

# The Application of Satellite Positioning Technology and its Industrialization in China

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**Abstract:** Satellite positioning technology has been widely used in all kinds of military and civil land, marine, space and aeronautical target positioning tasks, navigation activities and accurate surveying measurements since 90s in the last century due to its advantage in providing all-weather, real-time, three dimensional and high precision positioning information, as well as speed and accurate timing information. By now, it has already formed a new hi-tech industry basically. This paper briefly reviews the development of the global satellite positioning and navigation technologies including the basic information of China's "Plough navigation system", introduces the history of satellite positioning technology and its major application fields as well as the status quo of this being industrialized trade in China, gives an account of the writers' vision for the application and prospect of the satellite positioning technologies in China, and approaches the tactics and stresses of the satellite positioning technology's application and its industrialization future in China.

**Keywords:** satellite positioning technology, global navigation satellite system (GNSS), Plough navigation system, global positioning system (GPS), Galileo plan (GALILEO).

## I. Introduction

Since the global positioning system (GPS) of the United States' was first put into use, this technology has been rapidly being applied to almost all walks of life due to its convenience in use and other characteristics such as the general use on earth, accurate positioning, all weather availability, real time, multi-functions, etc. This then leads to a great push to the upgrading and reforming of some traditional industries and has given rise to a series of new products and trades. This satellite navigation positioning application trade is a newly initiated hi-tech industry, which is at present being vigorously developed all over the world. It is also one of the eight major wireless industries currently recognized by the world, and one of the three information businesses (covering cellular net and internet) as well, which are the most rapidly developing trades in the world nowadays. Production value of the industries related to space positioning technology has already reached dozens of billion US dollars worldwide. Utilizing the space positioning technology to reform traditional industries and to develop new hi-tech products has already become one of the necessities in the construction of a country, in the social development and even in national defense.

In today's national economy and society's moving towards the information age, most of the dynamic information can't do without time and location parameters. The application of satellite navigation positioning technology is just a powerful tool in this process. With the advance in technology in the field of satellite navigation, the application reality of this technology has already become something of which no other technology and industry can replace. The satellite navigation system holds an important place in the development of national economy. It is a significant component and force in the construction of

national economic information system. It is an indispensable part of the infrastructure of the national information system.

## **II. Development of Global Satellite Positioning Technology**

In October 1957, the first man-made satellite of the world was successfully launched on earth. This not only provided an optimum platform for geo-resources survey through remote sensing, but also prepared a prerequisite for satellite positioning system because the satellite position can be derived from calculation using its orbit parameters. At present, the world has three satellite navigation positioning systems in running, i.e. the "Navigation by Satellite Timing and Ranging Global Positioning System, NAVSTAR GPS" developed and launched by the United States, GPS for short; the "Global Orbiting Navigation Satellite System, Global'naya Navigatsionnaya Sputnikovaya Sistema, GLONASS" launched by Russia; and China's "Plough Navigation System". Among them, the GPS and GLONASS are global satellite navigation positioning systems. Now, the Europeans are in the process for constructing their own civil-purpose satellite navigation positioning system, which is called "Galileo Plan".

GPS research work was started in 1973 and its first experimental satellite launched in February 1978. The 24th working satellite of the system was launched in March 1994, and the whole system was announced of being in full play in 1995. In order to improve the performance of GPS, the United States has decided to modernize it. The GLONASS system began being researched and developed from 1978, and its first navigation satellite was launched in October 1982. From 1982 to 1987, this system had 27 GLONASS experimental satellites launched in total.

China began the study and research into the navigation satellite system from 1970s, and in early 1990s started the independent construction of the solely-owned satellite positioning system — the "Plough Navigation System". It is a

regional navigation system which is able to provide navigation information all the time and in all weather. This system consists of satellites, control stations and receiver sets. The two working satellites numbered "Plough No.1" and "Plough No.2" were launched respectively one at the early morning 00:02, October 31, 2000 and the other at 00:20, December 21, 2000. Both were launched from the Xichang Satellite Launch Center and precisely entered the designed orbits. This demonstrates that China has possessed the first generation satellite navigation and positioning system developed by her own.

The target of the European Galileo Plan is to set up a civil-purpose global satellite navigation service system solely controlled by Europe. The Department of Communication and Energy of the European Union is responsible for its overall designing, and in technology the Space Bureau of Europe takes the responsibility. The plan will be carried out in four stages: system definition period (1999-2001), system development period (2002-2005), system construction period (2006-2007) and system running and application period (2008-2020). GALILEO system is made up of several parts, covering constellations, satellites, ground facilities, ground parts, EGNOS, etc. The satellite constellations of the system are composed of 30 medium high satellites that are distributed on three orbits, 10 on each; among them 9 are operational and 1 is kept as an active spare. Inclination angle of the orbit is  $56^\circ$  and the orbit height is 23,616 km. The orbital period is 14 hours and 4 minutes.

At present, the accuracy of the satellite navigation positioning system for civil-purposes can only achieve about 15 meters. In many civil-purpose navigations such as the ocean ship going, surveying ship navigation, port entering, mooring, helicopter navigation, civil aviation route guiding and near landing, precise farming guidance, city vehicle manipulation, special vehicle controlling, etc., all these need higher accuracy for real-time navigation and positioning. To meet the above-mentioned requirements, monitoring and enhancing

techniques for satellite navigation have been adopted including the differential technique and the satellite integrity monitoring. The enhanced system has two types, i.e. Local Area Augmentation System (LAAS) and Wide Area Augmentation System (WAAS). The LAAS system uses a differential technique, and the accuracy of the differential positioning will drop with the increasing of the distance between user unit and base station. The WAAS system calculates the measurement errors separately, depending on whether they are related to the spatial distribution (e.g. ionosphere delay error) or not related to it (e.g. satellite orbit error and satellite clock error), then corrects them accordingly. So, it is able only by deploying several base stations to meet the requirements for a larger area differentiation. At present time, the built and being built WAAS systems are: United States' Federal Aviation Administration's WAAS plan, Japan's Transportation Ministry's MSAS plan, Australia's Civil Aviation Administration's WAAS plan, India's WAAS plan, European Union's EGNOS plan, China's wide area enhancing system, etc.

### **III. The Application of Chinese Satellite Positioning Technology**

The satellite positioning technology has already been widely used in all kinds of military and civil land, marine, space and aeronautical target positioning tasks, navigation activities, accurate measuring works, etc., and has preliminarily formed a new hi-tech industry already. Internationally, the GPS receivers, GPS navigation systems, GPS control systems for air, marine, roadway and railway transportations, and the general purpose machines resulted from the combination of GPS receivers with other electronics such as the GPS cameras, GPS radios, GPS watches, etc. all these together have formed a considerable sized industrial group that is one of the areas in which the space information technology has first entered for a large scale development. According to the 1999's data of the United Nations, the aeronautical industry of the world has been increasing over 9% each year on average in recent years in spite of the depression

of the world economy. In the satellite navigation positioning area, the increase on average is over 30% each year, and in the last two years the actual increase is far more than this. The trend is that the navigation and positioning products are going to be integrated with the mass consuming products such as mobile phones, etc. to form a new big market, which is quite promising.

In the middle of 1970s China imported the Transit satellite navigation positioning technology and adopted the Doppler positioning method, mainly used for geodesy, island surveying and petroleum exploration. In the middle of 1980s, started importing the GPS satellite positioning instruments. As GPS becomes increasingly complete and the satellite positioning technology improves better and better, the satellite navigation and positioning technology has entered many sectors of the national economy, playing important roles in them. Major application fields of this technology are:

- Application in geodesy, e.g. establish the national high precision geodetic control network and urban engineering control network, large structure's deformation monitoring, aerial photography surveying, topography/ground/real estate surveying and mapping, geographical information updating, national communication network data acquisition and database establishment, marine survey and mapping, etc.
- Application in agriculture;
- Application in earth atmosphere monitoring;
- Application in earthquake monitoring;
- Application in emergent incidents;
- Application in pipe-line network management;
- Application in wild life resources management;
- Application in transportation system, e.g. road network management/monitoring and maintenance, vehicle positioning navigation, ocean shipping navigation and management, civil flight navigation, etc.;
- Application in scientific investigation;
- Monitoring tectonic plate movement of the earth, and

studying the earth dynamics, including the international earth dynamics service net – IGS, China’s earth crust movement monitoring network, areal land change monitoring, etc.;

- Monitoring the change of sea-levels, ice sheets and glaciers;
- Measuring the precipitable water vapor content in the troposphere;
- Application in flood prevention and reduction, e.g. real time monitoring for fighting flood, Changjiang waterway hydrographic survey, lakes’ hydrographic survey, Three Gorge engineering survey and damming monitoring, Yellow River flood prevention and disaster relief;
- Application in people’s life, e.g. the digital cameras with GPS information, the watches with GPS functions, the hand phones with GPS positioning signals, etc.

#### **IV. The Trend and Focus of the Chinese Satellite Positioning Technology’s Application and Development**

According to the “tenth five-year plan” of the Chinese science and technology development plans, the basic thinking for the development of space information technology in the next 5 - 15 years is: orientated to the applications, to the economic sectors and to local areas; address and completely solve the key technical problems facing real applications; push forward the actual use of the space information in local areas and in different sectors; probe into new models for project implementation and management methodology; in considering our own country’s conditions and actual sci-tech systems, along with the reforming of the mechanism of all sectors, foster an active environment highly effective for sci-tech research and development; strongly push forward the activities of combining sci-tech research with industrial development, through sci-tech work to promote industries, and through industries’ support to maintain the space information application and service have a long-lasting development. The overall objective is: under the guidance of the demand for

space information technology required by sustainable development of the society, national macro-decisions, national security, major applications in different sectors and local areas and the industrialization process, to promote in full swing the development and industrialization of the space information technology in our country.

For the “tenth five-year plan” period, both the nation as a whole and the local areas have made decisions regarding information infrastructure constructions, which are major projects for satellite navigation applications, such as the construction of the integrated multi-function satellite navigation positioning network, the construction of the intelligent communication related projects, the “digital China”, and the “large scale development in the west of China”. All these are big landmark projects of the country and provinces. They are involved with many national economic and social sectors and cover many different fields, e.g. the telecommunication and navigation, communication and transportation, oil and geology, meteorology and earthquake, water conservancy and power supply, environment protection and tourism, ocean going and aviation, exploration and surveying, city planning, farming/animal husbandry/forestry/fishery, security and disaster prevention, emergency aid, etc. Therefore, it is proved that the satellite navigation system has a great impact and far-reaching significance for the construction of the information society.

The hot spots of the market and the product development focuses for satellite navigation applications include: (1) emergency alarm and aid (including burglar alarm and special vehicles) will expand further; (2) the kind of products used for vehicle management will be increased explosively; (3) along with the development of city information systems, the self-navigation systems will be perhaps having a dramatic increase; (4) time transmission and synchronous market is on track for a steady development; (5) the market demand for products resulted from the combination between telecommunication machines and PDA will evolve into the highest place of all; (6) having a close tie with the

intelligent communication systems is a long lasting way out for the satellite navigation products, the Telematics? is an extremely appropriate solution; (7) in other consuming markets, especially of those products such as hand phones, watches, people finding machines, children orientated gadgets, meteorological probes, etc. the development momentum in each of them vies for the first; (8) along with the rapid expansion of the satellite navigation applications, a new information service business which is based on positioning service (and can also be called mobile electronic commerce) is going to emerge; (9) to reform the traditional industries through using hi-tech satellite navigation technology is a heavy task, having a long way to go, e.g. the precise and refinery farming, the mechanic controls, the large project monitoring, etc. all need to be taken care of with great concerns and done well. From the above we have known that the vehicle application system shall be the focus for development, another focus shall be on such consuming products resulted from the combination between telecommunication and PDA. In order to have these two focuses done well, the key is that the single chip and single board satellite navigation receivers must be made perfect.

In order to develop and achieve somewhere the satellite positioning application technologies, China has actively set up some "special projects for satellite navigation application industry" in the "tenth five-year" national economic development plan, and also defined in the national hi-tech research and development plan (863 plan) the items regarding satellite positioning application and its industrialization.

In the period of the "tenth five-year" plan, the main objective of the key projects of the hi-tech industrialization items for satellite navigation applications is: through government policies adjustment and fund flowing guidance, by making use of the social forces to build up gradually three major systems --- 1. product research and development, 2. system standard norms and 3. integrated information service, to break through kernel technologies, to foster domestic market of navigation applications, to expand the application scales,

and to get closer to the world advanced countries in technology and applications, and arrive at the point having these applications preliminarily industrialized. The concrete target of these key projects is: to form a new industry about which its market size shall be well over ten billion *yuan*. Through four year's efforts, the scale and amount in making and producing the basic products for satellite navigation applications shall enter first places of the world, the total production of the main processor board of the receivers' shall exceed one million sets, the service value of the navigation operations shall exceed two billion *yuan*, and the overall production value of this trade shall be over 10 billion *yuan*, which is about 4% of the world market in total. Around the basic products, the situation for importing chips, main processor boards, etc. shall be changed from totally depending on import to having 60% or more to be depended on the products with our own property rights, and 10% of the total domestic production in this respect shall be exported. Those products with our own intellectual property rights such as chips, system software, products for special data types and products for information services shall be seen in the market. Through construction of model projects for satellite navigation applications, push forward the usage and spreading of the satellite navigation devices and their expansion systems in different sectors of the national economy and in the people's daily life in a hope to result in apparent economic and social effects.

The special subject "satellite navigation positioning technology" stipulated in the "863" plan is a subject aimed at researching into the technologies for receiving and processing satellite navigation positioning information, breaking through the crucial techniques in the field of satellite navigation positioning and pushing forward a deeper development of related applications, in the purpose of setting up a technological foundation for a new generation of satellite navigation positioning systems. In this subject, the research item "satellite navigation positioning crucial technologies" is aimed at: through international cooperation, research into the leading edge technologies for satellite navigation and positioning, and develop the technologies for producing

mini-receivers for satellite navigation and positioning reception and the technologies of satellite navigation and positioning simulator, etc. Researching directions cover: (1) high precision, highly dynamic, real time, fast positioning algorithm; (2) minimized satellite navigation receivers; (3) satellite navigation and positioning simulator technology; (4) new algorithm for mingled and combined multi-satellite navigation.

Research aim of the item “space information mobile user application service system” stipulated in the “863” plan is: through combining the geographical space information technology with the mobile communication and satellite navigation positioning technologies, supported by the space information mobile service central system, to provide the public with a kind of multi-dimensional information application terminal system which is movable, light and convenient, and to popularize the application of space information with the corresponding research achievements. The main researching contents are: (1) technologies, standards and protocols for space information transmission and exchange; (2) interface technologies and standards between space information and mobile communication; (3) the sharing and distributing technologies for multi-user, multi-platform and multi-data source space information; (4) embedded modules and swappers for space information operation; (5) demo system for space information mobile service central station; (6) research into the highly efficient technologies for mobile user application terminals, and the prototype hand terminals and their mass producing issues.