AISAN TECHNOLOGY CO.,LTD.

Evaluation of GNSS for the realization of the autonomous car

2015 Cross-ministerial Strategic Innovation Promotion Program～Autonomous Driving WG～

AISAN TECHNOLOGY CO., LTD.

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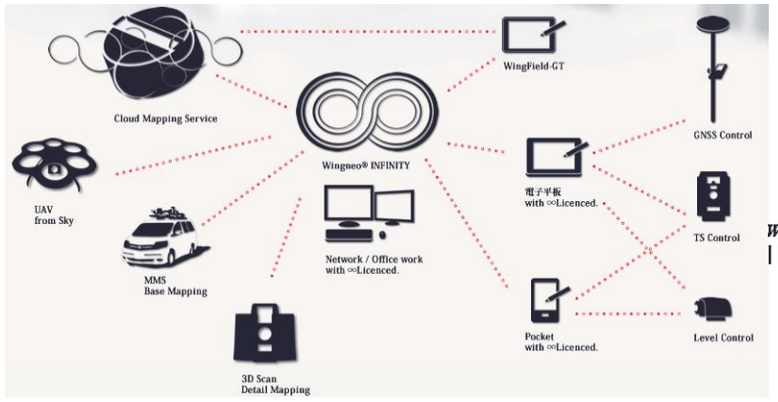
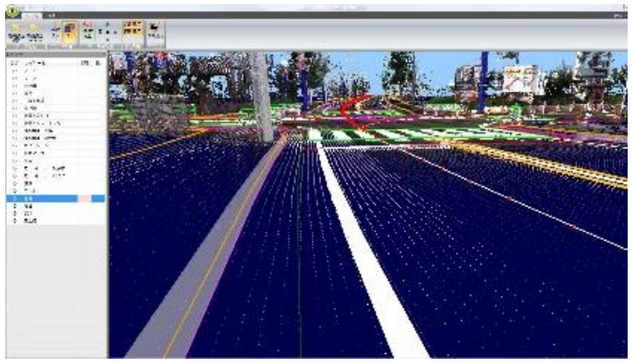
Corporate Name	AISAN TECHNOLOGY Co., Ltd.
Representative	Tetsuji Yanagisawa, President and Representative Director
Established	August 1970
Capital	520,840,000 yen
Securities Exchange Listed	Tokyo Stock Exchange, Inc. (JASDAQ market, Securities code: 4667)
Head Office Address	AT Bldg., 3-7-14, Nishiki, Naka-ku, Nagoya City, Aichi Prefecture TEL: +81-52-950-7500 (main) FAX: +81-52-950-7507
No. of Employees	106 (Male: 81 / Female: 25)
Businesses	1.Design, development, distribution, maintenance of CAD systems for public survey, registration surveying and civil engineering and construction industry 2.Entrusted development of analysis software and conversion module for world coordinate system 3.Research and development of software used for maintenance of 3D maps
Main Banks	Bank of Tokyo-Mitsubishi UFJ, Bank of Nagoya, Aichi Bank
Main Clients	Mitsubishi Electric Corporation, Mitsubishi Electric Information Systems Corporation, Domestic Major Legal Affairs Bureaus, Group companies of Toyota Motor Corporation, Nissan Motor Co., Ltd., Group companies of Honda Motor Co., Ltd., Google Inc., Group companies of NTT Group, PASCO Corporation, NTT DATA Corporation, Autodesk, Inc., Annaka Co., Ltd., Leica Geosystems Co., Ltd., Leopalace21 Corporation, GENBA SUPPORT. CO., LTD. and more
Main Shareholders	Mitsubishi Electric Corporation, Mitsubishi Electric Information Systems Corporation, CTS Co., Ltd., Mizukami Youkou Co., Ltd., Annaka Co., Ltd. (As of September 30, 2013)
Group Companies	AT Labo Co., Ltd.
	Threed Co., Ltd.

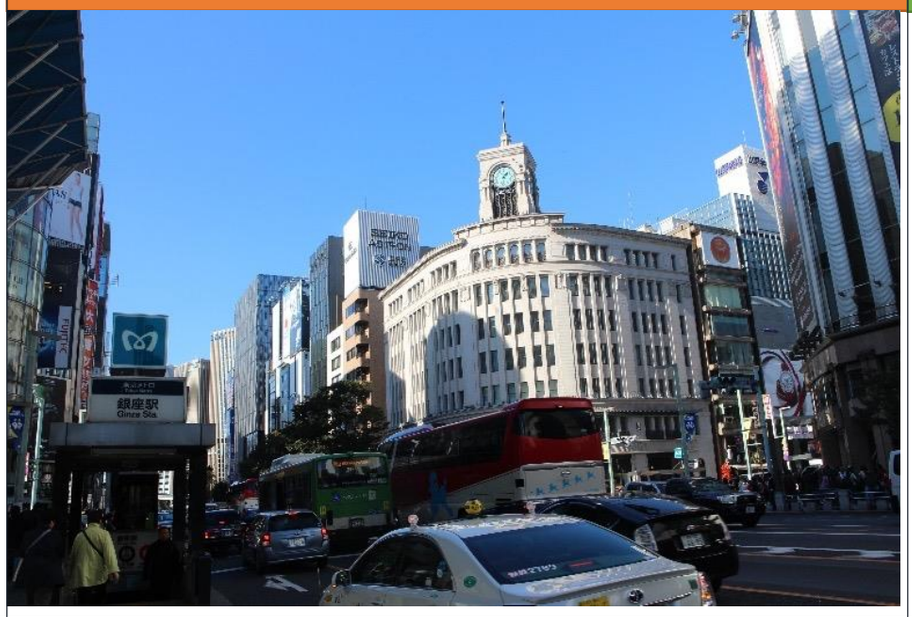


WingNeo INFINITY



The purpose of the investigation

The problem of satellite positioning is different by each environment.
Availability of satellite positioning technology was investigated to considerate and resolve these problems.

	Urban area	Expressway
Traffic environment.		
Request to adus.	Reducing traffic accidents. Reducing traffic jams.	Reducing burden of drivers. To enable efficient traffic and physical distribution.
Results of the investigation report. (2014)	Influence of multi-path is a problem. There is a possibility of the improvement by using multi-GNSS.	We confirmed improvement of positioning estimating by using augmentation signals of multi-GNSS and QZSS.
The purpose of the investigation. (2015)	Influence of multi-path is investigated. The mothod of multi-path noise reduction was considered.	Availability of new positioning methods and augmentation technology is investigated.

Experiment of satellite positioning

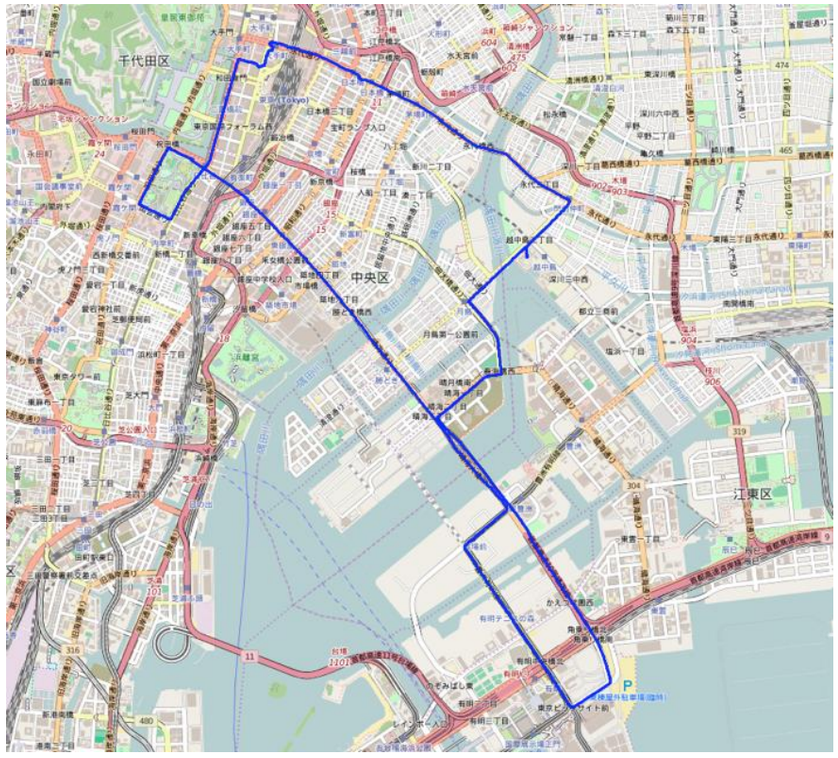
The consortium which considers utilization of satellite positioning

- AISAN TECHNOLOGY Co.,Ltd.
- Japan Aerospace Exploration Agency (JAXA)
- Satellite Positioning Research and Application Center (SPAC)
- Tokyo University of Marine Science and Technology
- KOZO KEIKAKU ENGINEERING Inc.

Discussion ⟷ ITS Japan OEM

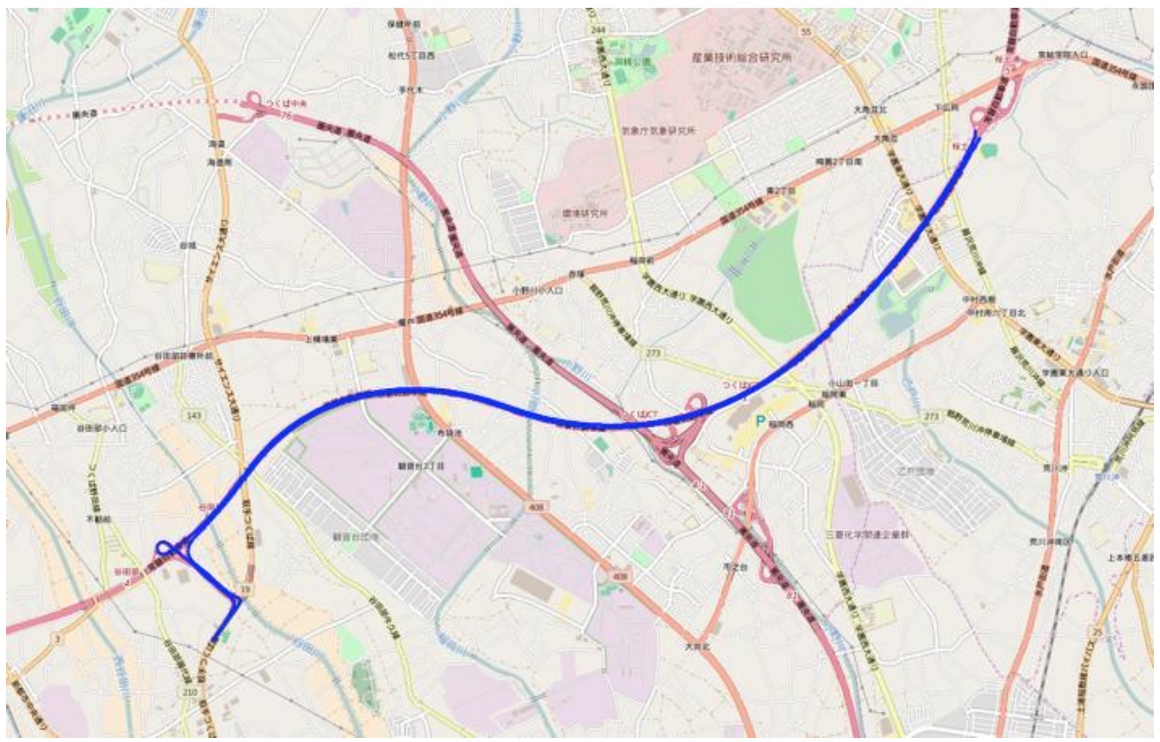
Cooperation ⟷ Electronic Navigation Research Institute (ENRI)

Urban area (Around Chuo Ward, Tokyo)



Influence of multi-path is investigated.

Expressway (Tukuba City, Ibaraki Prefecture)



Availability of new positioning methods and augmentation technology is investigated.

Experiment of satellite positioning

Mobile Mapping System (MMS)

NetR9

High precision GNSS receivers :

Three types receivers and LEX receiver

・Carrier phase positioning

Standard receivers :

Three types of multi-GNSS-compatible receiver

・Code phase positioning

Position of antennas: Dashboard and roof

EVK-M8T

The combination of data analysis

	Multi-GNSS
S1	GPS
S2	GPS+QZ
S3	GPS+QZ+GLO
S4	GPS+QZ+GLO+BDS

×

	Positioning method
M1	Single frequency
M2	Dual frequency
M3	Single frequency+ L1-SAIF
M4	Single frequency+ DGPS (L1S)
M5	RTK
M6	CMAS (L6)
M7	MADOCA-PPP

Experiment of satellite positioning

Mobile Mapping System(MMS)

Measurement data

Inspection

Survey

Correction

Spline curve

NMEA(GGA)

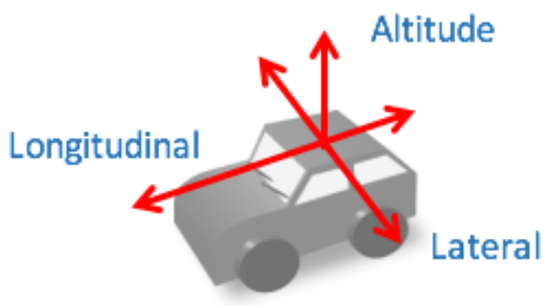
convert to a Rectangular coordinate system

・Correction of diastrophism
・Insertion of geoid

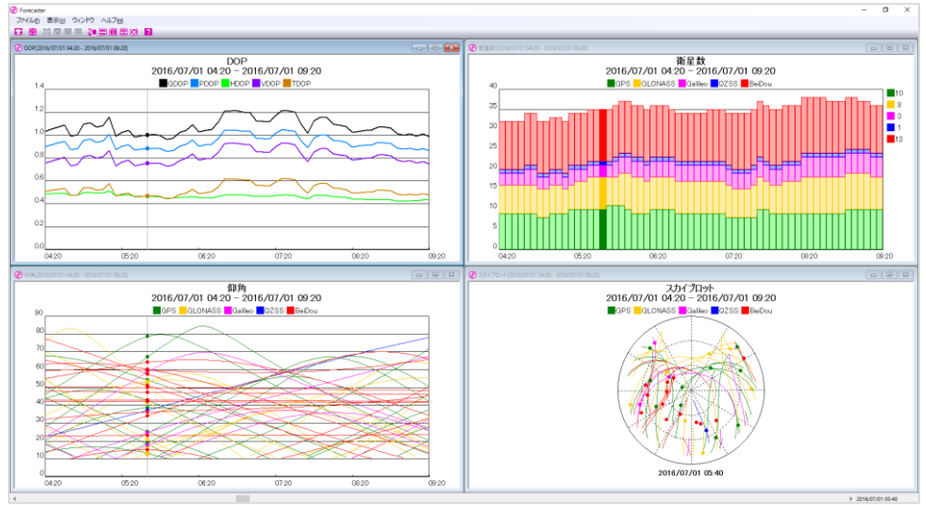
Time synchronization (The observed time)

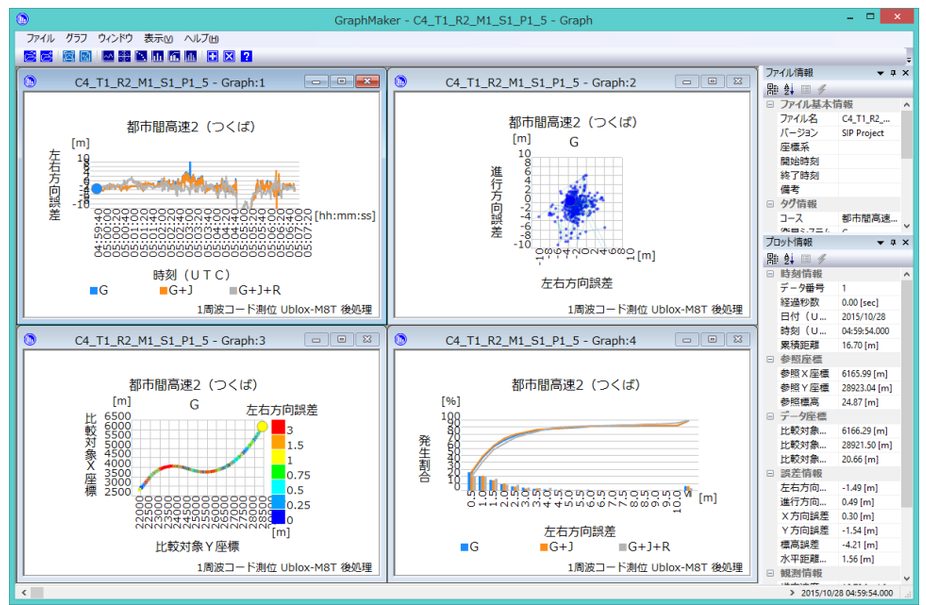
Coordinate(X,Y,H)

Comparison



・Time(UTC)
・Reference coordinates(MMS)
・Coordinates
・Speed(Estimation)
・Number of satellites in use
・HDOP



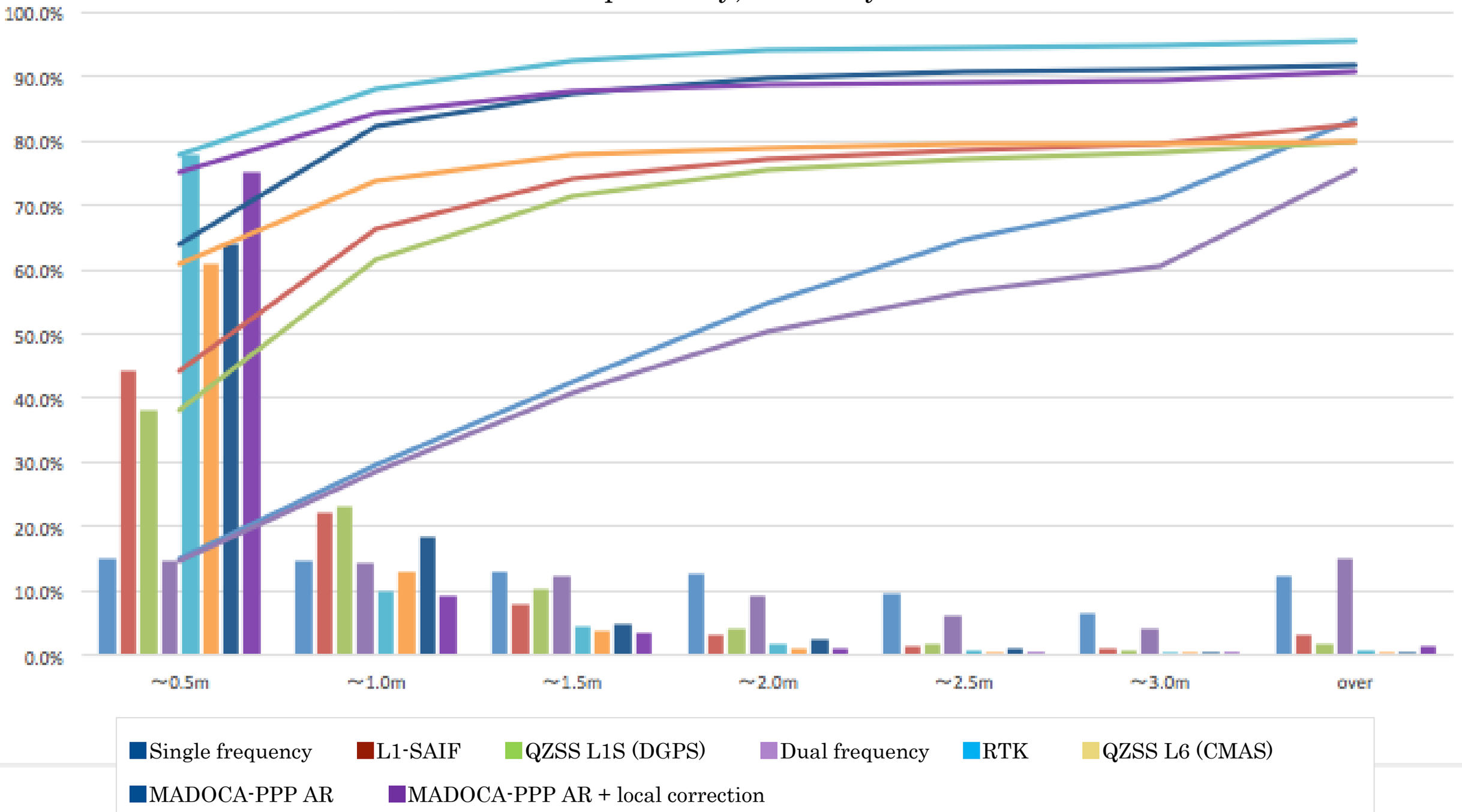


GNSS Explorer

Forecaster	Satellite Orbit Calculation Tool
NWatcher	NMEA Vizualize Tool
Mobcat	Evaluation Data Making Tool
GraphMaker	Evaluation Data Visualize Tool

Evaluation: positioning method

Lateral error of each positioning method
(Expressway, GPS only)

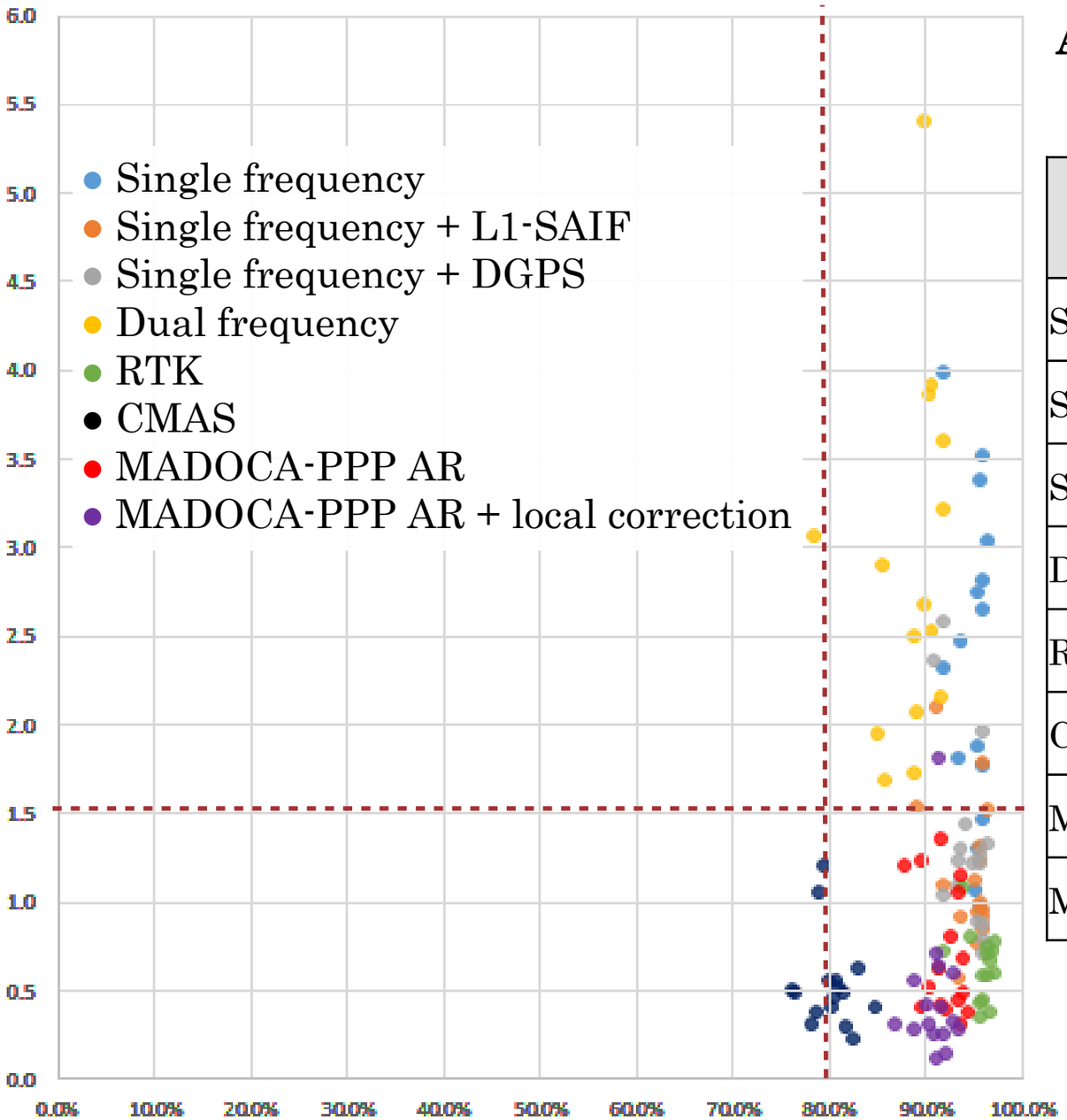


※CMAS results calculated only by a Fixed solution.

Evaluation: positioning method

Plot of each positioning method

RMS(Lateral error) / Positioning rate



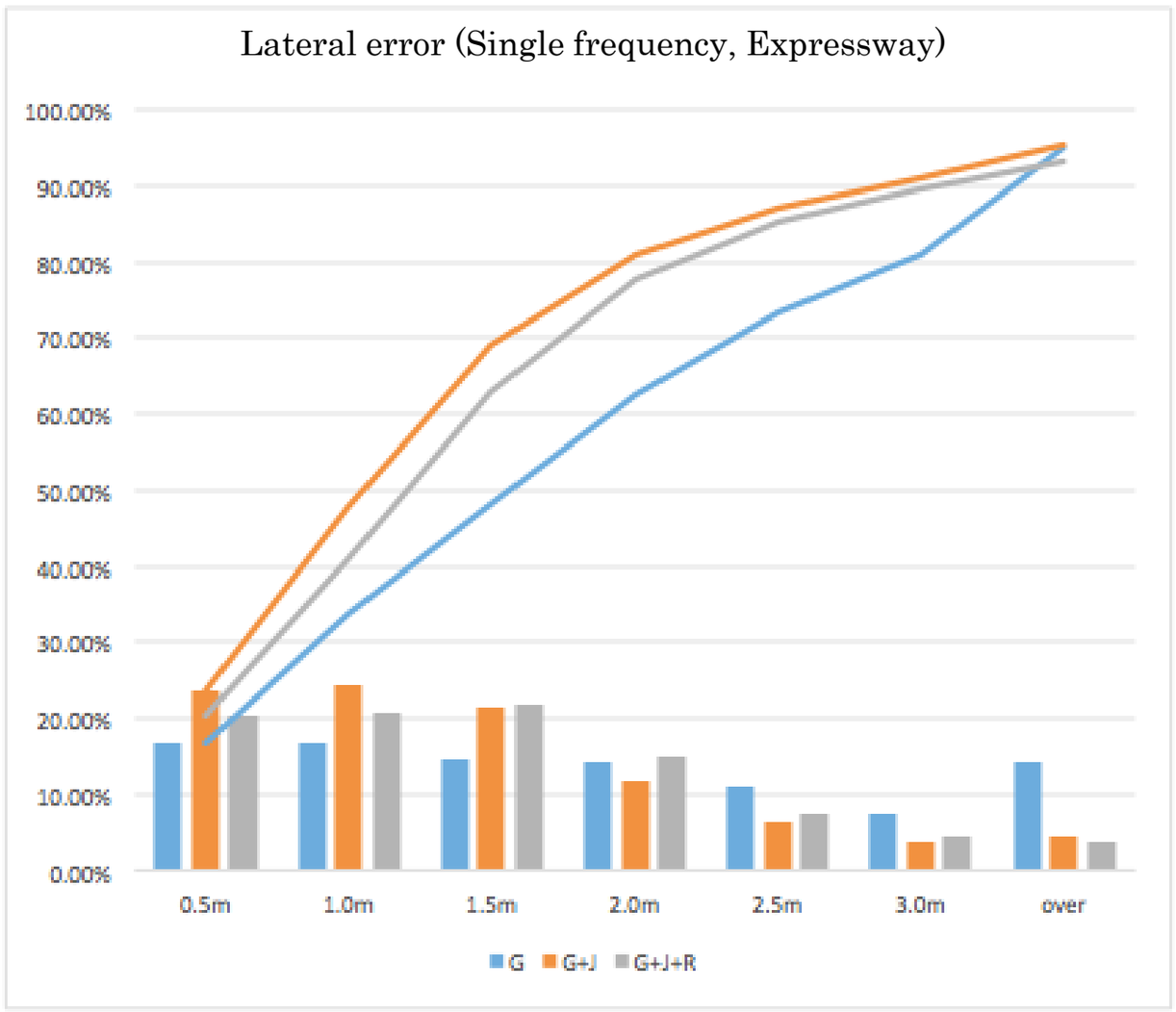
Average

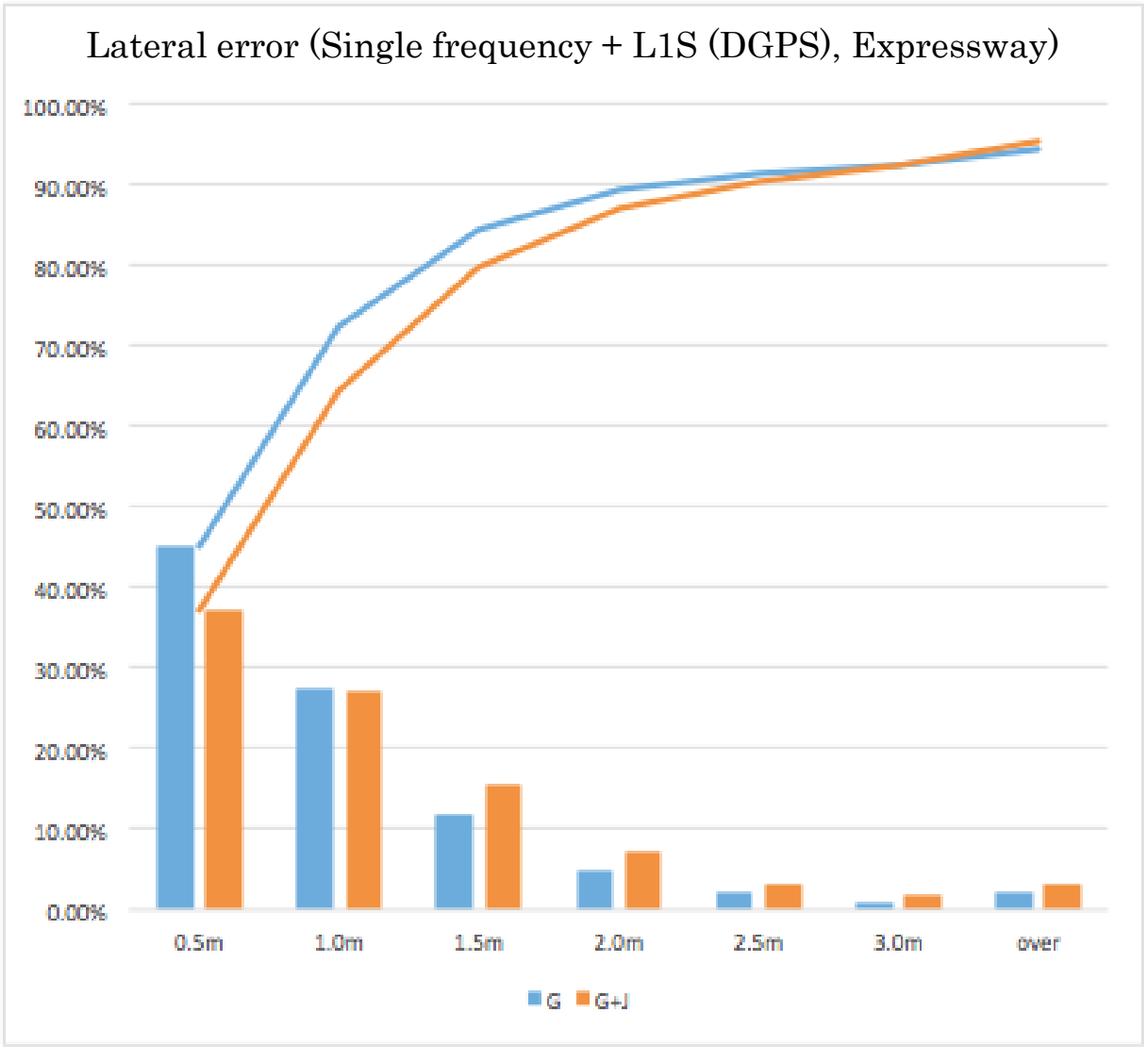
RMS (Lateral error) / Positioning rate

Positioning method	Positioning rate	RMS[m]
Single frequency	95.01%	2.3202
Single frequency+L1-SAIF	94.53%	1.1618
Single frequency+L1S(DGPS)	94.48%	1.3290
Dual frequency	88.01%	3.1317
RTK	95.56%	0.6379
CMAS	80.27%	0.5282
MADOCA-PPP AR	92.12%	0.7149
MADOCA-PPP AR + local correction	91.01%	0.4617

※ CMAS results calculated only by a Fixed solution.

Evaluation: Augmentation signal of QZSS





	Multi-GNSS	～0.5m	～1.0m	～1.5m	～2.0m	～2.5m	～3.0m	All
Single frequency	G	16.73%	33.62%	48.16%	62.49%	73.55%	80.96%	95.01%
	G+J	23.45%	47.69%	69.08%	80.93%	87.24%	91.04%	95.38%
	G+J+R	20.18%	41.03%	62.81%	77.73%	85.18%	89.55%	93.17%
Single frequency + L1S (DGPS)	G	45.15%	72.59%	84.49%	89.27%	91.34%	92.29%	94.48%
	G+J	37.19%	64.33%	79.89%	86.99%	90.30%	92.26%	95.27%

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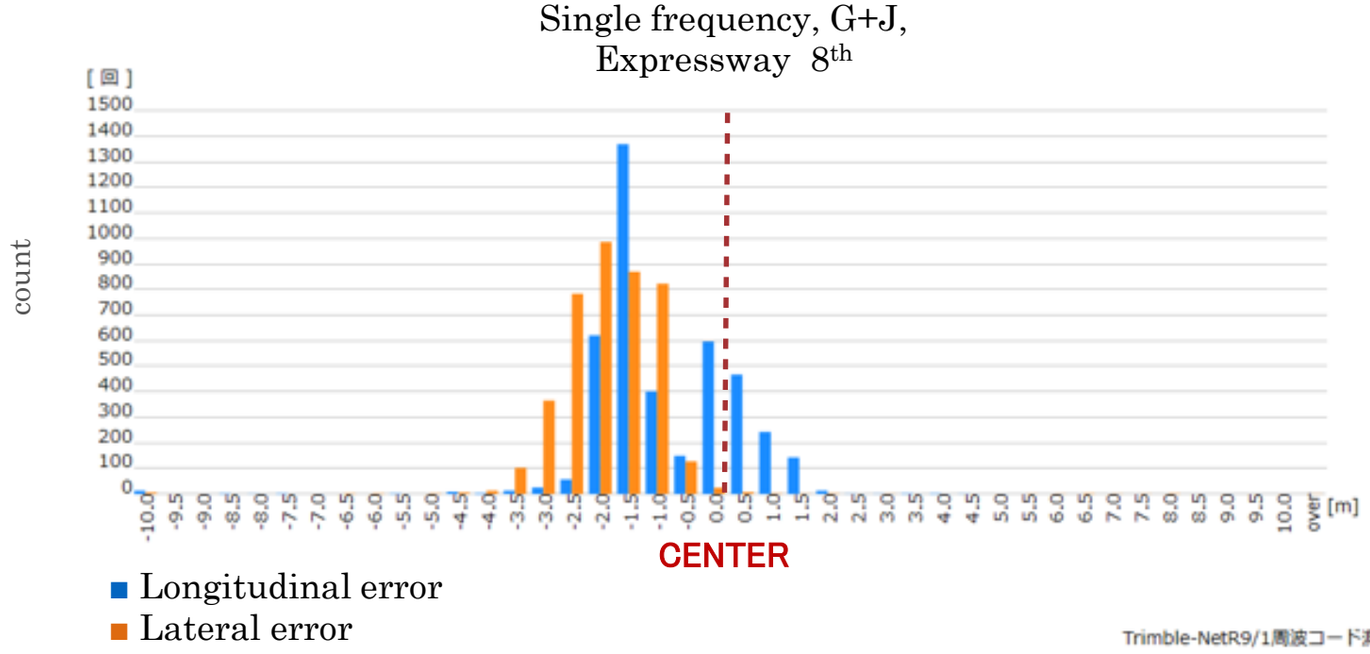
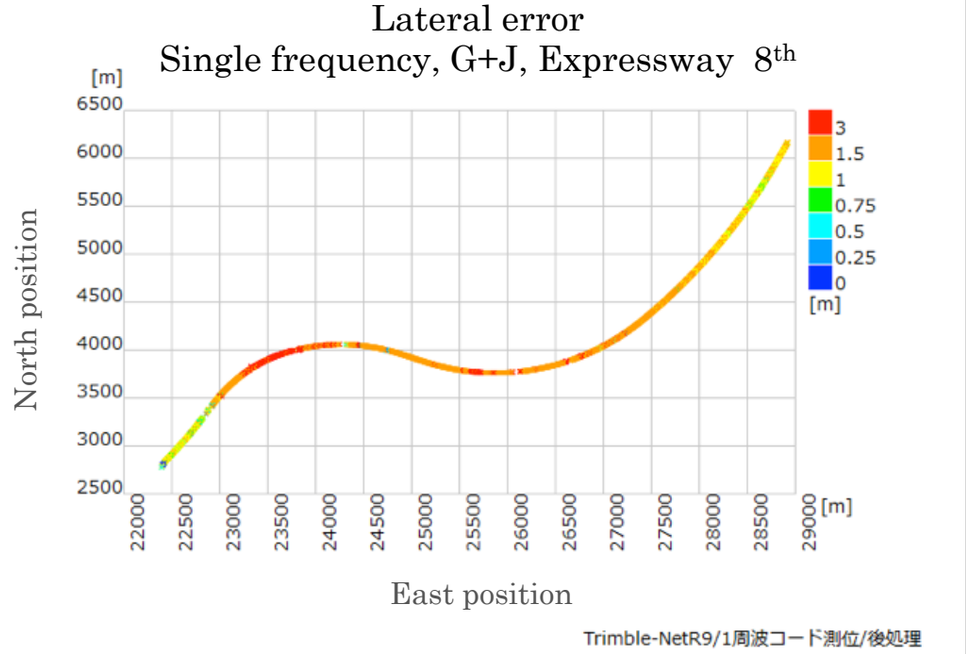
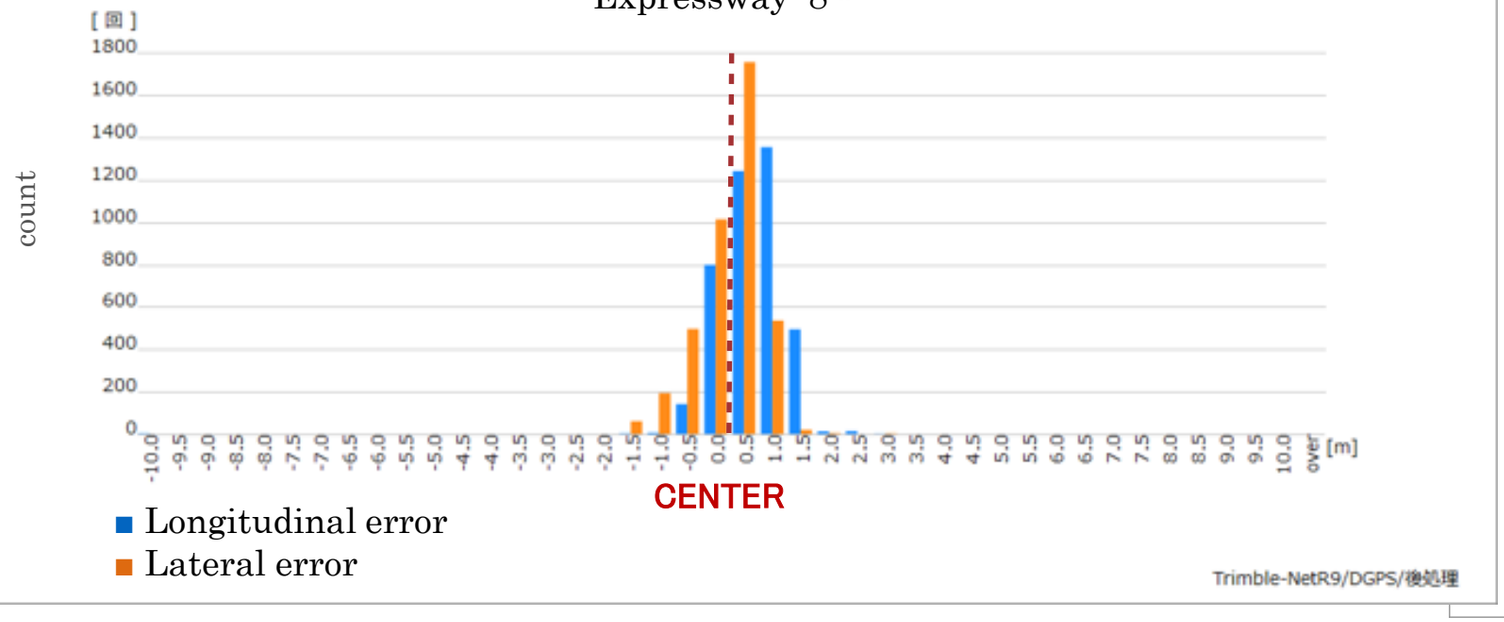
Evaluation: Augmentation signal of QZSS

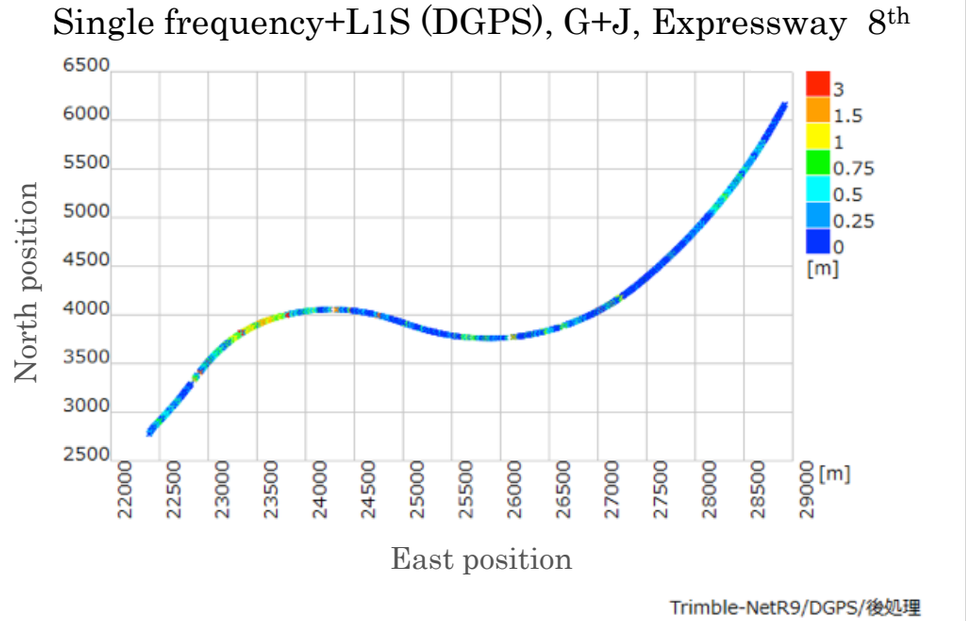
Single frequency





Single frequency+L1S (DGPS)



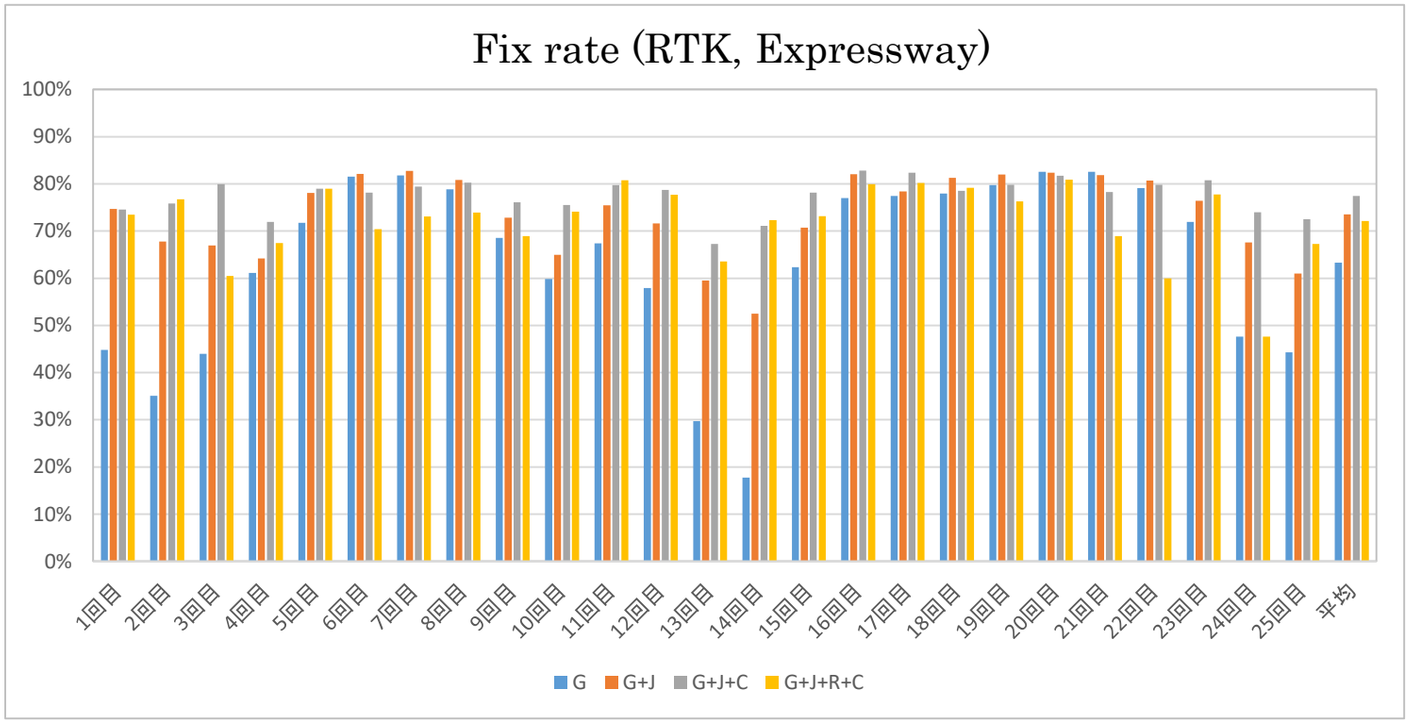


Evaluation: multi-GNSS

RTK / Expressway

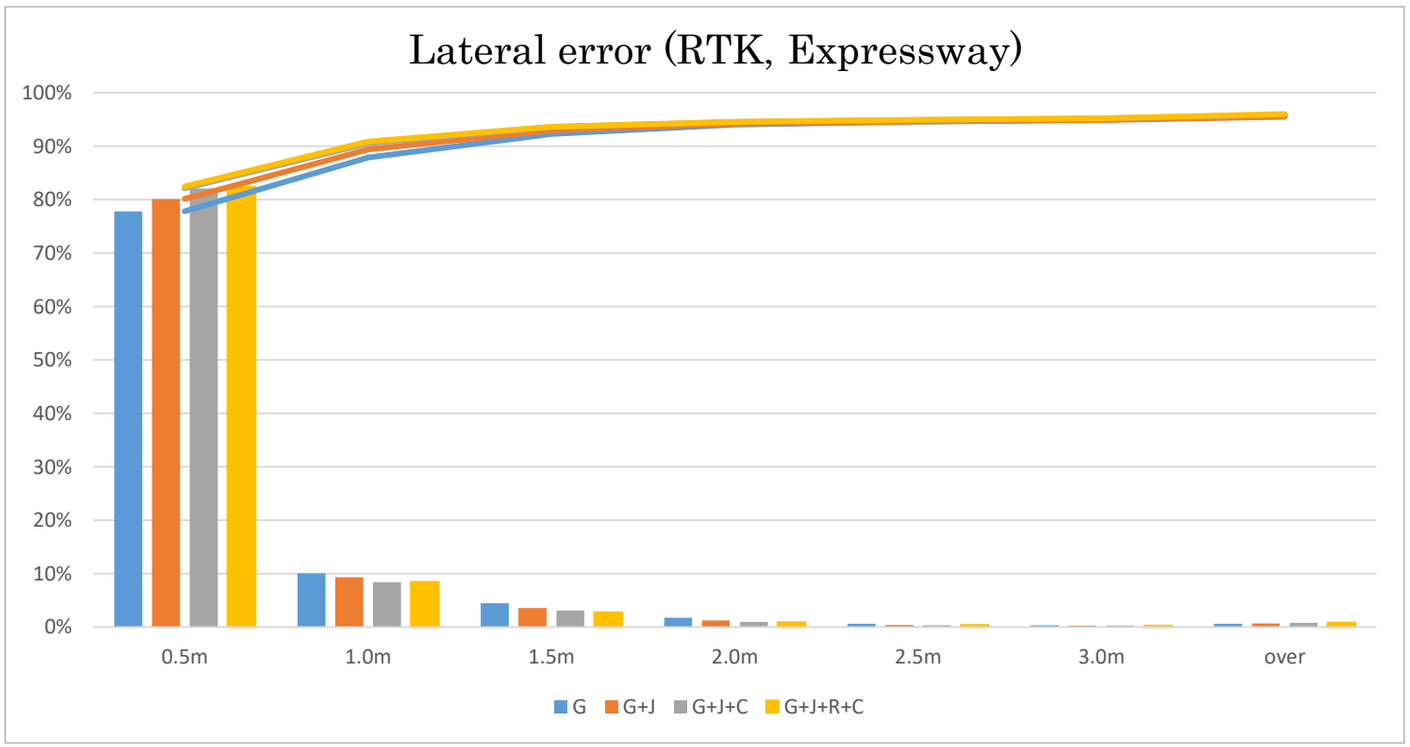
■ Positioning rate

	G	G+J	G+J+C	G+J+R+C
Positioning rate	95.56%	95.38%	95.84%	95.97%
Fix rate	63.30%	73.54%	77.45%	72.12%



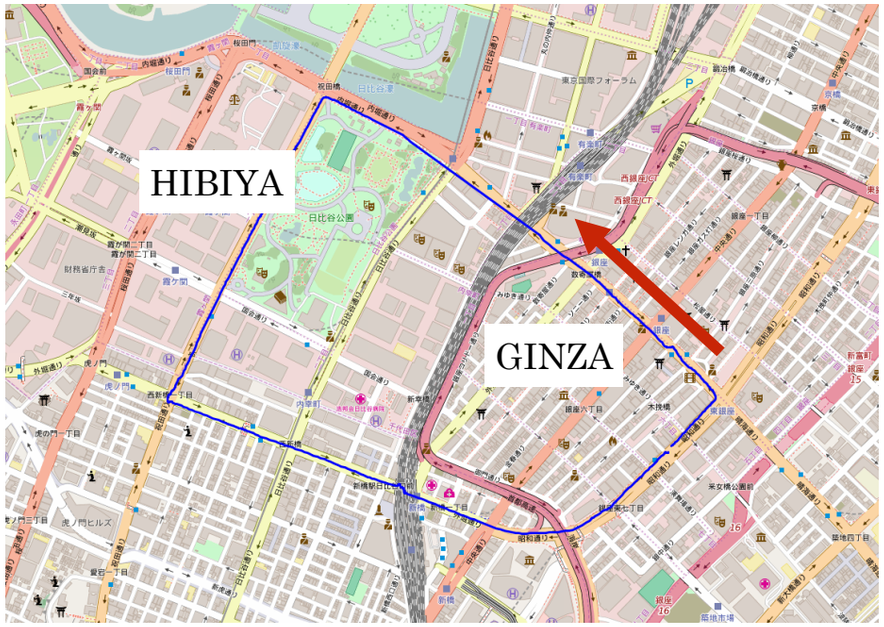
■ Lateral error

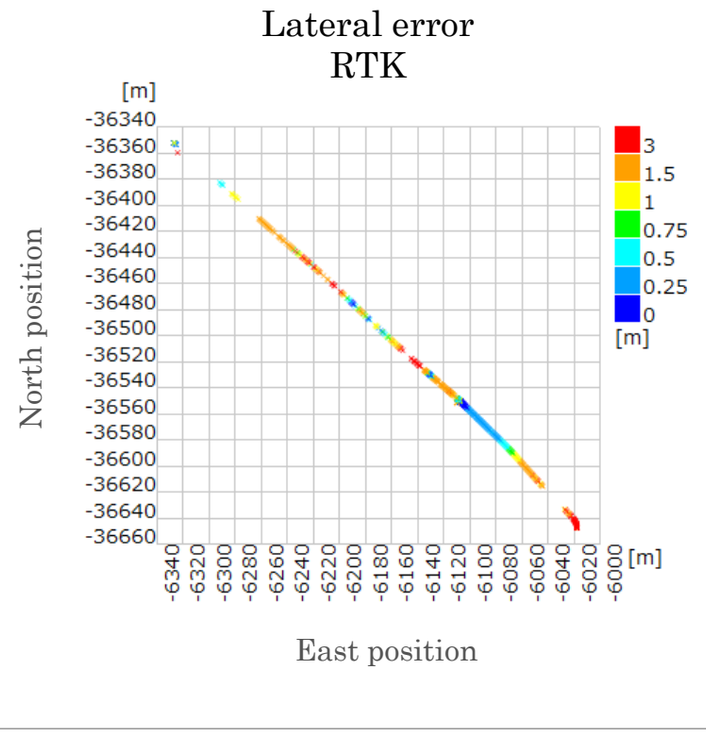
	G	G+J	G+J+C	G+J+R+C
～0.5m	77.83%	80.14%	82.12%	82.46%
～1.0m	87.88%	89.42%	90.55%	90.92%
～1.5m	92.32%	92.98%	93.64%	93.67%

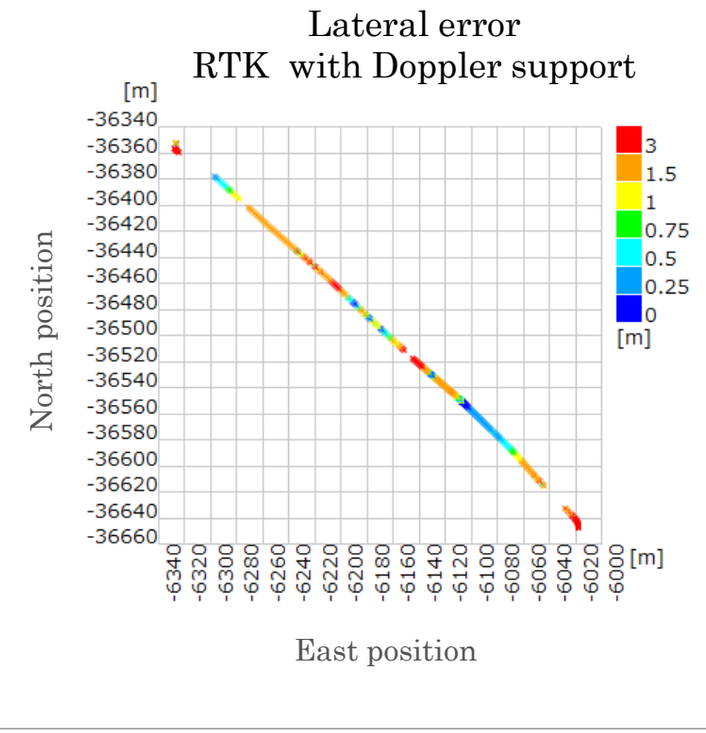


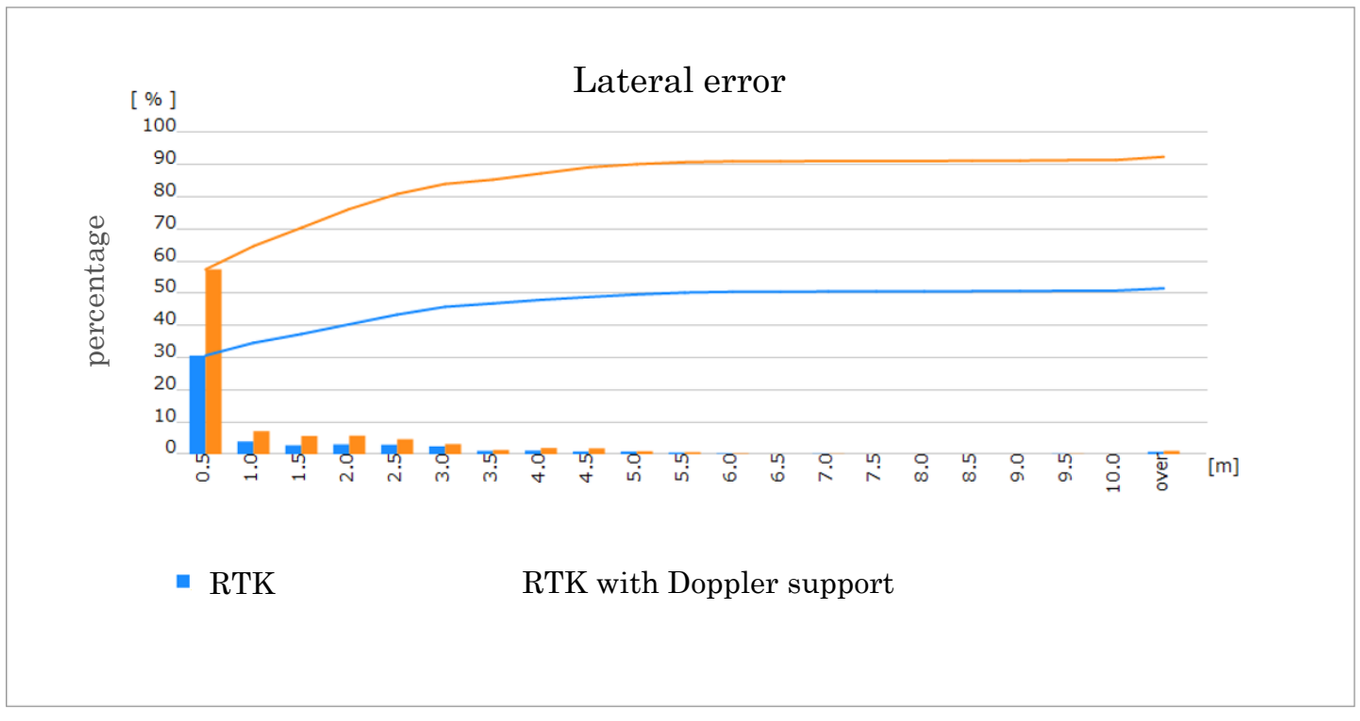
Consideration: multi-path

Urban area









■ Positioning rate

	RTK	RTK with Doppler support
Positioning rate	53.69%	93.16%

■ Lateral error

	～0.5m	0.5～1m	1～1.5m
RTK	33.56%	3.74%	2.81%
RTK with Doppler support	62.65%	6.59%	4.58%

Summary

Rusult and Problem

Availability of satellite positioning on expressway

- By using the augmentation signal of QZSS, positioning accuracy is improved and traffic lane recognition is enabled with code phase measurements.
- To achieve accuracy within 1 m, it is necessary to use carrier phase positioning system.

Multi-path in urban area

- Although it has a certain effect to improve positioning rate and accuracy to use information received from GNSS satellites, it's not enough to use autonomous driving with just that.。
- It is possible to make visible satellite mask by using 3D map and radio wave propagation simulator, however, there are problems to put it into practice.

Others

- It is important to consider about countermeasure for ionospheric disturbance because it has a significant influence on positioning accuracy in low latitude areas.

Future

Availability of satellite positioning on expressway

- It is effective to use the geospatial information because we can estimate locations where positioning rate and accuracy decline.
- We need to consider the method using ground waves for distribution of augmentation signal.

Multi-path in urban area

- It is necessary to collaborate with other information (sensor, map).

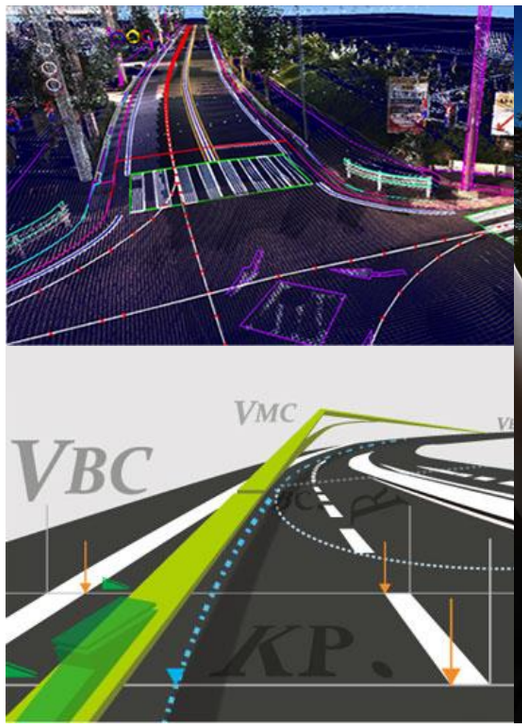
Others

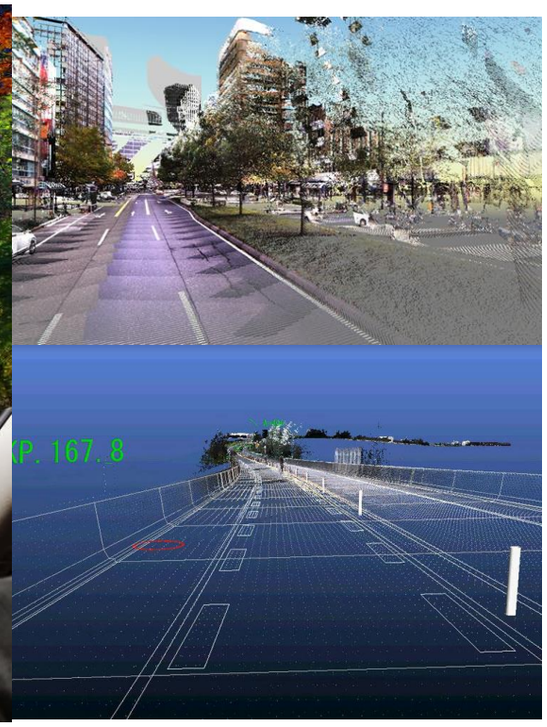
- Because it is expected that dual frequency measurement is effective for ionospheric disturbance, to improve the algorithm is needed.
- The continuous investigation associated with the upgrade of satellite positioning system is necessary.

Thank you for your attention

If you would like to know more detail, please access

http://www.meti.go.jp/meti_lib/report/2016fy/000463.pdf





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