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Expectations for Quasi-Zenith Satellite System in Mobile Mapping System

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INDEX

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MMS Overview

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Laser Scanners & CCD Cameras on precise GNSS platform innovate 3D mapping.

Laser Scanning

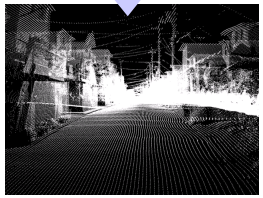
Overlay Image

Position & Attitude

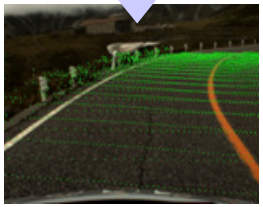
Automatic Recognition

Blue Item:
Optional Extras
Green Item:
Under Development

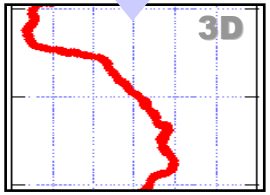
System's Output



Laser Point-Cloud

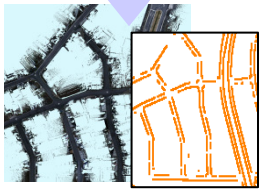


Overlay Image



Accurate Trajectory

White Line Recognition



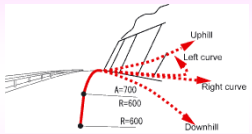
Curb Recognition

Road Sign Detection

User's Application

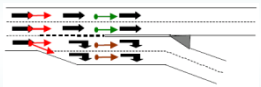
3D Modeling

ADAS Base Map



Panorama View

Multi-lane Mapping



Automatic Recognition

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MMS Overview

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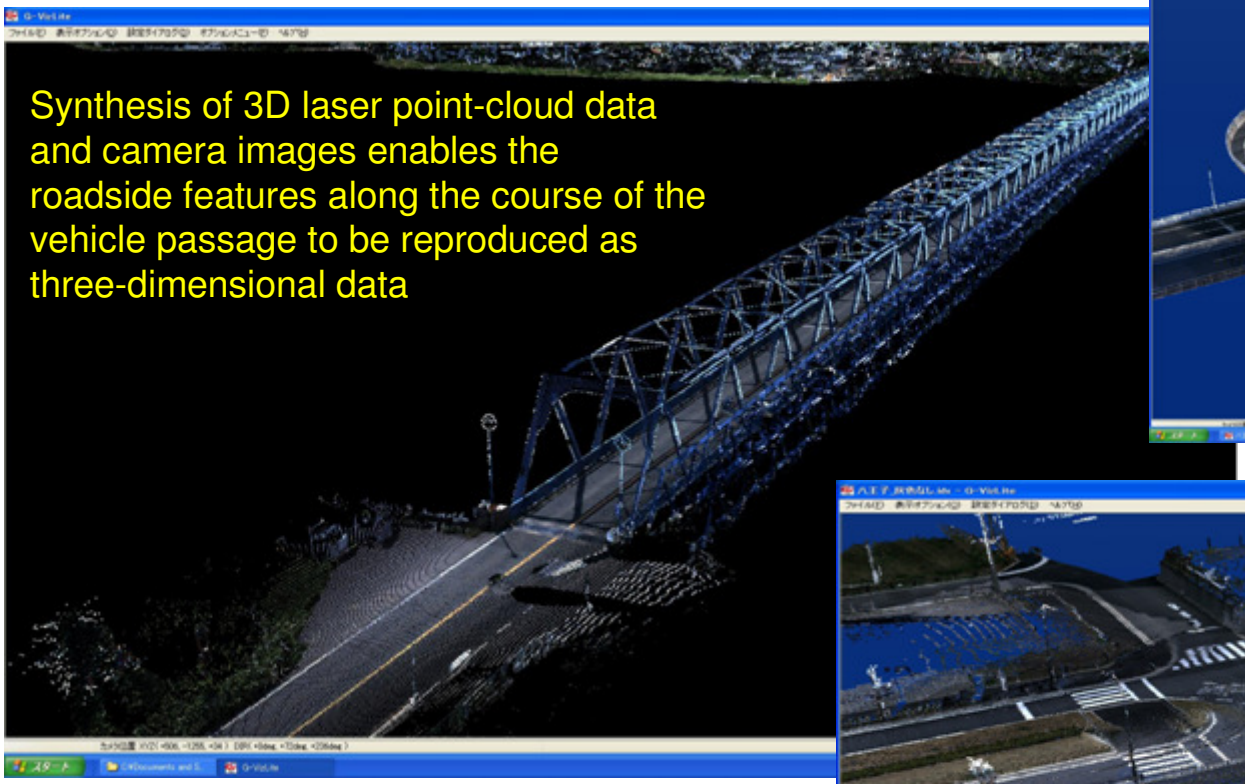

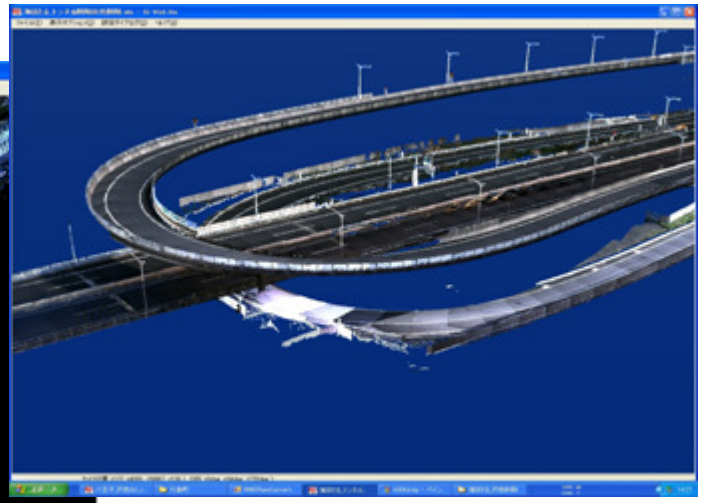

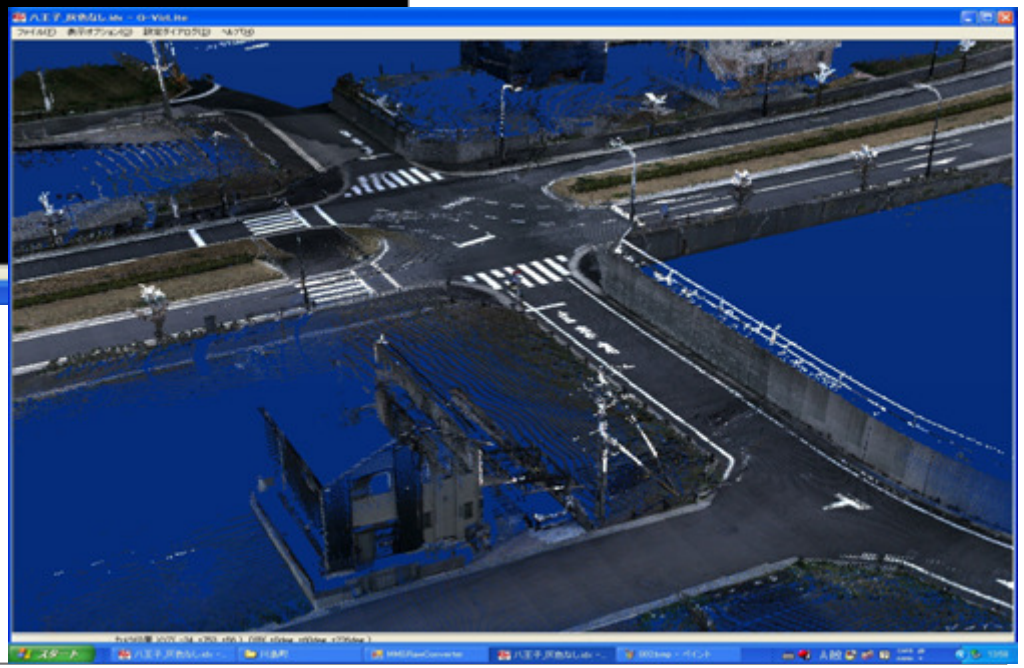

There are many examples of large scale 3D measurement, for example the entire length of the Tokyo Aqualine, or all the roads of a whole town.

Applications～Post-Processing

Vehicle position/orientation estimated by a GPS(FKP * correction)-equipped inertial measurement unit (IMU) and laser data and camera images obtained from mounted sensors provide accurate 3D topographic survey data of road objects simply by driving the vehicle.

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MMS Features

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- ***1. High Accuracy***
  - **Accuracy verified by the field test with various conditions**
    Absolute accuracy : ≤ 0.10 m (rms)
  - **Real time Monitoring and Management for the accuracy**
- ***2. Easy Operation and short processing time***
  - **On board measuring software**
  - **Automated Post-processing software**
    Full color 3D point cloud : 1 day for 8hr measurement
- ***3. Variety of Applications***
  - **AutoCAD collaboration**
  - **Road／Tunnel surface aspect for maintenance**
  - **Hazard maps**
  - **Road management**
  - **Seamless processing for multi Reference points**
  - **Landmark update**

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Outward appearance of Vehicle

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Verification of availability improvement in urban canyon utilizing QZSS

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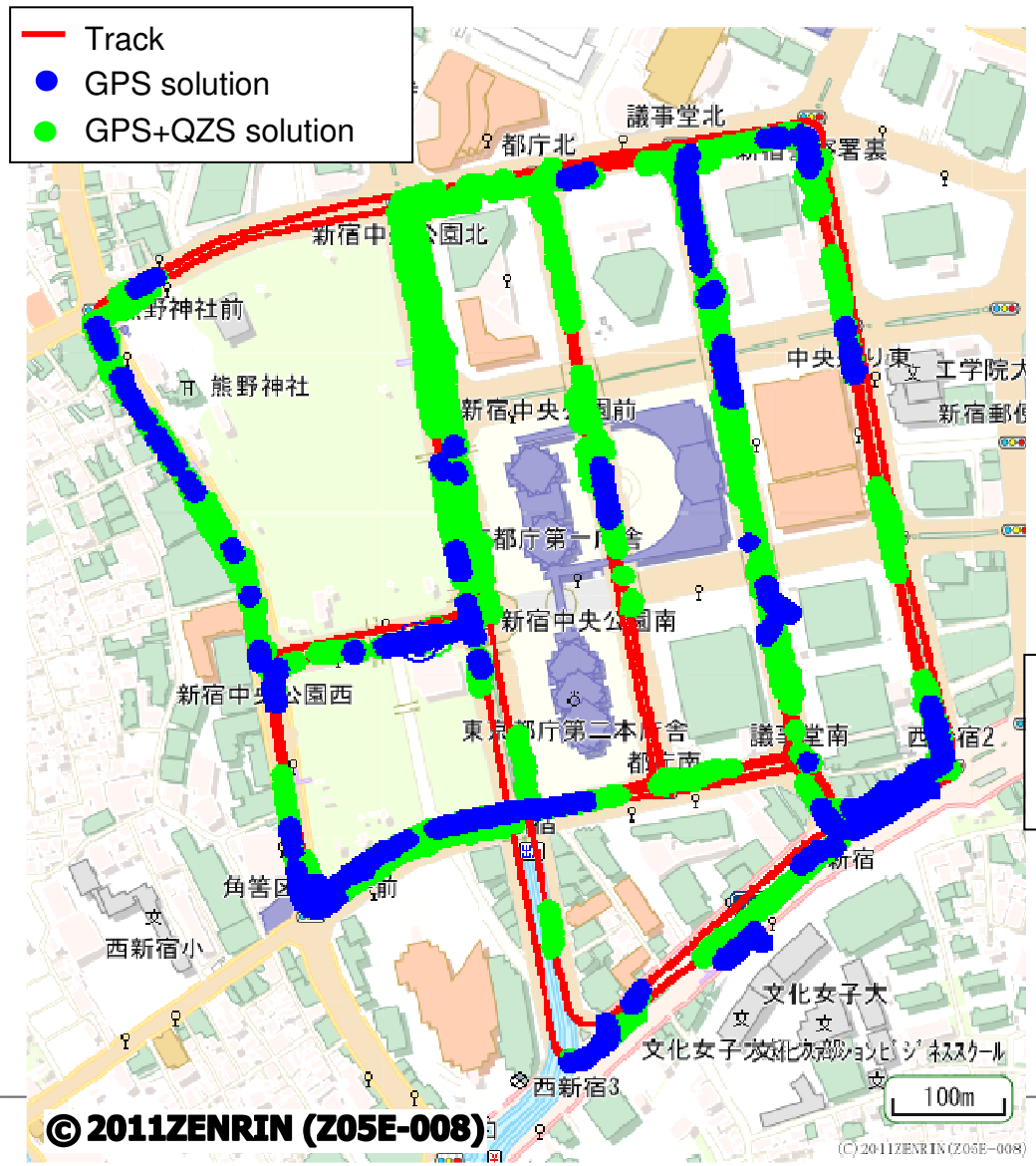
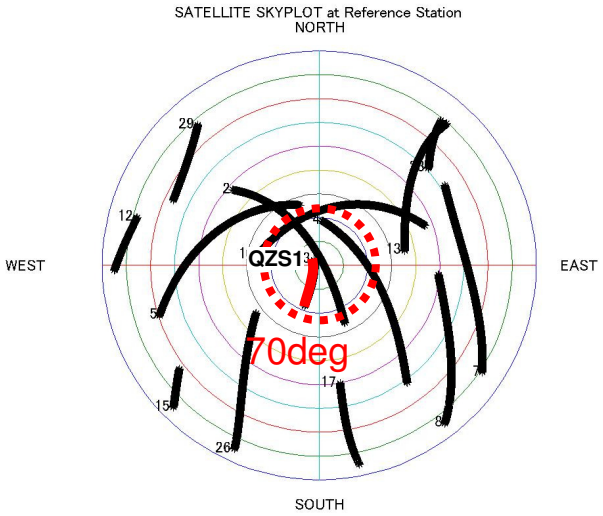
Measurement: **"Shin-juku",** January 21, 2011
12:30～15:10 Japan Time (160 minutes)





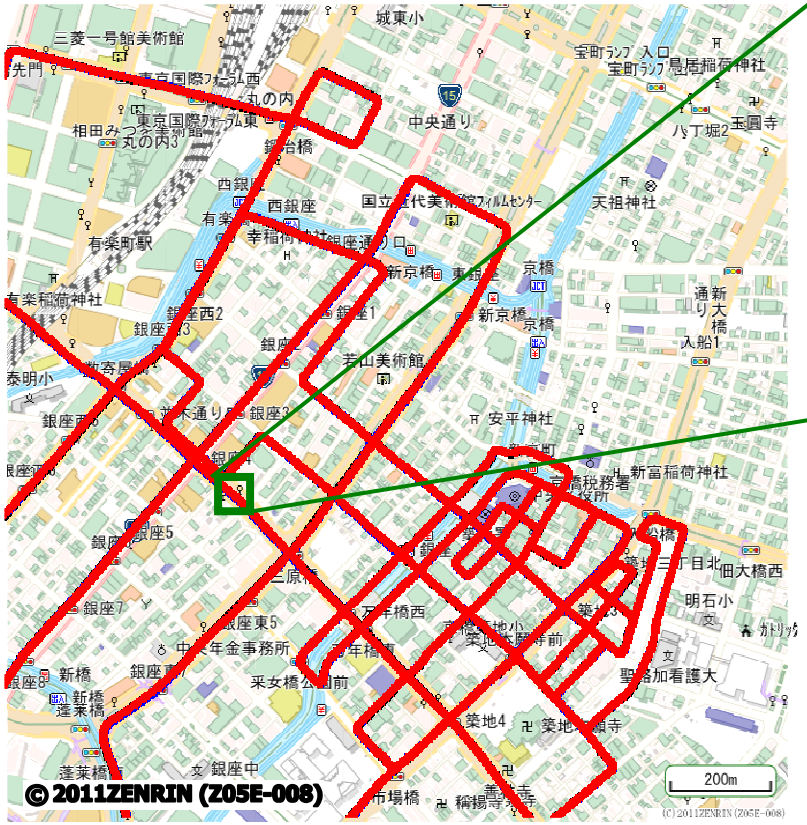
Availability	
GPS only:	28.5%
GPS+QZS:	70.0%

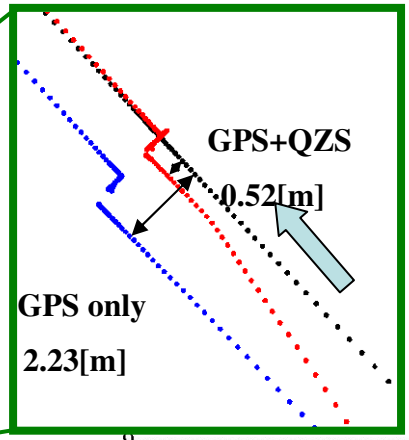
2.5 times

※ Code positioning with DGPS augmentation
※ GPS positioning rate is calculated based on voting process along with the vehicle track.
※ The repetition of the partial stop, etc. has been removed.
※ This is a result of collaborative research work by JAXA and Mitsubishi Electric Corporation.

Verification of accuracy improvement in urban canyon utilizing QZSS

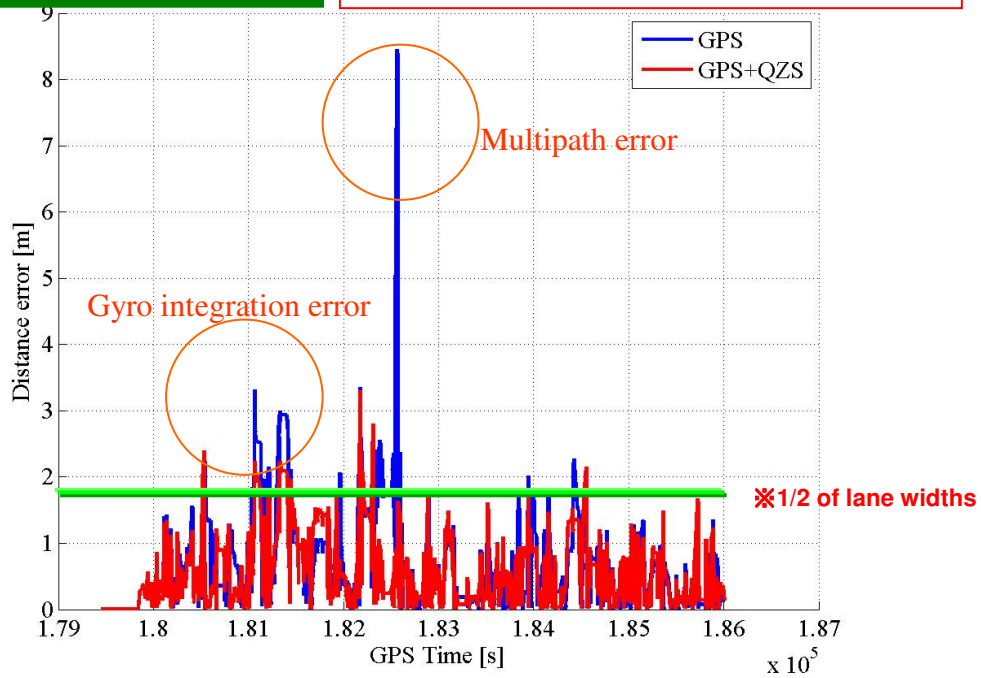
GPS/QZSS/Low-cost INS Integration Navigation





- Availability improvement contributes to reduce Gyro integration error.
- Multipath-free QZS contributes to eliminate low quality satellites .

Accuracy	RMS	MAX error
GPS only	0.76[m]	8.45[m]
GPS＋QZS	0.51[m]	3.30[m]



Measurement: **“Ginza”, Feburary 19**, 2011
11:15～12:30 Japan Time (75 minutes)

※ This is a result of collaborative research work by JAXA and Mitsubishi Electric Corporation.

Verification of dynamic accuracy of CMAS *1 (Centimeter-class Augmentation System) utilizing QZSS

CMAS verification result in Expressway

Latitude error

Average	-0.61 [cm]
Standard deviation	1.95 [cm]

Longitude error

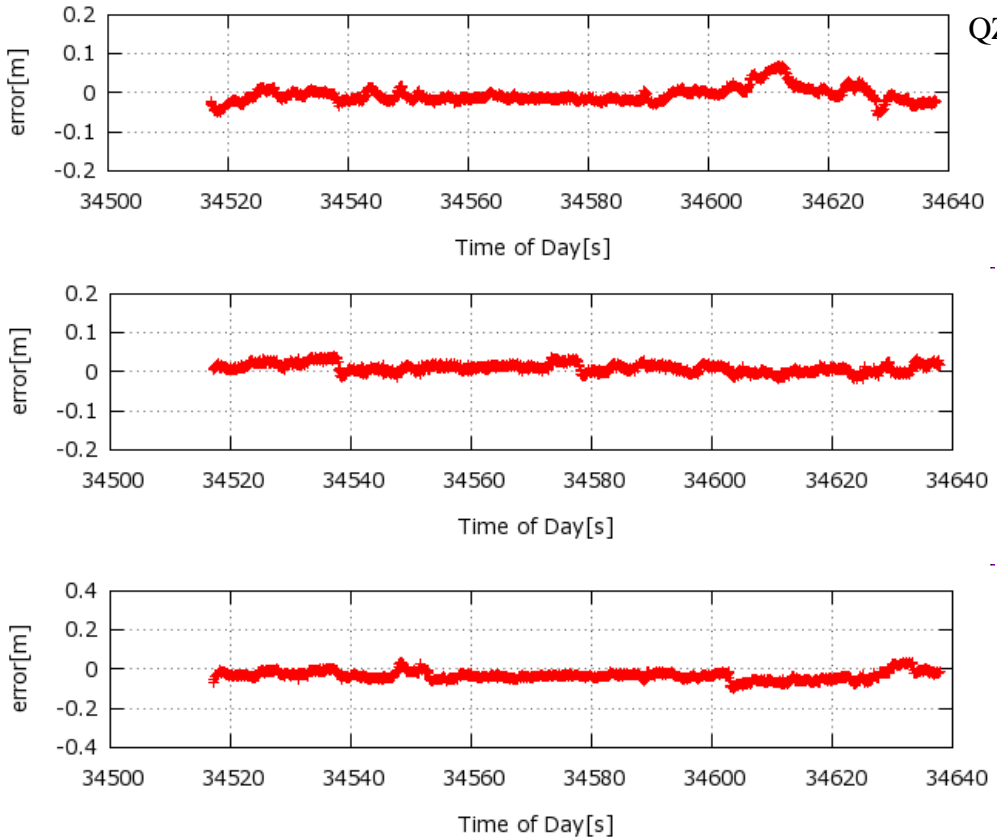
Average	0.97 [cm]
Standard deviation	1.12 [cm]

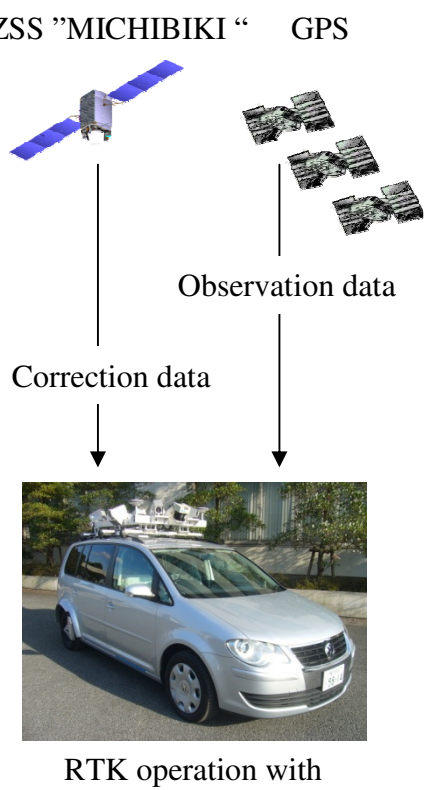
Horizontal error

Standard deviation	**2.25 [cm]**
DRMS *2	**2.53 [cm]**

Height error

Average	-3.34 [cm]
Standard deviation	2.15 [cm]
Root mean square	**3.98 [cm]**





RTK operation with corrected observations

- **Continuous correction data contributes to maintain centimeter-class accuracy on expressway.**

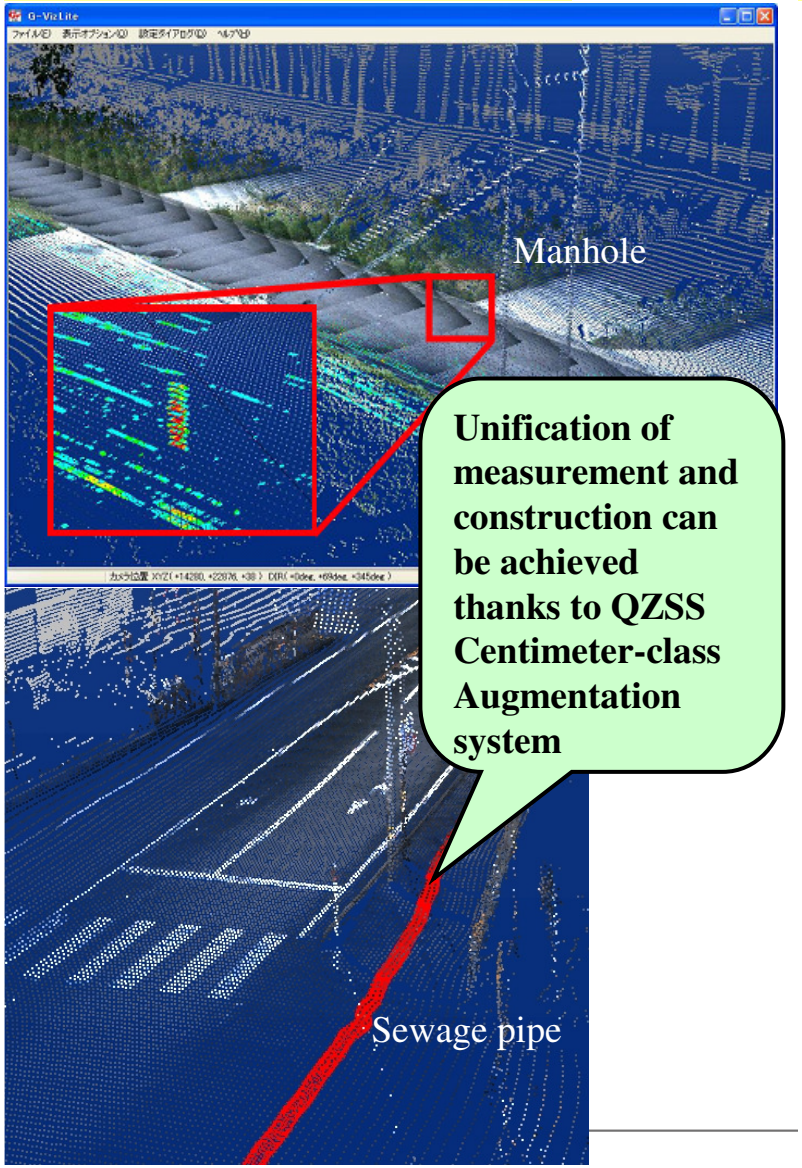
*1 CMAS was developed by SPAC and funded by Ministry of Education, Culture, Sports, Science and Technology (MEXT). CMAS estimates the individual GNSS error component and provides SSR (State Space Representation) that is a functional and stochastic description of the state. SSR is compressed less than 2kbps (1695bps) to transmit to the user through LEX signal of QZSS.

*2 Distance Root Mean Square of true differences (MMS's RTK operation with FKP corrected observations – referenced)

※ This is a result of collaborative research work by Niigata University and SPAC (Satellite Positioning Research and Application Center) under the technical support of Mitsubishi Electric Corporation.

Potential MMS application utilizing QZSS

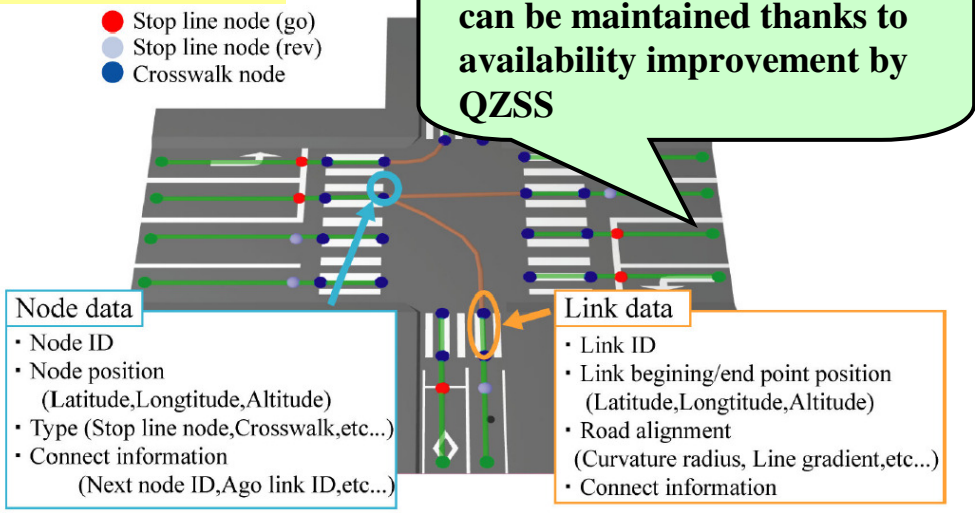
Real-time geospatial analysis



Unification of measurement and construction can be achieved thanks to QZSS Centimeter-class Augmentation system

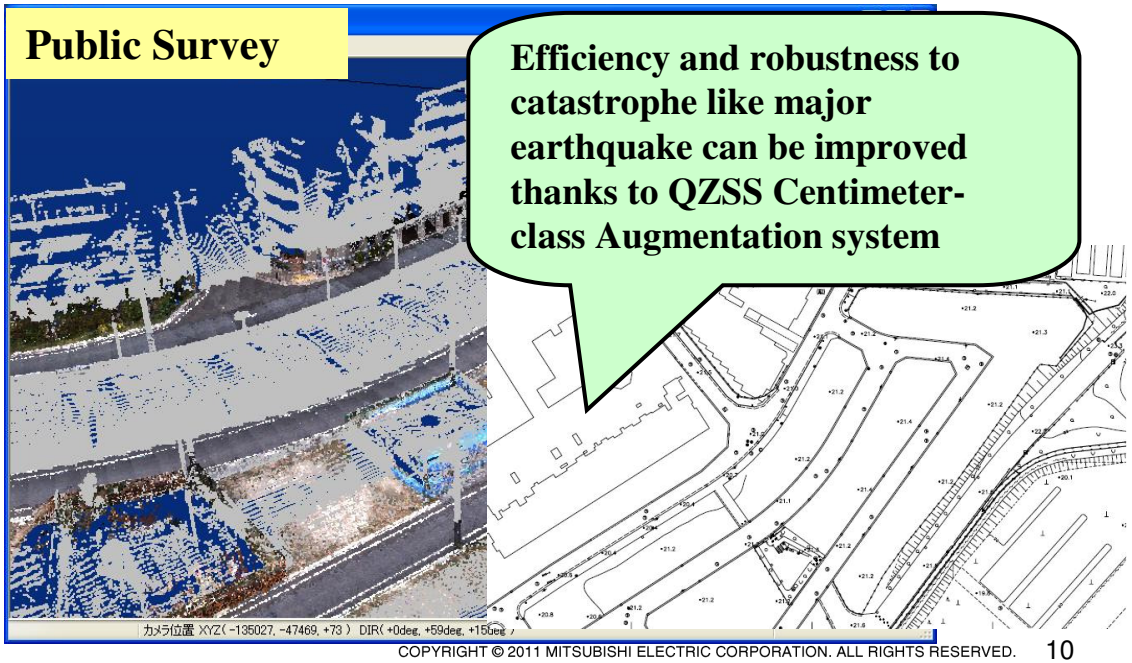
References：" Image Lab 2011.1 Vol22", p.79

3D digital lane map



Precise 3D intersection map can be maintained thanks to availability improvement by QZSS

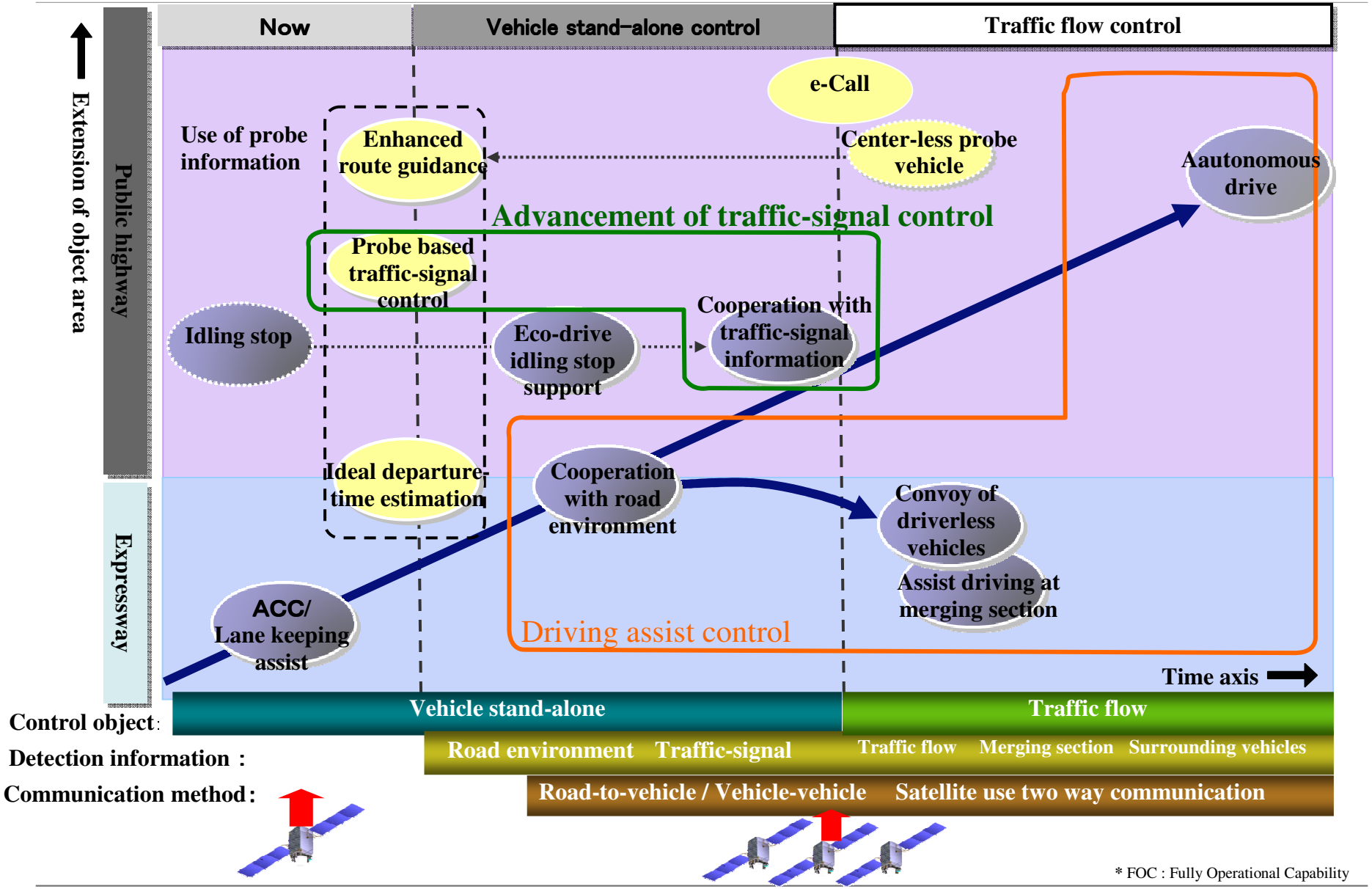
Public Survey



Efficiency and robustness to catastrophe like major earthquake can be improved thanks to QZSS Centimeter-class Augmentation system

References：" Image Lab 2011.1 Vol22", p78-79

ITS applications for "Safety, Trustability & Green Mobility" utilizing QZSS



QZSS: "Michibiki" first launch

QZSS FOC *

* FOC : Fully Operational Capability

Conclusion

1.Verification of GNSS navigation performance in urban canyon utilizing QZSS:

- Multipath-free QZS contributes to eliminate low quality satellites
- Availability improvement contributes to reduce INS integration error

→MMS performance & application area expansion

→GPS/QZSS/Low-cost INS Integration contributes to ITS driving assist application like "Lane keeping" or various LBS applications.

2.Verification of CMAS (Centimeter-class Augmentation System) utilizing QZSS:

- Continuous correction data contributes to maintain centimeter-class accuracy on expressway

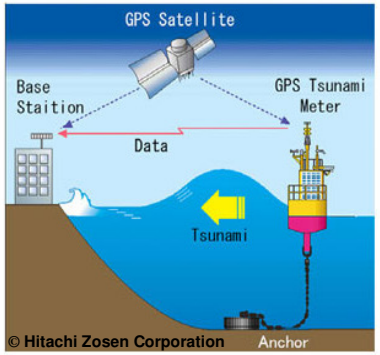
→Real-time MMS's geospatial analysis and ITS's driving assist control can be achieved.

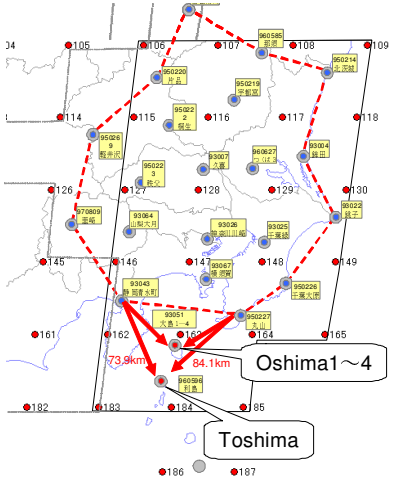
→Robustness to catastrophe like major earthquake can be improved by low ground communication infrastructure dependency.

Appendix : “GPS ocean wave meter “ utilizing QZSS

- **Tsunami** is observable with cm-class accuracy on the sea within 50km from the nearest ERP *1.
- With QZSS supplementation and INS integration, continuous 100% positioning can be realized.
- CMAS’s cm-class positioning contributes to **Ocean Civil Engineering**, **Maritime Security Operation** and **Maritime Charting**.

ERP		Distance from nearest ERP		Distance from CMAS network border	Positioning Results		
		Shimizu (93043)	Maruyama (950227)		Horizontal	Upward	Fix rate
93051	Oshima1	56.9km	59.4km	31km	2.02cm	2.33cm	100%
960594	Oshima3	62.2km	56.4km	33km	2.14cm	3.29cm	96%
960595	Oshima4	58.8km	63.6km	36km	1.93cm	3.73cm	89%
93055	Oshima2	67.9km	61.2km	41km	2.27cm	5.96cm	83%
960596	Toshima	73.9km	84.1km	53km	1.64cm	2.22cm	90%





*1 Electrical Reference Point

※ CMAS was developed by SPAC and funded by MEXT.

※This is a result of collaborative research work by SPAC and Mitsubishi Electric Corporation.