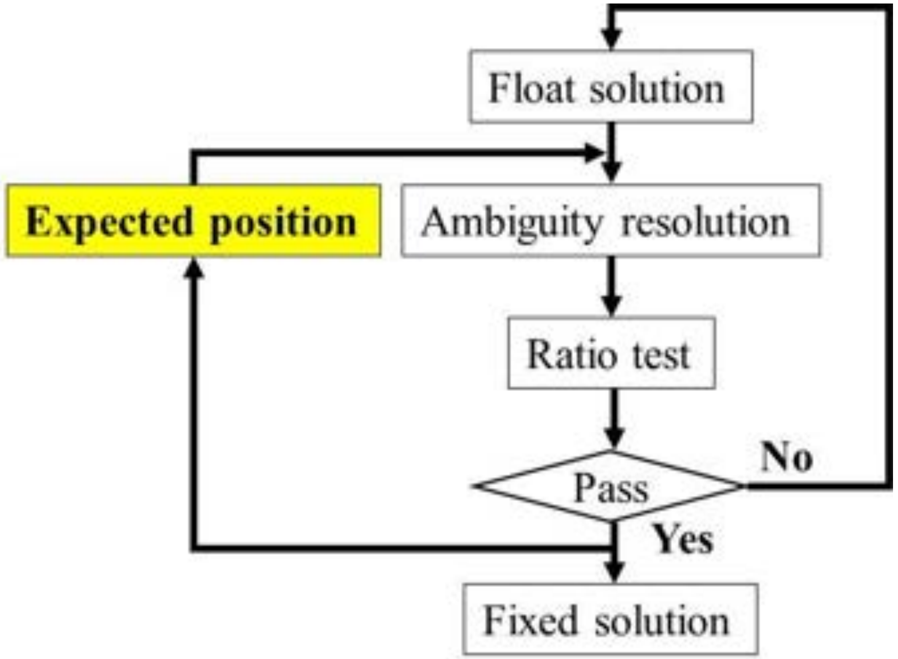
# Subsets of GNSS satellites

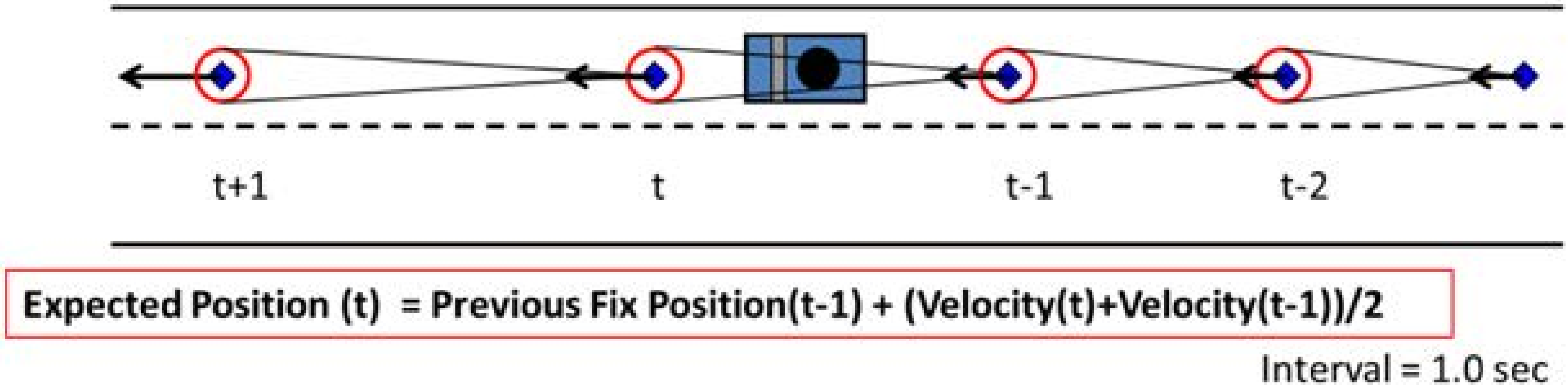
- We are now on multi-GNSS era.
- First of all, we use all 5 satellites (GPS/GLONASS/GALILEO/BDS/QZSS).
- If we can't get RTK fix solution, we re-select other satellite systems.
- The order is as follows.
- GREBQ→GEBQ→GREB→GEQ→GQ




**Over 60 degrees, 8 satellites are available !**

# Ambiguity Resolution using Velocity Information




The **expected position** is the previously fixed position, updated by adding half the present velocity estimate and half the previous velocity estimate.
**The reliability of the previously fixed position is important.**

# Data collection

| Sensor | Model name |
|---|---|
| GNSS Receiver (base and rover) | u-blox F9P |
| GNSS Antenna (rover) | Trimble AT1695 |
| GNSS Antenna (base) | Trimble Zephyr 2 Geodetic |
| Reference Position | POSLV620 (post-processed) |

**Test1 3,360 s**

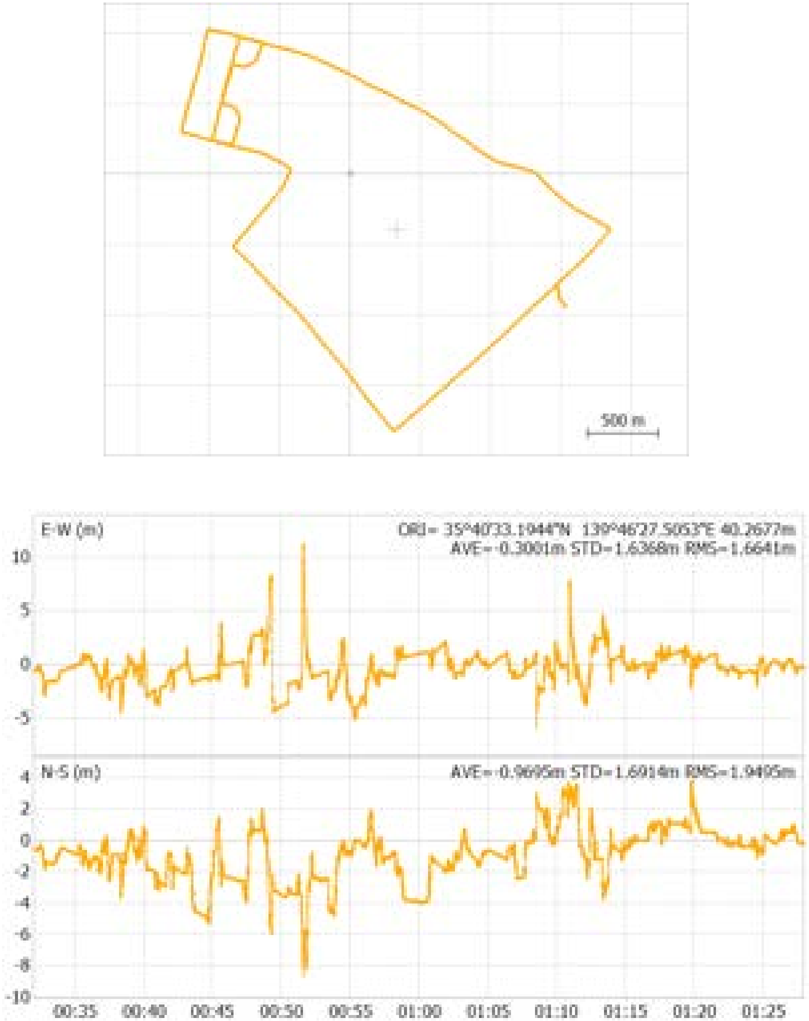
**Test2 3,088 s**

**Test3 2,852 s**

# Data analysis

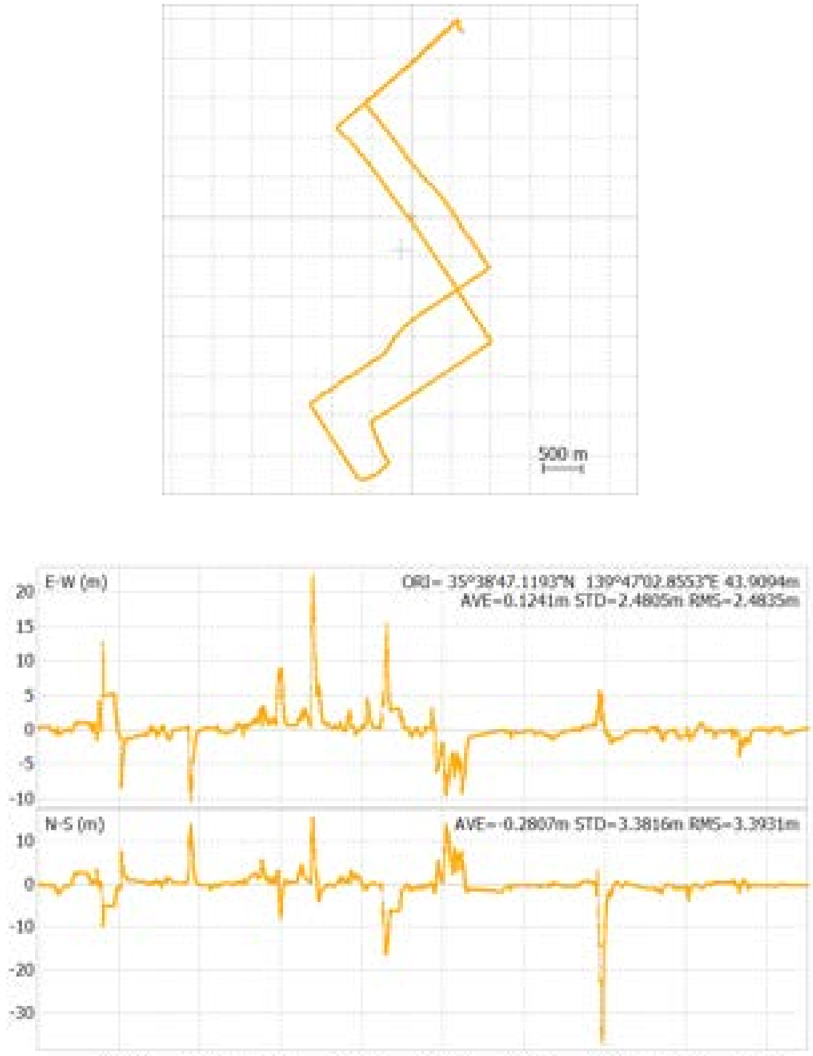
- Raw GNSS data of **dual-frequency** observations were post-processed using the algorithm mentioned above.
- The processing is **only forward** and can be used in real time.
- The settings of the important parameters were the same for all the tests. The mask angle was set to **10°.** The minimum carrier-to-noise ratio was set to **35 dB-Hz**. The threshold for the pseudo-range residual check was set to **10 m**.
- First, the test results of the float solutions (DGNSS+Velocity) are introduced. Second, the test results of the RTK-GNSS are introduced in terms of both the **fix rate** and accuracy (**Horizontal 2D RMS**). “rtkplot” in RTKLIB is used to show the test results.

# Test results of float solutions




Test1


Test2



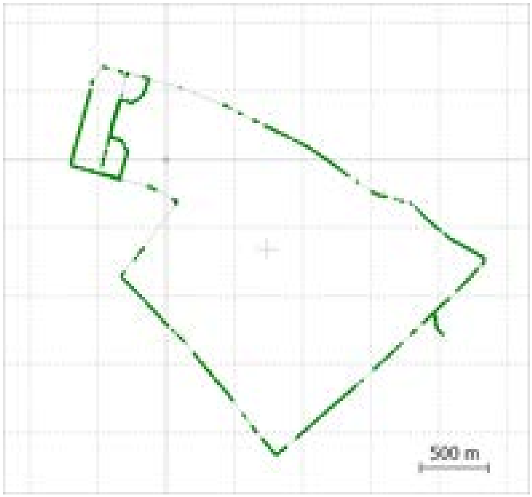

Test3

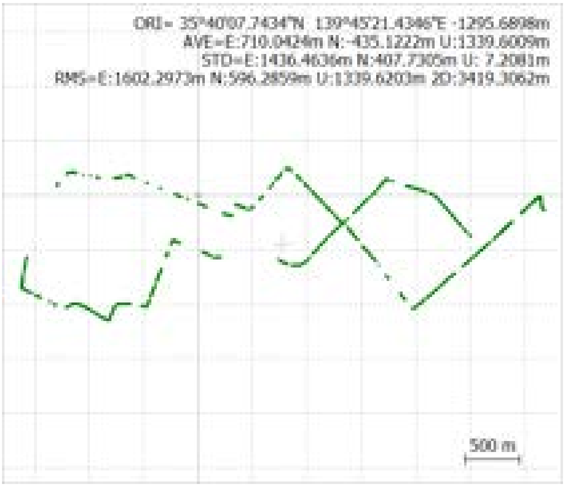
# Comparison with commercial receiver

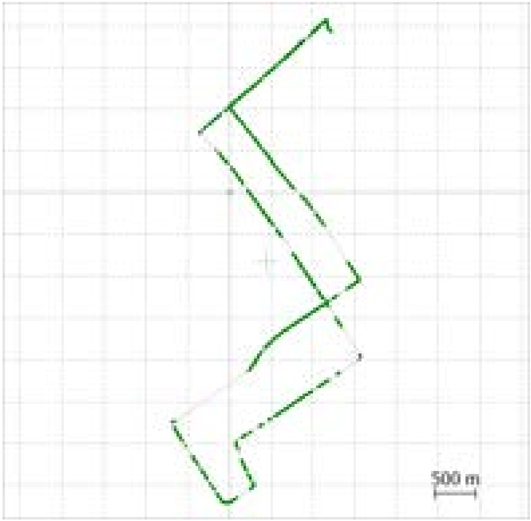
Horizontal 2DRMS comparisons between Modified RTKLIB and commercial receiver

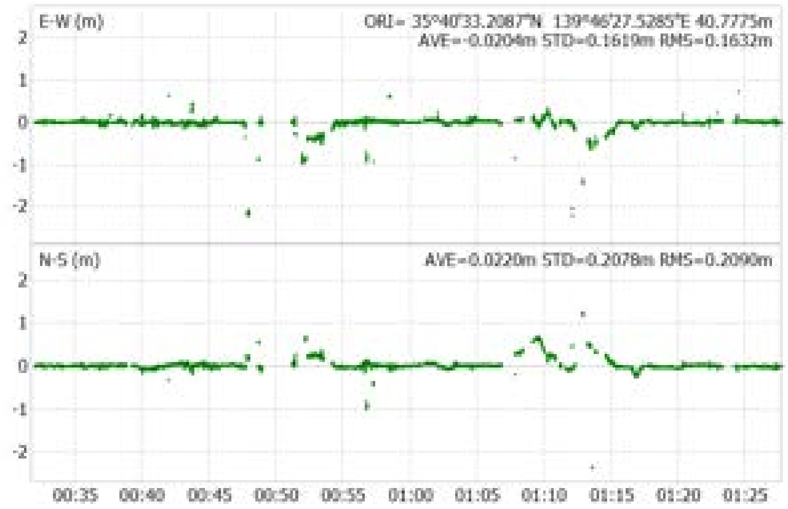
| Test number | Modified RTKLIB | Commercial receiver (u-blox F9P) |
| --- | --- | --- |
| First test course | 5.12 m | 11.88 m |
| Second test course | 5.68 m | 16.45 m |
| Third test course | 8.41 m | 7.97 m |

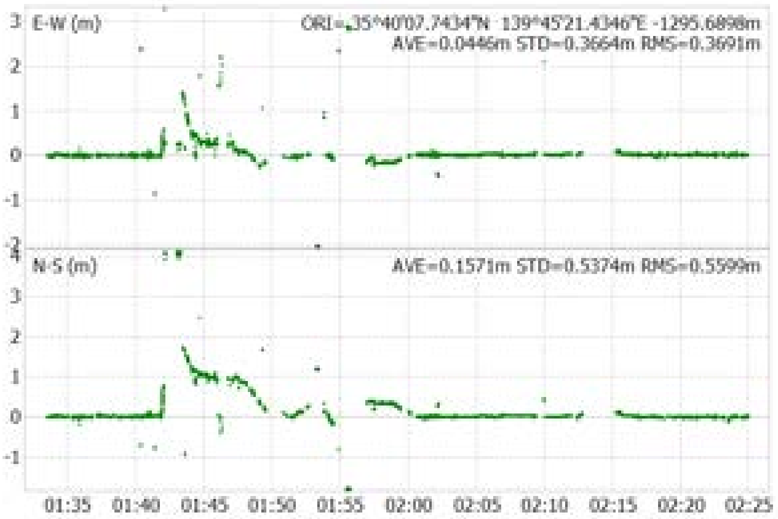
# Test results of RTK-GNSS

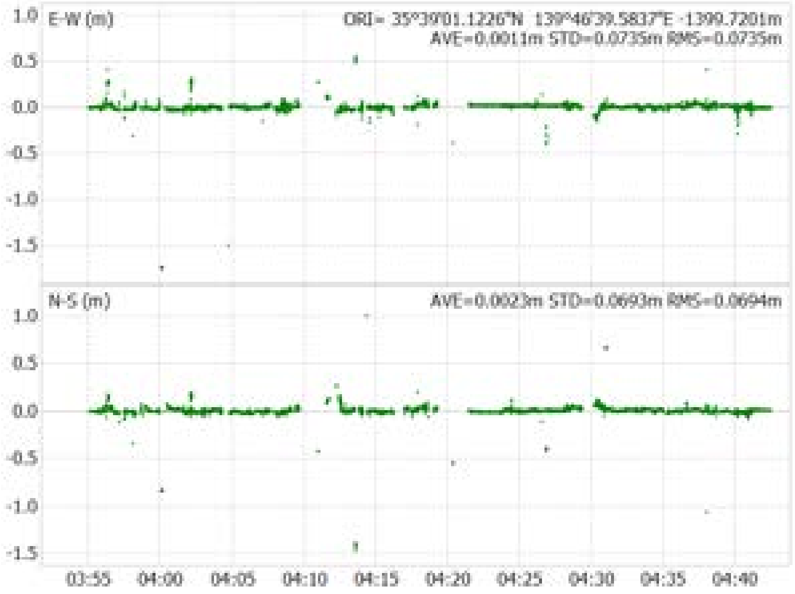


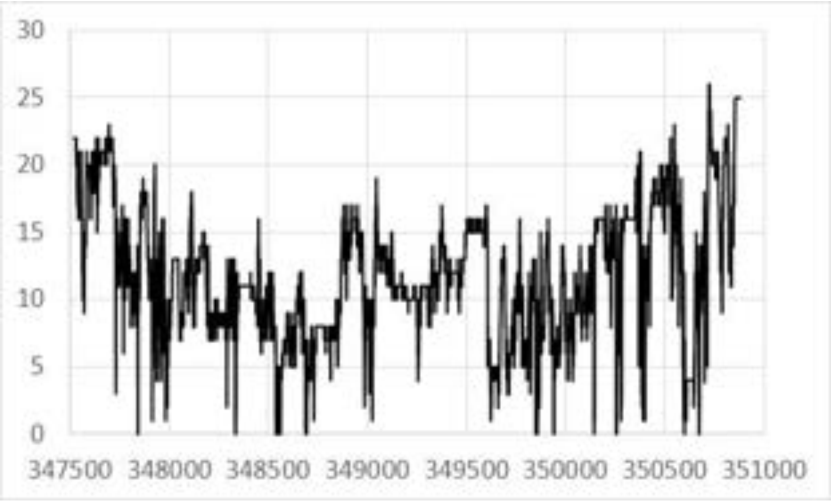



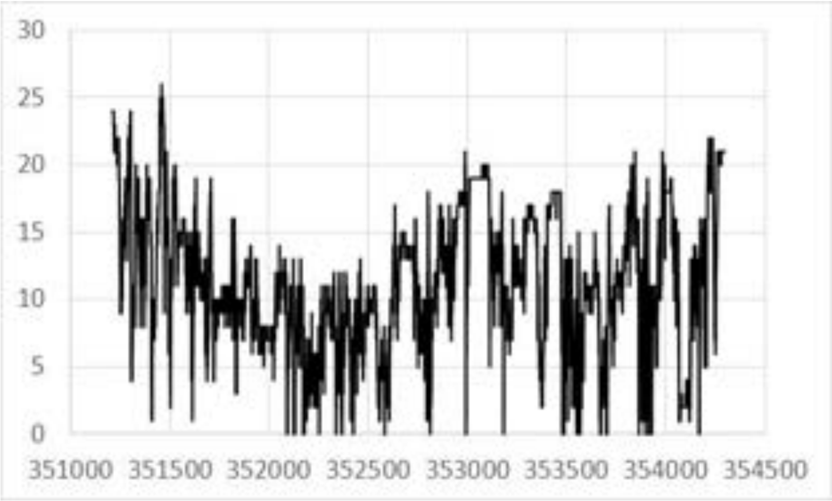
# Temporal used satellites for 3 Tests (Dual-frequency carrier phase : valid)




Average number of used satellites

Test1 : **<u>11.6</u>**

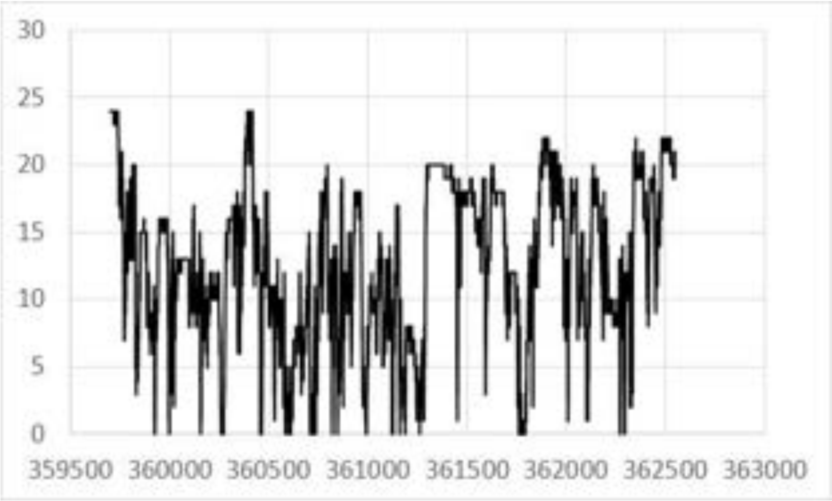
(25.8 for base station)




Average number of used satellites

Test2 : **<u>11.2</u>**

(25.3 for base station)




Average number of used satellites

Test3 : **<u>12.6</u>**

(24.8 for base station)

# Comparison with commercial receiver

| Test number | Modified RTKLIB | | Commercial receiver (u-box F9P) | |
|---|---|---|---|---|
| | Fix rate | Horizontal 2DRMS | Fix rate | Horizontal 2DRMS |
| First test course | 66.8 % | 0.53 m | 52.2 % | 0.32 m |
| Second test course | 58.0 % | 1.34 m | 47.9 % | 0.82 m |
| Third test course | 67.8 % | 0.20 m | 74.2 % | 0.54 m |

# Comparisons with RTKLIB/rtklibexplorer

- For the ambiguity resolution method, the **instantaneous mode** was used because the instantaneous mode is the best of the three modes using **RTKLIB** in urban areas.
- For the ambiguity resolution method, the **Fix and Hold mode** was used because the Fix and Hold mode is the best of the three modes using **rtklibexplorer** in urban areas.
- The following table summarizes the setting values of the parameters for RTK-GNSS. Each parameter to produce best performance was searched by changing these values. In fact, **Min Lock to Fix Amb** was also used here.

| Parameters | Setting values |
|---|---|
| Mask angle | 10, 15, 20, 25, 30, 35 |
| Minimum $C/N_0$ (dB-Hz) | 30, 32, 34, 36, 38, 40, 42, 44 |
| Code/Carrier ratio | 100, 200, 300 |

# Comparison with RTKLIB

| Test number | Modified RTKLIB | | RTKLIB | |
|---|---|---|---|---|
| | Fix rate | Horizontal 2DRMS | Fix rate | Horizontal 2DRMS |
| First test course | 66.8 % | 0.53 m | 41.1 % | 7.69 m |
| Second test course | 58.0 % | 1.34 m | 34.3 % | 7.36 m |
| Third test course | 67.8 % | 0.20 m | 54.3 % | 11.23 m |

# Comparison with rtklibexplorer

| Test number | Modified RTKLIB | | rtklibexplorer | |
|---|---|---|---|---|
| | Fix rate | Horizontal 2DRMS | Fix rate | Horizontal 2DRMS |
| First test course | 66.8 % | 0.53 m | 64.3 % | 1.24 m |
| Second test course | 58.0 % | 1.34 m | 60.8 % | 2.35 m |
| Third test course | 67.8 % | 0.20 m | 72.5 % | 0.39 m |

# Conclusion

- This paper presented the improvement of the generic and well-known RTKLIB GNSS software.
- RTK-GNSS was improved by applying velocity vectors and selecting satellites with good signal quality before positioning.
- However, the performance of low-cost commercial receivers was also observed to be good, and while our proposed modified RTKLIB was sometimes superior in terms of the fix rate, it was not as accurate.
- We also deduced that the performance could be considerably improved using the open-source rtklibexplorer by determining the optimal setting values.
- In the near future, we plan to evaluate methods to further reduce the wrong fixes of RTK-GNSS and improve the fix rate.