Performance Evaluation of Multi-GNSS RTK for Automobiles in Urban Areas

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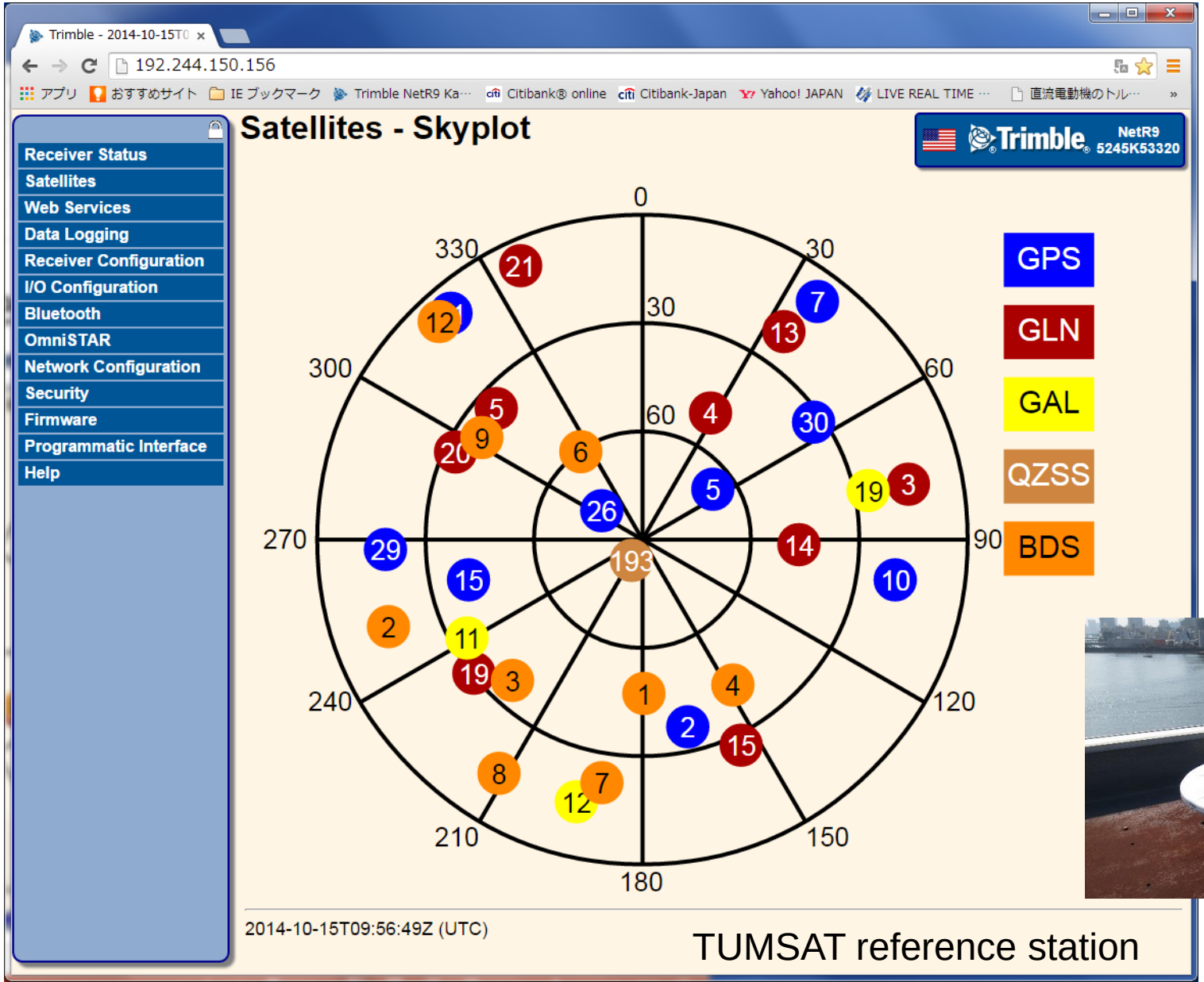
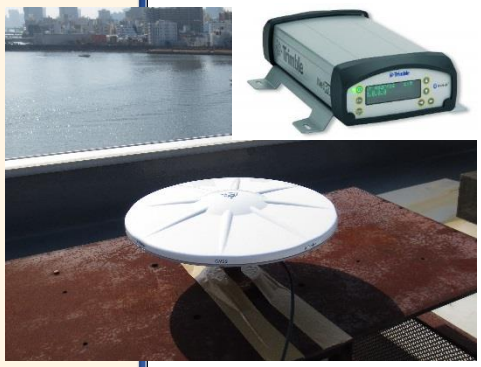
Contents

Current GNSS Constellation



GPS : 32
GLO : 23
BEI : 14
GAL : 3
QZS : 1

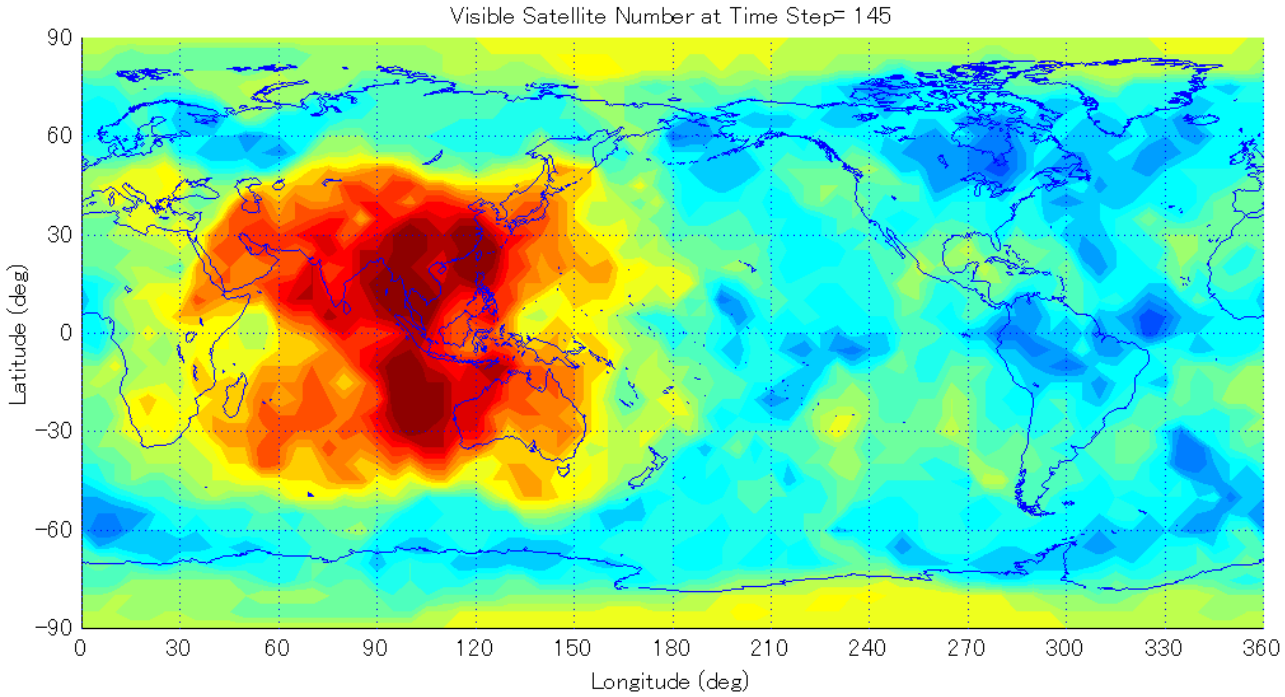


TUMSAT reference station

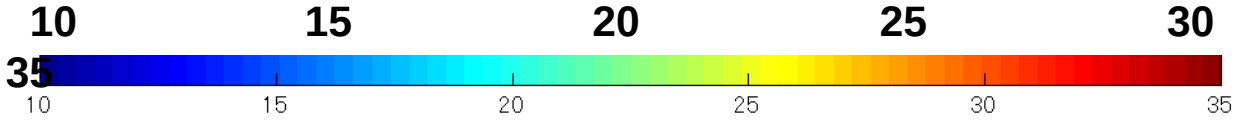
New GNSS Era : many more satellites

Visible satellite number (mask angle 30 degrees)

2020:

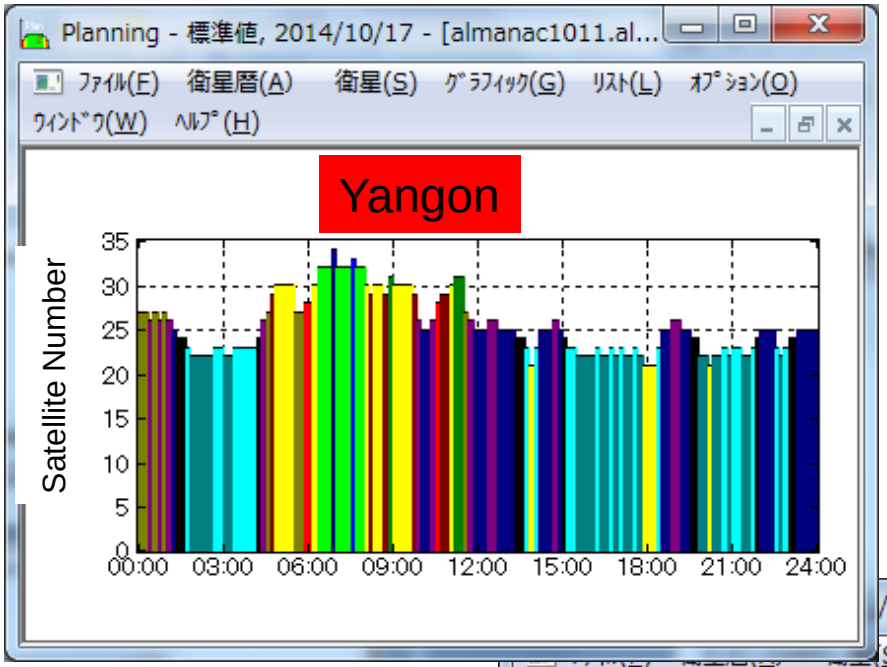


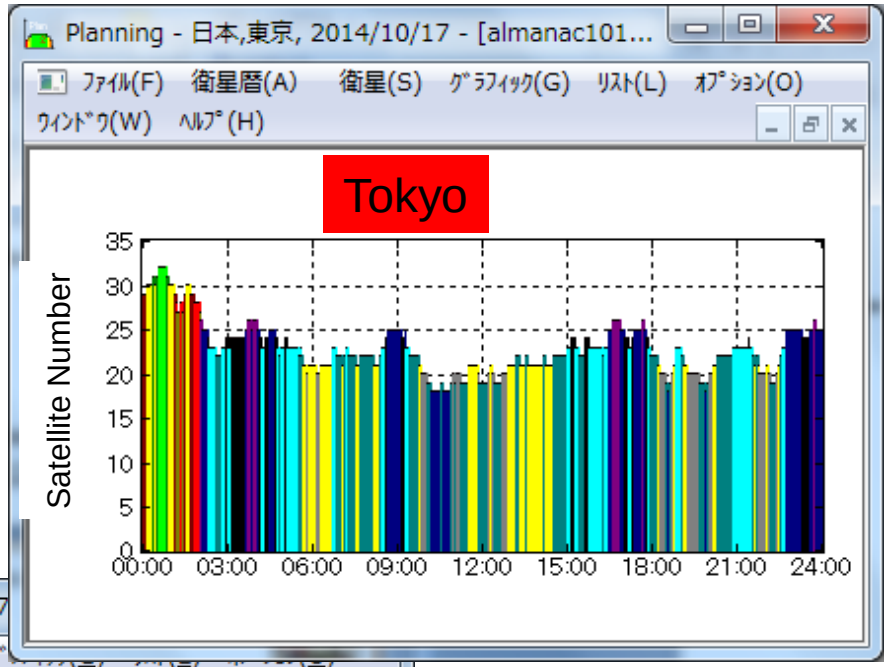
GPS(27)+Glonass(24)+Galileo(30)+Beidou(35)+IRNSS(7)+QZSS(3)+ SBAS(7)

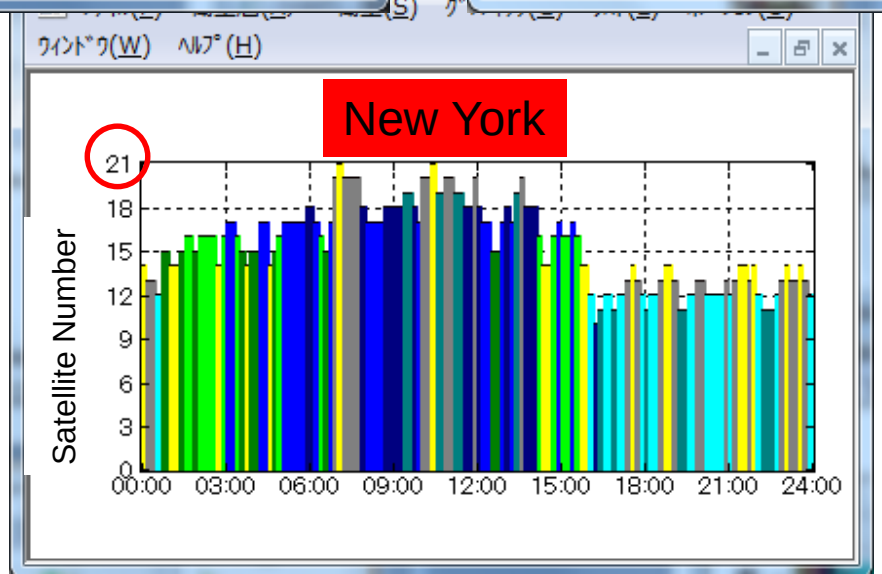


1-day number of visible satellites with all SVs

(Yangon, Tokyo, New York mask=15)

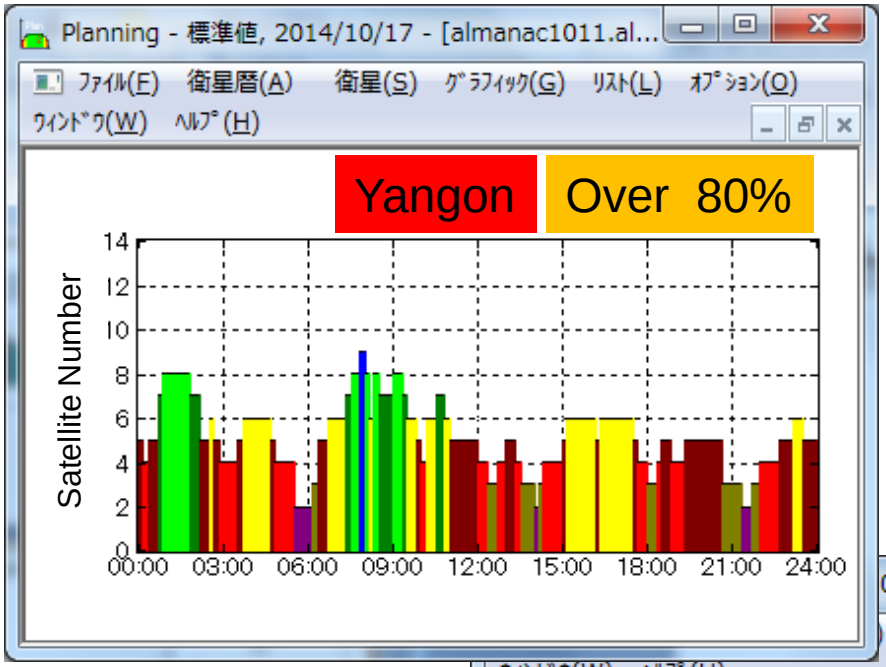


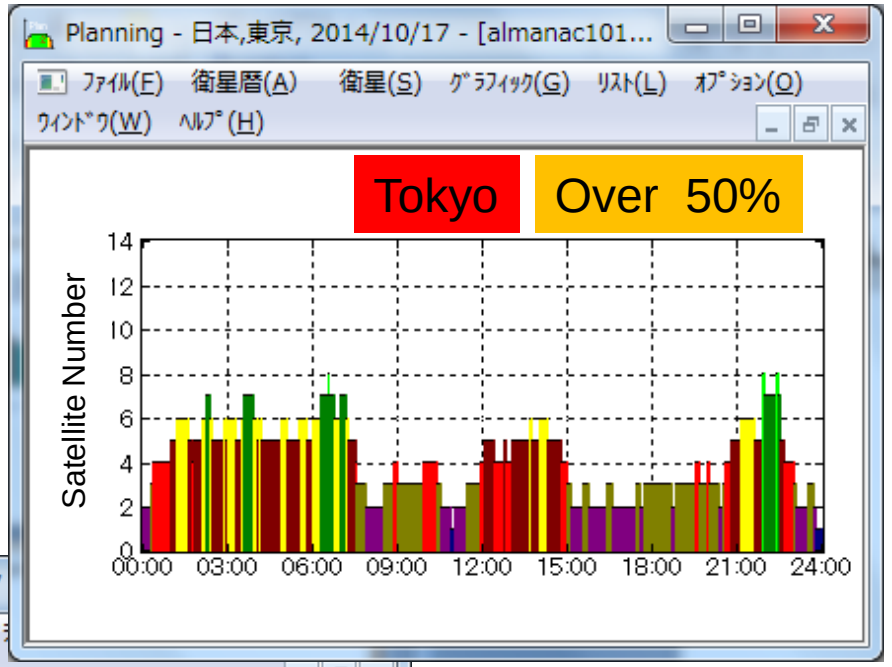


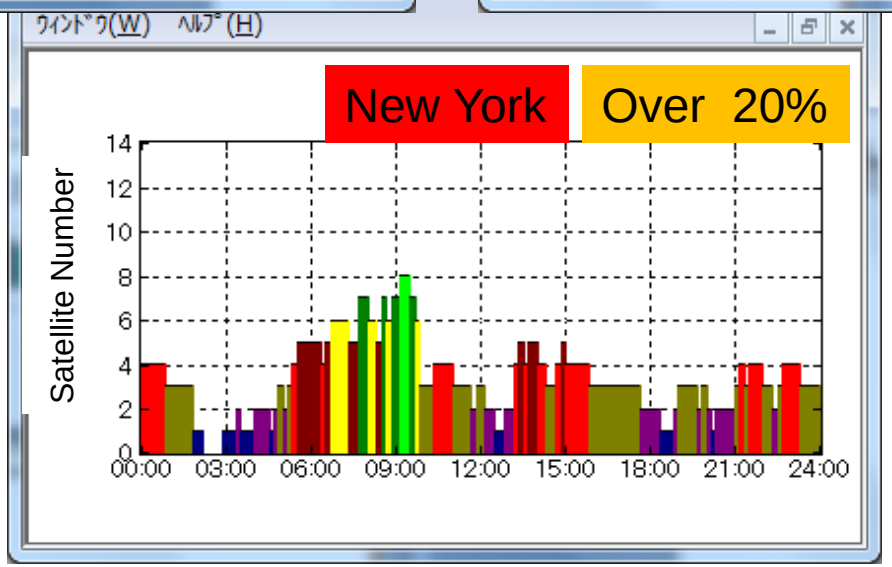


1-day number of visible satellites with all SVs

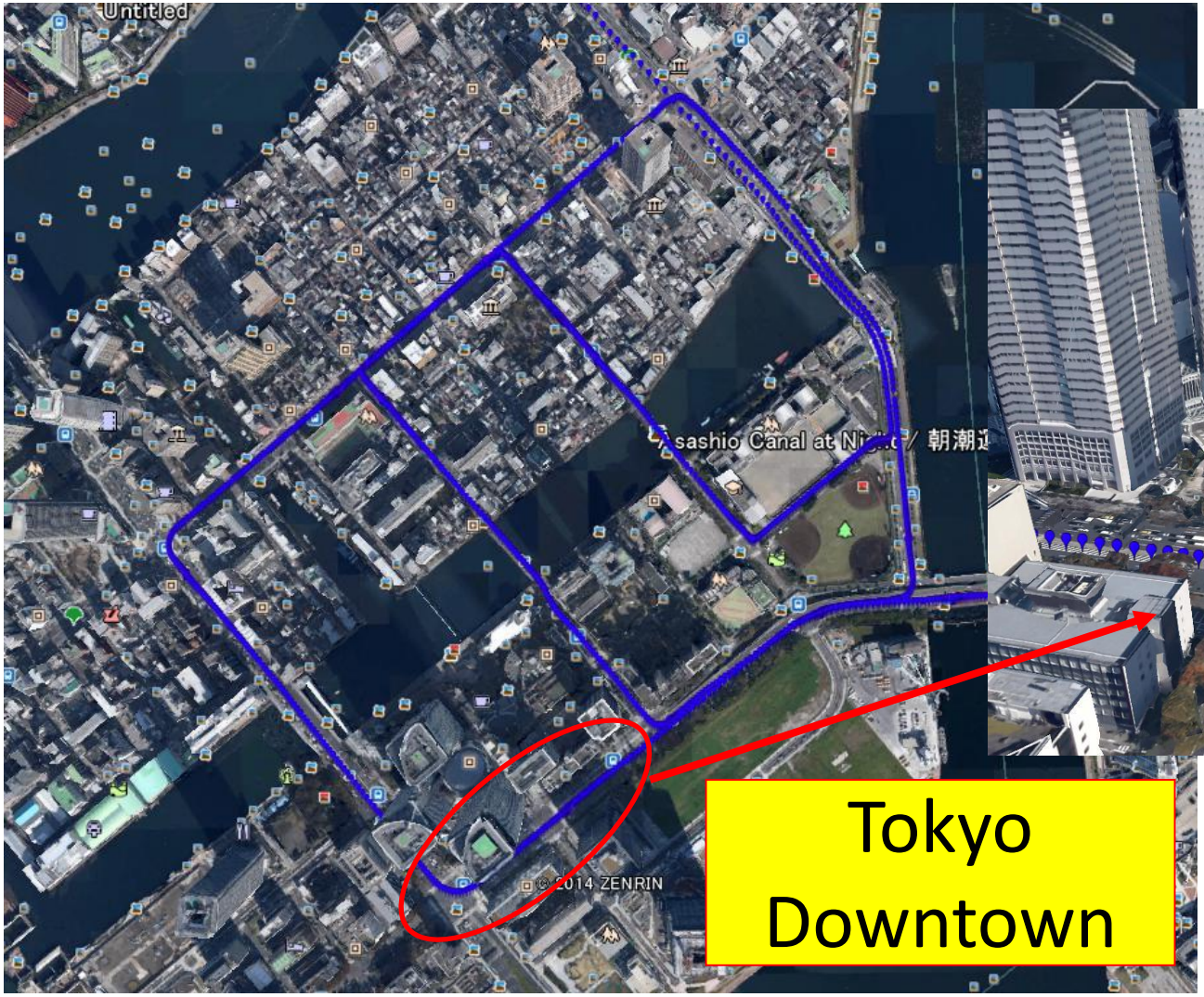
(Yangon, Tokyo, New York mask=60)

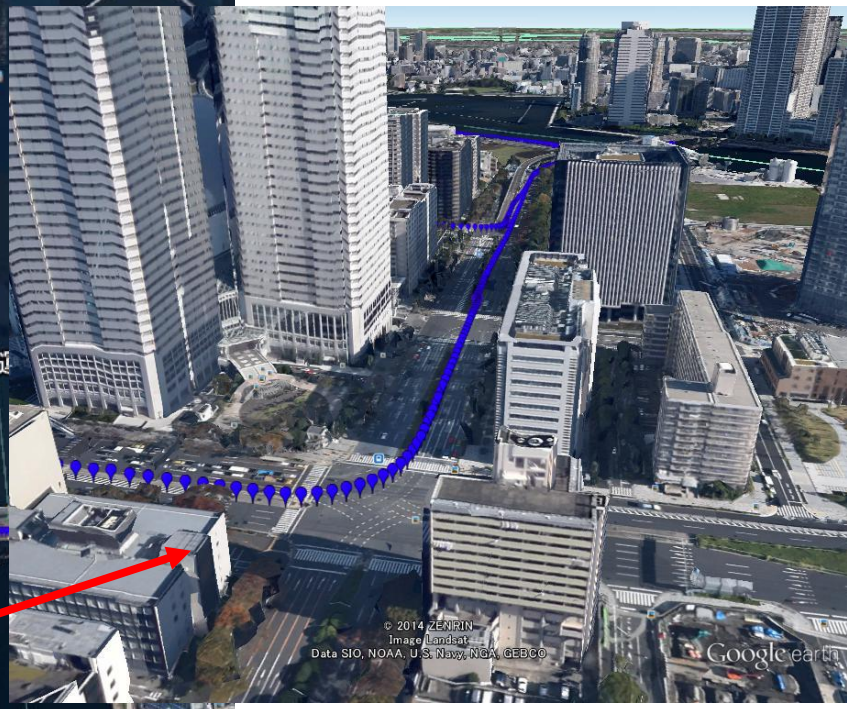






Performance of low-cost receiver with single-frequency GPS/QZS/BeiDou

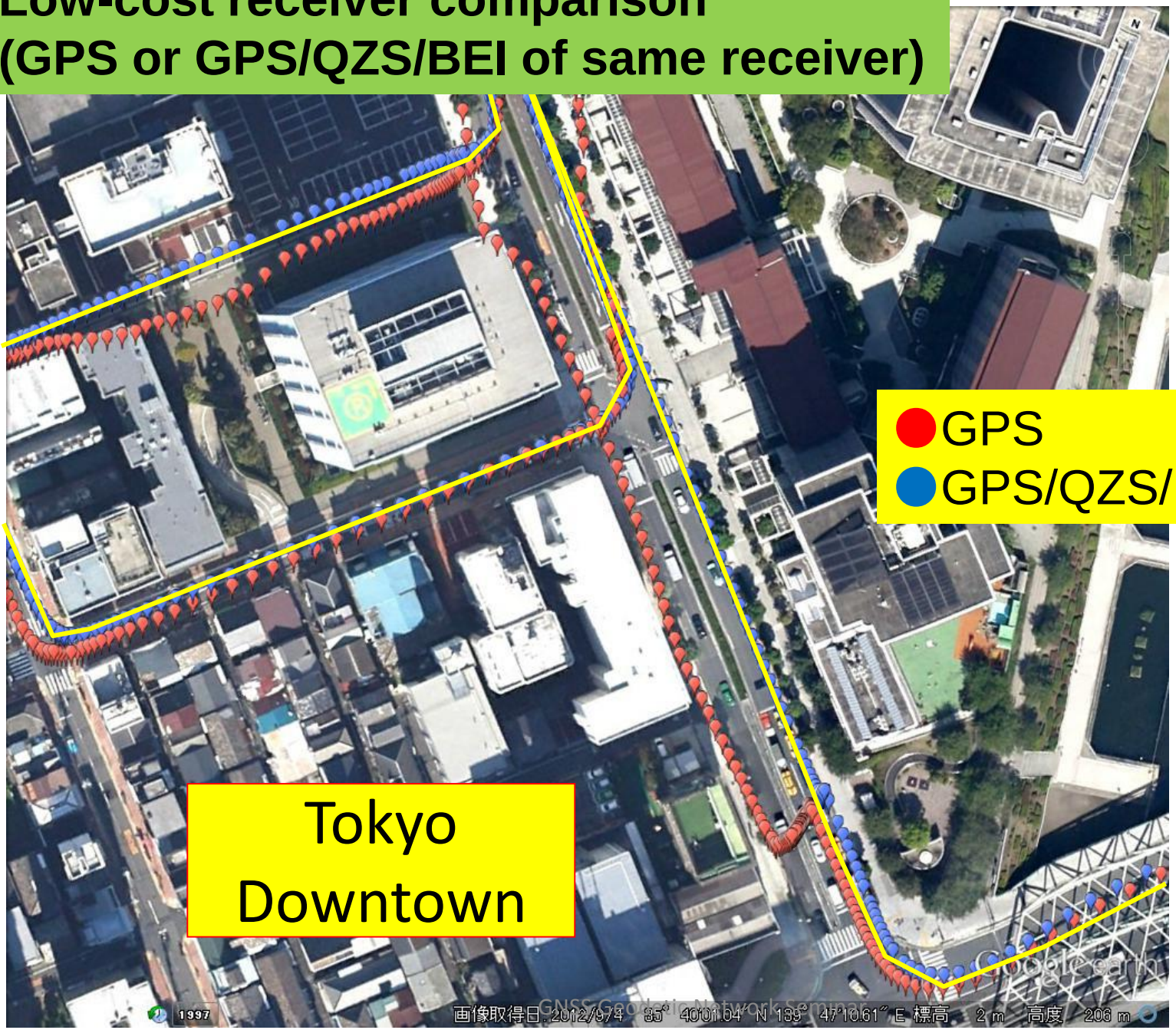


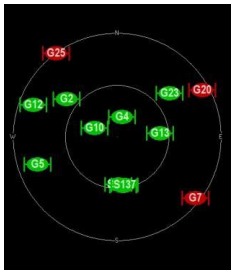


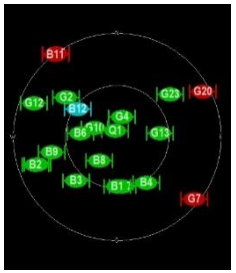
Tokyo Downtown

Many skyscrapers…

Low-cost receiver comparison (GPS or GPS/QZS/BEI of same receiver)

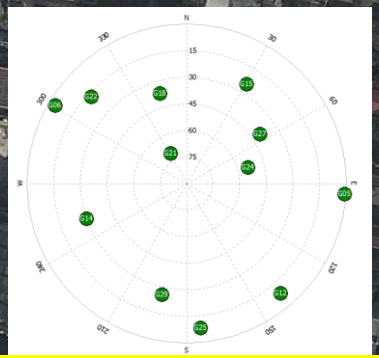






Low-cost receiver comparison (GPS or GPS/QZS/BEI of same receiver)

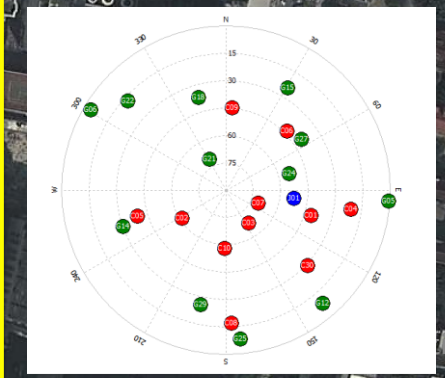
Bangkok Downtown



Under elevated train

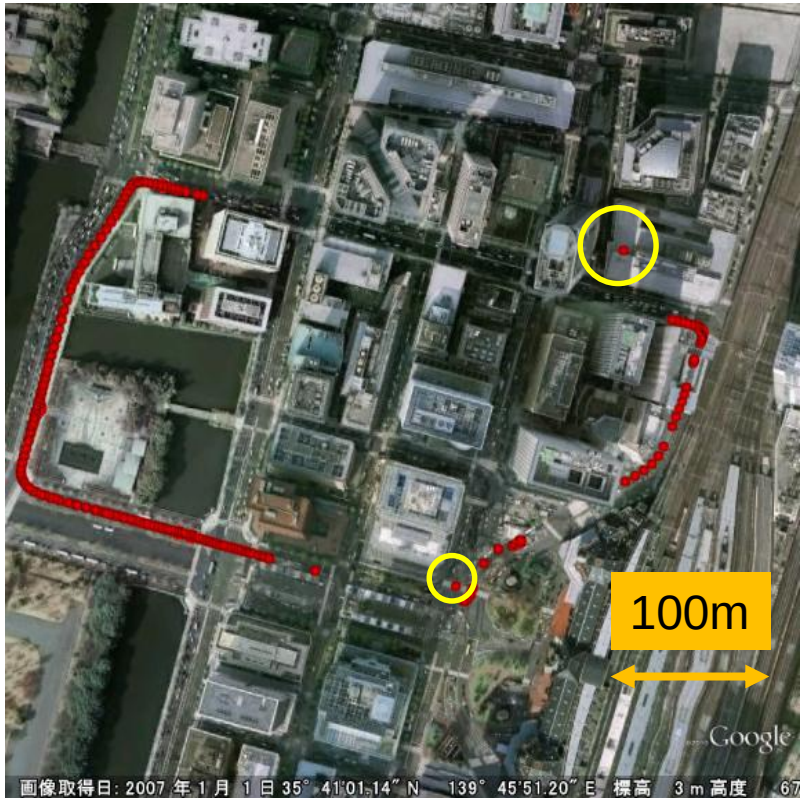
GPS

GPS/QZS/BeiDou



Challenge in RTK

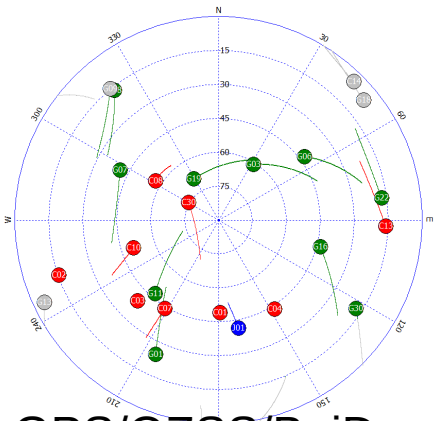
- Reliability as well as availability of RTK are quite important for future commercial users



RTK-GPS example in dense urban areas (Marunouchi Tokyo)

Both reliability and availability were not enough…

We need to know the current power of RTK-GNSS exactly…



GPS/QZSS/BeiDou

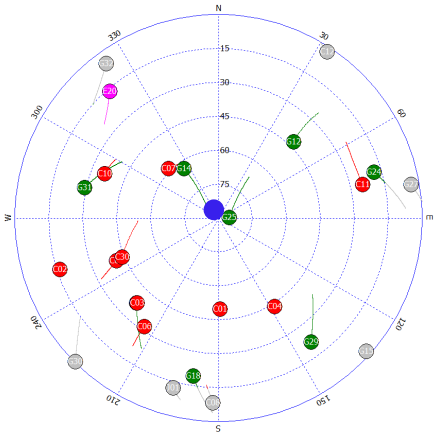
Yaesu

Two Test Routes

RTK-GNSS reliability ?

Start (Kaiyodai)

Tsukishima



GPS/QZSS/BeiDou

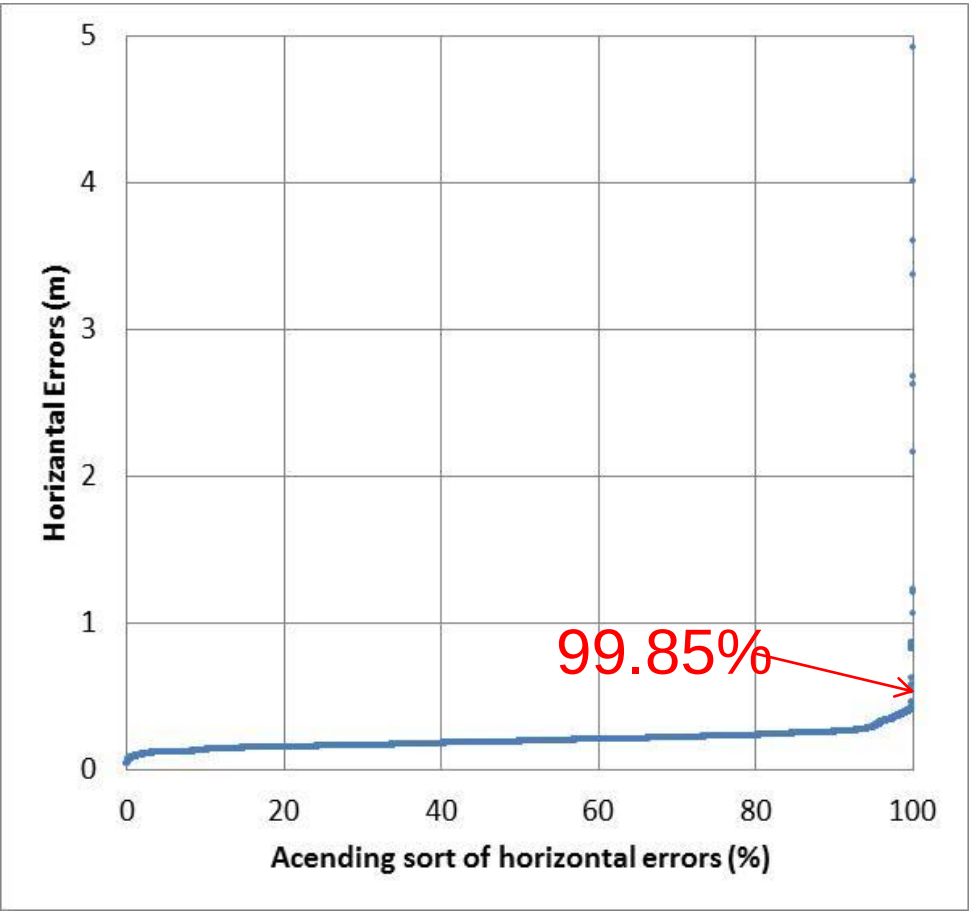
Tsukishima Route	FIX rate	Maximum Interval without fix	Percentage below 0.5m (Horizontal)
GPS	21.7 %	195 s	99.96 %
GPS/QZS	39.8 %	176 s	99.73 %
GPS/QZS/BeiDou	71.6 %	60 s	99.85 %

Yaesu Route	FIX rate	Maximum Interval without fix	Percentage below 0.5m (Horizontal)
GPS	22.0 %	416 s	99.74 %
GPS/QZS	27.1 %	415 s	99.80 %
GPS/QZS/BeiDou	33.1 %	128 s	96.56 %

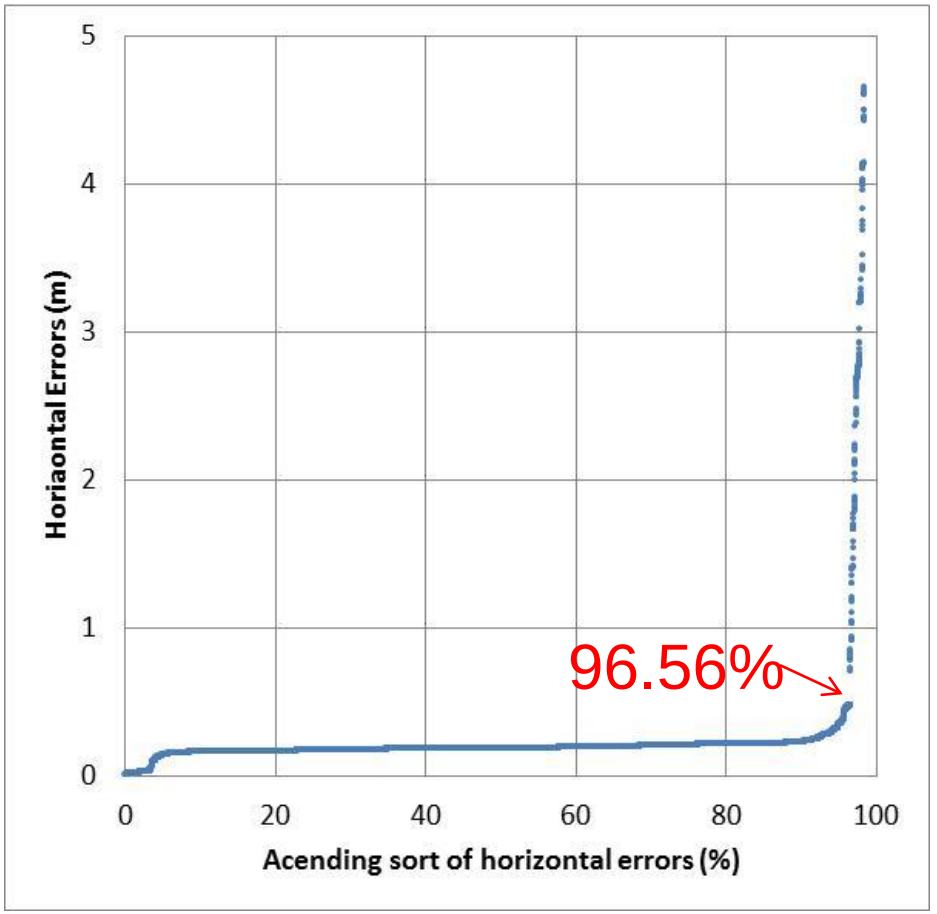
* “POS/LV” assures 20-30 cm errors under this route condition
* “60 s” interval happened under the elevated road
* RTK : Laboratory engine was used.

All RTK Horizontal Errors

10-20 cm errors are deduced from POS/LV

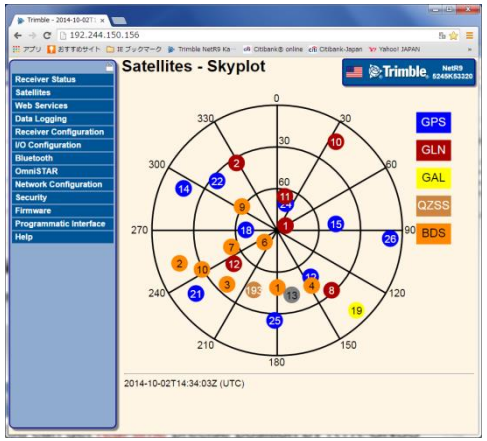


Tsukishima Route



Yaesu Route

We provide local-area CORS network
(collaboration between universities)



CORS(Continuously Operating Reference Stations)

observation data via the Internet

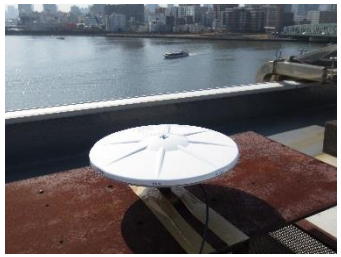
Tokyo(Univ. of Tokyo, Keio Univ., TUMSAT)
Bangkok(Thailand), Jakarta(Indonesia)

What you can do ?

You can get real-time precise position by RTK-GNSS

Rover

Communication Link



Reference

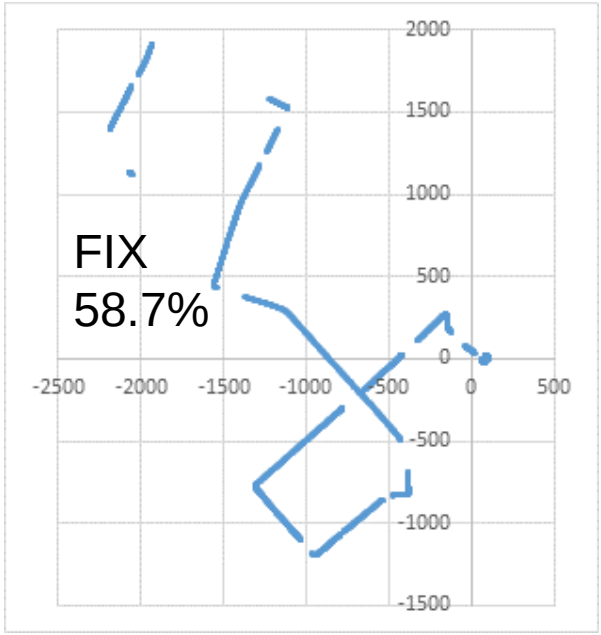
Multi-GNSS RTK Test using Car

Test	Schedule
1st	2014/8/13 13:07–13:32
2nd	2014/8/13 17:26–17:52
3rd	2014/8/13 22:26–22:50
4th	2014/8/14 8:36–9:02
5th	2014/8/14 12:07–12:35

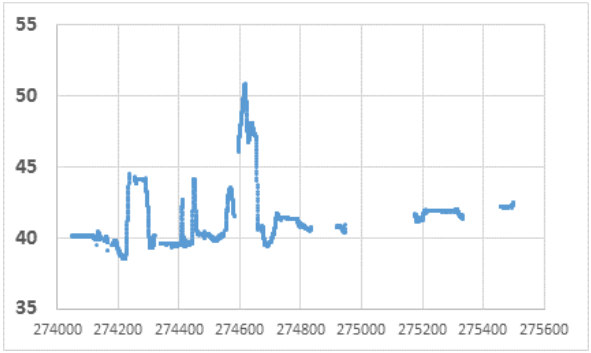
* GPS/QZS/GLONASS/GALILEO/BeiDou are entirely used in this test
* Trimble SPS855 receiver was used
* RTK : Trimble and Laboratory engine

Details of Test 1 Results

(Trimble RTK engine)

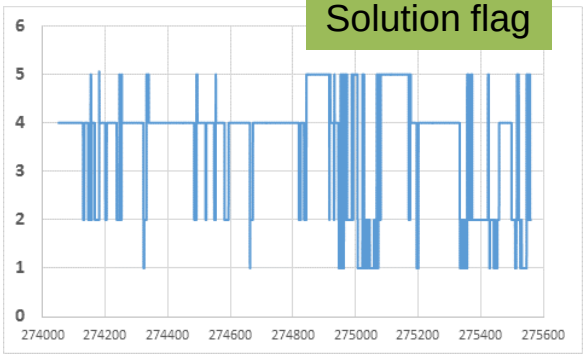


Horizontal results



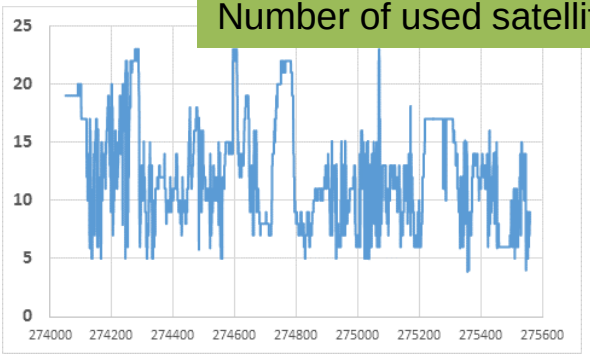
Height results

Solution flag

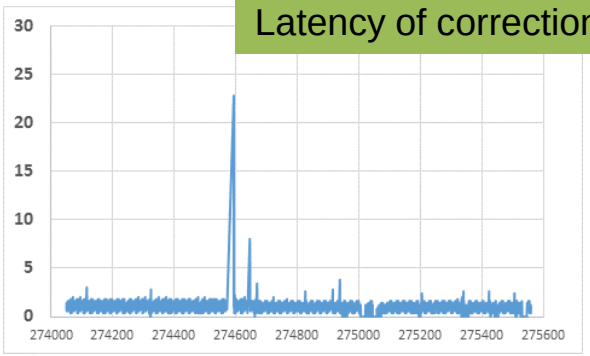


RTK:FLAG=4

Number of used satellites



Latency of correction



Summary of Test Results

Multi-GNSS RTK (Trimble engine)

	Average NUS	Fix rate
Test 1	12.3	58.7%
Test 2	12.3	75.4%
Test 3	13.6	65.5%
Test 4	12.4	60.0%
Test 5	14.2	70.5%

GPS VS. Multi-GNSS RTK (Trimble engine)

Test 5	Average NUS	Fix rate
GPS	5.8	26.8%
Multi-GNSS	14.2	70.5%

FIX rate comparison between GNSS combinations (Laboratory engine)

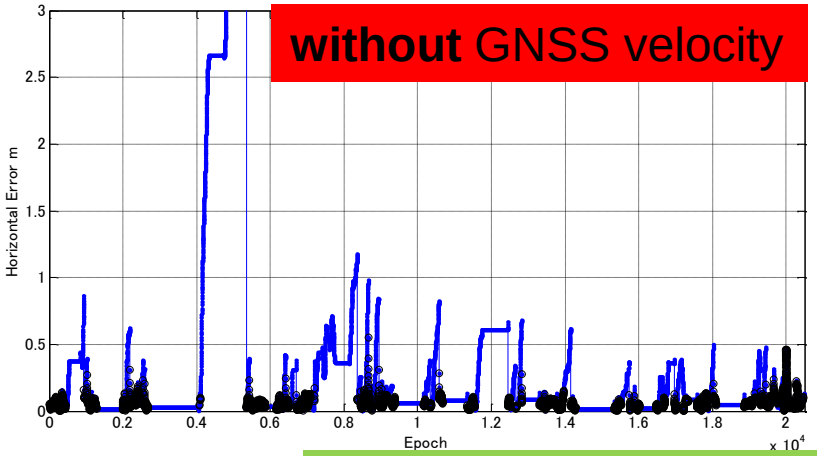
Test 3	G	GJ	GC	GR	GJC	GJCR
RTK FIX rate	48.2%	58.2%	55.5%	55.4%	64.7%	65.9%
Velocity output	67.0%	80.3%	86.5%	82.4%	91.5%	94.7%

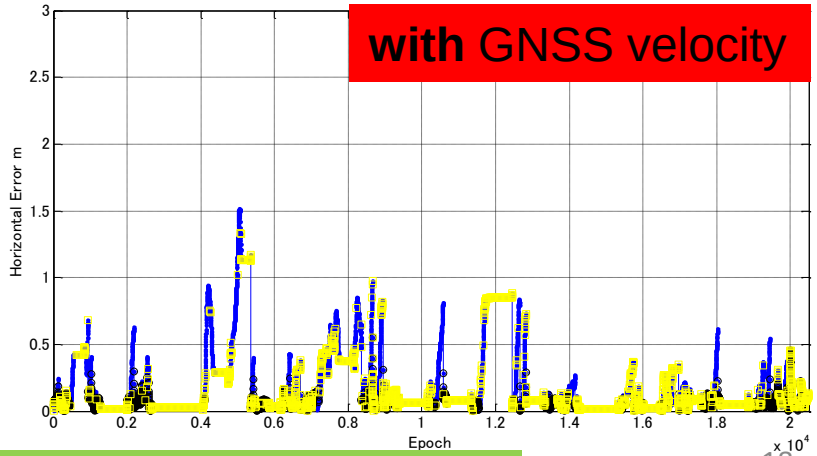
G:GPS J:QZSS C:BeiDou R:GLONASS

The reason for small contribution of BeiDou/GLONASS to RTK was just due to the shortage of high elevation those satellites

Why is “velocity” important ?

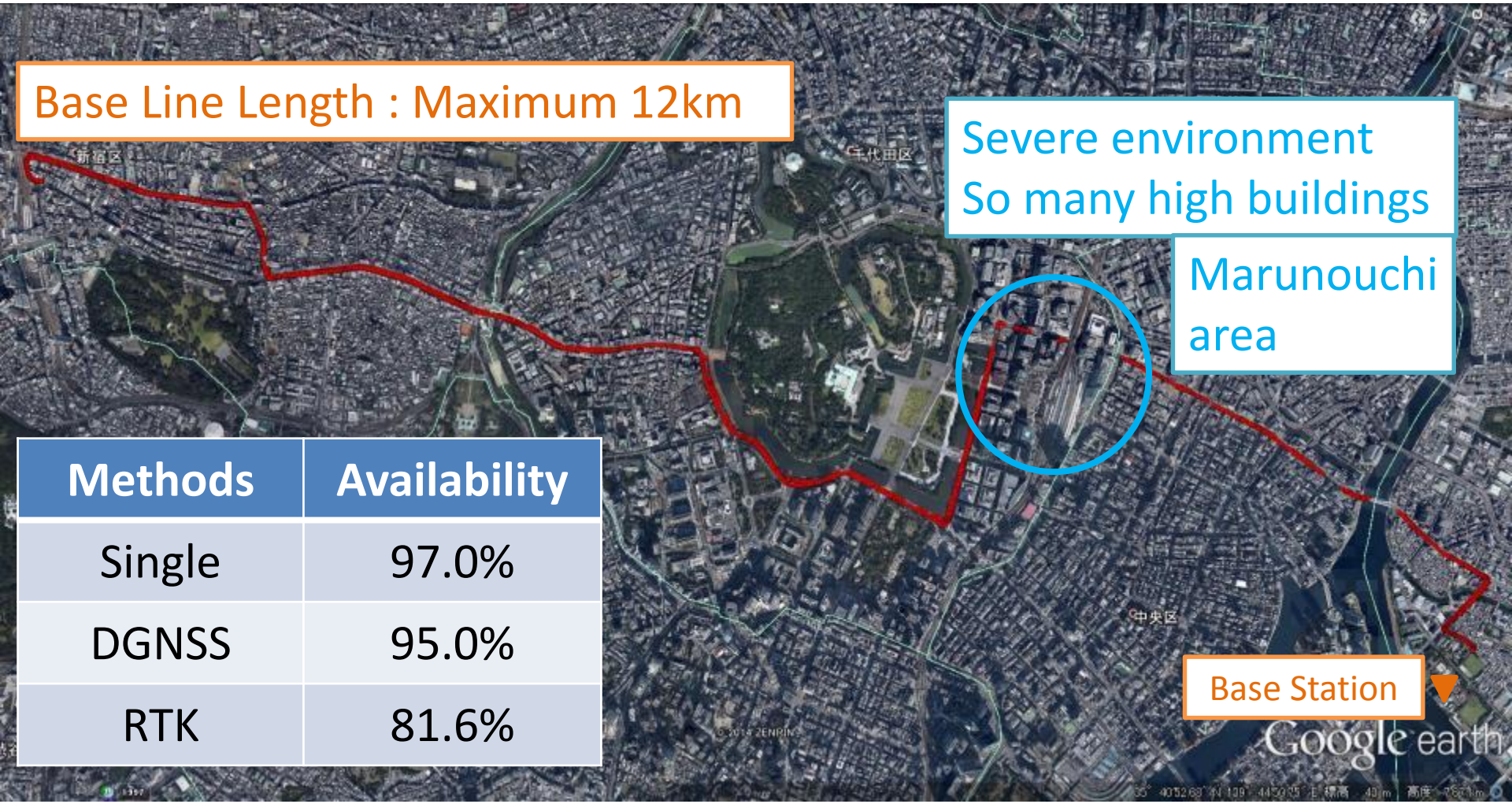
- GNSS is actually not perfect in urban areas
- We have to integrate GNSS with IMU/Speed
- Current speed pulse information is good but the direction is quite important
- With GNSS based velocity, you can correct the direction of low-cost IMU





Horizontal Errors in dense urban areas (35 min.)

Height determination using automobile



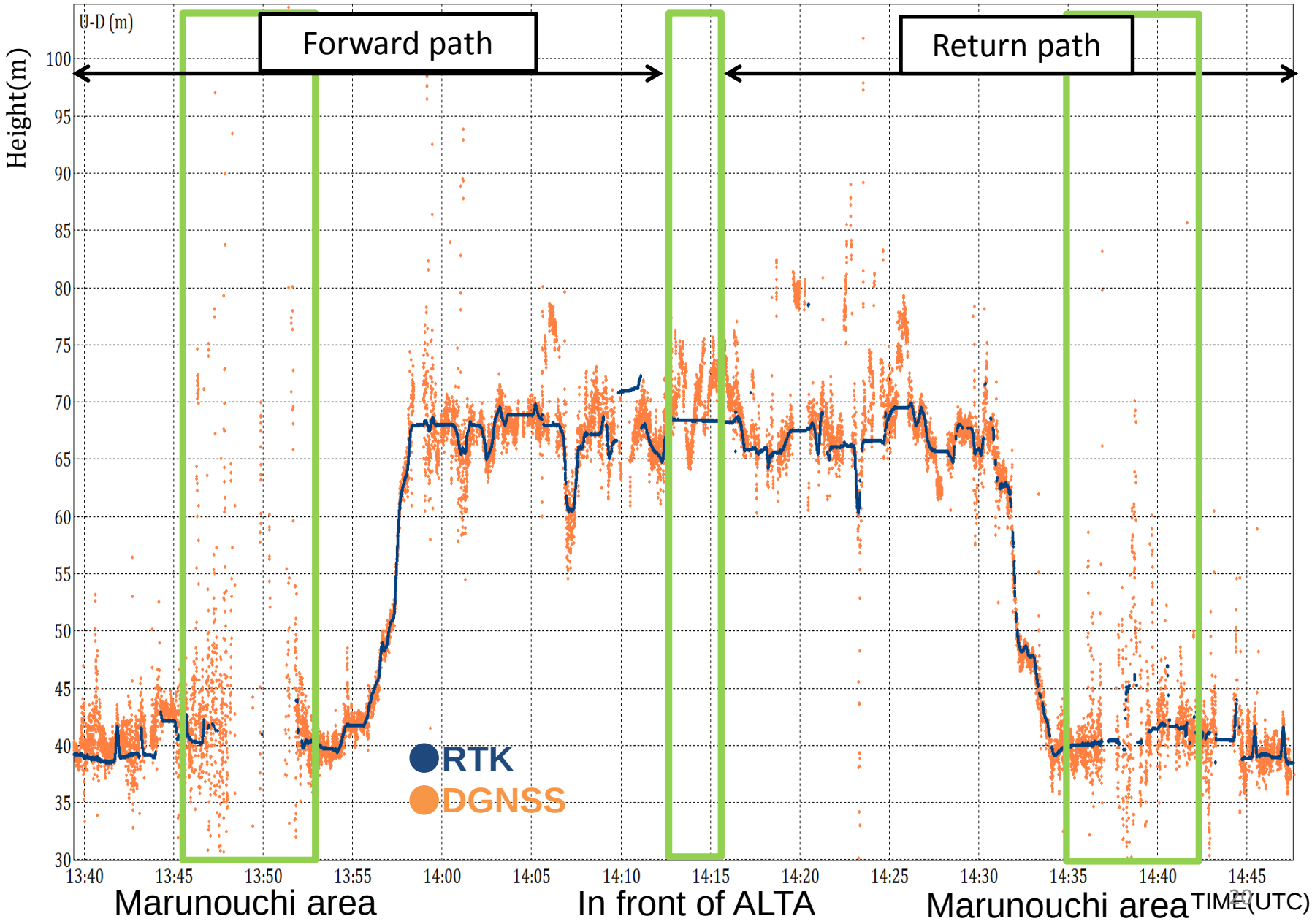
Methods	Availability
Single	97.0%
DGNSS	95.0%
RTK	81.6%

Shinjuku

Route 20

TUMSAT

U-D Results


U-D (m)
Height(m)
Forward path
Return path
RTK
DGNSS
Marunouchi area
In front of ALTA
Marunouchi area
TIME(UTC)

Summary

- Current multi-GNSS and the performance were introduced
- Multi-GNSS contributes greatly to RTK performance as well as low-cost receiver performance
- Higher elevation satellites are strongly necessary for RTK in dense urban areas
- The importance of GNSS velocity was also introduced
- All results were based on local area RTK. It’s time to discuss about the wide area RTK (internet or satellite or ?) service can be used for many commercial users.

Any comments and questions ?

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