

Satellite navigation technology in China

- After Russia's successful launch of the first man-made satellite in the fifties of the twentieth century, the U.S. began to develop a new technology to navigate by man-made satellite, i.e. Doppler navy navigation satellite system (NNS); since then, the human society entered a new space era.

GPS is even more one of greatest engineering achievements of human society in the twentieth century. In China, GPS has become an English initial abbreviation that is most familiar to Chinese. The vast majority of Chinese know GPS, including Russia's GLONASS, Europe's Galileo System and China's Compass Navigation Satellite System.

the history of satellite navigation in China

- From the middle of eighties to early nineties, Doppler satellite navigation technology completely stepped down from the stage of history while GPS satellite navigation technology gained rapid development. During this period, there are several historic events worthy to be reviewed.

- From the nineties to the present, the domestic GPS satellite navigation technology is at the stage of rapid development; many traditional technologies have been gradually replaced by GPS positioning technology. Various kinds of GPS receivers increased by the speed of 30% to 50% every year while the price decreased by the speed of 10% to 30% every year. The application of GPS to navigation field becomes more and more wide; various home-made GPS receivers of different kinds came into market in succession; its annual growth rates are almost around 100%. The development of GPS technology in China at this stage is worthy to be summarized seriously by us.

- Large numbers of theses and monographs introducing GPS navigation and positioning technology were published successively; GPS navigation and positioning courses were offered by many mapping, shipping major-related departments of colleges and universities. Famous institutions of higher learning as Wuhan Technical University of Surveying and Mapping, Ocean University of Qingdao, Southwest Jiaotong University, Tongji University, etc. began to enroll masters and doctoral postgraduates with the research direction in GPS navigation and positioning technology.

- In order to build information society, digitized cities and regions, from 2000, many places of China are preparing to construct the multi-functional, comprehensive GPS reference station network system; now, it has become an important task in the city planning and construction of various places, which aroused much concern and attention of various local government departments.

- More and more GPS satellite navigation and positioning equipments are made in China, which becomes an obvious trend. The number of home-made products nearly doubled every year; the model number of these products have covered all existing types in the world, including real-time navigation and positioning system of built-in wireless data communication equipment with different precision levels and Super Station instrument which integrated the traditional photoelectric measuring instrument (whole station instrument) and GPS system.

- From 1986 to 1987, our country cooperated with famous institutions of higher learning in U.S. and Canada, etc. and completed our country's first-generation GPS application software development, the measurement of the first high-precision long baseline (from Wuhan to Shanghai) and independently completed the baseline after-treatment internationally advanced then; its relative accuracy is superior to $\pm 0.1\text{ppm}$.

- The Compass Navigation and Positioning Experimental Satellite System of our country has been put into service for many years. Now, steps are taking to make system optimization, which will be extended into global satellite navigation and positioning system composed of 5 fixed earth satellites and 30 non-stationary satellites in the future. Besides, our government has committed to invest 200 million Euros in Galileo Satellite Navigation System of European Cooperation for Space Standardization (ECSS) and also signed a relevant contract in August 2005 to start up various research items of future application in an all-round way.

II. Satellite navigation technology's main user groups in China

- At present, the precise number of the satellite navigation technology's users is still not available in China; it is estimated that the GPS receivers in active service should be more than 80,000, which all belong to the GPS satellite navigation system. Of which, low-precision navigation type receivers' use groups (including meter-level, sub-meter level difference navigation equipment) accounts for about 95% while high-precision measuring type users only account for about 5% (including home-made receivers' users) and there are still less than 1% special user groups which use the satellite navigation system in technical application items other than the purpose of navigation and positioning.

- The purpose to determine the first-class points of attention is to acquire the precise coordinates of these points. Such types of users replaced the traditional earth survey and precision engineering survey with satellite navigation and positioning technology. The user groups of this type are mainly distributed in specialized surveying, designing and engineering construction departments under the State Bureau of Surveying and Mapping, the Ministry of Land Resources as well as other ministries and commissions.

- The other part of users pursues the high precision of positioning. Generally speaking, the precision of points may vary from several meters down to several centimeters in different specialties and engineering projects. Therefore, tasks can be completed by using equipments of different grades (measurement positioning type, difference navigation type and hand-held autonomous navigation) respectively. The very large proportion of users among them pays more attention to the attribute of points, which is usually defined as GIS data acquisition at home.

- The purpose for navigation users to use the satellite navigation system is only to guide carrier tools or receiver holders to reach the scheduled destination accurately, reliably and safely by messages displayed on the receiver screen. The device used by these users has fewer functions; as the single machine operation needs no communication guarantee, the precision is lower (meter grade level; the maximum error is around $\pm 10\text{m}$). Generally speaking, they can command the basic operation of the relevant equipment as long as they receive simple operation training offered by the equipment suppliers.

- Therefore, the navigation type GPS receivers based on pseudo range positioning principle need to combine with other hardware equipment (such as communication system) and software system to form a complicated system. For example, a road automatic system, it not only can offer the current position of points to users but also can offer the optimal routes to destination, the predestined arrival time as per the current speed of vehicles as well as meter-level, sub-meter-level difference navigation correction information and traffic congestion conditions along the way. The large-sized passenger ships and cargo ships have been gradually provided with GPS navigation equipment of Automatic Identification System (AIS) and thus the vessels under navigation can not only know its own position, direction and route but also can know clearly all relevant information of vessels around it; its performance far exceeds the traditional radar detection instrument.

- Machinery automatic guidance system is used in such engineering tasks as the road construction of highway, paving, open-air excavation of industrial and mining enterprises, field operation of industrial and agricultural production, navigation channel dredging, etc. for example, recently, the China Central Television (CCTV) recorded and played a program of information control by GPS navigation system; at present, this user group is basically at the start-up stage; the matched product series and market promotion mechanism have not been formed yet. The foreign products of the same kind haven't come into domestic market because of expensive prices.

- By means of electromagnetic wave signals provided by GPS satellite, high-precision time transfer is made (to replace atomic clock move in time distribution and time conversation as well as distant time synchronization).

- By measuring transmission delay amount of GPS satellite's electromagnetic wave signals, the content and distribution of the water vapor in the atmosphere can be determined for the purpose of studying the relevant laws of rainfall and high-precision numerical weather forecasting, etc.

III. Technical status quo and problems of the navigation type GPS

- Presently, most part of users based on the applied technology of the navigation type GPS receivers in our country belongs to one of the four conditions below:
- (1) Single machine navigation. Directly use the basic navigation functions provided by the navigation type receivers (including hand-held receivers for individual exploration and travel) to determine location, indicate routes and seek target.
- (2) Beacon difference navigation. Adopt single machine with built-in beacon signal reception function to conduct difference navigation by receiving the difference correction figures send out by beacon stations installed in our country and neighboring countries as well as along the coast.
- (3) Conduct difference navigation by the reception of information sent out by reference stations. Use wireless communication equipment (such as frequency modulation broadcasting, UHF/VHF data wireless modem, GSM/CDMA/GPRS mobile communication equipment) to receive the difference correction figures provided by other networks of difference stations (such as regional ground reference stations) and conduct higher precision difference navigation.
- (4) There is still a small part of users that subscribe for difference navigation information provided by means of receiving maritime satellites, etc. to conduct meter-level, sub-meter-level navigation operation.

Integrated Multi-Satellite Navigation Applying System

- GPS Satellite Navigation technology will be still in technological mainstream in next three or five years, even ten years. Whatever the “GLONASS Satellite Navigation System”, which is applied and advanced in Russia, the ”GALILEO System” on constructing and perfecting, or “Compass Navigation Satellite System” in China, no one could replace GPS in a short time. People need time to be familiar with a new navigation technology.
- We have noticed that GPS is also modernized further, whose capability is advanced further, applications is developed further, and consumers enlarged further.

Trend of Miniaturization Cannot Reverse

- The first commercial GPS receiver of last century looks more like Mesozoic dinosaurs today. For example, the whole set of the Macrometer V-1000, made by Litton Aero Service company of America, totally weighs three hundred kilograms (including a one-meter square flat antenna and a gas dynamotor), and its power is 350 watts. After a 20 years' competition in the market, a smallest watch-style GPS receiver used for individual navigation only weighs about one hundred grams, and the main body of the receivers, formally used for navigation positioning work, mostly weigh about one kilogram.
- With the development of Micro-electronics, CMOS chips, communications, memory and power supply, it is not faraway that the total weight of a high-precision GPS receiver with an integration of all hardware, which is made in China, could be decreased to under one kilogram.

Price of GPS Facilities Will Have a Big Fall

- In early years, each commercial GPS receiver's price was fixed from tens of thousands to hundreds of thousands dollars. The price of a Macrometer II type GPS receiver made by Litton Aero Service Co. was 240,000 dollars. A five-channel T-SET low dynamic navigation made by another company was still quoted 50,000 dollars in 1986. At present, a cost between 1,000 dollars and 5,000 dollars will purchase a GPS receiver with farther more advanced capabilities, and the same receiver made in china only costs 600 dollars. Even the RTK GPS only costs 4,000 dollars.

- In next few years, once automatization assembly lines being in used for production, the prices of high-end and low-end GPS receivers will quickly fall down to under 1,000 dollars in expect, in one or two years separately.
- As for the pocket GPS receiver, the price will be no more than 100 dollars after a large quantity of production being launched into market for individuals, and finally the price will be fixed between ten to fifteen dollars as children's toys returning to the European and American markets.

Multi-functional, High-precision Navigations Will Become Mainstream Products

- Industrialization brings a boon of big descending on costs of products to human being, moreover, costs of electronic products in modern information society are decreased to a insignificant level. Special hardware for satellite navigation are some CMOS chips of higher integration degrees plus software, whose costs are further more decreased. Due to fall of the hardware costs, the advantage of low-end products is dying out. In the future not faraway, Multi-functional, high-precision navigations will become mainstream products.

Diversiform and Personalized Satellite Navigation Products

- Besides, as a result of low-cost, portable and low-consume navigation products, it will be easily integrated into other daily electrical products (such as mobile phone, watch, notebook computer, digital camera, MP3, even children's toys), providing a brand-new navigation positioning function to those commodities, which opens a new door for application of navigation.

GPS on Network Serves Information Society

- Concepts of network exist everywhere. In modern times, the networks of Railway, electricity, communication, freeway and Infobahn boost human beings into modern civilization.
- Only if we advance the GPS Satellite Navigation System and other systems about to come out and extend to be used to the level of network service system, could we maximize their potential. In the process of the international society going into information and digital times, basic establishments are necessary for the fiducial interspace information - an integrated service system of continual working Satellite navigating consult website. The differences between this system and the present working and constructing GPS station website are:

- (1) Fluxion stations could get more reliable navigation positioning results at a higher speed under much harder conditions.
- (2) In use of synchronizing multi-channel information received itself, fluxion stations could truly realize most optimized network solutions and provide more economical navigating results in higher precision.
- (3) It dispenses with extra special serving websites for Satellite navigation on the ground. The third and fourth generation of wireless communicating web bases could be used to directly rebroadcast relative navigation positioning observing datas, which lifts up using efficiency of communicating webs.

China Leads the Trend of Applying Satellite Navigation in Future

- (1) Firstly, as a great country with a population of 1/5 people in the world, China is a very huge market. If we decrease the prices of Satellite navigating terminals until every common consumer in China could accept them, she will become such a big market with a total consumption of millions, tens of millions, even hundreds of millions on each kind of Satellite navigating equipments, who exceeds out and away present consumption and present output of production. And this will greatly drive the popularization of application on Satellite navigation technology.
- (2) Secondly, China owns a comparatively inexpensive labor resource and large quantities of technological personnel with basic theories and researches in Satellite navigating industry, who have a lot of experiences on practice. If only there are enough venture capital, proper encouraging policies and perfect managing mode, It is not difficult to set up an exploiting, researching and producing base in a very short time, which could manufacture more Satellite navigating products in Chinese, even the global markets to share her navigating fruits with common people around the world, like Chinese home appliances.