China's Beidou Navigation Satellite System (BDS) to provide global coverage with millimeter level accuracy

On Sept. 29, 2017 China launched two Beidou 3 satellites from a Long March 3C rocket from the Xichang Satellite Launch Center in Sichuan province. Another two Beidou 3 satellites will launch before the end of 2017, part of a network of 20 Beidou 3 and 10 older Beidou 2 satellites set to go up by 2020. BeiDou Navigation Satellite System (BDS) , is being developed as an alternative to U.S. GPS.

Now, scientists in China have successfully demonstrated a cold atom clock in space, an achievement that could lead to more accurate terrestrial timekeeping and better tests of fundamental physics. The device, called Cacs, or Cold Atomic Clock in Space, was launched in Sep 2017 along with other instruments of the Tiangong-2, China's second orbital lab. China's Beidou satellite navigation network currently provides less precise guidance than the US GPS system, but Xu said that using Cacs as a time reference in space would give a "significant boost" to Beidou's performance.

The system will also likely have new, jam-proof chips. Allystar Technology has unveiled a computer chip for use in Beidou receivers, providing instant accuracy without the aid of augmentation by ground control stations. This computer chip's ability to enhance satellite navigation signals could enable military Beidou users to withstand enemy attempts to jam satellite navigation.

It is part of a plan to put 35 BeiDou satellites into space to form an orbiting satellite network and offer worldwide

navigation services by 2020, said Yang Yuanxi, deputy chief designer of the BeiDou satellite navigation system. Compared to earlier generation products, the BeiDou-3 is able to cover a wider range and has a longer lifespan of 12 years, according to Bao Weimin, another CPPCC National Committee member and an official with China Aerospace Science and Technology Corporation. “New technology has significantly improved the performance of the BeiDou-3, with the signal accuracy in space higher than half a meter while its positioning accuracy has reached 2.5 to five meters, said Yang Changfeng, chief designer of the BeiDou system. The completed Beidou Navigation Satellite System is expected to provide global coverage, with millimeter-level accuracy.

China’s home-grown BeiDou Navigation Satellite System (BDS) will expand its cooperation to Thailand and Sri Lanka, and then to the entire Southeast Asia, in a bid to go global, the system’s operator has said. Du Li, general manager of Wuhan Optics Valley BeiDou Holding Group Co., told Xinhua recently that his company will continue to explore models for international scientific and technical cooperation on BDS, including the joint construction of base stations, joint technical development and research, personnel training and exchanges, and others. China has registered it as standard and become part of Global radio Navigation system.

The space-based Silk Road initiative was proposed in 2014 by the International Alliance of Satellite Application Service (ASAS), a China-based organization of aerospace companies, institutions and scholars that promotes Chinese satellite services around the world. The space-based Silk Road will use dozens of these satellites to meet the communication and remote-sensing application demand for the “One Belt, One Road” initiative, according to Wang Zhongguo, executive vice-president of the ASAS.

BeiDou Navigation Satellite System (BDS)

China stated goal is to build a world-class navigation satellite system to meet the needs of the country's national security as well as economic and social development, and providing continuous, stable and reliable services for global users; developing BDS-related industries to support China's economic and social development, as well as improvement of people's living standards; and enhancing international cooperation to share the fruits of development in the field of satellite navigation, increasing the comprehensive application benefits of Global Navigation Satellite System (GNSS).

The first BDS satellites were launched by China in 2000. In December 2012, the system became operational providing positioning, navigation, timing and short message services to users in China and parts of the Asia-Pacific region. It will provide an operational coverage for all countries concerned by the "Belt and Road" initiative by 2018, and global coverage with 35 operational satellites by 2020.The 35 satellites global system will include five in geostationary earth orbit, 27 in medium earth orbit and three in inclined geostationary orbits.

The network will be dual use: a free service for civilians, and a licensed service for the Chinese government and military.
The civilian service will provide an accuracy of about 33 feet (10 meters) in the user position, 0.45 mph (0.2 m/s) on the user velocity, and 50 nanoseconds in time accuracy. The restricted military and authorized users' service will provide higher tracking accuracies of 0.33 feet (0.1 meters).

At the technical level, Beidou offers a short messaging service through which messages of up to 120 characters can be sent to other Beidou receivers, unlike GPS. Via this service, Chinese fishing vessels are reportedly able to sound "instant

alarms” to fishing departments when emergencies arise, while a supplementary “vessel management system” allows them to request assistance from nearby vessels. This feature is particularly relevant to the ongoing disputes in the South China Sea, where fishing rights are at stake and where China’s maritime militia—a quasimilitary force of fishermen that are tasked by and report to the PLA—plays a key role in advancing Beijing’s claims, according to U.S.-China Economic and Security Review Commission report.

Fear of Security Risk

The concern has also been raised that Beidou could pose a security risk by allowing China’s government to track users of the system by deploying malware transmitted through either its navigation signal or messaging function (via a satellite communication channel), once the technology is in widespread use, according to U.S.-China Economic and Security Review Commission report.

“Our priority is to expand BDS from China to the frontline of the Belt and Road Initiative, and Optics Valley BeiDou is a pioneer,” Li said. China-made smartphones, such as Huawei smartphones, will be good platforms for BDS to go overseas as they carry Chinese chips, Li said.

The Taiwan Ministry of Science and Technology said government employees should avoid using phones that use Beidou to prevent ‘targeted attacks’. China’s Beidou Satellite System (□□□□) poses an information security risk to Taiwan in that the satellite is able to track smartphone users via embedded malware in devices with Chinese-manufactured chips directly tied into the system or phones manufactured in China, according to the latest mobile device security report that the Ministry of Science and Technology submitted to the Legislative Yuan. The ministry also suggested that national

defense units should monitor the Beidou Satellite System's transmitted signals and warn of any anomalies, adding that such monitoring would reduce the risk of hacking attacks from China via satellite-broadcast signals.

Military Impact

The PLA has considered [its] dependence on a foreign PNT system to be a strategic vulnerability since at least the mid-1980s. These fears were exacerbated during the 1995–1996 Taiwan Straits Crisis. According to a retired PLA general, the PLA concluded that an unexpected disruption to GPS caused the PLA to lose track of some of the ballistic missiles it fired into the Taiwan Strait during the crisis. He then said that 'it was a great shame for the PLA … an unforgettable humiliation. That's how we made up our mind to develop our own global [satellite] navigation and positioning system, no matter how huge the cost. Beidou is a must for us. We learned it the hard way as reported by U.S.-China Economic and Security Review Commission report.

The system provides China a distinct advantage in navigation capabilities, targeting for conventional and nuclear missiles, precision weapons, relative strategic independence and immunity from manipulation by other countries. The People's Liberation Army (PLA) recently tested application of its independently developed global satellite navigation system in combat in Guangxi Zhuang Autonomous Region. The military used the Beidou Navigation Satellite System for precise positioning and navigating, real-time location reporting and data transmission over long distances, according to a news release from the PLA General Staff Headquarters. Beidou has allowed the armies to be more precise in command, weapon firing and logistics and that the technology has "been integrated into the PLA's modern command system and weapon platform".

Cooperation with Russia on BDS and GLONASS

The Beidou system constitutes China's attempt to develop a global navigation system to compete with (or at least reduce Chinese commercial, civil and military reliance on) the U.S. run Global Positioning System and Russian run GLONASS, according to Tate Nurkin Senior Director, IHS Aerospace, Defense and Security Thought Leadership.

Russia and China have signed an agreement for navigation cooperation to increase the compatibility and interoperation between BDS and GLONASS. This will provide a more robust satellite navigation system with each architecture filling in the gaps of the other and jointly reaching further regions of the Globe."In addition to developing Beidou, China is also looking for a chance to cooperate with Russia", the paper said. Russian deputy prime minister Dmitry Rogozin told the Moscow-based RIA Novosti that Russia's GLONASS satellite system is capable of cover up the weaknesses of the Beidou Navigation Satellite System in future operations." Russia and China signed a memorandum of understanding on cooperation between Russia's GLONASS navigation system and China's Beidou, each is considering placing three ground stations in the other's country.

BeiDou Navigation Satellite System (BDS)

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

– The space segment. The BDS space segment is a hybrid

navigation constellation consisting of GEO, IGSO and MEO satellites.

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

– The user segment. The BDS user segment consists of various kinds of BDS basic products, including chips, modules and antennae, as well as terminals, application systems and application services, which are compatible with other systems.

The BDS possesses the following characteristics: First, its space segment is a hybrid constellation consisting of satellites in three kinds of orbits. In comparison with other navigation satellite systems, the BDS operates more satellites in high orbits to offer better anti-shielding capabilities, which is particularly observable in terms of performance in the low-latitude areas. Second, the BDS provides navigation signals of multiple frequencies, and is able to improve service accuracy by using combined multi-frequency signals. Third, the BDS integrates navigation and communication capabilities for the first time, and has five major functions – real-time navigation, rapid positioning, precise timing, location reporting and short message communication services.

The Satellite Navigation Center of the PLA National University of Defense Technology (NUDT) has developed a Beidou electromagnetic shield to protect satellites, aircraft, missiles and other user equipment from interference.

Beijing UniStrong Science& Technology Co., Ltd has set up a network in Pakistan including five base stations and one processing center, covering Karachi and the second stage of the network will cover the whole of Pakistan. It can provide positioning with a precision of 2 centimeters, while the precision can reach 5 millimeters after post processing.

The company Shanghai Beiga Satellite Technology has developed

first 40-nanometer satellite navigation chip called Hangxin-1, which will soon be used in consumer electronics, such as tablet PCs, wearable devices, and vehicle navigation system. Wuhan University, Techtotop Microelectronics and ZTE, launched country's first mobile phone phone that utilizes Beidou GNSS chip and runs on the Xihe system, a self-developed positioning system which connects to various satellite navigation systems, including Beidou. The Shanghai government has also announced to bolster further R&D of another type of chip which will be used for map drawing, lane positioning and unmanned systems.

Different from other GNSS, BDS adopts two-way satellite time and frequency transfer (TWSTFT) method to realize both station to station and satellite to ground time synchronization. Precise satellite clock errors are calculated by two-way pseduorange measurements, and then the Beidou Time (BDT) standard kept by ground atomic clock sets is transferred to each BDS satellite.

While the receivers in GPS systems are entirely passive and emits no signals make it immune from interference, the many to and fro transmissions involved in Beidou tesults in higher vulnerability to interference. The second generation IGSO satellites are bigger with and reports also suggest they carry a hydrogen maser based atomic clock and involves transmission signal compatibility with GPS. All second generation GSO and IGSO satellites have in-orbit mass of around 2000 kg.

The Beidou Phase III system includes the migration of its civil Beidou 1 or B1 signal from 1561.098 MHz to a frequency centered at 1575.42 MHz – the same as the GPS L1 and Galileo E1 civil signals – and its transformation from a quadrature phase shift keying (QPSK) modulation to a multiplexed binary offset carrier (MBOC) modulation similar to the future GPS L1C and Galileo's E1. The current (Phase II) B1 open service signal uses QPSK modulation with 4.092 megahertz bandwidth centered at 1561.098 MHz.

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