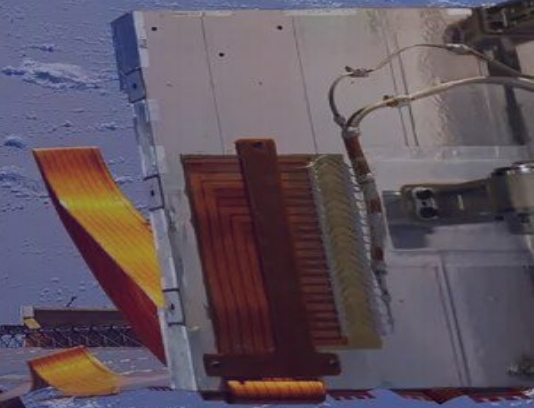
15th Meeting of the International Committee on Global Navigation Satellite Systems

BeiDou Navigation Satellite System Development

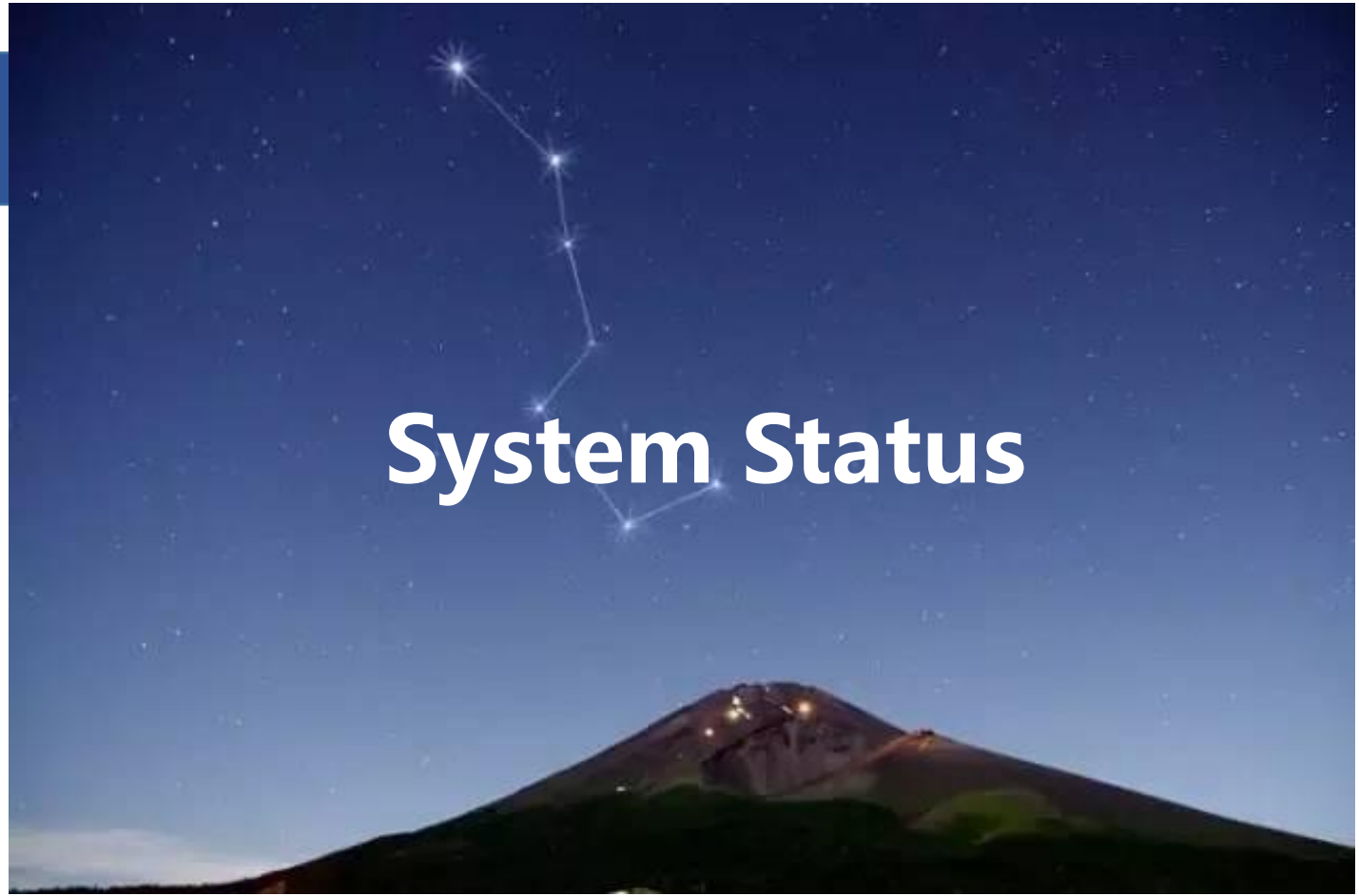


CHEN Gucang

China Satellite Navigation Office

September 28, 2021

01



System Status

01 System Status

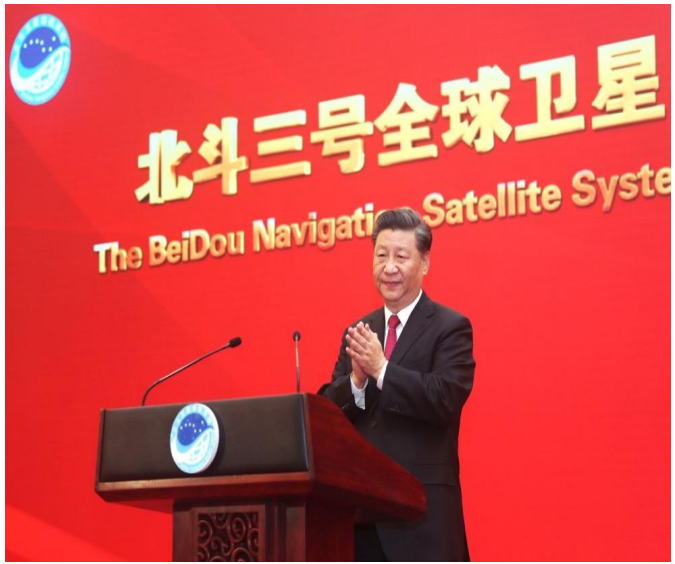
1. Constellation Deployment

Since ICG-14, 4 BDS-3 satellites (including 2 MEO and 2 GEO) have been launched, marking the full constellation of BDS.

Satellite	Launch Time	Orbit
52th, 53th	2019.12.16	MEO
54th	2020.03.09	GEO
55th	2020.06.23	GEO

01 System Status

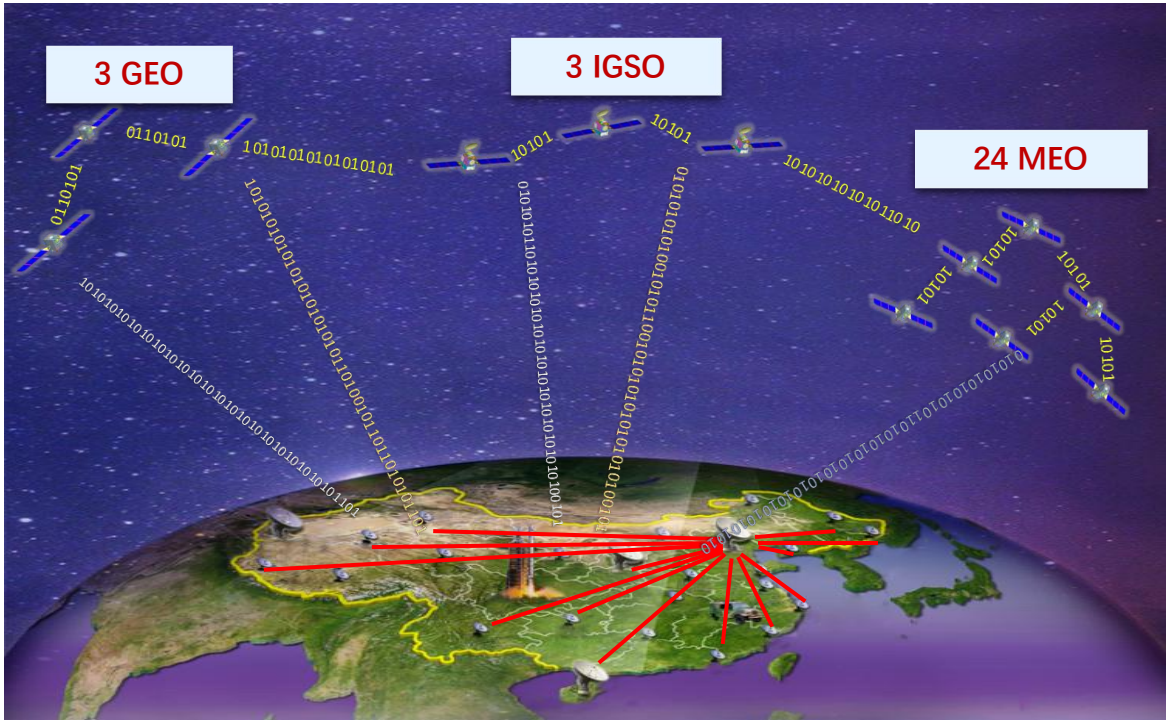
2. Completion and Commissioning



On July 31st, 2020，Chinese President XI Jinping announced the completion and commissioning of the BeiDou Navigation Satellite System (BDS-3).

01 System Status

3. System Components



BDS is mainly comprised of three segments: a space segment, a ground segment and a user segment.

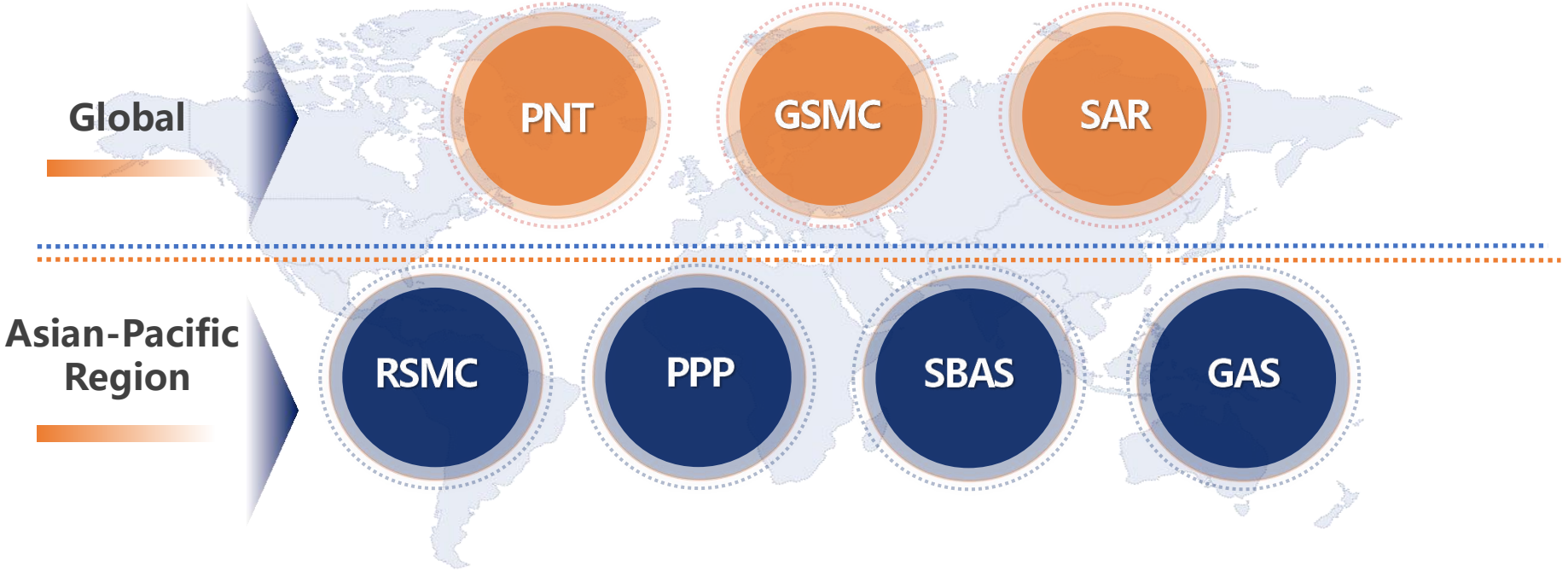
Up to now, BDS-3 constellation consists of 3 GEO satellites, 3 IGSO satellites, and 24 MEO satellites.

The BDS ground segment consists of various ground stations, including master control stations, time synchronization/uplink stations, monitoring stations, etc.

The BDS user segment consists of various kinds of the BDS terminals.

01 System Status

4. Various Services with Powerful Functions



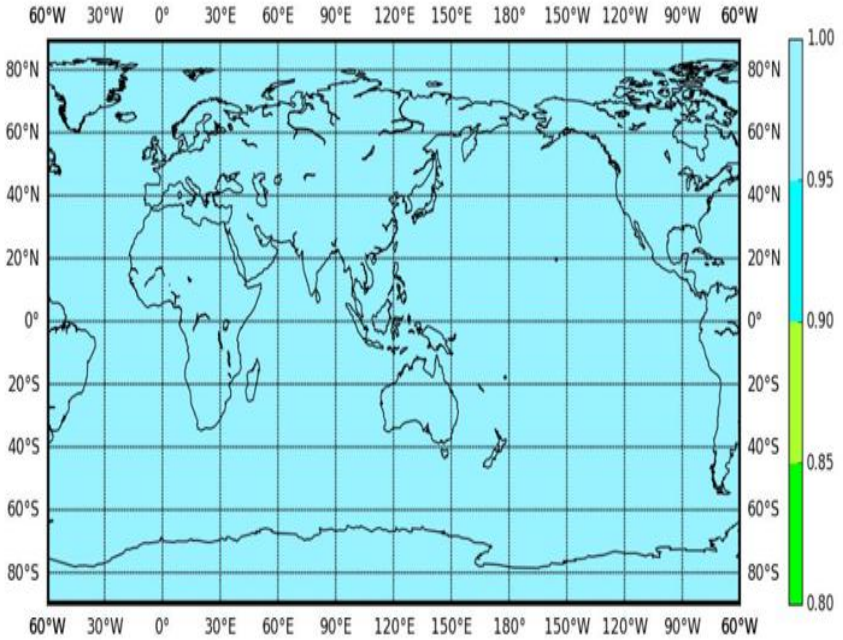
01 System Status

4.1 Positioning, Navigation and Timing (PNT)

BDS Service Performance Indicator

Performance Characteristics	Performance Specification
Space Signal Accuracy	≤0.5m
Space Signal Availability	≥98%
Space Signal Continuity	GEO/IGSO: 0.995/h MEO: 0.998/h
Global Positioning Accuracy (95%)	Horizontal≤7m Vertical≤9m
Global Timing Accuracy (95%)	≤20ns
Global Velocity Measurement Accuracy (95%)	≤0.2m/s

BDS Availability (5° Elevation Mask, PDOP≤6)



01 System Status

4.1 Positioning, Navigation and Timing (PNT)

01. Space Signal Quality

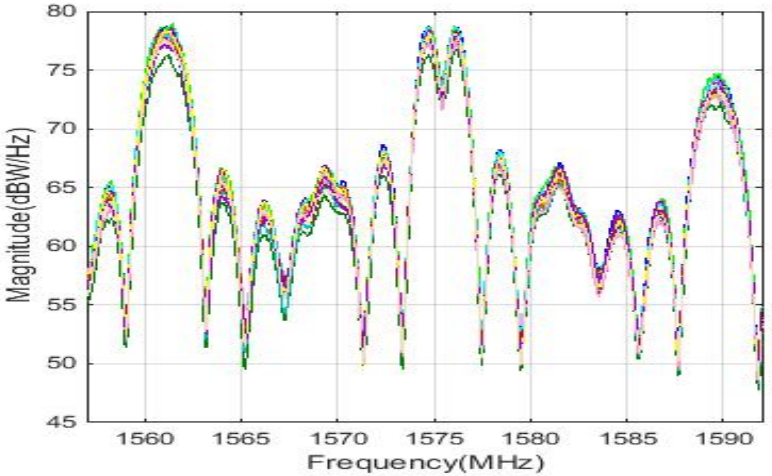


Figure 1 Power Spectral Density of the BDS Satellites

02. Space Signal Precision

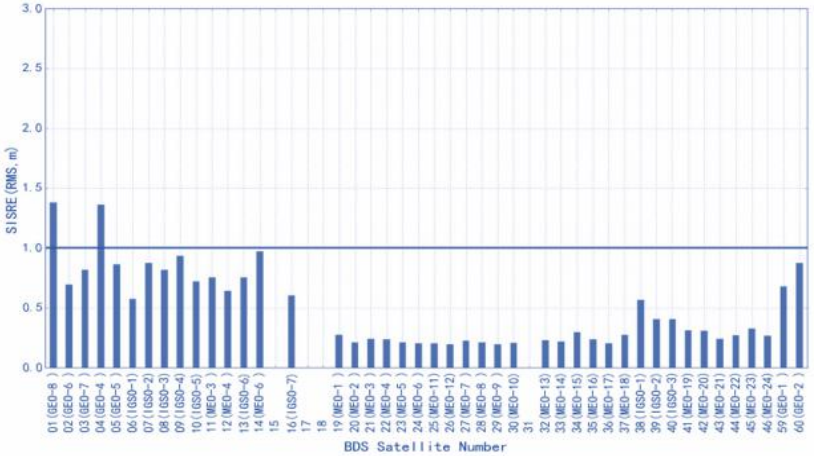


Figure 2 URE of the BDS Satellites

01 System Status

4.1 Positioning, Navigation and Timing (PNT)

03. BDS Coordinate Reference Frame

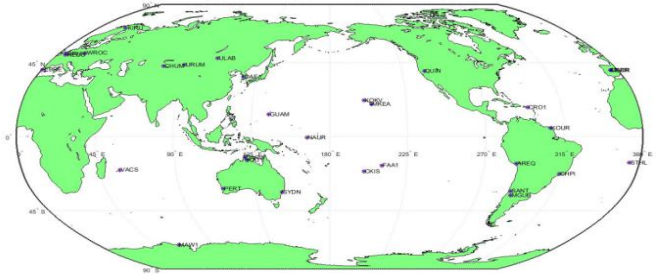


Figure 3 BDS Monitoring Stations and Globally Deployed IGS Monitoring Stations

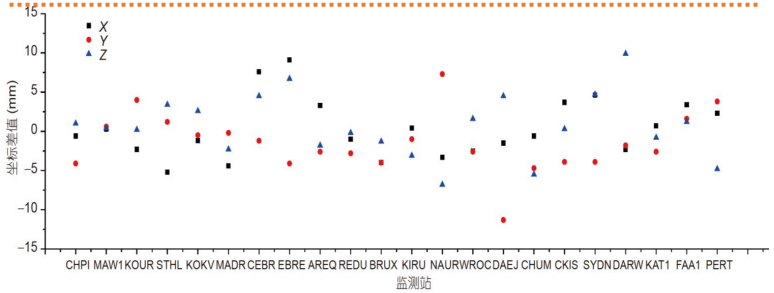


Figure 4 Difference between BDCS and ITRF 2014

04. Stability of BDT

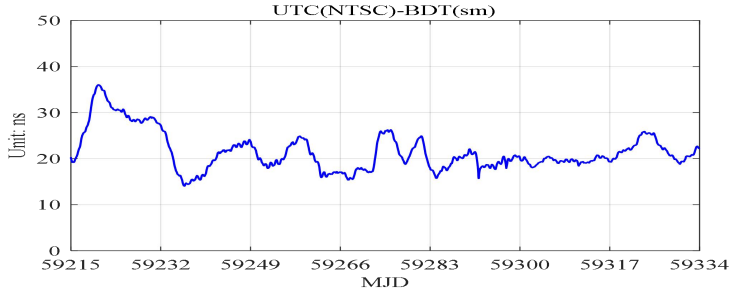


Figure 5 Time Deviation between BDT and UTC(NTSC)

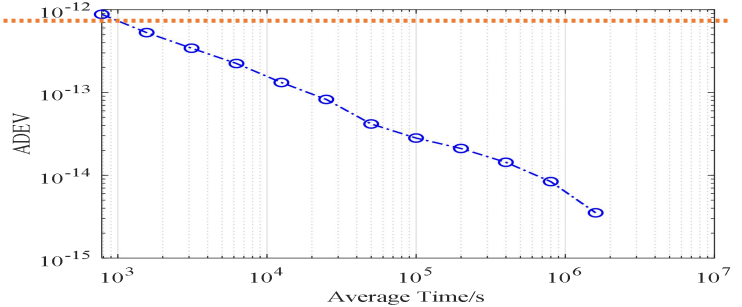
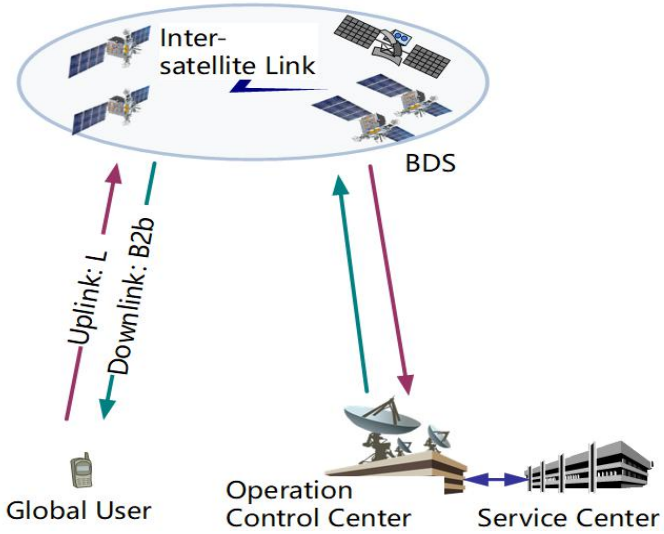


Figure 6 Stability of Clock Bias between BDT and UTC(NTSC)

01 System Status

4.2 Global Short Message Communication (GSMC)

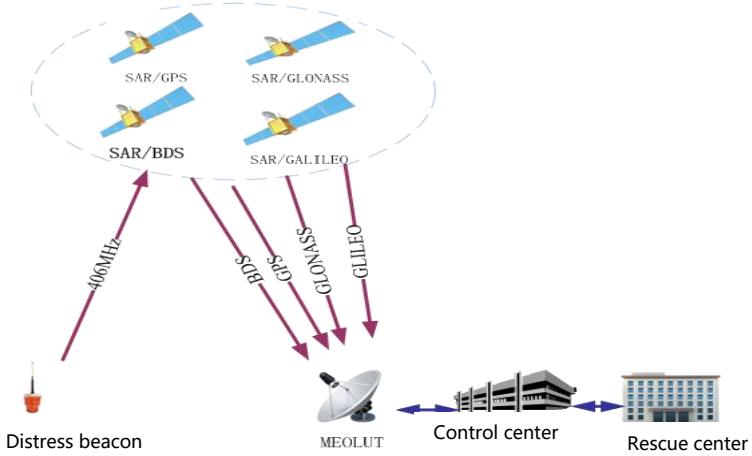


- **Satellites: 14 MEO Satellites**
- **Method: Global Random Access**
- **Maximum length of a single message: 560 bits (40 Chinese characters per message)**

Performance Characteristics	Performance Specification
Service Capability	Uplink 300,000 times/hour Downlink 200,000 times/hour
Service Success Rate	≥95%

01 System Status

4.3 Search And Rescue (SAR)

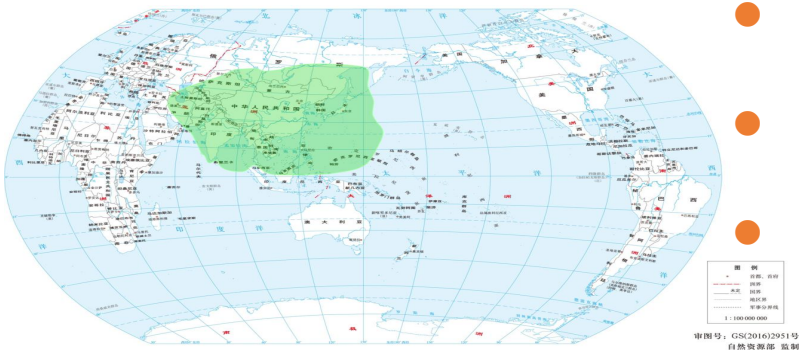


- **Satellites: 6 MEO&SAR Payloads**
- **Standard: COSPAS-SARSAT**
- **Characteristics: Return Link Service**

Performance Characteristics	Performance Specification
Positioning Accuracy	≤5km
Detection Probability	≥99%
Availability	≥99%
Return Link Time Delay	≤2 min
Return Link Success Rate	≥95%

01 System Status

4.4 Regional Short Message Communication (RSMC)

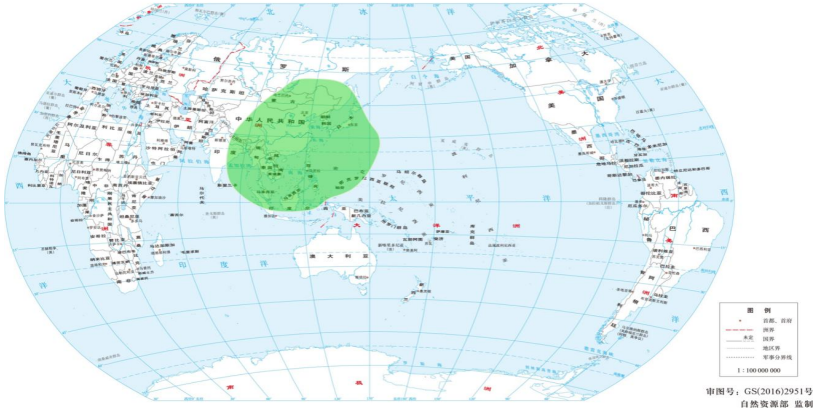


- **Satellites: 3 GEO Satellites**
- **Coverage Area: China and surrounding areas**
- **Maximum length of a single message : 14,000 bits (around 1,000 Chinese characters)**

Performance Characteristics	Performance Specification
Service Success Rate	≥95%
Service Time Delay	better than 2s on average
Service Frequency	30s per time
Capability per Message	≤14000 bits

01 System Status

4.5 Precise Point Positioning (PPP)

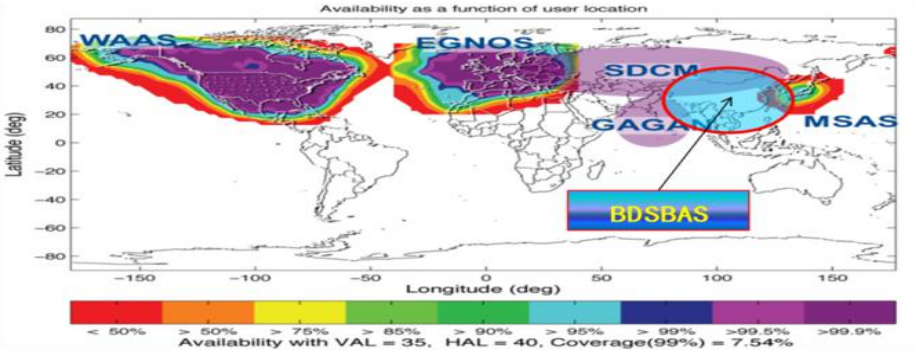


- **Satellites: 3 GEO Satellites**
- **Coverage Area: China and surrounding areas**
- **Accuracy: decimeter (dynamic), centimeter (static)**

Constellation	Performance Characteristics	Performance Specification	
BDS	Accuracy (95%)	Horizontal	≤0.3m
	Accuracy (95%)	Vertical	≤0.6m
	Convergence Time	≤30 min	
BDS+GPS	Accuracy (95%)	Horizontal	≤0.2m
	Accuracy (95%)	Vertical	≤0.4m
	Convergence Time	≤20 min	

01 System Status

4.6 Satellite-Based Augmentation System (SBAS)



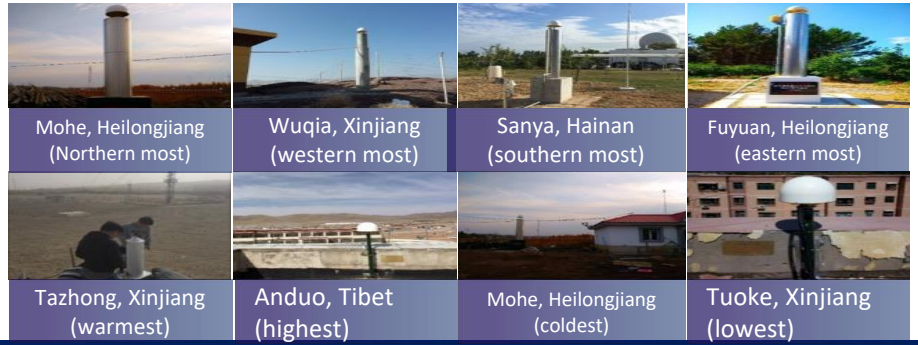
- **Satellites: 3 GEO Satellites**
- **Standard: ICAO**
- **Coverage Area: China and surrounding areas**
- **Services Mode: Single-Frequency or Dual Frequency Multi-Constellation**

Performance Characteristics	Performance Specification
Dual-Frequency Positioning Accuracy for Civil Use (95%)	Horizontal 1m Vertical 1.5m
Warning Time	Single Frequency for Civil Use 10s Dual Frequency for Civil Use 6s
Integrity Risk	$2x10^{-7}$/150s
Continuity	$1-8x10^{-6}$/15s(99.992%)
Avaliability	99%

01 System Status

4.7 Ground-Based Augmentation System (GAS)

- **Service is provided through mobile communication networks or the Internet, with positioning accuracy at meter, decimeter, centimeter and millimeter levels**



Dual-Frequency Static Post-Processing Service	Performance Specification
Horizontal Positioning Accuracy (RMS)	≤5mm+1mmx10^{-6}xD D means baseline length.
Vertical Positioning Accuracy (RMS)	≤10mm+2mmx10^{-6}xD D means baseline length.
Relative positioning accuracy of repeated baseline length measurements	better than 3X10^{-8}

01 System Status

5. Information Dissemination

- **The latest released documents of Open Service Performance Standard, Signal In Space Interface Control Document are shown as followings.**
- **More information is available at: en.beidou.gov.cn**

Document	Date
BeiDou Navigation Satellite System Open Service Performance Standard (Version 3.0)	2021.05
BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B2b (Version 1.0)	2020.08
BeiDou Navigation Satellite System Signal In Space Interface Control Document Precise Point Positioning Service Signal PPP-B2b (Version 1.0)	2020.08
BeiDou Navigation Satellite System Signal In Space Interface Control Document Satellite Based Augmentation System Service Signal BDSBAS-B1C (Version 1.0)	2020.08
BeiDou Navigation Satellite System Signal In Space Interface Control Document Search and Rescue Service (Version 1.0)	2020.08
BeiDou Navigation Satellite System Ground-based Augmentation Service Interface Control Segment	2020.08
Development of the BeiDou Navigation Satellite Syste (Version 4.0)	2019.12
The Application Service Architecture of BeiDou Navigation Satellite System	2019.12

02

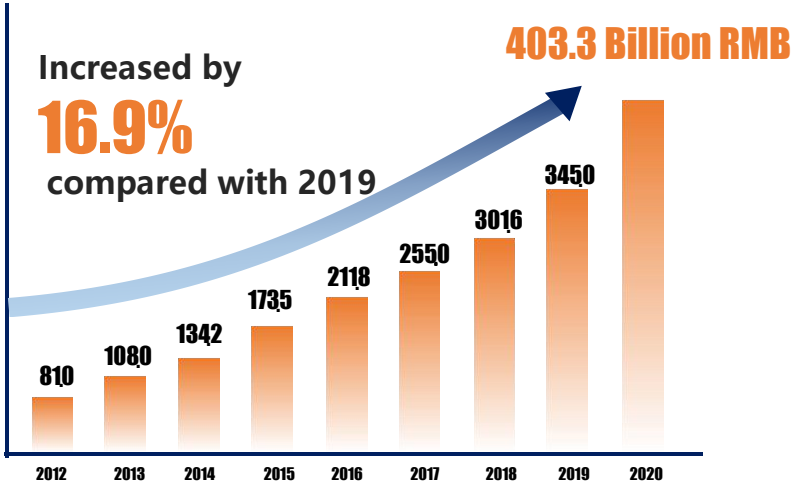
Application Promotion

02 Application Promotion

1. Domestic output value of satellite navigation and location-based service industries reached 403.3 billion RMB.

2020

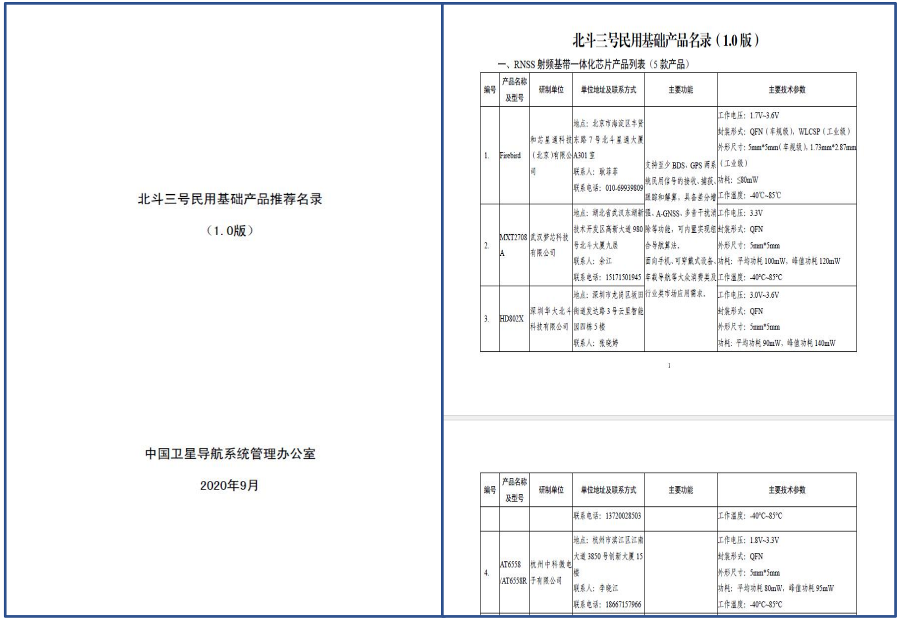
Domestic output value of satellite navigation and location-based service industries:



02 Application Promotion

2. Information Dissemination

The Official documents, such as *Recommendation List of Basic Products for Civil Use, Applications of the BeiDou Navigation Satellite System* are available at www.beidou.gov.cn



北斗三号民用基础产品推荐名录

（1.0版）

中国卫星导航系统管理办公室

2020年9月

北斗三号民用基础产品名录（1.0版）

一、RNSS 射频基带一体化芯片产品列表（5 款产品）

编号	产品名称及型号	研制单位	单位地址及联系方式	主要功能	主要技术参数
1.	Firebird	和芯星通科技（北京）有限公司	地点：北京市海淀区丰贤东路 7 号北斗星通大厦 A301 室 联系人：耿菲菲 联系电话：010-69939809	支持至少 BDS、GPS 两系统民用信号的接收、捕获、跟踪和解算，具备差分增强、A-GNSS、多音干扰消除等功能，可内置实现组合导航算法。 面向手机、可穿戴式设备、车载导航等大众消费类及行业类市场应用需求。	工作电压：1.7V~3.6V 封装形式：QFN（车规级），WLCSP（工业级） 外形尺寸：5mm*5mm（车规级），1.73mm*2.87mm（工业级） 功耗：≤80mW 工作温度：-40℃~85℃
2.	MXT2708A	武汉梦芯科技有限公司	地点：湖北省武汉东湖新技术开发区高新大道 980 号北斗大厦九层 联系人：余江 联系电话：15171501945		工作电压：3.3V 封装形式：QFN 外形尺寸：5mm*5mm 功耗：平均功耗 100mW，峰值功耗 120mW 工作温度：-40°C~85°C
3.	HD802X	深圳华大北斗科技有限公司	地点：深圳市龙岗区坂田街道发达路 3 号云里智能园四栋 5 楼 联系人：张晓婷		工作电压：3.0V~3.6V 封装形式：QFN 外形尺寸：5mm*5mm 功耗：平均功耗 90mW，峰值功耗 140mW

1

编号	产品名称及型号	研制单位	单位地址及联系方式	主要功能	主要技术参数
			联系电话：13720028503		工作温度：-40°C~85°C
4.	AT6558/AT6558R	杭州中科微电子有限公司	地点：杭州市滨江区江南大道 3850 号创新大厦 15 楼 联系人：李晓江 联系电话：18667157966		工作电压：1.8V~3.3V 封装形式：QFN 外形尺寸：5mm*5mm 功耗：平均功耗 80mW，峰值功耗 95mW 工作温度：-40°C~85°C

02 Application Promotion

3. Estabilshment of Complete Industrial Chain & Breakthroughs in Basic Products

The sales volume of domestic BDS navigation chips and modules reached 100 Million

Terminals with BDS positioning function

1 Billion+

The increase of shipments of domestic centimeter-level high-precision chips, modules and boards

1 Million+

02 Application Promotion

4. Entry into Mass Market, Sharing Economy and People's Livelihood

79% smart phones sold in China in the Q1 of 2021 supported BDS positioning function

Domestic smart phone supporting BDS high precision positioning function launched

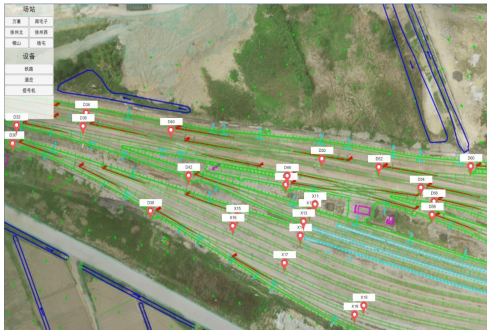
Meter-level positioning is available based on BDS ground-based augmentation service signal

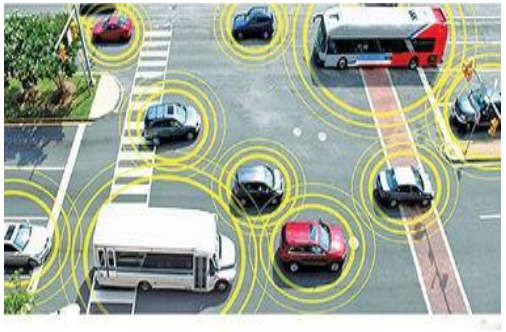
02 Application Promotion

5. BDS Improves the Level of Traffic Informatization

- A large dynamic monitoring and management system for operating vehicles has been built
- 7 million operating vehicles
- 36,300 postal and express delivery vehicles
- 1,400 official vessels
- 350 Common Aero Vehicles

Incidence of severe traffic accident decreased by 93%





02 Application Promotion

6. BDS Serves Smart and Precision Agriculture

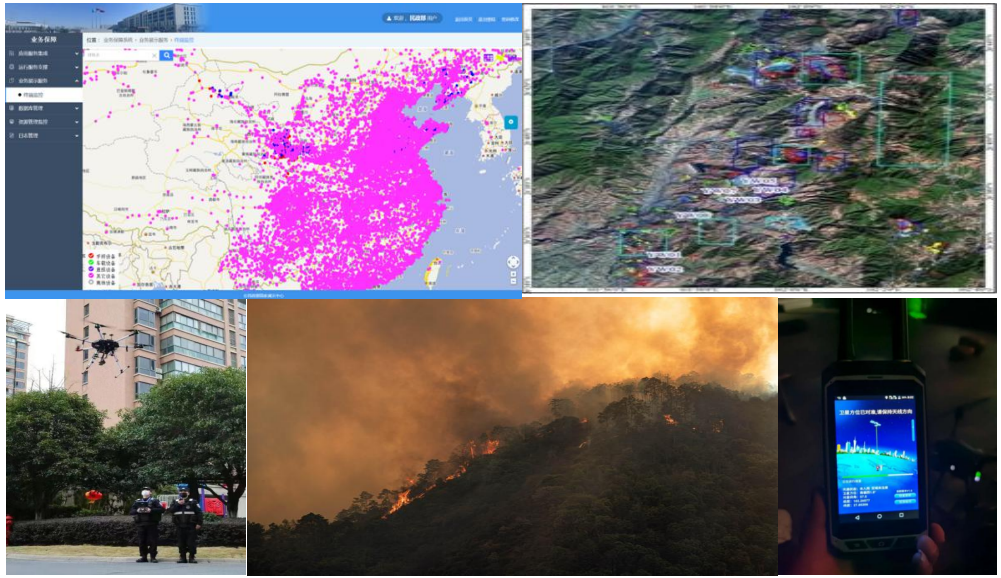
- **Over 45,000 sets of agricultural machinery are equipped with BDS-based autonomous-driving systems**
- **More than 400,000 sets of agricultural machinery support BDS agricultural working monitoring platform and IoT platform**
- **70,000 vessels are served by BDS**

Labor cost cut by 50%

02 Application Promotion

7. BDS Protects the Safety of People's Lives and Property

- 3-level of disaster relief management platform is built
- Over 45,000 BDS-based terminals and equipment are deployed
- BDS-based high-precision geological disaster monitoring and alert system has been built



The capabilities of disaster and emergency relief, quick response, and coordinated command has been enhanced. Geological disasters have been successfully forecast for many times

02 Application Promotion

8. BDS Promotes the Intelligent Health Services and Epidemic Prevention

- Travel record monitoring
- Epidemic prevention
- Tele Medicine
- Smart old-age insurance
- Personal health management
- Material distribution
- Precise disinfection through UAV

Real time data and decision support have been provided

02 Application Promotion

9. BDS Enables Precise Digital Construction

- **Emergency communication for field construction**
- **Precise construction and machinery control**
- **BDS+BIM visual management on construction**
- **Monitoring, dispatch, and management of workers, equipment, and vehicles**
- **Security monitoring of construction environment**

Quality and efficiency has been improved

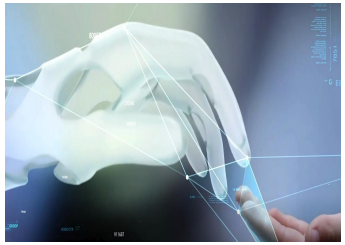
Labor and material costs has been reduced

Security has been enhanced

02 Application Promotion

10. More Diversified Application Mode

BDS & Technologies



BDS & Terminals

BDS & Platforms

BDS & Data

BDS & Services

BDS+5G→More Mature Fusion of Communication & Navigation

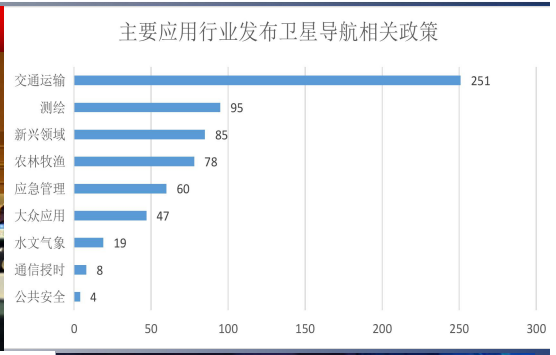
02 Application Promotion

11. BDS Provides Good Services for Global Users

BDS-based products have been exported to and used in more than 120 countries and regions. BDS has been widely used in ASEAN, Southern Asia, Eastern Europe, Western Asia, Africa in land ownership confirmation, precision agriculture, intelligent port management, etc., promoting local economic and social development.

02 Application Promotion

12. Reinforce the BDS Policies and Regulations



2016年，成立了由中央、国家、军队20多个有关部门组成的条例起草工作组，**北斗系统杨长风总设计师任组长**，并召开起草工作组会议对起草工作进行全面部署。会议强调，条例是国家立法，是我国第一部卫星导航基本法规，对于确立北斗系统作为国家基础设施法律地位，建设一流世界卫星导航系统

中华人民共和国国民经济和社会发展
第十四个五年规划和2035年远景目标纲要

第九章　发展壮大战略性新兴产业
第一节　构筑产业体系新支柱
深化北斗系统推广应用，推动北斗产业高质量发展。

第十四章　加快培育完整内需体系
第二节　拓展投资空间
面向服务国家重大战略，实施川藏铁路、西部陆海新通道、国家水网、雅鲁藏布江下游水电开发、星际探测、北斗产业化等重大工程，推进重大科研设施、重大生态系统保护修复、公共卫生应急保障、重大引调水、防洪减灾、送电输气、沿边沿江沿海交通等一批强基础、增功能、利长远的重大项目建设。

北斗卫星导航系统法治建设报告

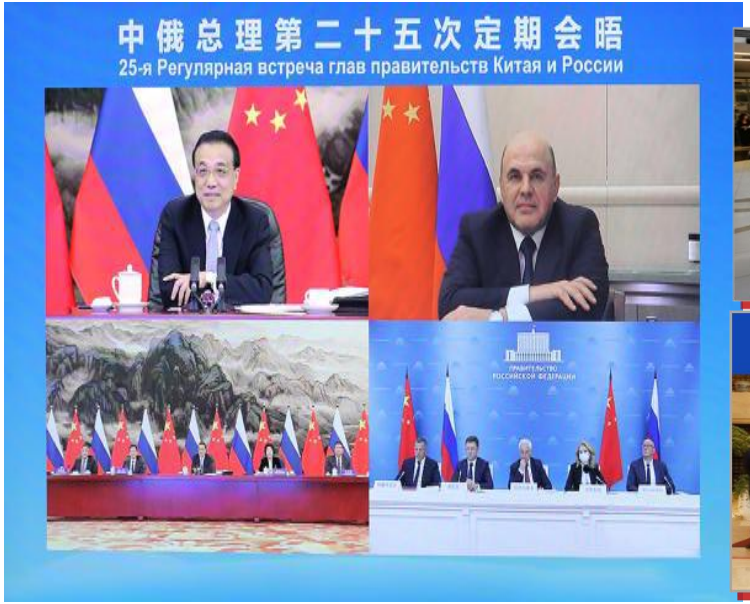
中国卫星导航系统管理办公室
二〇二一年五月

03

International Cooperation

03 International Cooperation

1. Compatibility and Openness to Provide Better Service (China - Russia)



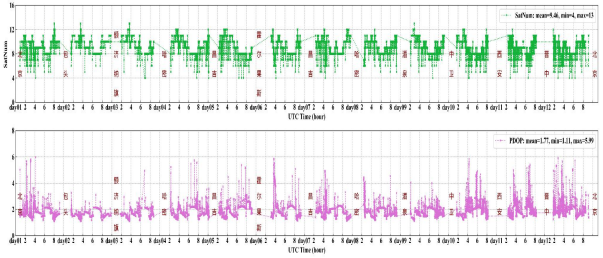


Figure 7 Number of BDS visible satellites and PDOP at B1C/B2a frequency point in Test

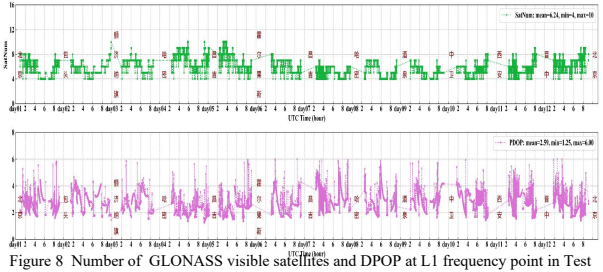


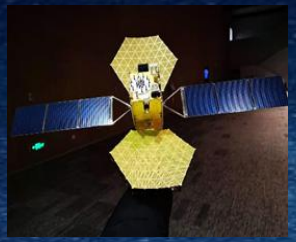
Figure 8 Number of GLONASS visible satellites and DPOP at L1 frequency point in Test

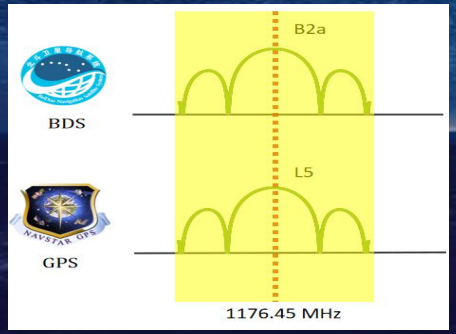
Cooperation in joint test, station construction, and precision agriculture under the China-Russia Satellite Navigation Key Strategic Cooperation Project Committee

03 International Cooperation

2. Compatibility and Openness to Provide Better Service (China – U.S.)

PRN130
PRN143
PRN144





L1 C/A PRN Code Number	C/A			System (Satellite)	Orbital Slot	Effective Through	Assignment Type
	G2 Delay (chips)	Initial G2 Setting (Octal)	First 10 Chips (Octal)				
130	355	0341	1436	BDSBAS (GEO-1)	140E	Aug 2030	Final
143	307	1312	0465	BDSBAS (GEO-3)	110.5E	Aug 2030	Final
144	127	1060	0717	BDSBAS (GEO-2)	80E	Aug 2030	Final

L5 PRN Code Number	XB Code Advance (Chips)		Initial XB Code State (Octal)		System (Satellite)	Orbital Slot	Effective Through	Assignment Type
	I5	Q5	I5	Q5				
130	1224	1092	17754	12737	BDSBAS (GEO-1)	140E	Aug 2030	Final
143	3745	8126	05474	15167	BDSBAS (GEO-3)	110.5E	Aug 2030	Final
144	4723	7017	02275	16761	BDSBAS (GEO-2)	80E	Aug 2030	Final

Fostered the cooperation in compatibility and interoperability, SBAS, and civil use industries

03 International Cooperation

3. Compatibility and Openness to Provide Better Service

Virtual Signing Ceremony of MoU between CSNO and CONAE

CSNO and CONAE has built a kind of normal cooperation mechanism in satellite and navigation, and will carry out cooperation in joint applications, test and assessment, education and training, etc., to accelerate economic and social development in Argentina.

03 International Cooperation

4. Joint Discussion, Construction and Sharing with The Belt and Road countries

3rd China-Arab States BDS Cooperation Forum
Nov. 2, 2021

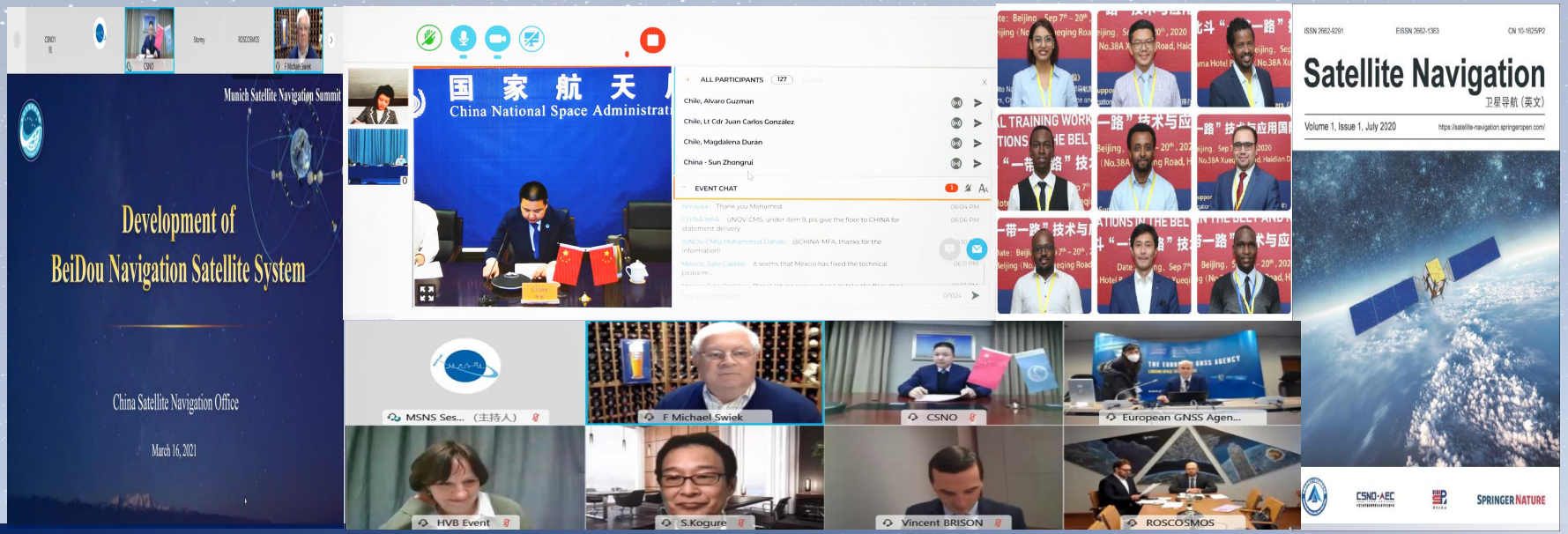
2nd China-Central Asia BDS Cooperation Forum
Oct. 13, 2021

1st China-Africa BDS Cooperation Forum
Nov. 5, 2021

EXPO 2020 Dubai BeiDou Showcase
Oct. 2, 2021

03 International Cooperation

5. Chinese Wisdom and Contribution through Multilateral Exchanges



Communicated with other GNSS providers technically, and issued updates on BDS in multilateral academic platforms such as Munich Satellite Navigation Summit, Scientific and Technical Subcommittee, UNOOSA, etc.

03 International Cooperation

6. Ratification by International Standards

3GPP™ A GLOBAL INITIATIVE

IEC International Electrotechnical Commission

COSPAS-SARSAT.INT
INTERNATIONAL SATELLITE SYSTEM FOR SEARCH AND RESCUE
406™ DISTRESS ALERTING SERVICE
COSPAS SARSAT

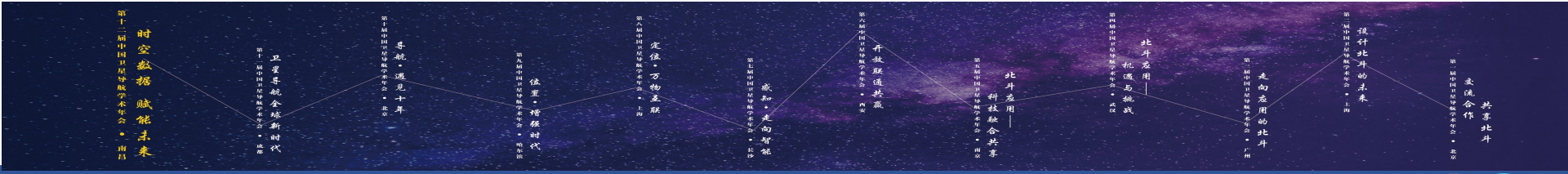
IMO

ICAO • OACI • ИКАО
国际民航组织 • ايكاو

RTCM RTCM

03 International Cooperation

7. Host of China Satellite Navigation Conference and Extensive Exchanges



04

Future Plans

04 Future Plans

1. A Comprehensive PNT System will be Established with BDS as the Core

Systematization = Focus on Core Competencies + Reconstruct Industrial Structure + Fuse Various Abilities

Quantity (subtraction) + Efficiency (Addition & multiplication)

04 Future Plans

2. Adoption of Standardized Solutions to Meet Common Needs

- Positioning precision at decimeter level
- Global integrity services

Satellite Navigation

- Navigation and communication empowers each other
- Communication accessible areas are navigable

Communi cation

- Acquire PNT information autonomously

Micro autonomous PNT

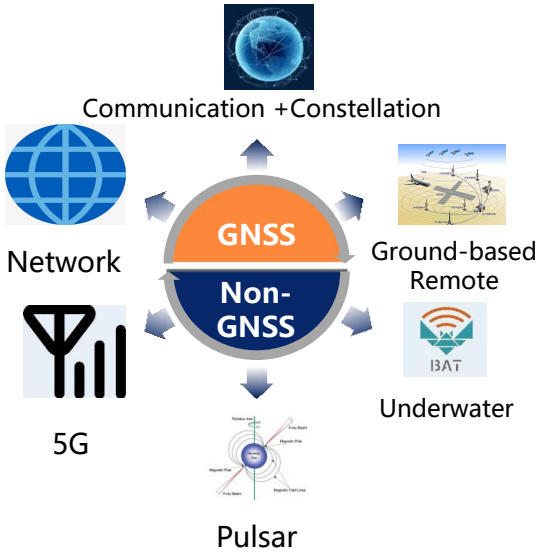
Deeply Integration

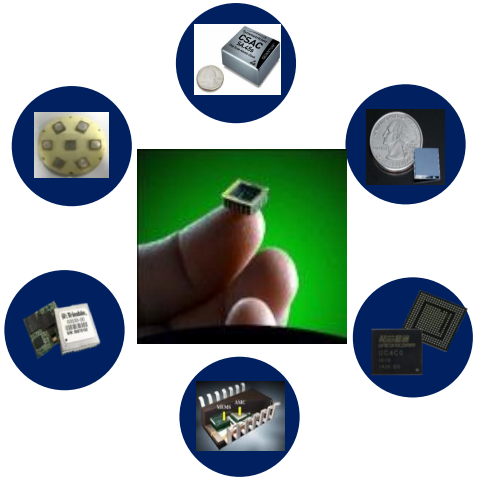
- High Accuracy
- High Availability
- High Continuity
- Low cost

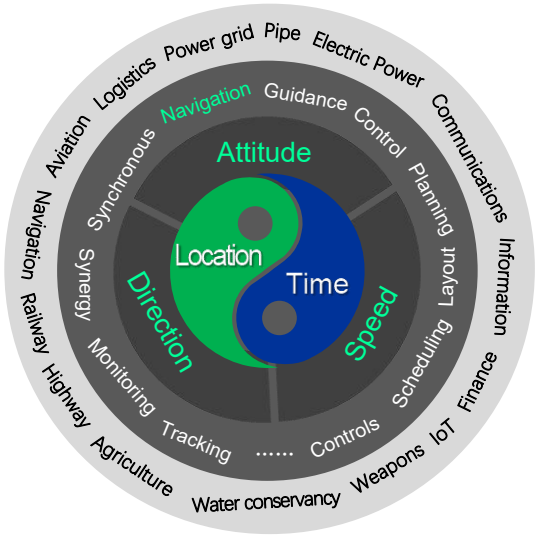
04 Future Plans

3. Breakthrough of the PNT Capacity Generation Chain

Supply Side: Enable(easy to use) | **Demand Side/Industrial Chain** | **Demand Side: Value(good use)**







04 Future Plans

4. Full Support for the Future Development

Unified Reference

Unified traceability of spatial-temporal reference

Global Coverage

From abysmal sea to deep space, open space to indoor space

High Accuracy

Positioning precision at decimeter level at global surface & near-earth space

High Security

Secure and trusted PNT services

High Intelligence

Intelligent management, operation and maintenance of infrastructure

Use resources intelligently

High Benefits

The integration and sharing of infrastructure reduces the cost of construction, maintenance and use

Realize the unification of high precision and high availability based on low cost handheld terminal


Thanks for your continuous attention
and support to the BDS development.
http://en.beidou.gov.cn