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Introduction of Positioning Augmentation Center for High Precision Application in Brunei Darussalam

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   - Satellite based centimeter class augmentation system
   - Application Demonstration
2. How does Geospatial Information work in Brunei?
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   - What is “Positioning Augmentation Center”?
   - Data Generation and Distribution
4. Typical design of Augmentation Data Center
5. Conclusion

1. Introduction

- High precision augmentation system is very much promising technology in coming Multi-GNSS era when more than 100 navigation satellites would be available.
- Application of Centimeter class high precision positioning service is expected to grow rapidly in Asia-Pacific region and contributes economic growth in the region.
- The needs in Brunei have been surveyed and analyzed. Authorization of “Mapping” by the government would be an essential to assure its consistency with “Positioning”. Authorized CORS*is a key to assure consistency within the map and “Positioning”.

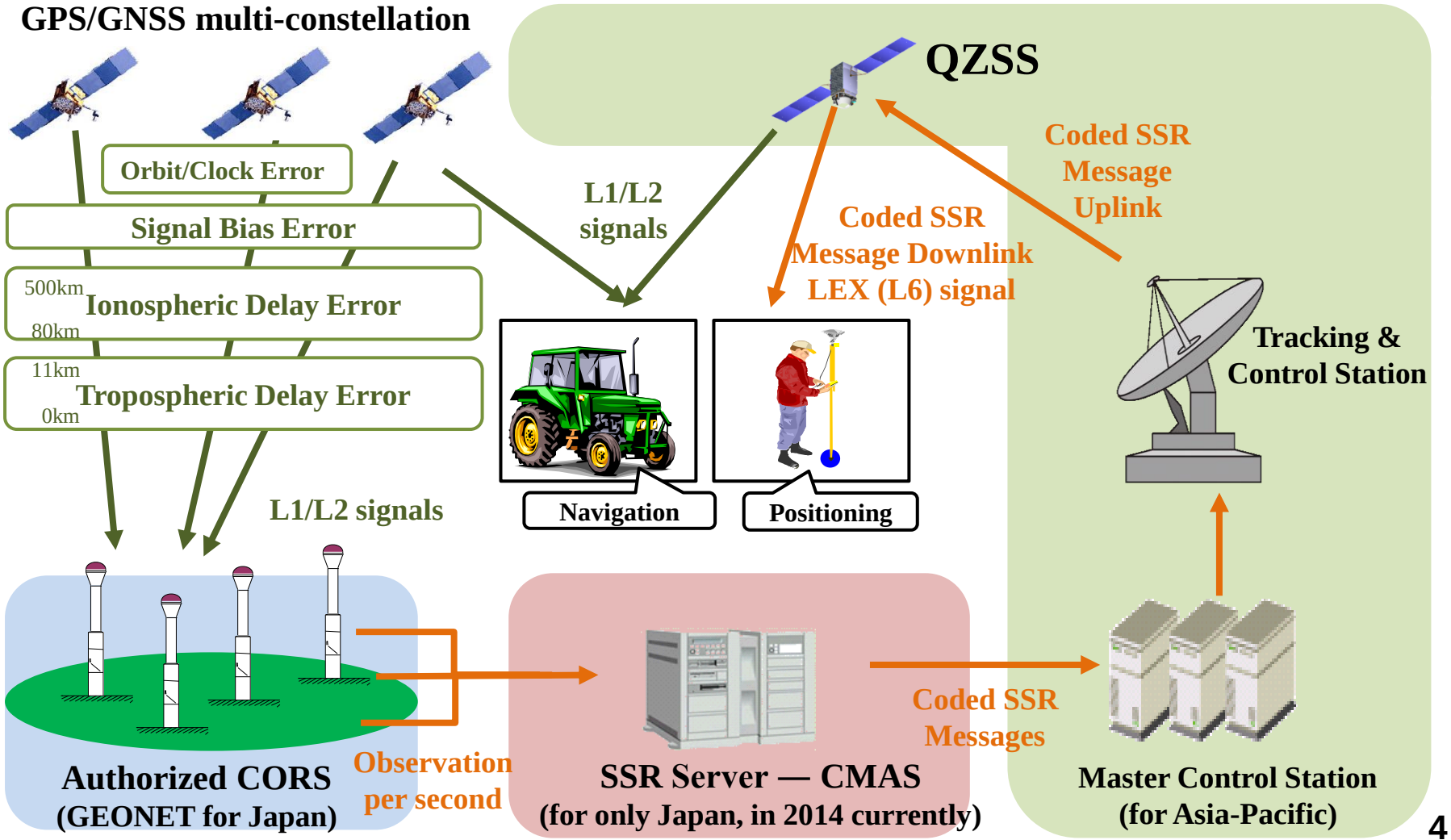
  * Continuously Operating Reference Station

- Conceptual Design of “Positioning Augmentation Center” using CORS data has been made considering variety of applications.

1. Introduction-CMAS*

Satellite based centimeter class augmentation system (CMAS)

CMAS using GPS/GNSS multi-constellation, Authorized CORS is distributed through QZSS LEX signal.

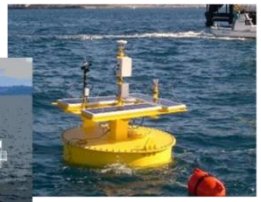


※ This figure shows a case of Application Demonstration since 2011

1. Introduction-Utilization Demonstrations

Sea route experiment
航路実験

Positioning GPS Buoy
GPSブイへの適用検討



Driving experiment in case of an earthquake disaster
震災時の走行軌跡実験

Air route experiment
空路実験

Action support Application Urgent information reception→Refuge place display

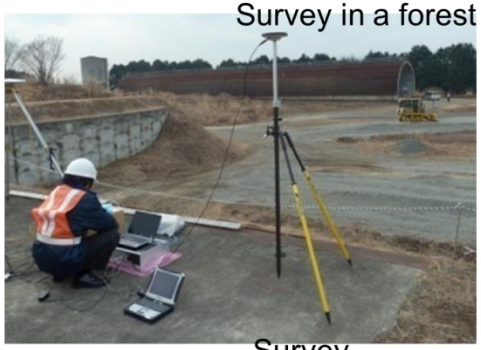
Combine Automatic Run
コンバイン自動稲刈り

Overnight Operation 夜間耕耘作業

Bulldozer Blade Control System
ブレード自動制御

Automated System Operation 無人運転

Survey in a forest



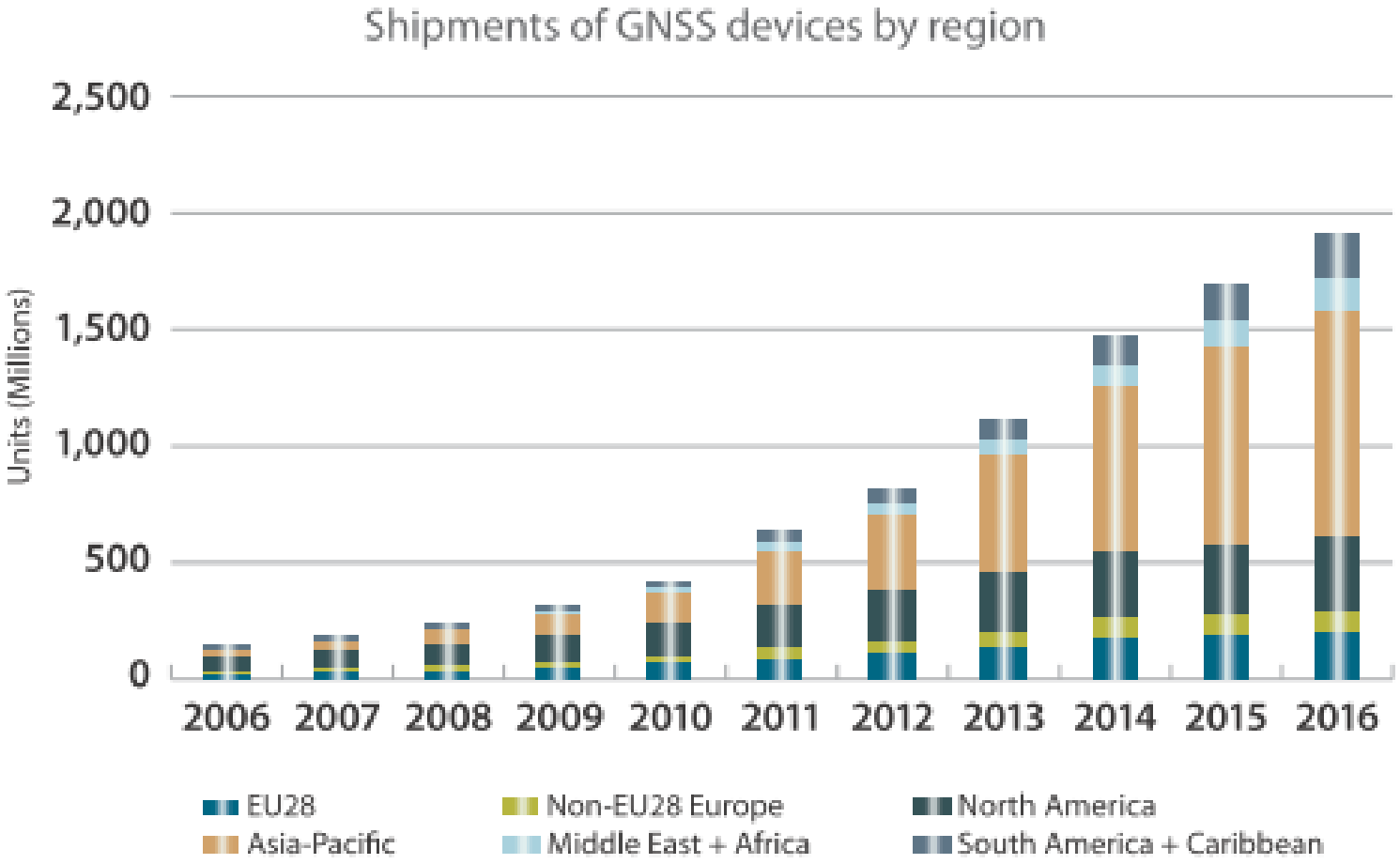
Survey

Navigation for Stamp Rally
スタンプラリーナビ

Location Guidance System for visually-impaired person
視覚障碍者へのガイダンスナビ

Senso-ji Navi experiment
浅草寺ナビ実験風景

1. Introduction-Growing Potential Market of High precision positioning service



Asia-Pacific accounted for over 50% of global LBS shipments in 2016

GNSS Market Report Issue 5, May 2017

2. How does Geospatial Information work in Brunei?

- **Why Geospatial Information is so important?**

-Geospatial Information is social infrastructure to support daily life of the people

  - **Land Development of the nation and local areas**
  - **Development and Maintenance of Infrastructure**
  - **Water Environment, Biological System**
  - **Urban Problems**
  - **Disaster Mitigation, ….**

- **How Geospatial Information to be established, maintained, efficiently?**
  - **standardization**
  - **Integration on the same basis**
  - **Information Sharing**

"Positioning "and "Mapping" should be based on the same accuracy and get together for installation and control!

2. How does Geospatial Information work in Brunei?

- **How does Geospatial Information work in Brunei?**

- Market Survey is done to make a strategic approach for establish "Geospatial Information " infrastructure in Brunei

☐ Potential Users

- **Government Agencies:31**
- **Private Industries:7**

☐ Possible Applications

☐ Analysis

- **Positioning Accuracy**
- **Map Accuracy**
- **Measurement Technology**

SEEDS Soartech Systems Sdn Bhd
Soartech Engineering Enhancement Development & Services

Potential Brunei End-Users for Brunei Permanent GNSS Network:

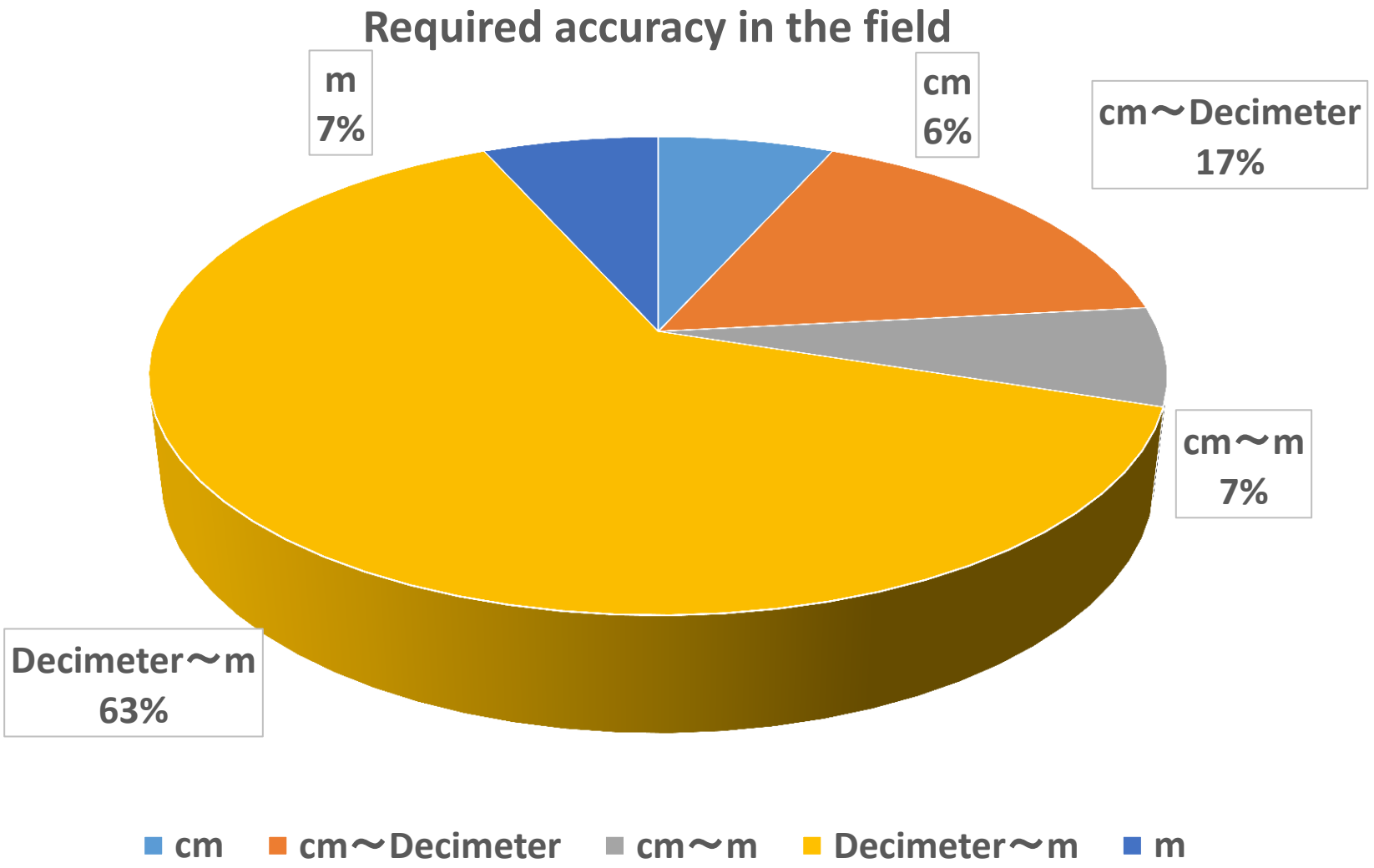
No.	Name of Organisation	Remarks
Government Ministries		
Ministry of Development		
Ministry of Development is Brunei's lead agency in providing the nation with infrastructures, public housing, buildings, facilities and services; and in regulating construction industry, the environment, physical master planning, land and real estates. MOD provides services by receiving public request, inquiries, complaints & feedback from end-users thru Talian Darussalam 123 which covered:- • Public Work Department (PWD) - Water Services, Road Services, Drainage & Sewerage Services, Technical Services, Building Services, Mechanical & Electrical Services, Administration & Finance Services and Development Services • Housing & Development (HDD) • Town & Country Planning (TCP) • Survey • Land • Environment, Park & Recreation (JASTRE) • Authority for Building Control & Construction Industry (ABCI)		
Department from **Ministry of Development**		
1	Land Department	Registration, administration and management of land to secure socio-economic of the country. Land Register, Land Ownerships and Dealings, Land Valuation, Licenses, transportation of soils, sand and gravels. url: http://www.tanah.gov.bn/Theme/Home.aspx
2	Survey Department	Providing comprehensive and accurate geomatic information and services. Such as House Numbering, Kiblat Direction, DSO Digital, Field Survey, Sky watch, topographical survey and map of Brunei. Cadastral, Geodetic, GIS Mapping, International Boundary and even Land Development Real Data Coordinates for geological studies.
4	Environment Park and Recreation (JASTRE)	Planning for Solid Waste and Hazardous Waste Management, Transboundary Haze url: http://www.env.gov.bn/Theme/Home.aspx
5	Authority for Building Control and Construction Industry (ABCI)	Reference of government agencies that control the development of land and buildings. The safety of newly constructed or renovated buildings
6	Public Water Department	Managing and Planning of Water resource such as Dams, Drainage and Pipelines.
7	Public Works Department	To develop a comprehensive infrastructure, buildings and services for nation building towards quality living PWD plays an important role to realize the national aspirations as set out in Wawasan Brunei 2035 through our Vision to provide the Built Environment of Distinction. We possess the technical capacity to build the infrastructure & render project management services for sustainable socio-economic development. Planning of Roads, Drainage, Sewerage, Mechanical and Electrical Components such as preparation of national events http://www.mod.gov.bn/pwd/Theme/Home.aspx
Ministry of Primary Resources and Tourism		
The Ministry of Industry and Primary Resources (MIPR) was formed in 1989 and is responsible for promoting and facilitating industrial development. The MIPR is also helping to develop areas of growth as wide ranging as manufacturing, tourism, agriculture, fisheries and forestry		

Samples

2. How does Geospatial Information work in Brunei?

	Potential Users	Accuracy		Measurement Technologies										
		Positioning	Map	RTK	DGNSS	TS	MMS	LiDAR	Photo	Sensing	UAV	TSL	IMU	NMB
1	Land Department	cm	Special map	○		○								
2	Survey Department	cm～m	Level500 ～200000	○	○	○	○	○	○	○				
3	Housing and Development Department ,Town and Country Planning	cm	Level500 ～2500	○		○			Samples					
4	Environment Park and Recreation (JASTRE)	m	Level250 0 ～5000		○									
5	Authority for Building Control and Construction Industry	cm～ Decimeter	Special map	○		○								
6	Public Water Department	cm～ Decimeter	Level500 ～2500	○		○	○	○	○					
7	Public Works Department	cm～ Decimeter	Level500 ～2500	○		○	○	○	○					

2. How does Geospatial Information work in Brunei?



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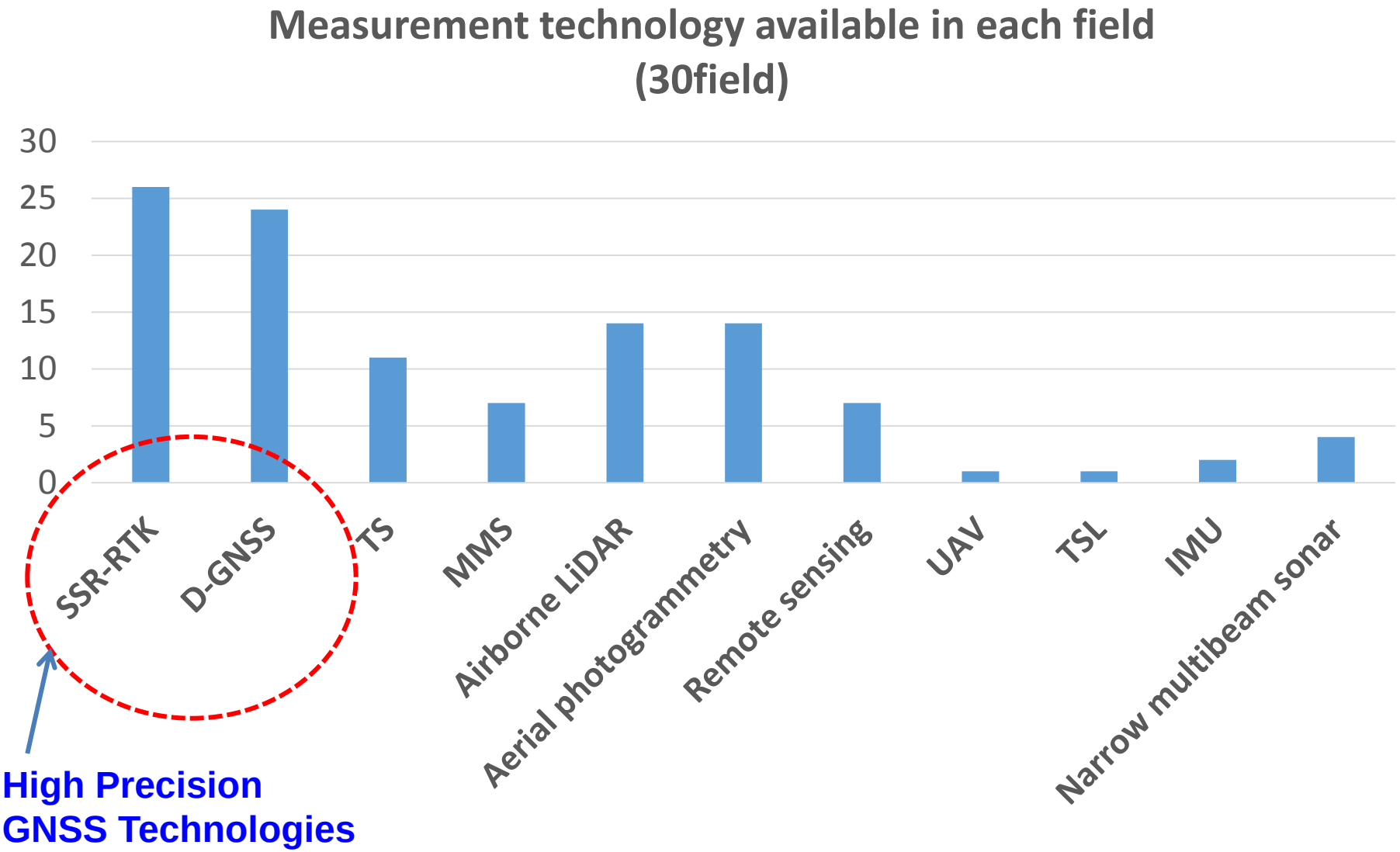

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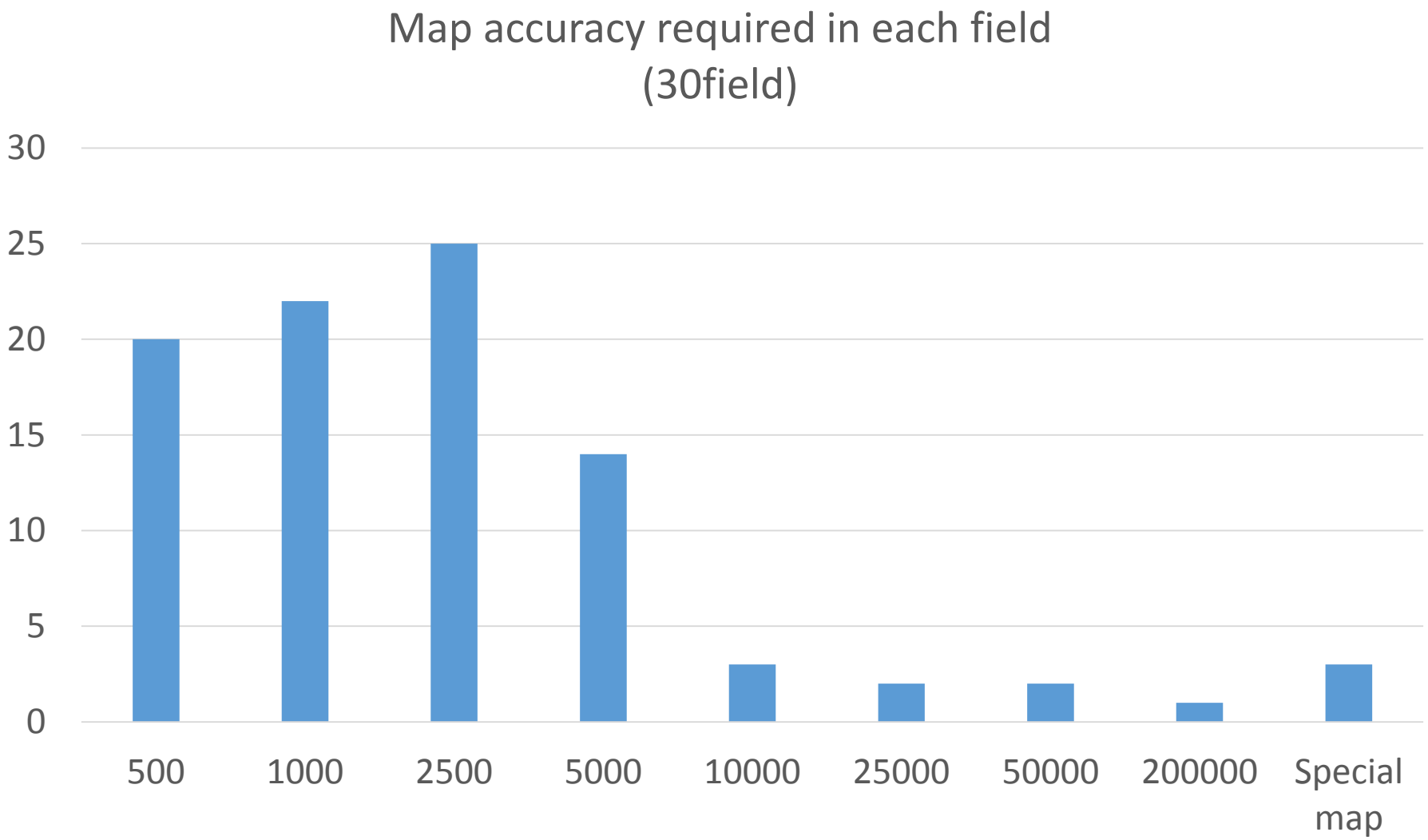
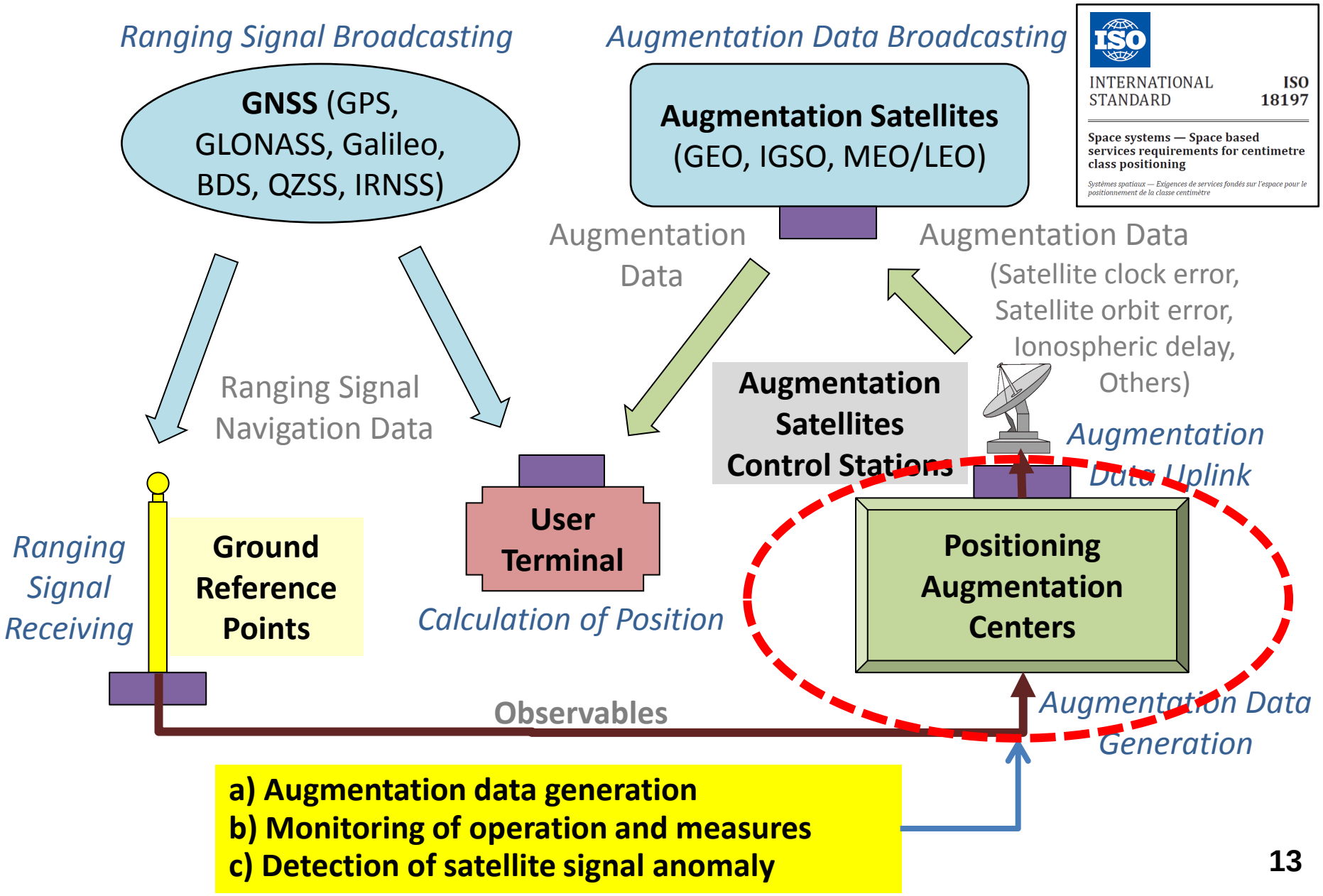
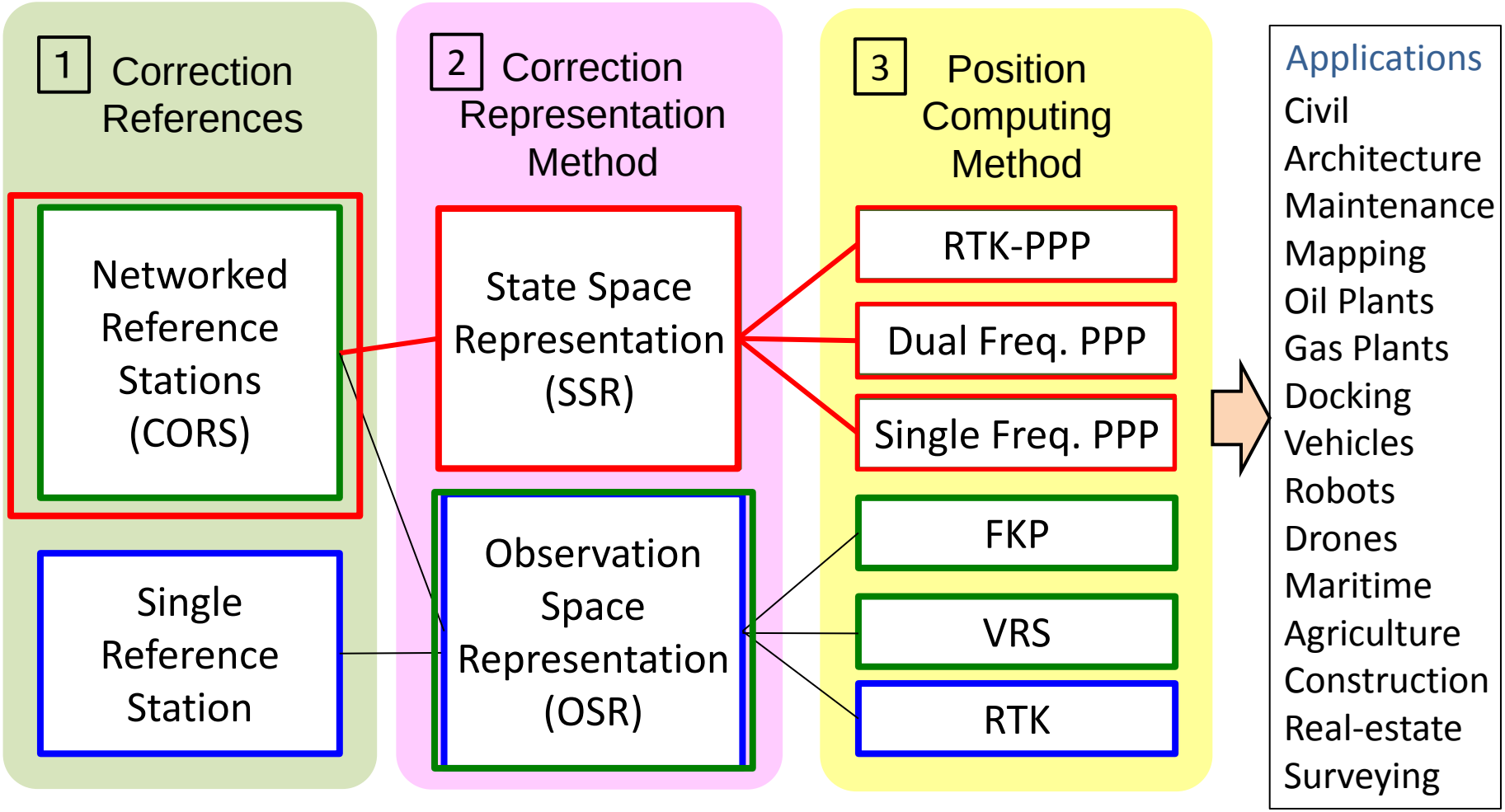


3.Introduction of “Positioning Augmentation Center”



3.Introduction of “Positioning Augmentation Center”

The latest satellite positioning methods had better be classified in following 3 steps.



3.Introduction of “Positioning Augmentation Center”

Comparison of Centimeter-class Augmentation Generation Methods

Augmentation Generation Method			Positioning Accuracy (rms)	Data Transmission	Nation-wide Broadcast volume	TTFF	Real-time	Adaptability for moving vehicles
Network RTK	Absolute Positioning	SSR	3cm	One Way	1695 bps	within 1min	Yes	Adaptable
		FKP	3cm	One Way	1.5Mbps	within 30s	Yes	Adaptable
	Relative Positioning	VRS	3cm	Two Way	—	within 30s	Yes	Adaptable only near virtual reference stations
RTK (Relative Positioning)			3 cm	Two Way	—	within 30s	Yes	Adaptable only near reference stations

[Note] FKP: Flaechen Korrektur Parameter (in the German language), VRS: Virtual Reference Station

SSR has advantage in applying to Nation-wide broadcasting cost effectively by;

1. **One way data transmission**
2. **Small data transmission rate**

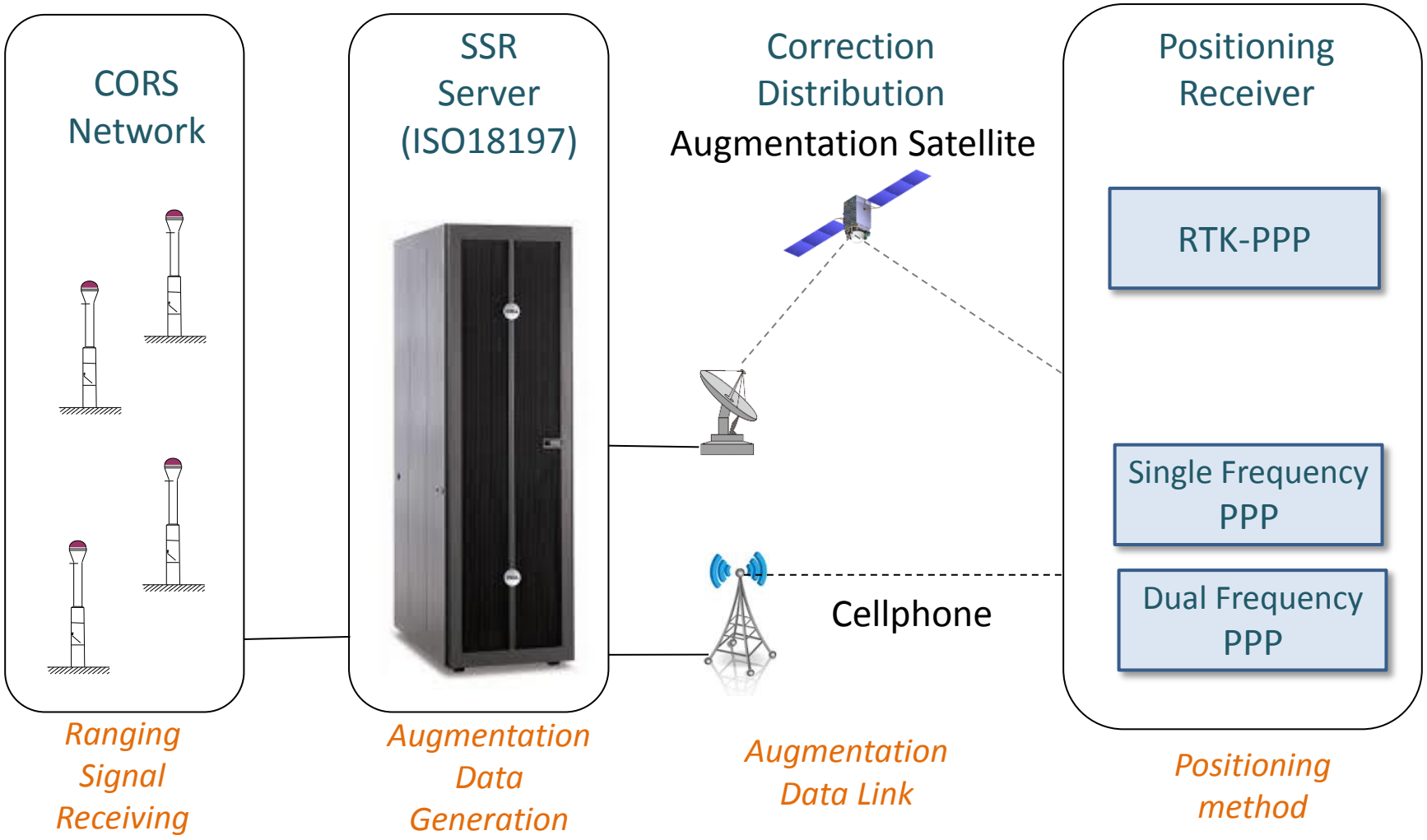
3.Introduction of "Positioning Augmentation Center"

Data Distribution Methods			Network Evaluation			Examples
			Capacity	Coverage	Cost	
Ground Network	One Way	● Radio Broadcasting	△	△	○	● DGPS using radio freq.
	Two Ways	● Fixed Line Internet	○	×	○	● Global augmentation service
		● Mobile Phone	○	△	△	● Network PPP
Satellite Network	One Way	● Broadcasting Type Satellite Usage	○	○	○	● EGNOS using Inmarsat ● CMAS using QZS
	Two Ways	● Communication Type Satellite Usage	○	○	×	● Global augmentation service

DGPS: Differential GPS using radio frequencies
SBAS: Space Based Augmentation System using Geostationary Satellite

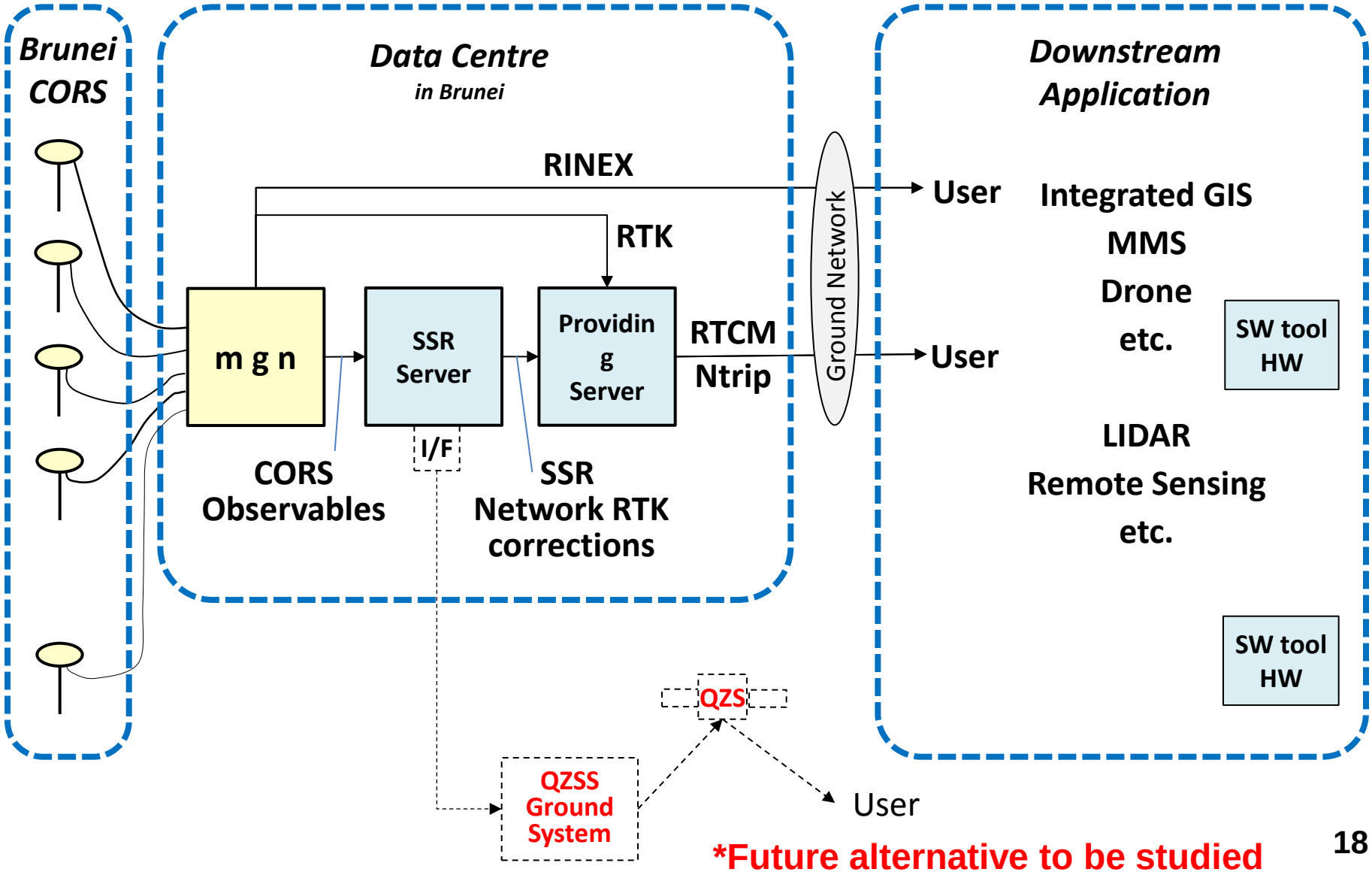
4. Typical design of Augmentation Data Center

SSR Server developed by SPAC can generate “augmentation data” to correct position error due to ionosphere, troposphere, etc. The data are universally applicable to any positioning method to be chosen for Forest Management or other purposes.



【NOTE】SSR : State Space Representation. Standard Corrections for all types of error factors.

4. Typical design of Augmentation Data Center (Case study for Brunei)



Network Coverage for High Precision Services

SPAC
SATELLITE POSITIONING RESEARCH AND APPLICATION CENTER

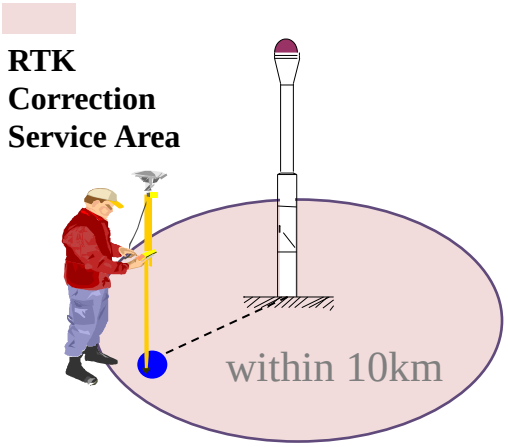
(Case study for Brunei)

Priority	Application	Expected Working Area	Mobile Phone Coverage	Remarks
1	Construction	Urban area	95%	Better coverage in Urban Areas since more development at Urban.
2	Transport	Urban and Certain Rural Areas	70% (Certain areas no coverage at all)	Old highway infrastructure has better coverage. New highway from Telisai to Lumut has limited coverage.
3	Mapping	Urban area is the first priority	80%	Better coverage in Urban Areas.
4	Oil & Gas	Onshore(Coastline/Offshore using their offshore radar reception)	60%	Oil Rigs, Platforms and Jetty Control Post.
5	Farming	Forest/Certain Rural Areas	40% Very weak	Very low and limited coverage.
6	Forestry	Certain Forest/Inlands/Onshore	Less than 40% Extremely weak	Very low and limited coverage.

Satellite Network Usage for High Precision Services

‘Centimeter in seconds at anyplace and anytime’

RTK	Network RTK	RTK-PPP
10 Kilometer Area from a Reference Station	Ground-based Transmittable Area	Nation-wide Area Per a Satellite Channel



Since 1990s

Since 2000s

Since 2010s

RTK to RTK-PPP evolution

QZSS Application Demonstration started on 27 Dec 2010.

6. Conclusion

- High precision augmentation system is very much promising technology in coming Multi-GNSS era.
- Surveyed results the needs of Geospatial Information in Brunei have suggested that authorization of “Mapping” and “Positioning” is very much important.
- Authorized CORS* is a key to assure consistency between Map and Positioning.
- Conceptual Design of “Positioning Augmentation Center” using CORS has been made considering variety of applications. SSR method has been focused.
- Geospatial Information should be stored, exploited and shared as “Treasure” of commodity.

- CORS : Continuously Operating Reference Station
- SSR : State Space Representation

Thank you for your kind attention.

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Complementary Slides

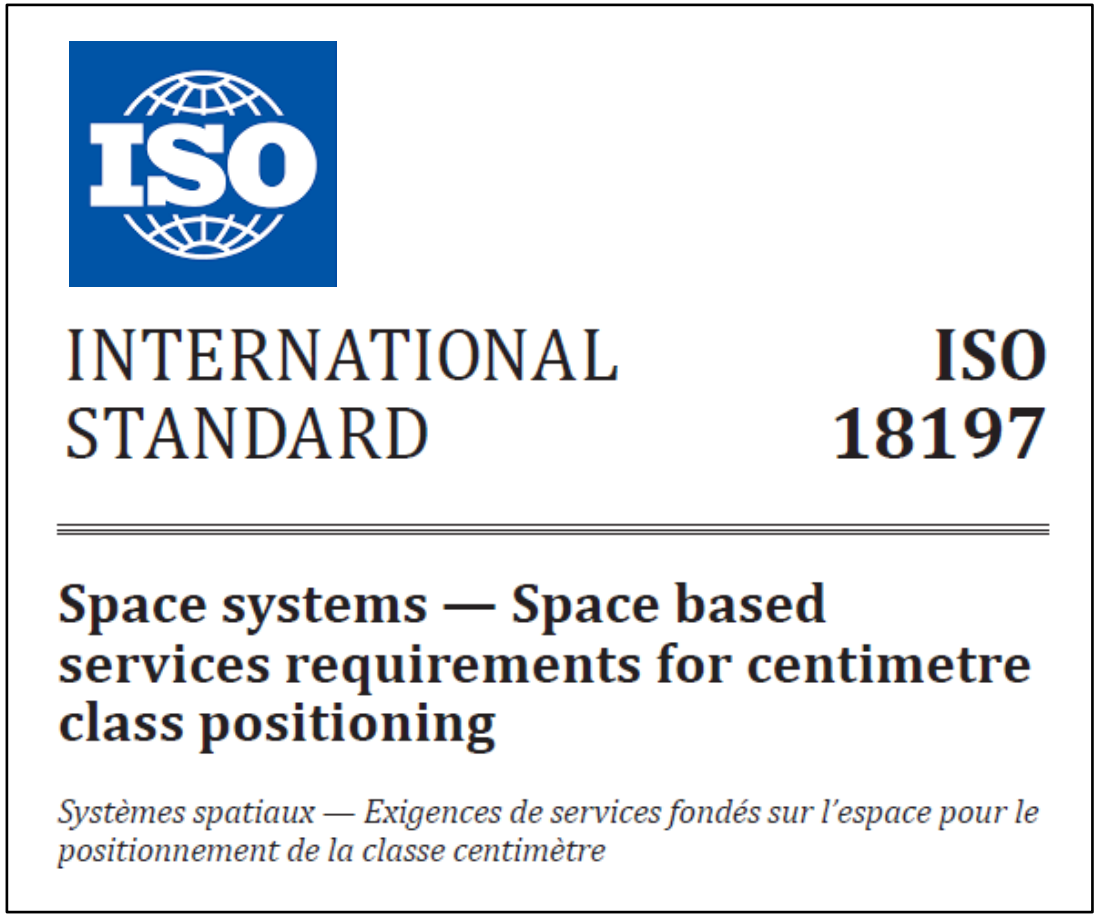
CMAS major specification

Items			Specification	Remark
Broadcasting Target			Stationary and Mobile	・Use dual frequency carrier phase (When using single frequency carrier phase, only TTFF degrades.)
Position Accuracy	Stationary	Horizontal	3 cm RMSE	
		Vertical	6 cm RMSE	
	Mobile	Horizontal	3 cm RMSE	・ 4 km/hr representing low-speed ・ 40 km/hr representing middle-speed
		Vertical	6 cm RMSE	
Time To First Fix (TTFF)			within 60 s	・Using dual frequency carrier phase
Transmission Rate of Augmentation Data			1695 bps	・QZSS L6 signal ・1/1000 High-level compression

(*1) : Position accuracy under condition of good visibility and alignment of satellites
(*2) : Receiver error not considered.

ISO 18197 : Centimeter-class positioning

CMAS is original system which derived ISO 18197 in 2015. It can convert position errors due to 6 different causes into one set of augmentation data, pseudorange and carrier-phase, so that the augmentation data volume to be broadcasted becomes far smaller than conventional methods.



ISO

INTERNATIONAL STANDARD

ISO 18197

Space systems — Space based services requirements for centimetre class positioning

Systèmes spatiaux — Exigences de services fondés sur l'espace pour le positionnement de la classe centimètre

Augmentation Data by **State Space Representation (SSR)**

① GNSS Orbit Correction
② GNSS Clock Correction
③ GNSS Code Bias
④ GNSS Phase Bias
⑤ Ionospheric Correction
⑥ Tropospheric Correction

These augmentation data are provided by SSR server.

RTK-PPP covers Diverse Needs

RTK-PPP has all of corrections to realize centimeter-accuracy.
Partial uses of corrections enable various needs at terminals.

RTK-PPP
- Satellite Clock & Orbit
- Inter-Signal Bias
- Ionospheric Delay
- Tropospheric Delay

1 minute to Fix & Centimeter-class Quality

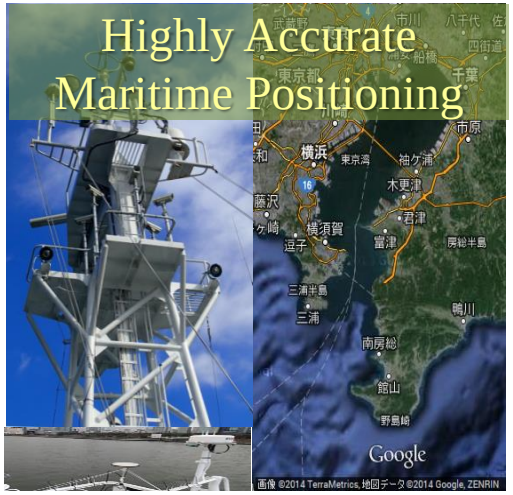
DF-RT-PPP
- Satellite Clock & Orbit
- Inter-Signal Bias

Tens of minute convergence & 10 centimeter-class Quality

SF-RT-PPP
- Satellite Clock & Orbit
- Ionospheric Delay

Rapid Fix & Decimeter-class Quality

<Application Example>



<Application Example>

Glossary

CORS	Continuously Operating Reference Station
G.	Government
GIS	Geographical Information System
GNSS	Global Navigation Satellite System
HW	HardWare
I/F	InterFace
LIDAR	Laser Imaging Detecting And Ranging
Ntrip	Networked Transport of RTCM via Internet Protocol (RTCM 10410.1)
mgn	Managing GNSS Network (SEGAL)
MMS	Mobile Mapping System
QZS	Quasi-Zenith Satellite (G. of Japan)
QZSS	Quasi-Zenith Satellite System (G. of Japan)
RINEX	Receiver INdependent EXchange Format (RTCM SC-104)
RTCM	Radio Technical Commission for Maritime services
RTK	Real-Time Kinematic GNSS data (RTCM 10402.3 and 10403.2)
SSR	State Space Representation (RTCM 10403.2)
SW	SoftWare