Progress of iGMAS and IGMA Joint Trial Project

iGMAS TEAM

Kyoto Japan
2th Dec. 2017

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1.Introduction

In order to **assist with public confidence in GNSS service and interoperability**,**IGMA Workgroup** was set up in 2011, the **Joint Trial Project(JTP)** was recommended in 2015.

- In Feb. and Jun.2016,the **TOR was drafted and discussed during IGS workshop and ICG middle meeting.**The **JTP was launched in** 2016 Nov.,ICG-11**.**

- In May.2017,during **IGMA workshop and IGMA Task Force Meeting in Shanghai,Methodology and Format was discussed.**The **JTP was launched inside IGS** in Jul. 2017 during IGS workshop**.**

- In Oct. 2017, the **format documents** drafted by John and Shuli **was distributed in IGMA Task Force. The preliminary assessments results from several MACs have been provided.**

2.Progress of IGMA Joint Trial Project

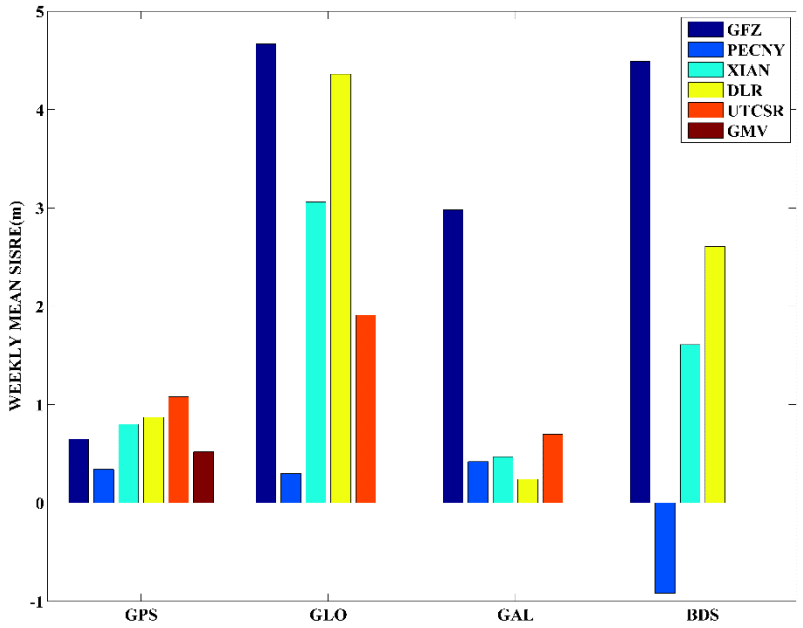
➢ Preliminary results from MACs

Six MACs(DLR,GFZ, PECNY, CSR, GMV, XIAN) have provided initial GNSS assessment results .

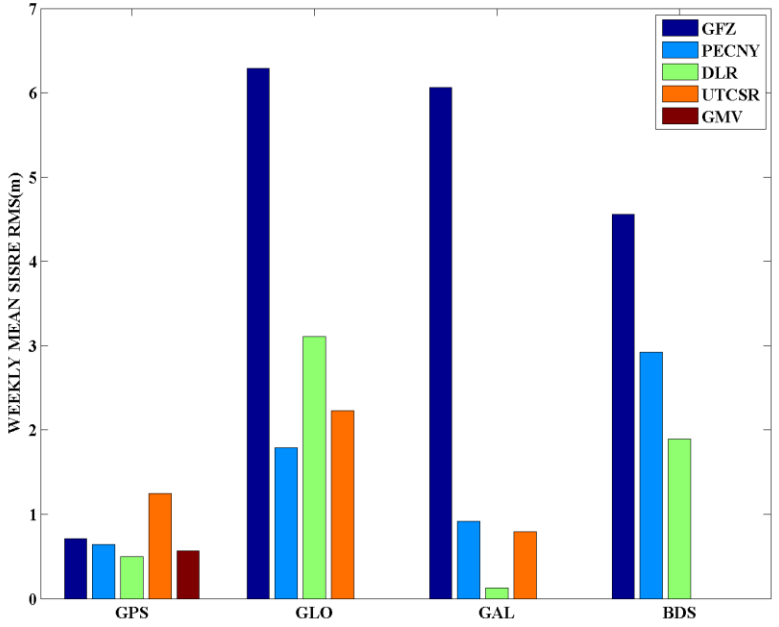
MAC	Sys	Num. of Par	Statistic Method	Parameters and Sampling Interval	Reference Files
GFZ	GPS,GLO, GAL,BDS	6	Daily SISRE RMS for each satellite	900s:R,T,N,C,SISRE 1day:SISRE RMS	GFZ MGEX product
PECNY	GPS,GLO GAL,BDS	28	Daily SISRE RMS for each satellite	3hour: RMS/STD/ MED(for CLK, POS,RAD, ALO,CRO) 900s: DIF (for POS, RAD, ALO, CLK, CRO), PDOP, UREEPO,SISRE, LATLON 1day: TOT_RMS/STD/MED, SISRMS	CODE MGEX product DLR navigation(brdm)
UTCSR	GPS,GLO, GAL	9	Daily and Weekly SISRE RMS for each satellite	600s:SISRE ,(X,Y,Z,R,T,N,C)_diff 1day:SISRE RMS	GFZ MGEX product
XIAN	GPS,GLO GAL,BDS	7	Daily 95% SISRE statistics for each satellite	1day:95% SISRE, (CLK,POS,R,T,N)_RMS 1hour:PDOP	iGMAS product
GMV	GPS	3	Daily SISRE RMS for each satellite	900s:PDOP ,SISRE 1day:SISRE RMS	IGS product
DLR	GPS,GLO GAL,BDS	11	Weekly 95% SISRE for each satellite Weekly SISRE RMS for each system	900s:R,T,N,C, dr_wul 1week:95% SISRE,SISRE,(R,T,N,C)_RMS	CODE MGEX product

2.Progress of IGMA Joint Trial Project

➢ Preliminary Analysis of MACs Results



Weekly Mean SISRE

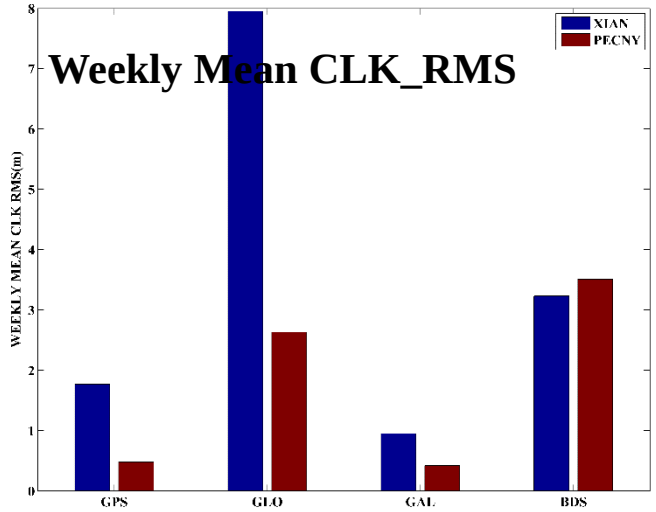


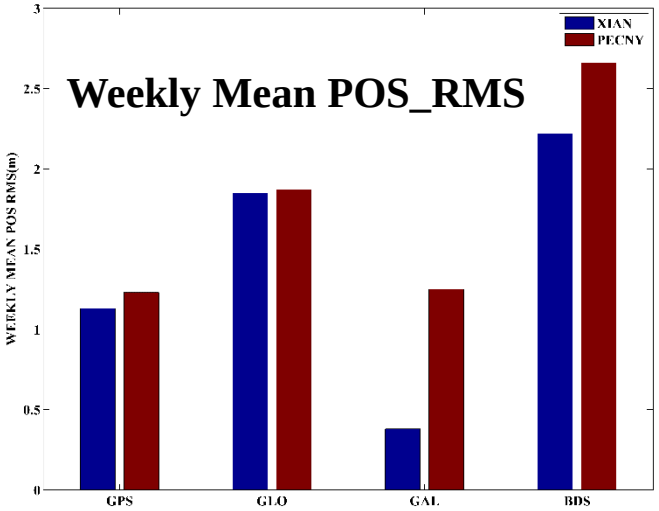
Weekly Mean SISRE RMS

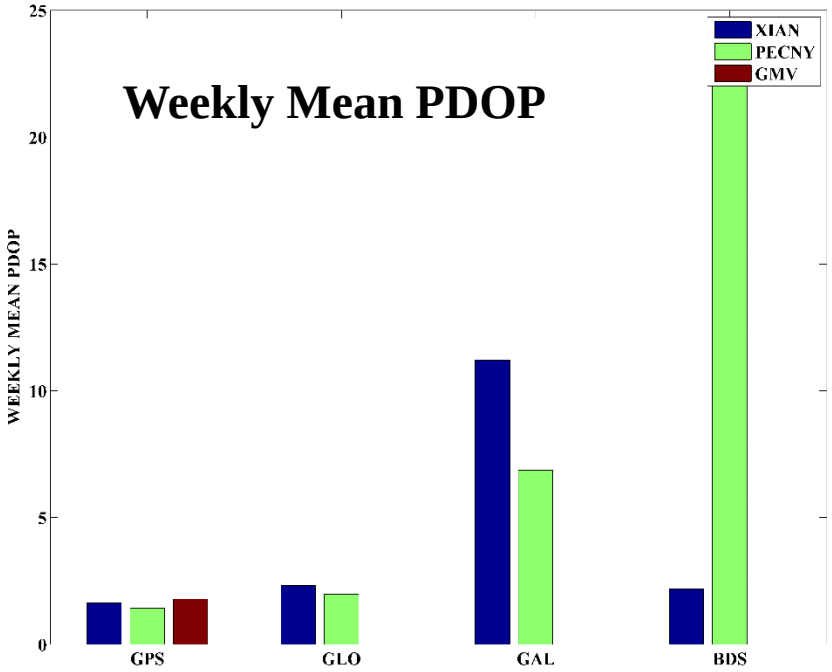
The Results from MACs are quite different at SISRE,especially for GLO,Gal and BDS.

2.Progress of IGMA Joint Trial Project

➢ Preliminary Analysis of MACs Results







Even for PDOP,CLK and Orbit Position,it's also not consistent .

2.Progress of IGMA Joint Trial Project

- **There’re so many differences at the number of parameters, assessment reference, calculation method, correction model, statistic method, sampling intervals. As well as the output filename, format, results intervals, time system of epoch mark, file output frequency,and the result itself.**
- **In order to make the results from MACs comparable, these issues should be discussed in detail and unified.(We have drafted the technical documents about the Standard for GNSS Monitoring and Assessment in including the definition, methodology and output format.)**
- **As the reference of the monitoring and assessment, the status of GNSS orbits with high accuracy from different ACs are analyzed first here.**

3.Reference for Monitoring and Assessment

IGS MGEX multi-GNSS orbit/clk

No.	AC	Orbit			CLK		
		Final	Rapid	Ultra	Final	Rapid	Ultra
1	CODE	gps glo gal bds qzs	Gps glo	Gps glo	gps glo gal bds qzs		
2	GFZ	gps glo gal bds qzs	gps glo	gps glo	gps glo gal bds qzs	gps glo	-
3	CNES	gps glo gal			gps glo gal		
4	JAXA	gps qzs			-		
5	TUM	gal qzs			-		
6	Wuhan	gps glo gal bds qzs	gps glo gal bds	gps glo gal bds	gps glo gal bds qzs	gps glo gal bds	gps glo gal bds
	IGS	gps	gps	gps	gps	gps	gps

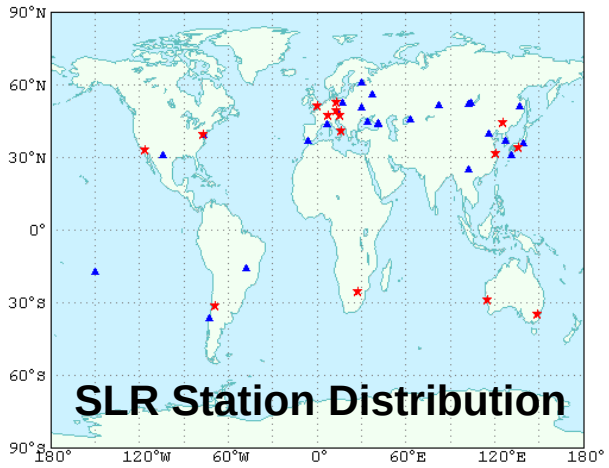
iGMAS multi-GNSS orbit/clk

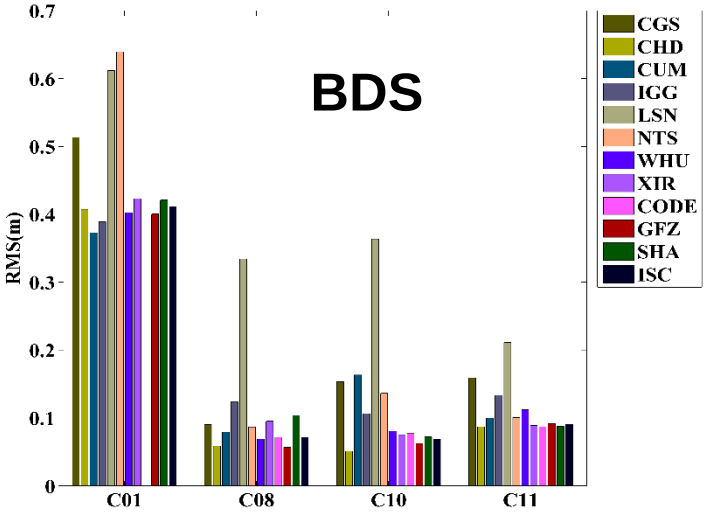
No.	AC	Orbit			CLK		
		Final	Rapid	Ultra	Final	Rapid	Ultra
1	BAC	4(gps glo gal bds)	4(gps glo gal bds)	3(gps gal bds)	4(gps glo gal bds)	4(gps glo gal bds)	3(gps gal bds)
2	CGS	4	gps gal bds	4	gps gal bds	gps gal bds	4
3	CHD	4	glo gal bds	4	4	glo gal bds	4
4	CUM	4	4	4	4	4	4
5	IGG	4	4	4	4	4	4
6	LSN	4	4	4	gps glo gal	gps glo gal	4
7	NTS	4	4	4	4	4	4
8	SHA	4	4	4	4	4	4
9	TAC	-	4	4	-	4	4
10	TLC	4	4	4	gps glo gal	-	4
11	WHU	4	4	4	4	4	4
12	XRS	4	4	gps glo	4	4	gps glo
13	XSC	-	4	4	-	4	4
	iGMAS(BDT)	gps glo gal bds	gps glo gal bds	gps glo gal bds	gps glo gal bds	gps glo gal bds	gps glo gal bds

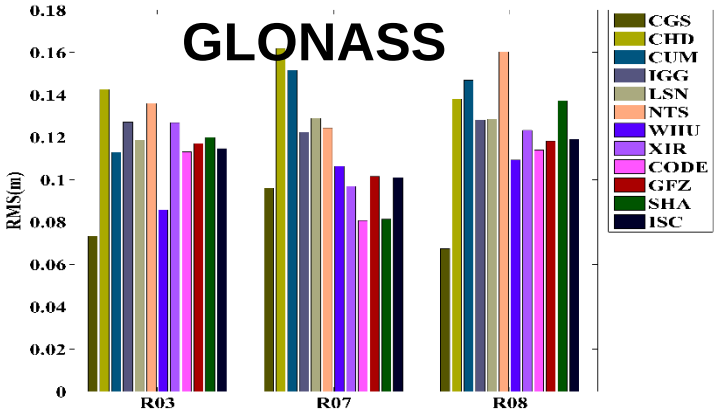
3.Reference for Monitoring and Assessment

SLR Validation of BDS/GLONASS orbit from ACs

The BDS,Galileo,Glonass orbit from IGS(CODE,GFZ) and iGMAS(9 ACs+iSC) are validated by SLR observations during 1-30th Sept. 2017.





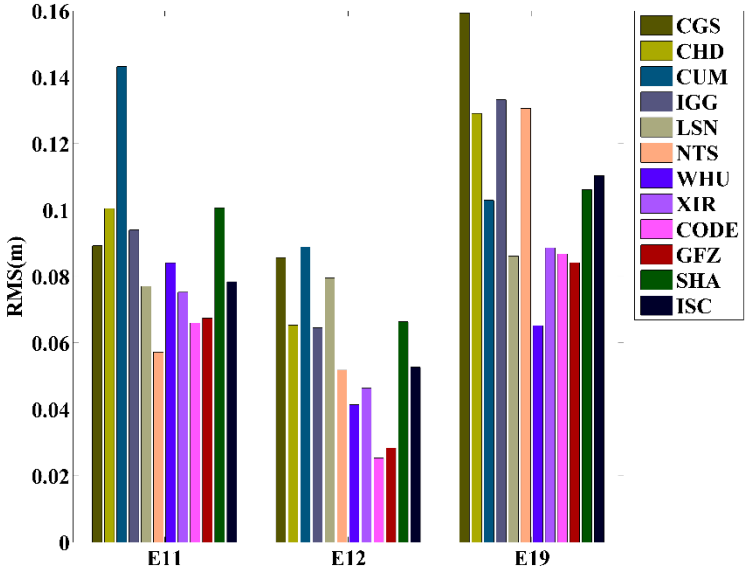


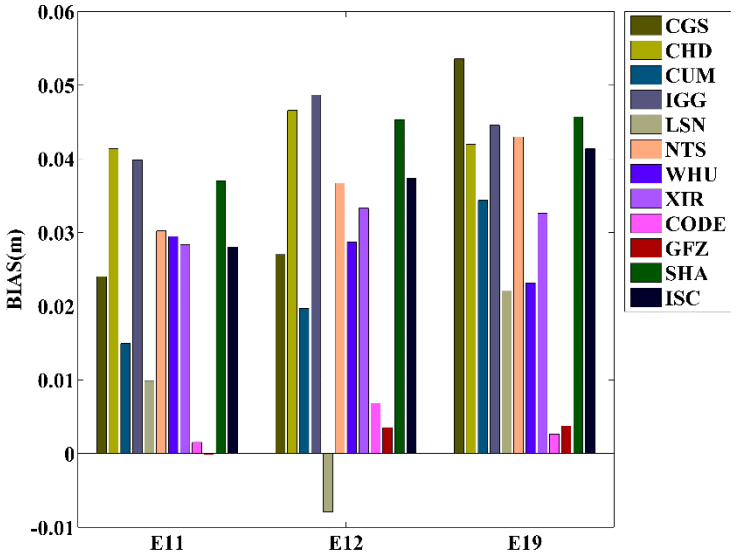
(PINK:CODE,RED:GFZ)

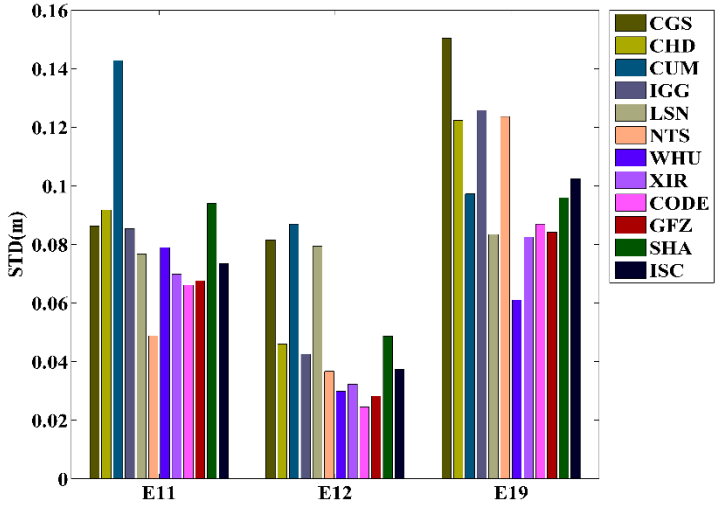
- For BDS and GLONASS, the accuracy of most iGMAS ACs are consistent with IGS(CODE,GFZ).

3.Reference for Monitoring and Assessment

SLR Validation of Galileo orbit from ACs



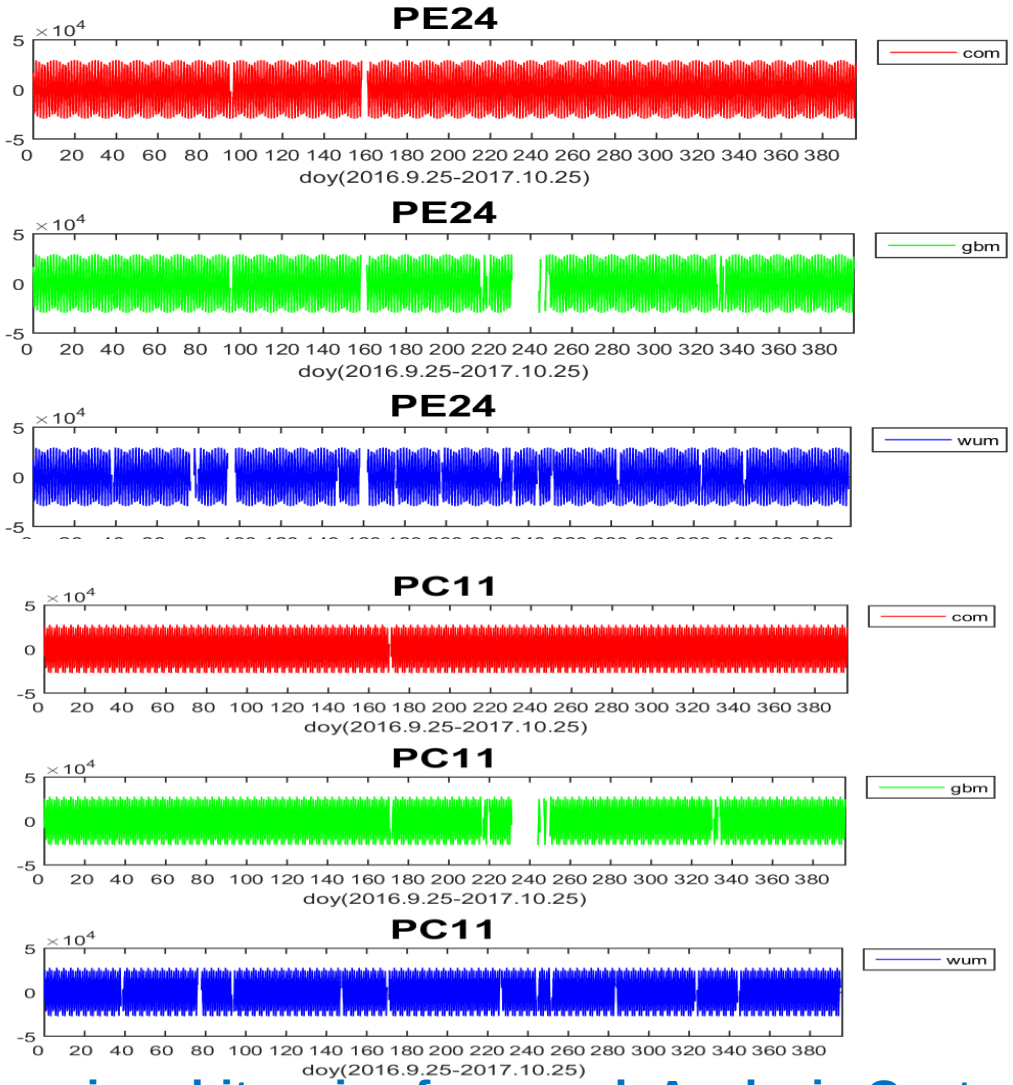




- For Galileo, there're some differences between iGMAS ACs and IGS ACs.Some model corrections should be consistent.

3.Reference for Monitoring and Assessment

Combination products are necessary



Gaps in orbit series from each Analysis Center

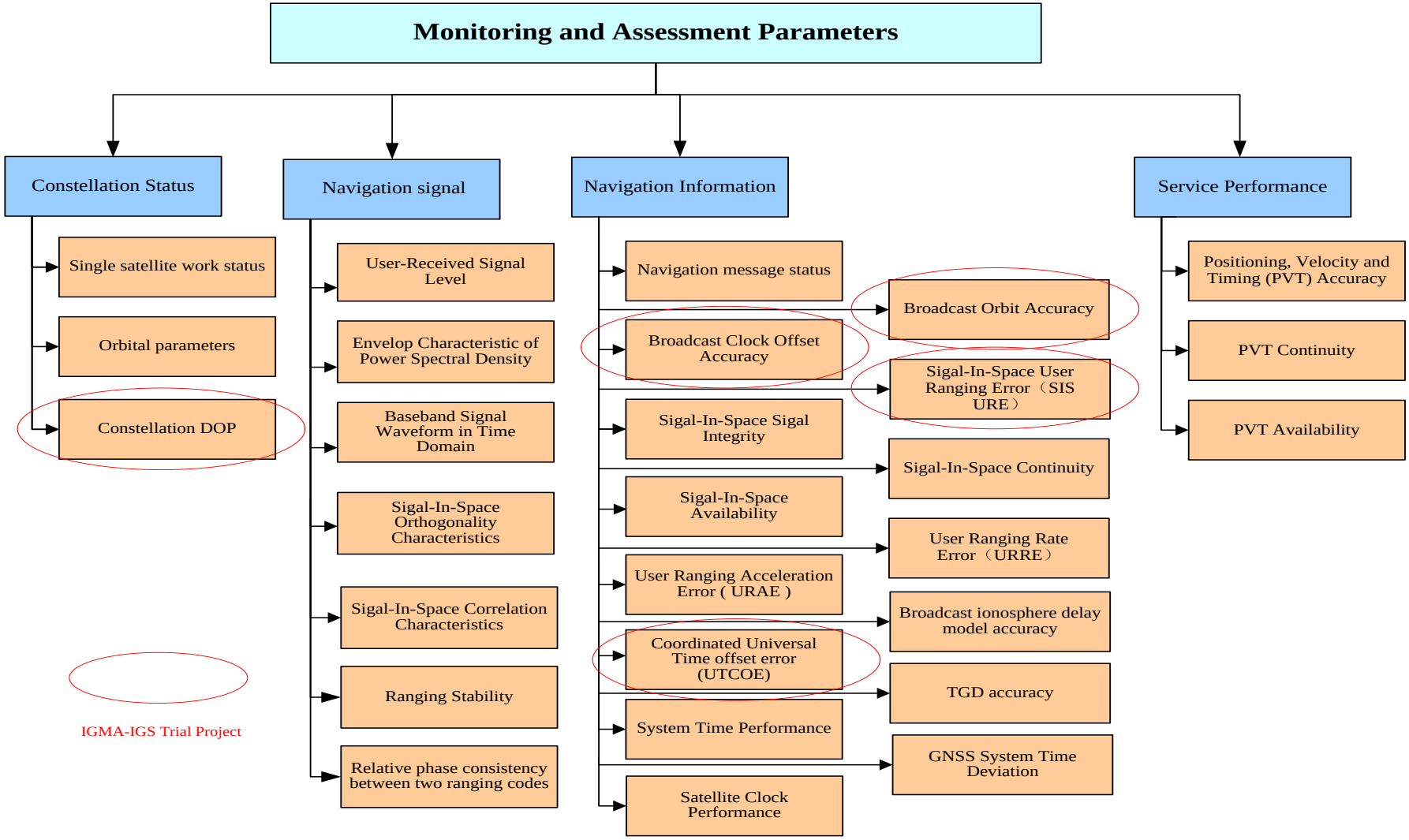
- Difficult to keep the series continuous and stable absolutely for one AC.The combination is necessary.
- For GPS, the IGS final combination products are very continuous and stable. It's also necessary to make combination products for other GNSS systems.
- **iGMAS** is improving its multi-GNSS combination products gradually which can be a choice for the reference.

4.Capability of iGMAS

- In Jul.2016, iGMAS started open routine service. 7+ ACs for GNSS reference solution,1 MAC for M&A,Tracking network,3 Data Centers,et al.
- iGMAS can M&A constellation status, quality of navigation signals, accuracy of navigation information and service performance.
- iGMAS can provide basic BDS/GPS/Glonass/Galileo products with hign accuracy as reference for M&A.

4.Capability of iGMAS

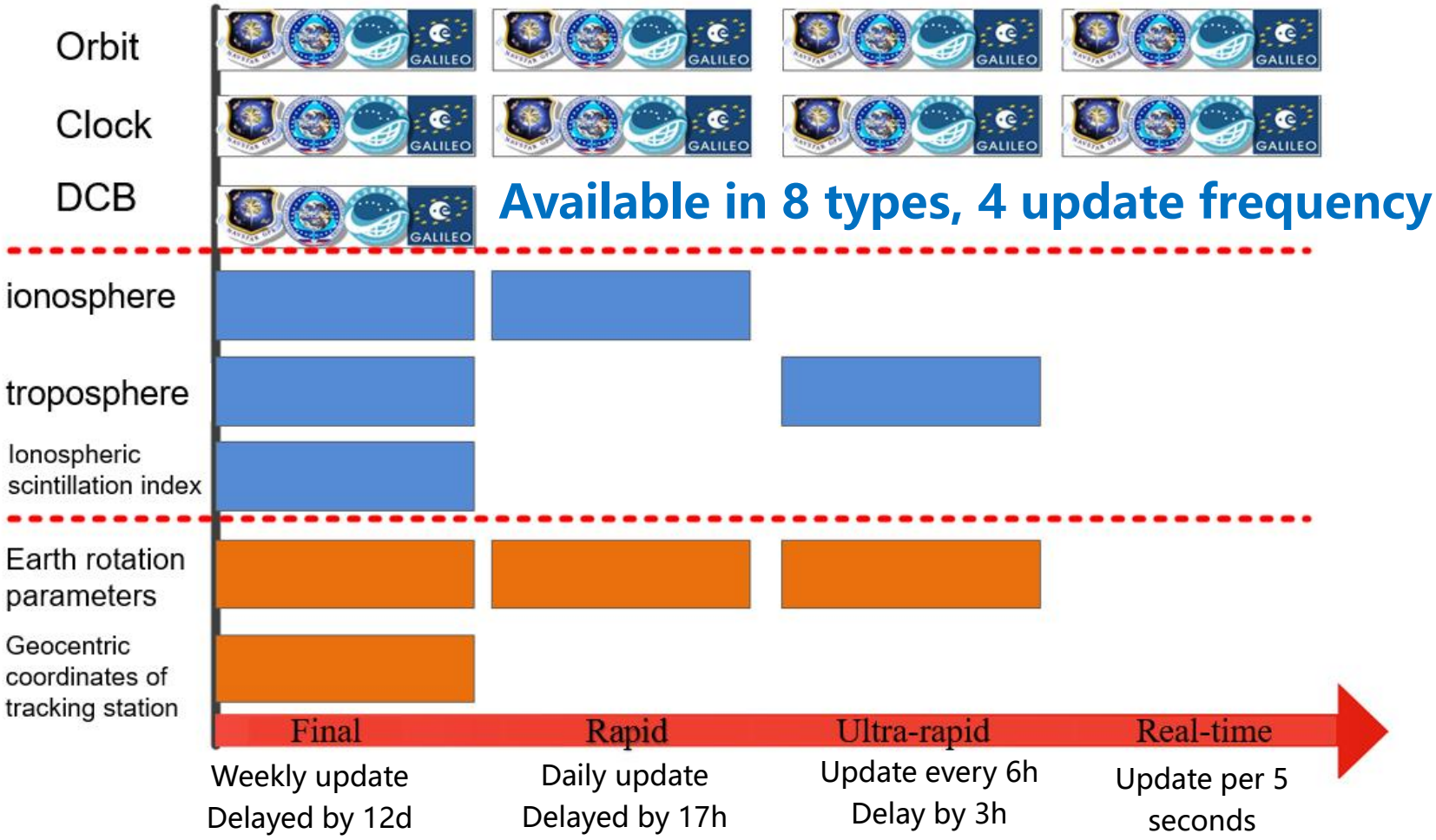
Monitoring and Assessment Elements of iGMAS



4 types M&A elements and 32 parameters

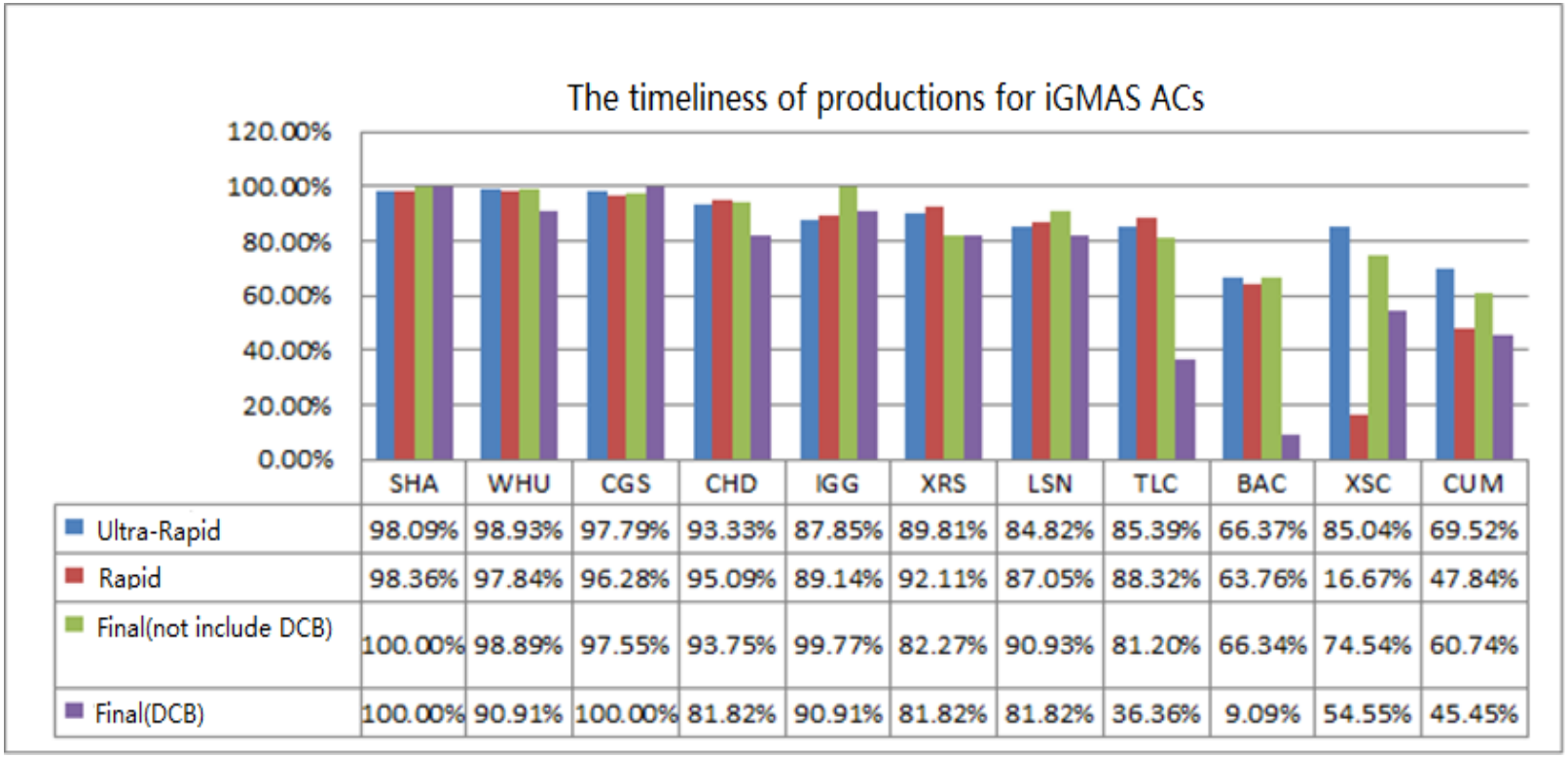
4.Capability of iGMAS

Basic Products of iGMAS



The basic products can provide the reference for Monitoring and Assessment, also for research and system technology test.

4.Capability of iGMAS

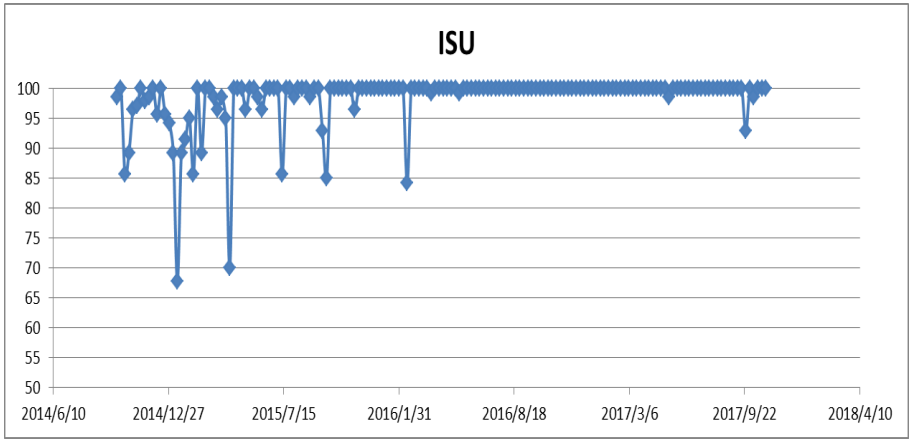


	SHA	WHU	CGS	CHD	IGG	XRS	LSN	TLC	BAC	XSC	CUM
Ultra-Rapid	98.09%	98.93%	97.79%	93.33%	87.85%	89.81%	84.82%	85.39%	66.37%	85.04%	69.52%
Rapid	98.36%	97.84%	96.28%	95.09%	89.14%	92.11%	87.05%	88.32%	63.76%	16.67%	47.84%
Final(not include DCB)	100.00%	98.89%	97.55%	93.75%	99.77%	82.27%	90.93%	81.20%	66.34%	74.54%	60.74%
Final(DCB)	100.00%	90.91%	100.00%	81.82%	90.91%	81.82%	81.82%	36.36%	9.09%	54.55%	45.45%

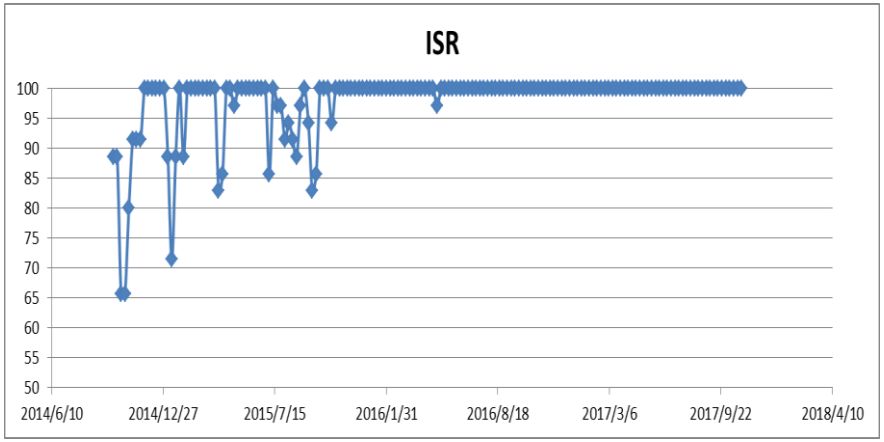
The timeliness of 5+ AC's productions is more than 90% in 2016.It will be much better in 2017.

4.Capability of iGMAS

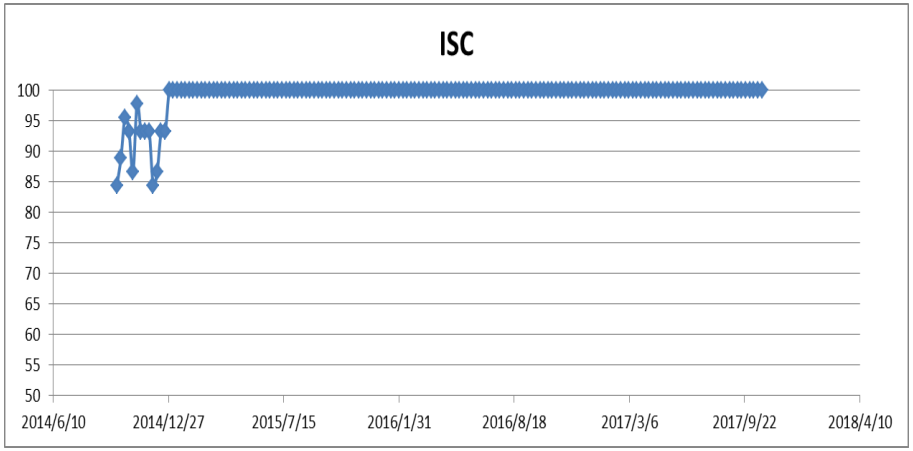
iGMAS Combination Products(iCS)



Ultra-Rapid



Rapid

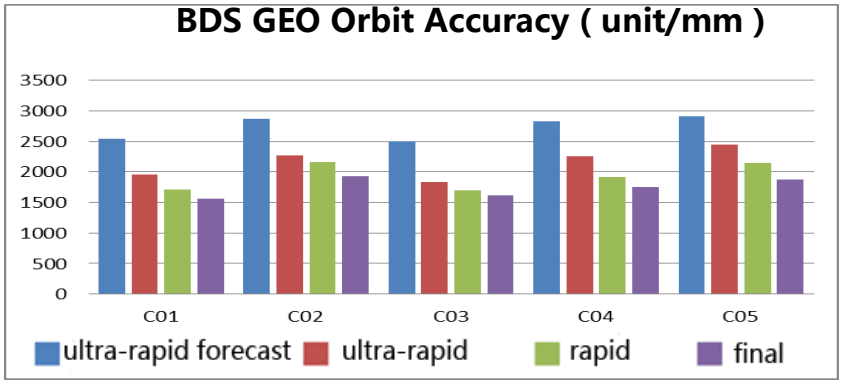


Final

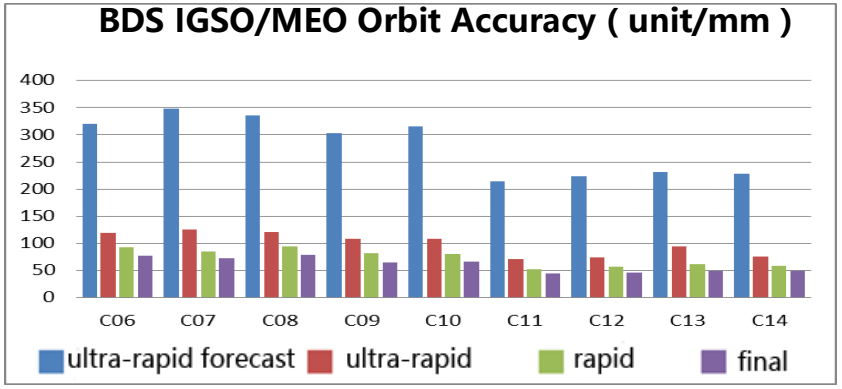
The availability in 2017 is more stable than 2016 and 2015.

4.Capability of iGMAS

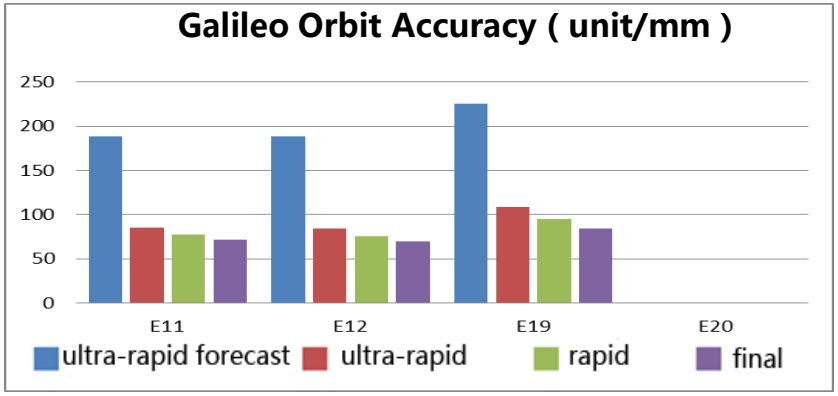
iCS BDS/Galileo Orbit Products



BeiDou GEO Orbit Accuracy



BeiDou IGSO/MEO Orbit Accuracy



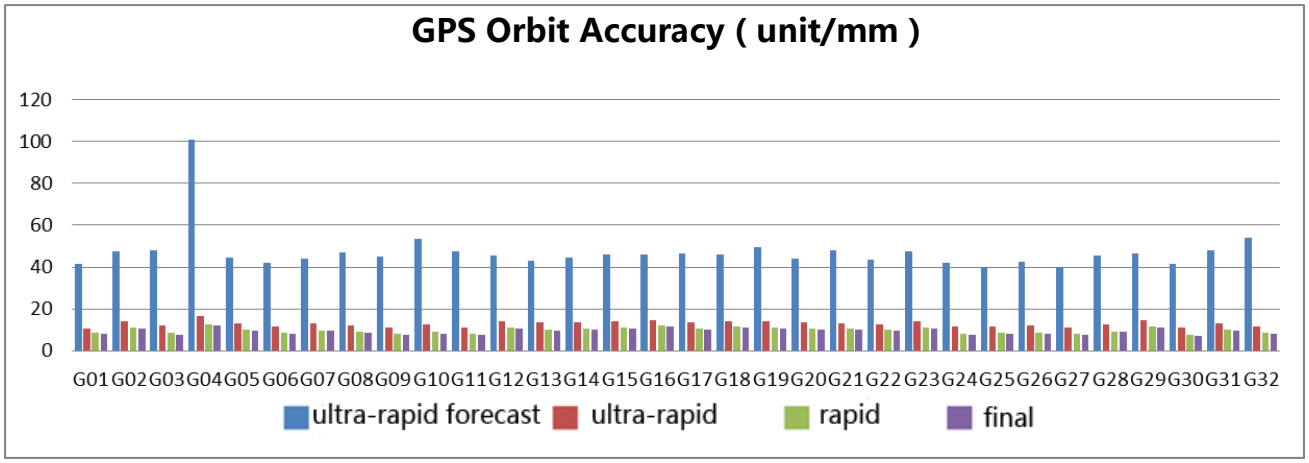
Galileo Orbit Accuracy

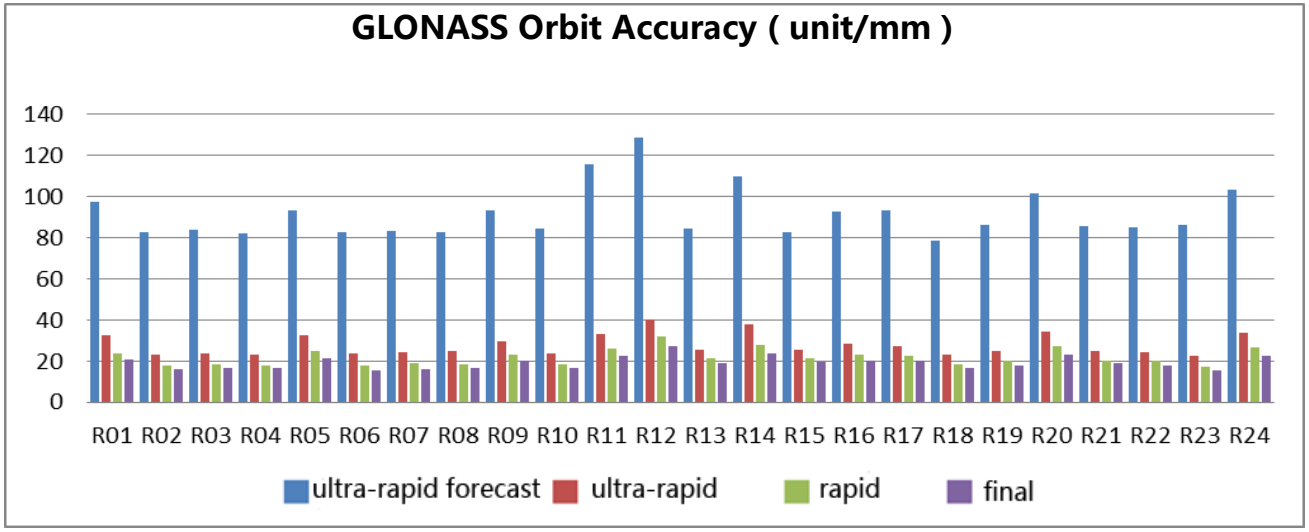
Compared to GFZ products:

- the accuracy of BDS final product in GEO is better than 200cm,as for IGSO / MEO is better than 8.0cm.
- the accuracy of Galileo final product is better than 9.0cm.

4.Capability of iGMAS

Comparison of iCS Orbit with IGS





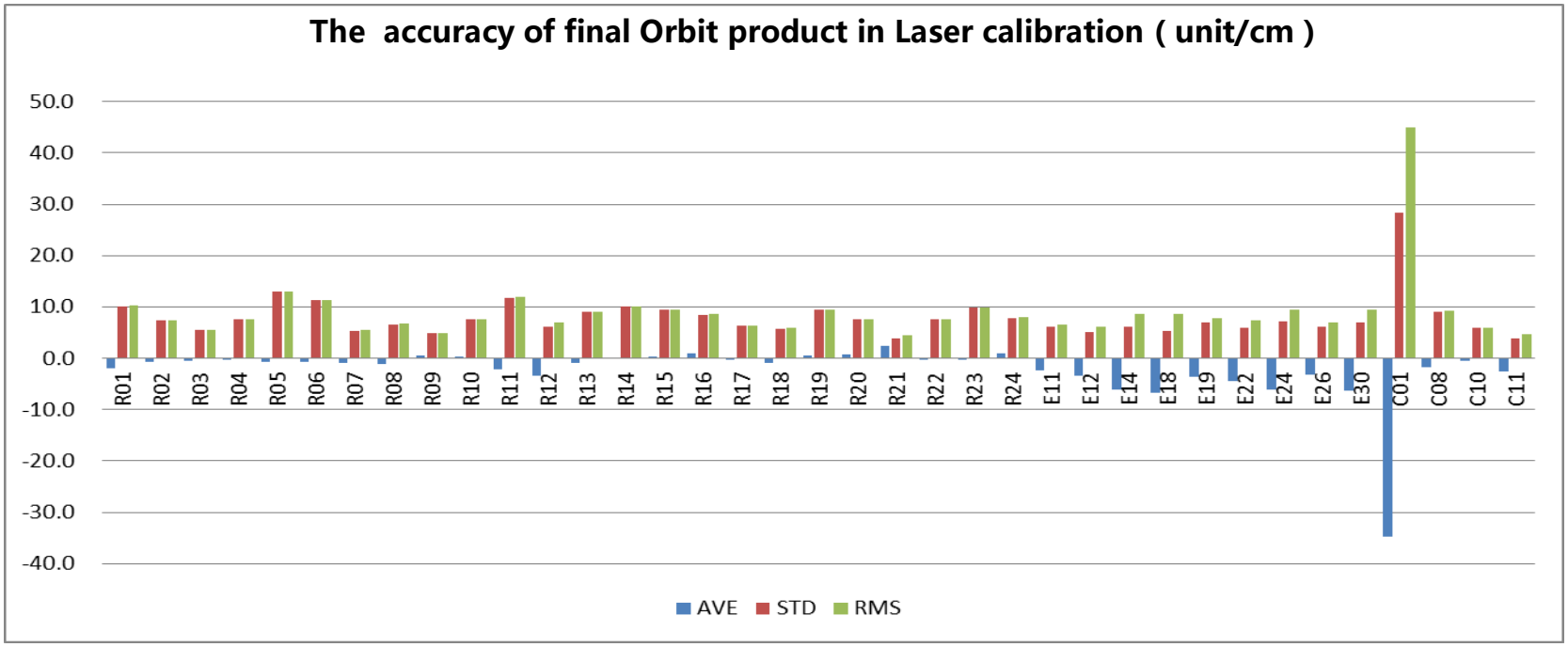
Compared to IGS products :

- the accuracy of GPS final orbit is better than 1.2cm.
- the accuracy of GLONASS orbit is better than 2.5cm.

4.Capability of iGMAS

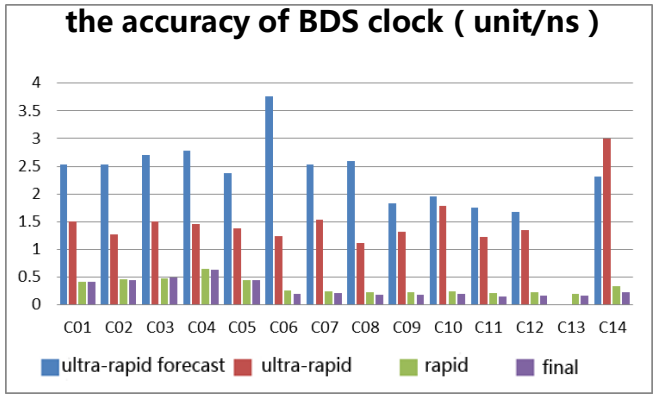
SLR Validation of iCS Orbit

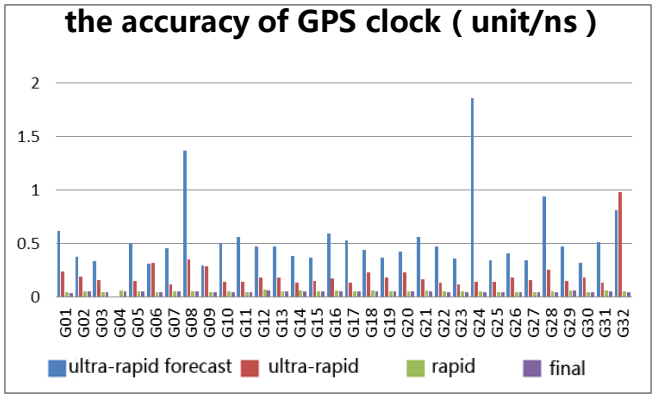
The final product accuracy (radial) of BDS GEO satellite orbit is better than 50.0cm, IGSO / MEO is better than 10.0cm, GLONASS is better than 13.0cm, and Galileo is better than 8.0cm.

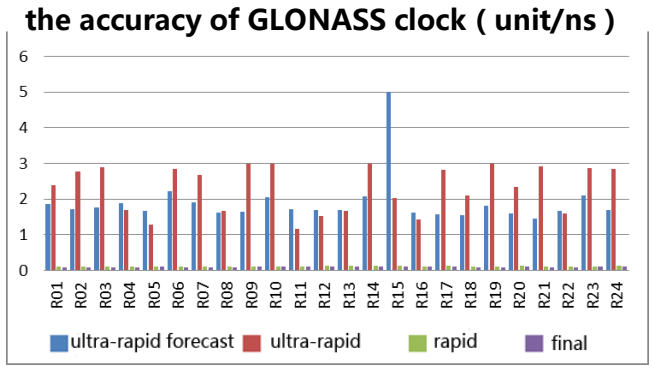


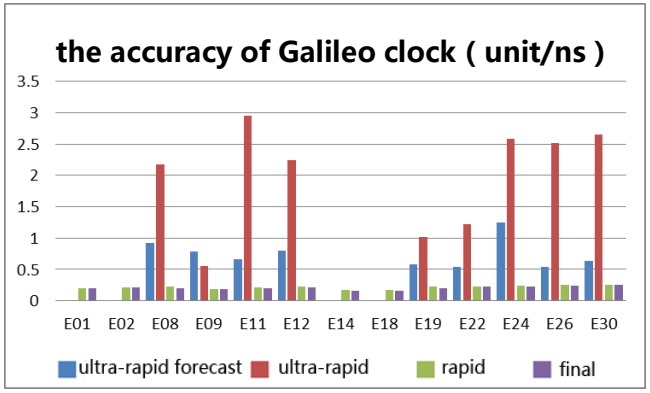
4.Capability of iGMAS

iCS Clock Products









Compared to GFZ products ：

- **BDS** final CLK, **GEO** is better than 0.7ns, **IGSO / MEO** is better than 0.3ns ；
- **GPS** final CLK is better than 0.1ns;
- **GLONASS** final CLK is better than 0.15ns;
- **Galileo** final CLK is better than 0.3ns;

iGMAS iCS products are prospective for reference too.

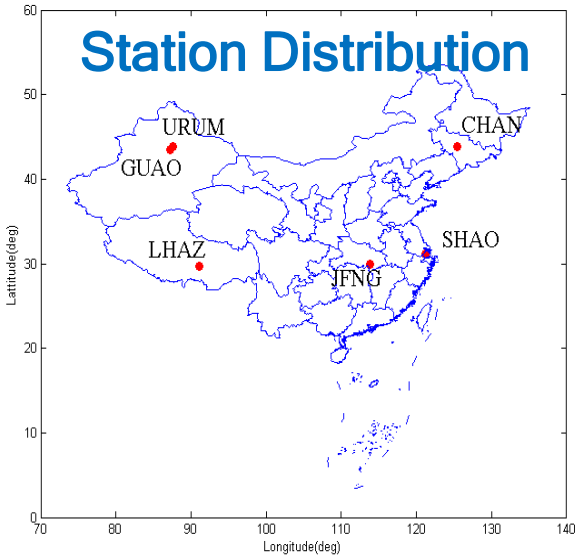
5.Scope of China Contributions to JTP

- Monitoring of all GNSS :
  GPS, GLONASS, Galileo, BeiDou, later also QZSS,etc
- Contribute the basic set of parameters but not limited
- Initially offline, later near-realtime and realtime
- Station resources
- Monitoring and Assessment Center (MAC)
- GNSS Reference Solutions
- HUB for information exchange and share

5.Scope of China Contributions to JTP

Station Resources

From IGS stations in China,SHAO (Shanghai), CHAN (Changchun), LHAZ (Lhasa) and GUAO (Urmuqi),some will be chosen to participate in the Joint Trial Project.



Station Status at present

Site Name	City/Town	Receiver Type	Antenna Type	Tracked Signals			
				GPS	GLO	GAL	BDS
SHAO	Shanghai	ASHTECH UZ-12	AOAD/M_T	√			
CHAN	Changchun	ASHTECH UZ-12	ASH701945E_M	√			
LHAZ	Lhasa	LEICA GR25	LEIAR25.R4	√	√	√	√
GUAO	Urumqi	ASHTECH UZ-12	ASH701945B_M	√			

Receivers will be updated for tracking GPS, GLONASS GALILEO and BDS signals.

5.Scope of China Contributions to JTP

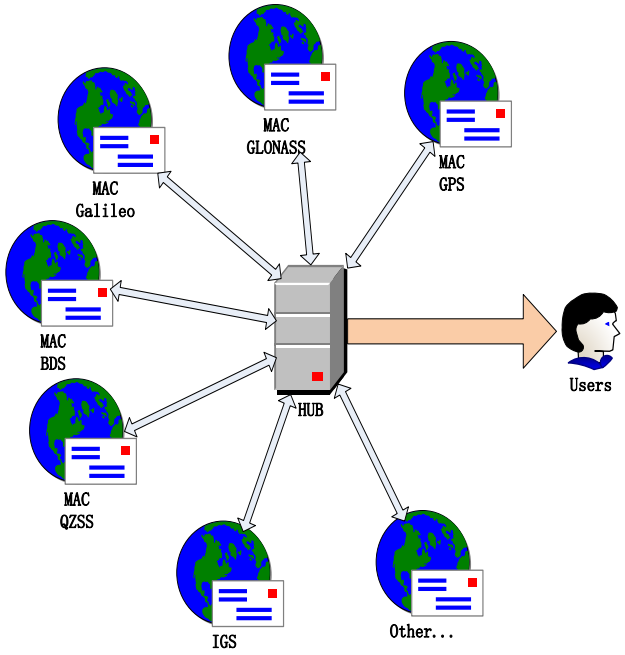
☐ Monitoring and Assessment Center

- ✓ **iGMAS Monitoring and Assessment Center is in Xi'an.**
- ✓ **Provide four types(32 parameters) M&A information with various update intervals.**
- ✓ **Routine running for more than two years.**

iGMAS MAC is ready to provide a fully operational monitoring service.The results has accumulated more than two years.

5.Scope of China Contributions to JTP

HUB for information Exchange and Share



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GFZ			
GMV			
PECNY			
UTCSR			
XIAN			
zPreliminary Analysis of the Initial GNSS Assessment Results from MACs.docx	2017-11-16 08:56	213 KB	

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The HUB is set for tracking data and M&A information collecting and sharing from-to all the participants of the JTP and other users.Now,the preliminary results from MACs and analysis report can be downloaded.

5.Scope of China Contributions to JTP

☐ HUB for information Exchange and Share

- **All users can register on http://112.65.161.230/Eng-register.html to download the data and products with FTP, and accessible IGS real-time data.**

6. Summary

- At present,so quite different at the methodology,output and the result itself from MACs.
- In order to make the results from MACs comparable, the definition, methodology and output format should be discussed in detail and unified. Standard for GNSS Monitoring and Assessment should be discussed together for all related activities, such as ICG IGMA,iGMAS,MGA.
- As the reference of the monitoring and assessment, for BDS and GLONASS, the accuracy of most iGMAS ACs are consistent with IGS(CODE,GFZ). For Galileo, model corrections should be consistent in iGMAS.
- For GPS, the IGS final combination products are very continuous and stable. It's also necessary to make combination products for other GNSS systems. iGMAS is improving its multi-GNSS combination products gradually which can be a choice for the reference.

Thanks !

- iGMAS WEBSITE：www.igmas.org
  (http://124.205.50.178:8011)
- Mobile APP