Development of BeiDou Navigation Satellite System (BDS) – A System Update Report (2016-2017)

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中国卫星导航系统管理办公室

1 System Development

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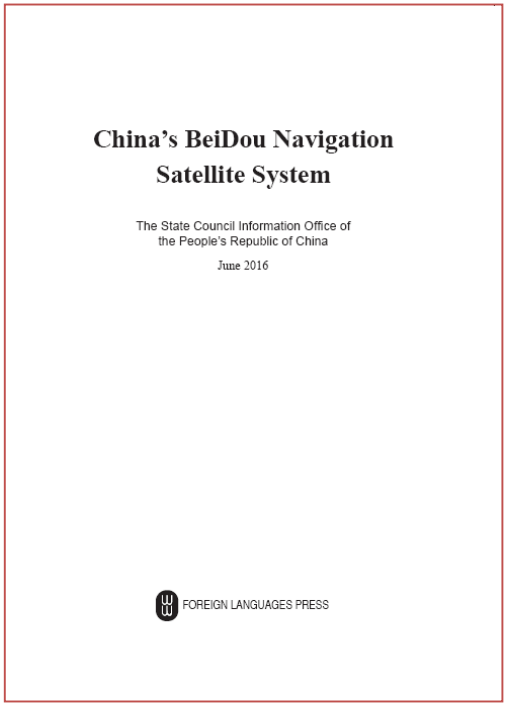
The BDS White Paper

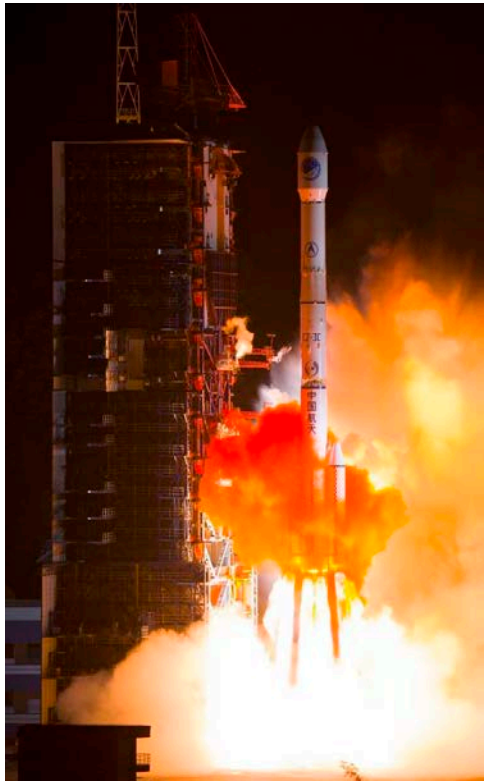
In June 2016, the Chinese government officially published a BDS White Paper, explaining the development concepts and policies:

- Provide open services free of charge for users
- Maintain and perfect the system constantly, improve service performance continuously, and offer services with higher quality
- Release open service performance specifications on schedule, bring the function of government and market to full play, promote innovation, popularization and internationalization of BDS/GNSS applications, and lay foundation for the national strategic emerging industries
- Adhere to the concept of development and win -win cooperation, realize compatibility and interoperability between BDS and other GNSS, give the system efficiency into full play and increase users' benefits



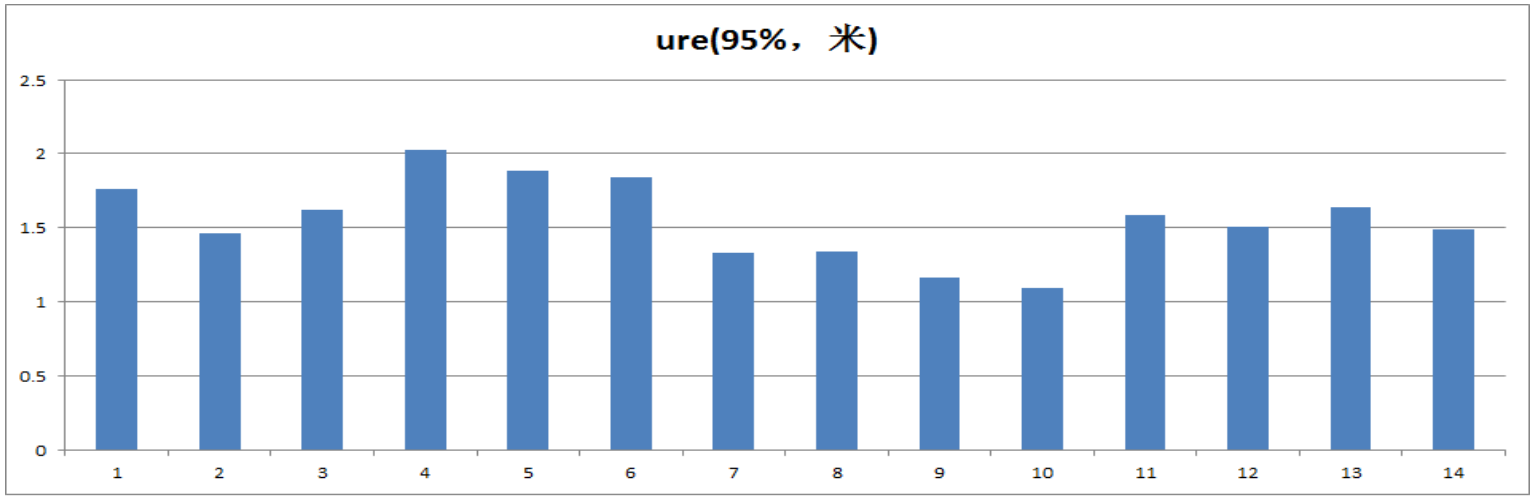
Steady Improvement of the BD-2 System Performance

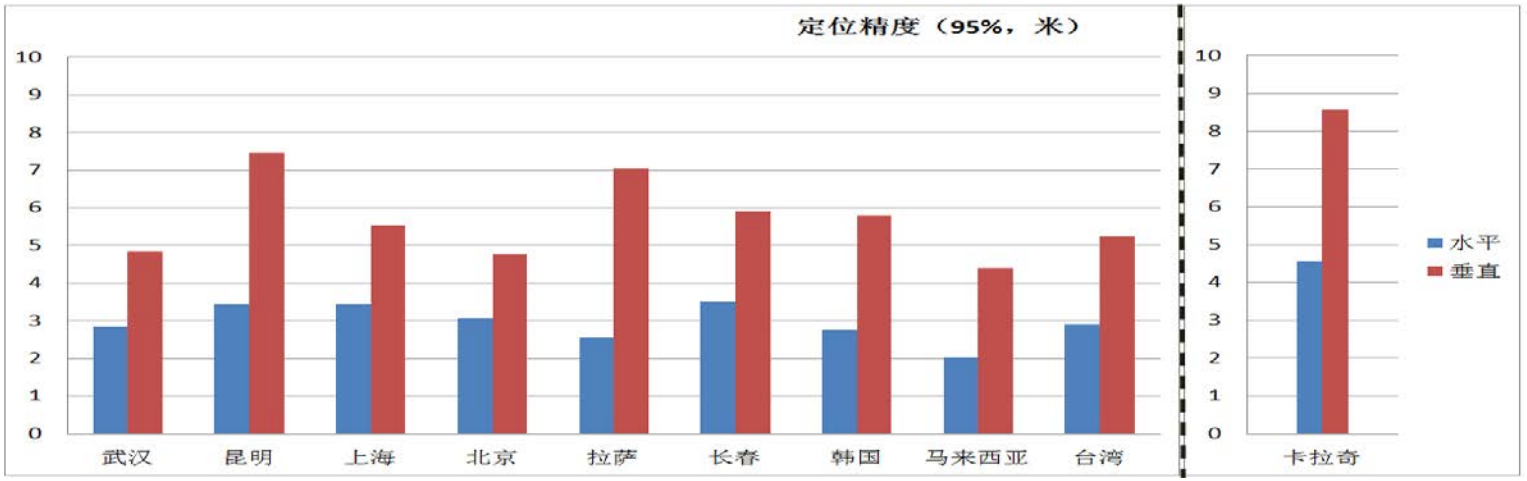
- To ensure steady operation of the BD-2 system, two additional on-orbit backup satellites have been launched in 2016.
- The steady operation of 13 on-orbit satellites improves the stability and availability of the BD-2 system constellation.



Steady Improvement of the BD-2 System Performance

- The nominal positioning accuracy in the BD-2 coverage area has been optimized from 10 meters to 8 meters.





Steady Improvement of the BD-2 System Performance

- Conduct service-improvement work and complete the annual tasks of upgrading and reconstruction of the ground system.

- To achieve user-oriented services, the updated interface control document (version 2.1) has been released in accordance with the constellation change.


北斗卫星导航系统

空间信号接口控制文件

公开服务信号（2.1 版）

中国卫星导航系统管理办公室

二〇一六年十一月

Steady Improvement of the BD-2 System Performance

- On January 9, 2017, the BD-2 Project won the top national scientific and technological progress award, initiating several innovative attempts in both fields of global satellite navigation and domestic aerospace .

- The BD-2 Project forms a unique development path of the satellite navigation system based on the state conditions.

Development of the BD-3 System

- Completed the tests and verifications of five BD-3 satellites in 2015 and 2016, achieved breakthroughs on the core system technologies in a comprehensive approach. The status of the BD-3 satellites has been solidified.

- The BD-3 satellites will be equipped with the B1C interoperable signal with optimized performance, while the B2I signal will be gradually upgraded to B2a.

- Further enhancement of the basic services, such as Satellite-Based Augmentation System (SBAS) and Search and Rescue(SAR) services will be developed according to international standards.

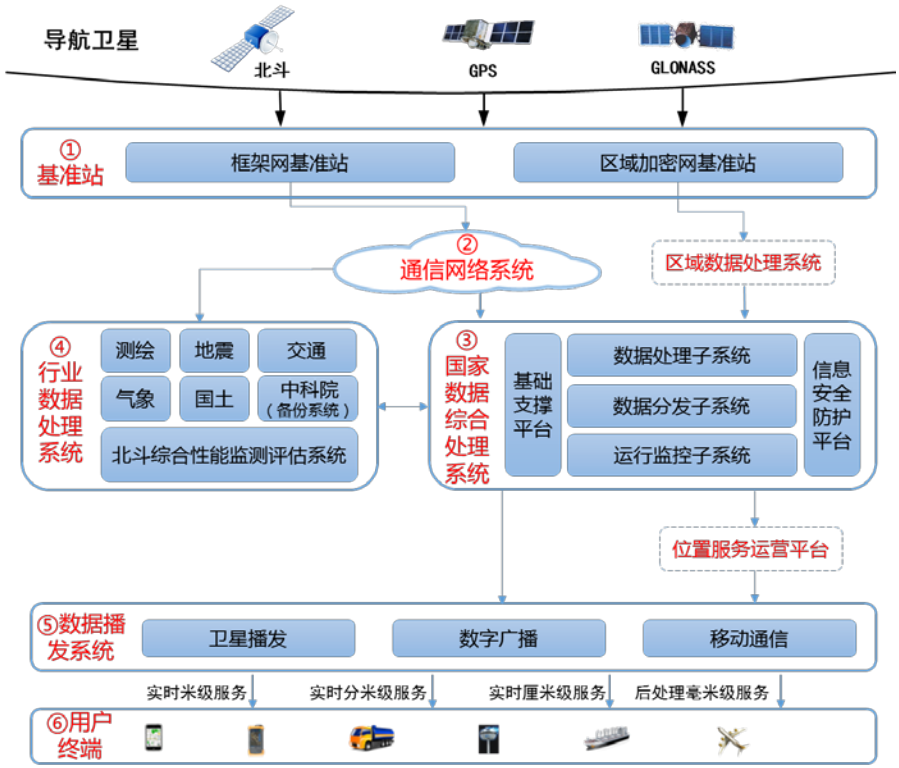
- Meanwhile, BD-3 will adopt the higher-performance rubidium atomic clock with stability of E^{-14} and hydrogen atomic clock with stability of E^{-15}. By utilizing new technologies, BD-3 satellite performance will be tremendously improved with better signal-in-space (SIS) accuracy superior to 0.5m.

Development of the BD-3 System

- On September 5, 2017, the Interface Control Document for B1C and B2a (Beta version) was released.
- Various related system documents will be released soon.

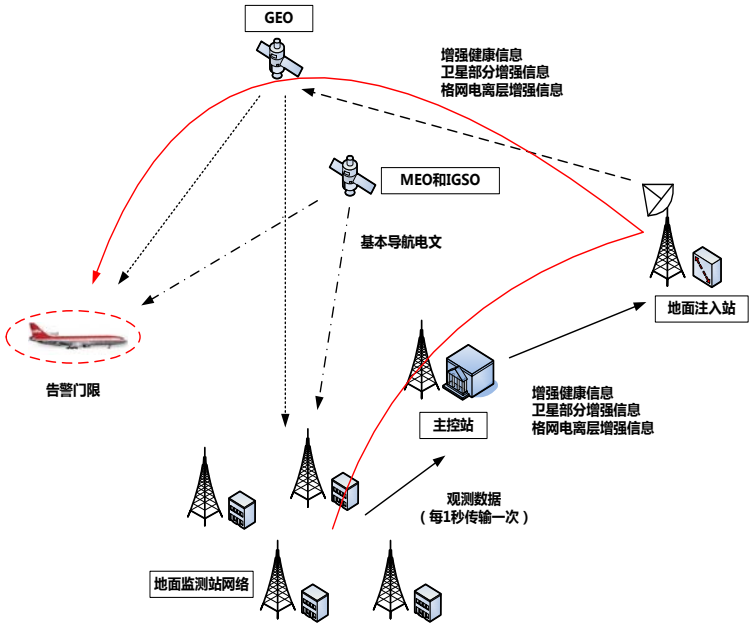
BDS/GNSS Ground-based Augmentation System

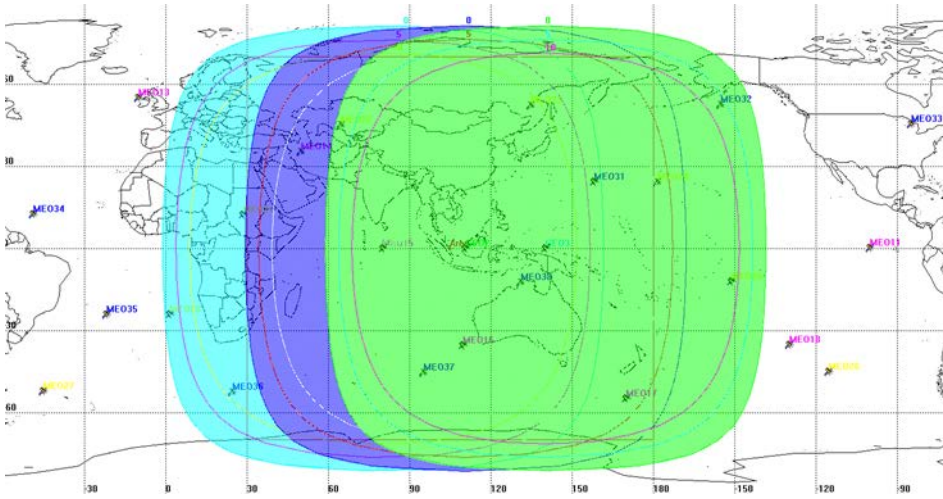
- Complete the Phase I construction of the BDS/GNSS National Differential Network – NDBDS.
  - 150 framework reference stations
  - 1200 reference stations of higher-density network
  - national data processing center
  - 6 industrial data processing center
  - user terminal etc.
- Possess the basic service capability.
- The service performance standard and the interface control documents will be released.
- NDBDS is committed to offer the meter-level and sub-meter level high-accuracy positioning services.



BDS Satellite-based Augmentation System (BDSBAS)

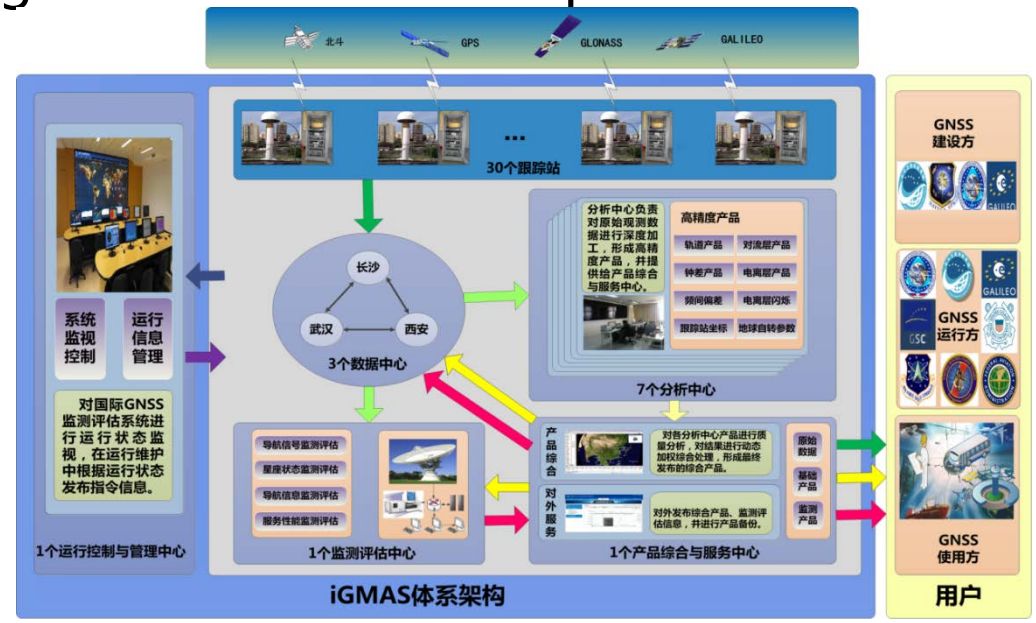
- Carry out the design, test and construction of the BeiDou Satellite-based Augmentation System(BDSBAS) based on the ICAO standards.
- Currently, system demonstration and validation work has been completed. It solidifies the technical status of the system in accordance of the next-generation SBAS Dual Frequency Multiple Constellation(DFMC) standards.
- BDSBAS will be providing both SF and DF services offered by 3 BDS GEO satellites and BDSBAS B1C and B2a signals.





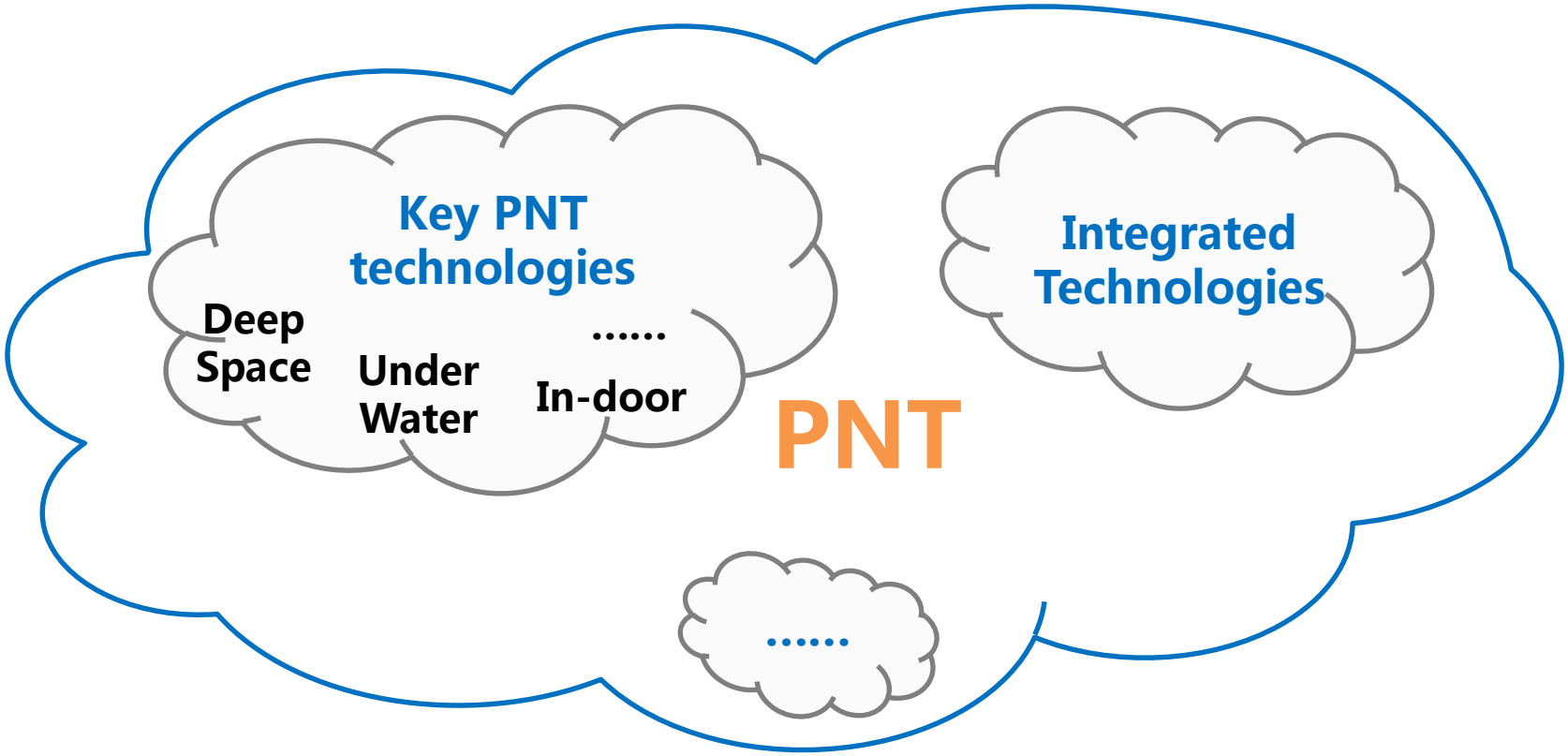
The international GNSS Monitoring & Assessment System (iGMAS)

- 8 domestic monitoring stations, 15 foreign monitoring stations have been built, with the monitoring and assessment capability of GPS, GLONASS, BDS and Galileo.
- The iGMAS plays an important role in steady operation of BD-2, as well as the development of BD-3.
- The iGMAS has been substantially advanced in APSCO, IGMA-IGS joint experimental project, Sino-Russian monitoring and assessment cooperation.



Development of a National Integrated PNT System

- Advanced research has been conducted on the national integrated PNT(Positioning, Navigation and Timing) system to develop key technologies and integrated technologies on positioning, navigation, and timing services in deep spaces, in-door spaces and underwater spaces.

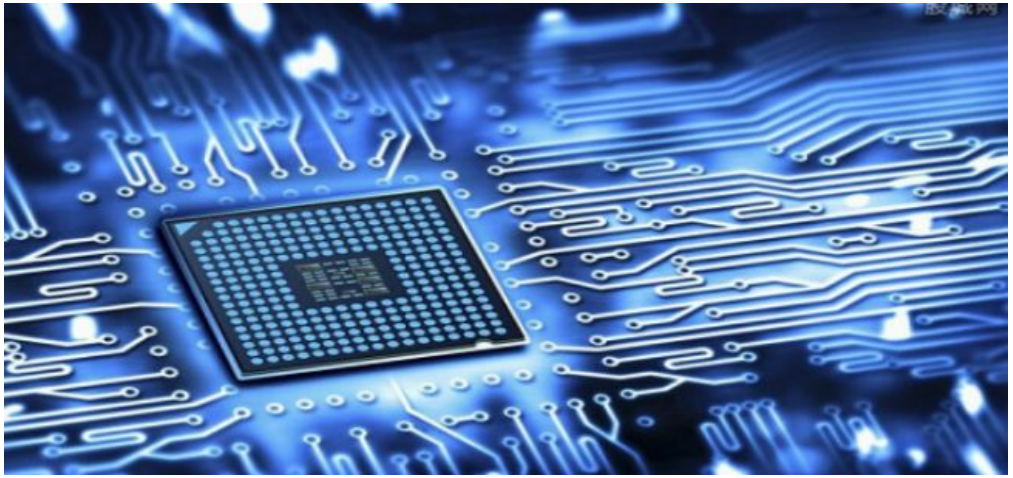


Development of a National Integrated PNT System

- XPNAV-1 has been successfully launched and several on-orbit experiments such as the Crab Pulsar observations have been carried out.
- The data obtained from the Pulsar observations has been published at official website (www.BeiDou.gov.cn/xpnavdata.rar) for public research and academic exchange as well as enhancing the development of Pulsar navigation technology.

Fundamental Products Provide Tailored Services

- Independent, self-controlled intellectual property rights on the fundamental BDS products have been achieved. World-class, advanced technologies have been developed.
- By the joint ecological cooperation of industrial giants and searching for the industrial and user needs, BDS has presented the advantages on products and services. With the release of the first Chinese in-house developed “meter-level fast positioning BeiDou chip”, BDS applications start to embrace the era of meter-level positioning.



Fundamental Products Provide Tailored Services

- By April 2017, the sales volume of BDS navigation chips and modules has exceeded 30 million pieces, and that of high-precision surveying boards and navigation antenna take 30% and 90% of market shares respectively.
- The products have accessed to the markets of over 70 countries and regions, over 30 of which are along the Belt and Road.

Industrial/Regional Demonstration Projects

- Jointly promoted by Cyberspace Administration of China, National Development and Reform Commission, Ministry of Science and Technology, Ministry of Industry and Information Technology, since 2016, BDS applications have made achievements and progressively enhanced in a spectrum of industries and fields such as agriculture, forestry, fishery, police equipment and disaster prevention and relief.

Industrial/Regional Demonstration Projects

- Regional demonstration project - “Demonstration on Satellite Navigation Applications in Yangtze River Delta” has been smoothly examined, which contributes to the development of Smart City and industrial cultivation in Shanghai.

High-precision BDS Services

- With the support of BDS high-precision positioning technologies, the defects on positioning, bicycle finding, irregular parking and bicycle management can be solved. BDS makes human-bicycle interconnectivity more integrated and smarter.
  - **bluegogo**—the shared bicycle has achieved precision positioning through BeiDou technologies
  - **Mobike** has been fully compatible with three-model satellite positioning of BeiDou, GPS and GLONASS
  - **ofo** has built strategic-partner relations with BNDST Co., ltd, with the purpose of fine management of bicycles based on BeiDou Smart Lock in order to push forward the establishment of new standards of positioning technologies in bicycle-share industry.

High-precision BDS Services

- Qianxun Spatial Intelligence is a company that developed FindNow, the first acceleration auxiliary positioning system compatible with Assist-BeiDou (A-BeiDou) worldwide.

- Based on the BeiDou ground-based augmentation system, FindNow achieves centimeter-level positioning accuracy and 3 second acquisition time.
- Currently, the acceleration positioning service has been adopted by over 40 million users in over 200 countries and regions and the number of daily use reaches up to 100 million.

Satellite Navigation Industry Market Size in China

- Promoted by the initiative of mass creative business and innovation and the “The Belt and Road "strategy, BeiDou industry will embrace the period of golden opportunities.

- By 2020, the sales volume of satellite navigation industry in China will surpass RMB 400 billion, in which BDS will take RMB 240 billion to RMB 320 billion of market shares.

By 2020

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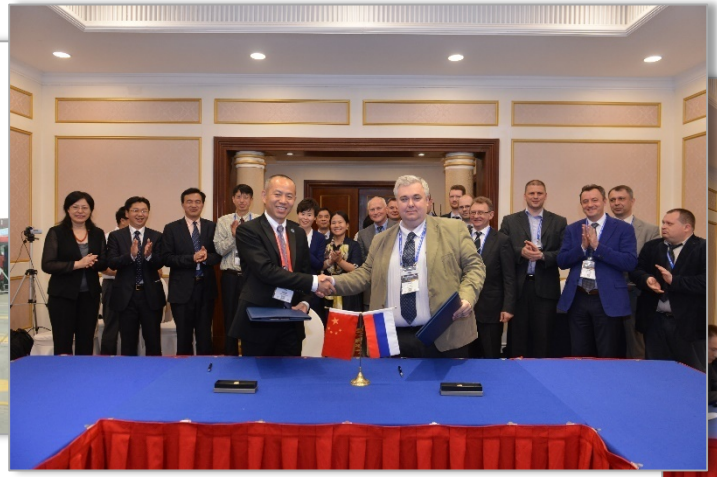
International Cooperation – Bilateral Cooperations

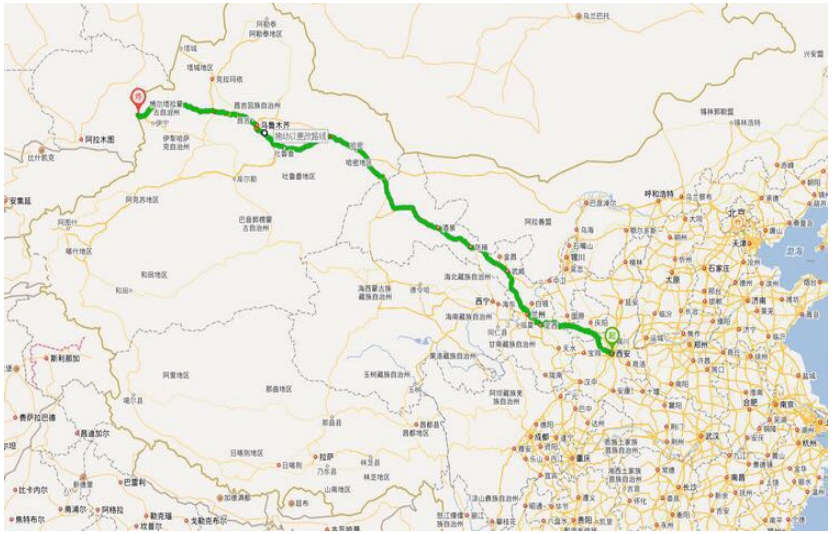
- Keep coordinating with other navigation satellite system providers in the sector of compatibility and interoperability, and provide users with high quality services.

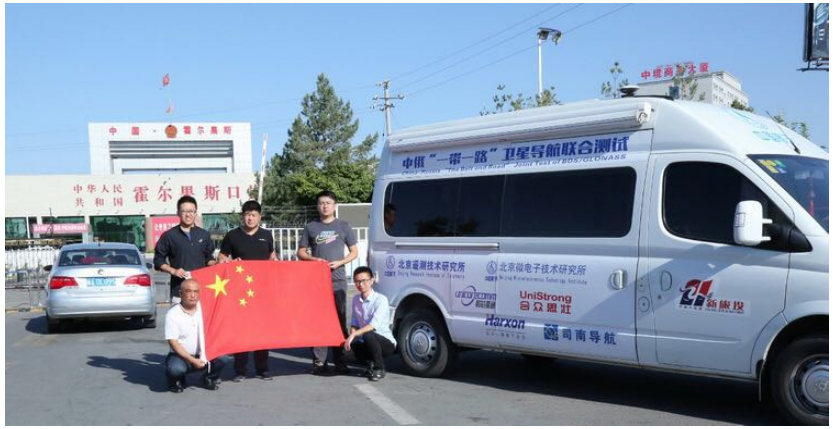
China-Russia Cooperation

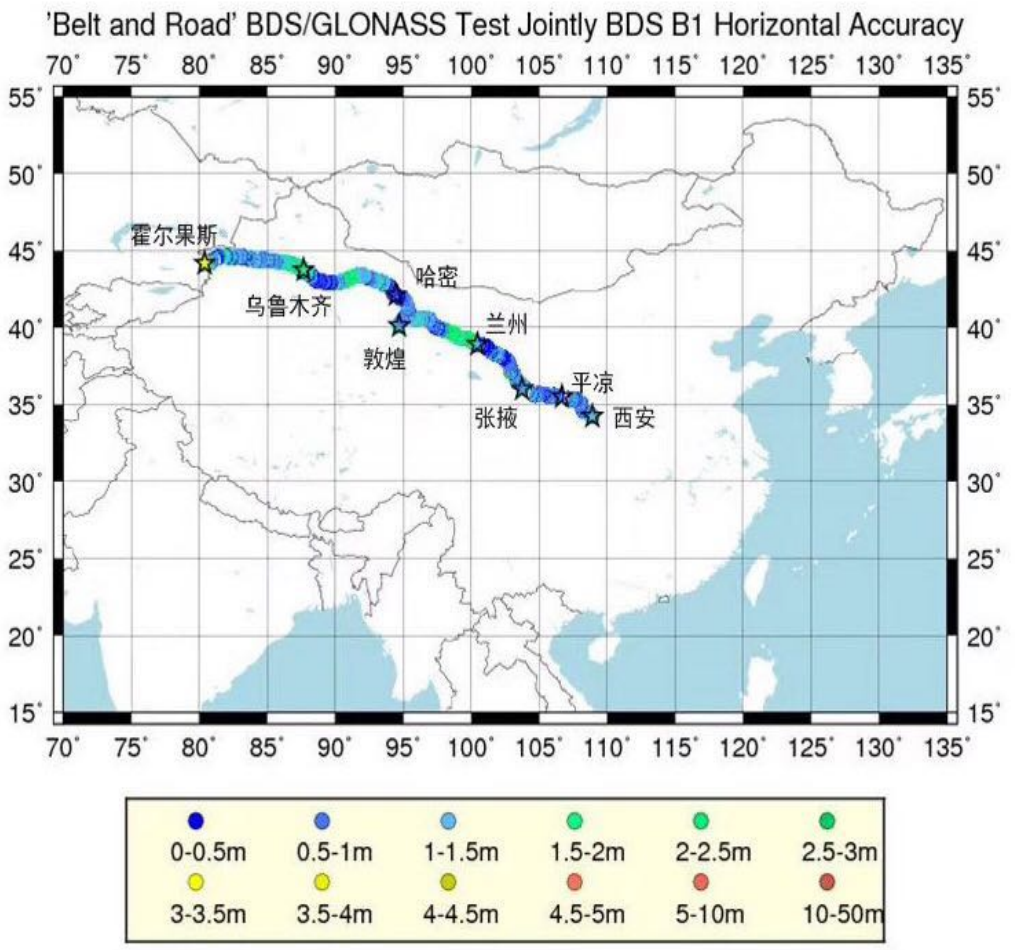


- The third meeting of the Chinese-Russian Committee on Important Projects of Strategic Cooperation in the field of Satellite Navigation has been convened in November 2016 which officially launched 7 cooperation projects including the Service Platform of Chinese-Russian Satellite Navigation Monitoring and Assessment, Joint Demonstrations on BeiDou and GLONASS-based Cross-border Transporters and Joint Design Center of Chinese-Russian Navigation Chips.
- The countries are pushing forward new cooperation on satellite-based augmentation system and education and training in the field of satellite navigation.

Belt-and-road BDS/GLONASS Joint Test (2017-7)







China-U.S. Cooperation

- Working group meetings have been convened to conduct the work on various issues of common concern.
- Promote the cooperation on system compatibility and interoperability, civil aviation applications, civil service provision, monitoring and assessment activities.

China -EU Cooperation

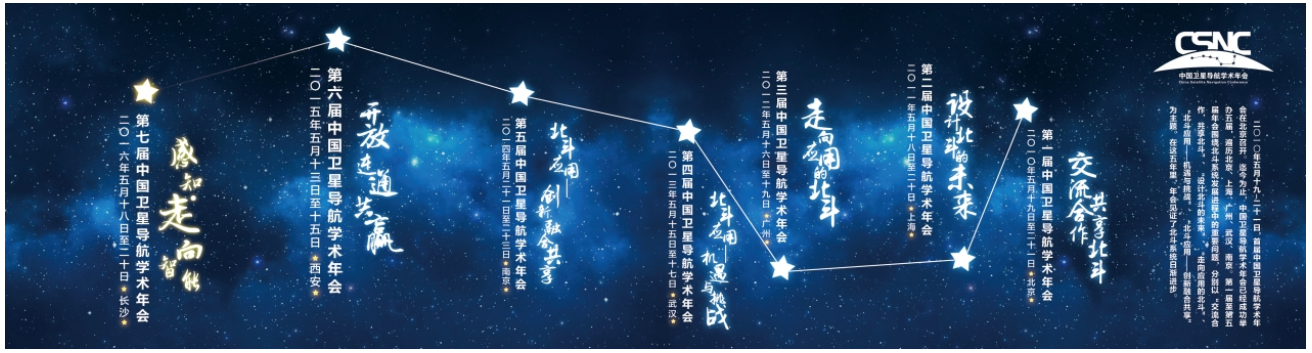
- The frequency coordination between BDS and Galileo has been completed, and the cooperation mechanism between these systems is under discussion, especially in the field of compatibility and interoperability.

Participate in International Satellite Navigation Organization Activities

- Participate in the meetings of the ICG, ITU and SBAS IWG, Munich Satellite Navigation Summit, Moscow SatNav Forum and ION conferences, to carry out technical exchanges and cooperation.

China Satellite Navigation Conference (CSNC)

- Encourage academic exchanges; the China Satellite Navigation Conference has been held for 8 sessions. It has become a most influential international academic exchange platform in China and worldwide.
  - The annual conference is dedicated to innovation which has make lots of contributions to the construction and application of satellite navigation system, PNT system and industrial development
  - The annual conference boasts distinct theme, adheres to the global scientific development trends and leads the edge of integrated development of applications on satellite navigation, mobile communication, internet, IoT and AI
  - The annual conference boasts plentiful contents including academic exchanges, exhibitions and science generalization which attract peers from all various sectors



Promote Application Cooperation

- The applications of BDS have been welcomed in overseas countries.
- Comprehensive cooperation with Pakistan, Thailand, United Arab Emirates, ASEAN, Arab League and other countries has been carried out.

Integrate BDS into the International Standardization

- Since BDS possessed legal status in international maritime applications last year, BDS has made material progress in the standards of International Maritime Organization (IMO). In March this year, the multi-system shipborne receiver standard which is compatible with GPS, BDS, GLONASS was approved; meanwhile, BDS has been included in the PNT guidelines of maritime applications.
- On the standards of international mobile communication, BDS has become one of the global satellite navigation systems approved by the international mobile communication standards. 26 international BDS standards have been formulated and the penetration of BeiDou in China' s mobile communication field has achieved 35% with support of related standards of mobile communication.

IMO

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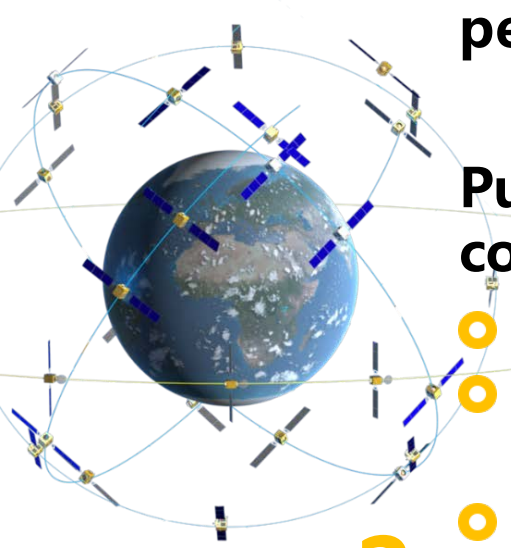
System Construction

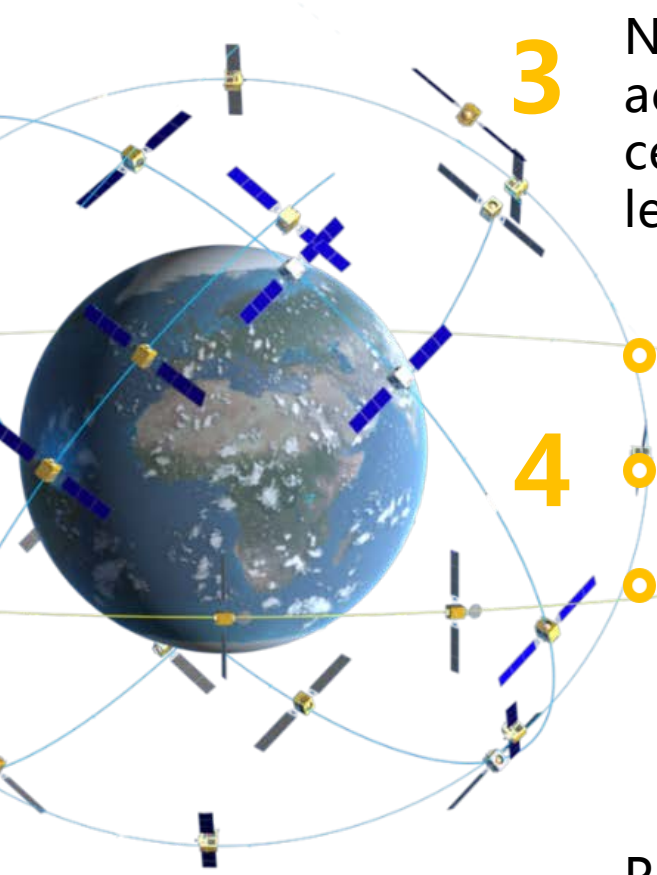
1 **Keep improving the continuous stability and service accuracy of BDS, and launch 2 BD-2 backup satellites in 2018, ensuring BDS regional service performance stable and enhancing.**



2 **Push forward the research, development and construction of the BD-3 system.**

- In 2017, it is planned to launch 4 BD-3 MEO satellites
- In 2018, about 14 BD-3 MEO satellites and 1 BD-3 GEO satellite will be launched
- From 2019 to 2020, 6 BD-3 MEO satellites, 3 BD-3 IGSO satellites and 2 BD-3 GEO satellites will be launched
- Further verify the accuracy and availability of interface documents based on the on-orbit satellite tests, and plan to publish the official version of ICD documents on B1C and B2a signals at the beginning of 2018

System Construction



3 In 2018, complete the construction of Phase II NDBDS with meter/decimeter-level positioning accuracy available to major regions nationwide, centimeter level to density regions, and millimeter level correction data for post-processing services.

4
- In 2018, the first BDSBAS GEO satellite will be under the phase of system integration and test
- In 2019, the construction of related ground-based monitoring network will be improved
- In 2020 , launching of 2 GEO satellite will be finished and initial service capability of satellite-based augmentation system covering China and the neighboring areas will take shape

5 Promote and complete the construction of the national integrated PNT system with the united benchmark, no-gap coverage, security and effectiveness by 2030.

Application Promotion

1. Carry out R&D and industrialization of new generation BDS/GNSS fundamental products, improve the core strength so as to promote the mass market applications of hundred-million units.

2. Bring GNSS in the integration procedure between industrialization and IT applications.

3. Accelerate the formulation of Regulations on Satellite Navigation of PRC.

4. Construct ecologic system for BDS applications and services; promote applications based on the convergence of the network, the collection of data, the harmonization of terminals and fund raising.

International Cooperation

1. Promote cooperation and exchanges with satellite navigation system suppliers from U.S., Russia and the Europe etc., strengthen bilateral cooperation on compatibility, interoperability, monitoring and evaluation, SBAS and applications, to name a few.

2. Continue international coordination on the global platforms such as ICG, ITU, ICAO and IMO, to push forward the BDS globalization and fulfill the responsibilities of a global power.

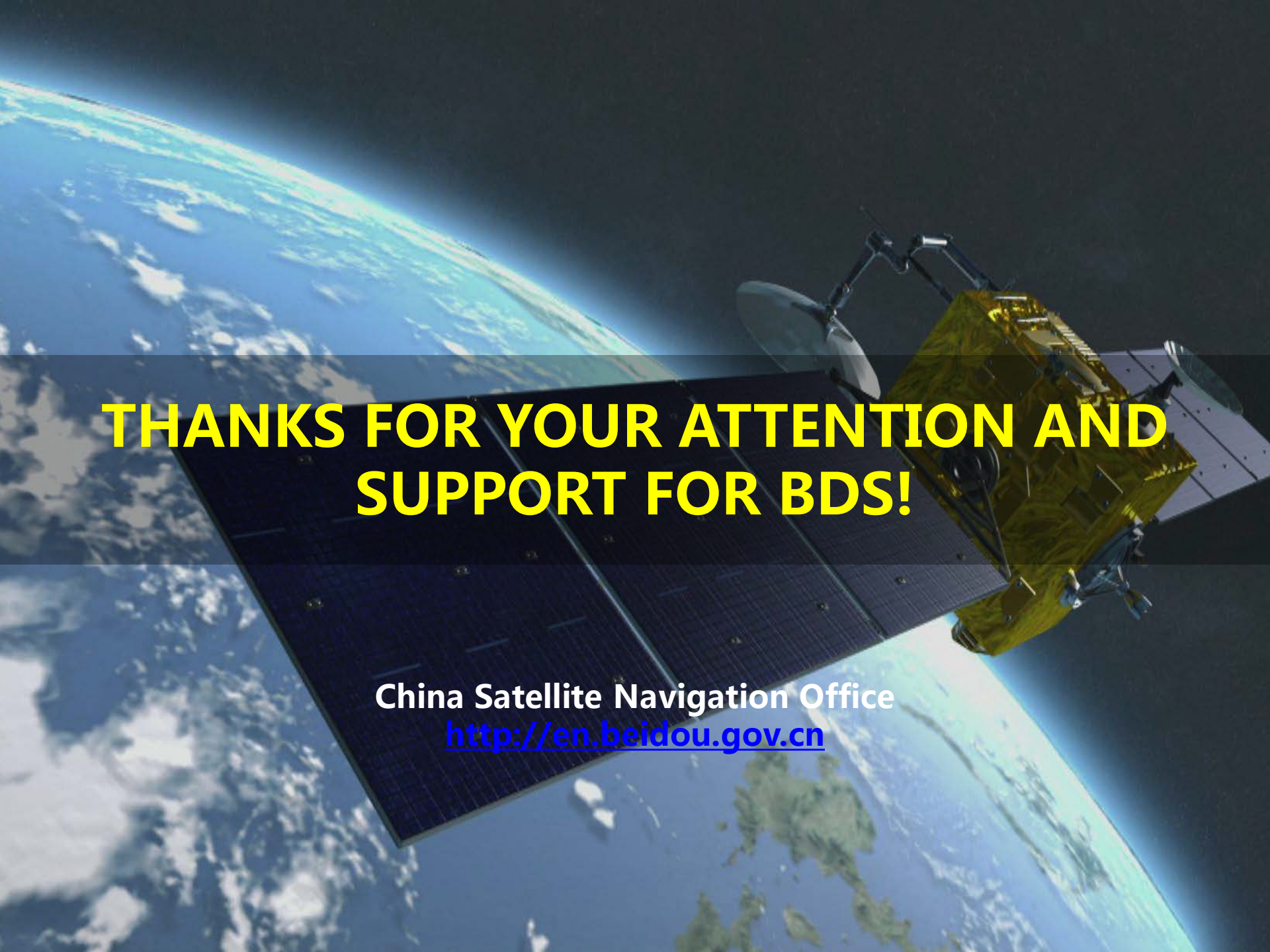
3. Promote the international development of BDS, and enable it to serve the world.

Conclusions

- BDS will guarantee continuous and stable operation, steady improvement on the service performance with meeting promised standards as a prerequisite, and gradually obtain the worldwide service capability.

- With the construction and development of the BeiDou global system, relentless possibilities will appear in the period of connecting everything.

- In the foreseeable future, BDS will be anywhere, positioning everything and connecting all!


THANKS FOR YOUR ATTENTION AND SUPPORT FOR BDS!
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