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Editor's note

With development and progress of human society, the satellite navigation and positioning technology is playing a more important role in human life. At present, the most successful positioning system is the Global Positioning System (GPS) developed by U.S.A with an extremely expensive investment. With such advantages as high precision, passive navigation and positioning, global coverage and unlimited number of users, the GPS has been widely used all over the world. In the late 1970s, GLONASS, a satellite navigation system with the principle similar to that of the GPS, was independently developed by the former Soviet Union at great expense. The launching of satellites started in 1982, and more satellites will be launched in 2009—2020 by Russia. The final constellation will be formed by 24 satellites.

Some weaknesses of the GPS have been exposed during the service of more than 20 years. For example, the GPS has some difficulty in acquiring precise codes, and does not have strong anti-interference ability. How to improve the GPS-typed positioning systems and develop a new navigation model to satisfy specific requirements? This issue has drawn broad attention from researchers and governments. After many years of discussion, some European countries decided in 2002 to jointly develop a commercial global positioning system, GALILEO. This system adopts some new techniques superior to the GPS and will have a constellation composed of 27 satellites. Now the satellite launching of GALILEO is under way.

The three systems described above are called direct broadcasting satellite navigating and positioning system.

In 2002, a group of Chinese astronomers led by academician AI Guoxiang at the National Astronomical Observatories of the Chinese Academy of Sciences (CAS) presented a new concept, i.e., transmitting satellite navigation and positioning. They suggested to use GEO commercial communication satellites and launch a certain number of inclined geosynchronous orbit (IGSO) satellites to form the navigating constellation, and use satellite transponders to transmit signals of the atomic clock and navigating messages from the ground station, while users receive navigation signals with a special terminal to solve the pseudo-range observation equations and enjoy services like navigation and positioning, measurement of velocity and time. In this way, because there is no need to launch the same number of satellites as in the traditional way, the investment and time may be largely reduced. Meanwhile, as time signals required for navigation are offered by atomic clocks at the ground station, no satellite atomic clock is needed any more. The easy maintenance of the atomic clocks at the ground station brings about very high accuracy and stability, making it possible to reduce the technical requirements and enhance the precision of navigation and positioning.

With great support from the CAS, Ministry of Science and Technology, Chinese PLA General Armament Department, and National Natural Science Foundation of China, researchers from the National Astronomical Observatories, National Time Service Centre, Shanghai Institute of Microelectronics and Institute of Automation of CAS worked hard together and solved the key technical problems in the transmitting satellite positioning system. The validating system of the transmitting Chinese Area positioning System (CAPS) was

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approved by the relevant government in June 2005.

In stead of launching IGSO communication satellites, the CAPS validating system rents the transponders on 4 GEO communication satellites to form the constellation. To realize the 3-dimensional positioning with transmitted signals by GEO satellites, the system uses atmospheric pressure altimeters in user receivers to measure the user altitude, which is an innovative idea for the virtual satellites. First, the control center sends navigation messages as well as pressure and temperature data collected from the weather stations all over the country to the satellites. All the information is then transmitted to the users. A user receiver calculates the user altitude with the received data and the real-time pressure and temperature data, and further calculates its 3 dimensions with navigation messages, thus realizing the real-time 3-dimensional positioning.

The new transmitting theory and technology of orbital observation and determination greatly improve the satellite positioning precision; additionally, the techniques, such as changing satellites, changing frequency and changing codes, significantly enhance the anti-interference ability of the positioning system. Meanwhile, in this system, the decommissioned GEO communication satellites to be abandoned are adjusted and controlled as slightly inclined geostationary (SIGSO) satellites, which have slight inclinations and may help improve precise positioning, so that their transponders can be of continuous service to navigation and positioning. Therefore, the CAPS constellation is composed of GEO, IGSO and SIGSO satellites. This not only largely reduces the system expense, but also saves social resources and protects the valuable space environment.

Besides providing the services of navigation and positioning, distance and time measurement, etc., the CAPS validating system also develops the two-way communication receivers using the abundant transponder resource on communication satellites, thus realizing the union of navigation and communication. With this function, the CAPS will find more applied applications, and has been proved successful in ocean exploration, navigation and positioning. It may also play an important role when severe natural disasters happen and ground communication capacities are destroyed.

The characteristics of the CAPS system may have some reference value when small- and medium-sized countries and areas establish their own independent satellite navigation and positioning systems at less expense. We hope that promotion of the theory and technology of the transmitting satellite navigation and positioning system may make greater contributions to human society.

During the development and improvement of transmitting satellite navigation and positioning principle and establishment of the CAPS system, much work has been done theoretically and technologically, and many key problems have been solved. This special issue is a collection of the most important research results, and it tries to cover the transmitting satellite navigation and positioning principle, theories and techniques for CAPS construction, experimental procedures to establish the system, the methods to solve key technical problems and the like. We hope that this special issue can display the latest progress in satellite navigation and positioning research in China, and that it will also promote communication and cooperation in this field.

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On behalf of Editorial Board of the special issue
“Innovation and exploration of the transmitting satellite navigation and positioning system”