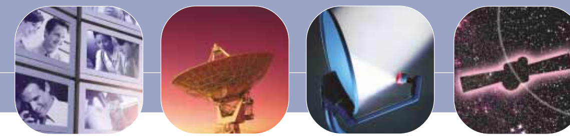


Small QZSS satellite. Photo courtesy of JAXA.

Gaining regional independence

In preparation for the location based service revolution, more and more regions of the world are working on their very own regional satellite navigation systems. The regions of Asia are no different. Satellite Evolution explores how Japan and India are developing their own systems to rival GPS and gain navigational independence.

The benefits of a satellite navigation system have been well and truly proved and location based services are being used for an array of different applications and are becoming increasingly important in our everyday lives. At present, the only fully operational Global Navigation Satellite System (GNSS) is NAVSTAR GPS (Global Positioning System), the US satellite navigation system. However, there are several other significant systems in development at present. The desire for other countries to gain 'independence' from the NAVSTAR constellation is strong and Europe, India, China and Russia are all working towards this aim. Socially, industrially and governmentally, the satellite navigation system can revolutionise the way we live our lives.

History

Satellite navigation was born around thirty years ago. Initially it was developed for military purposes but it is also now widely used by civilians. Satellite navigation basically allows anyone with a receiver to determine their position in time and space extremely accurately.

The system relies upon a constellation of geo-stationary satellites that each emit their own personalised signals. These signals indicate the precise time they left the satellite. The receiver picks up the satellite signal, recognises the satellite it was emitted from and determines the time taken by the signal to arrive at the receiver. It then calculates the distance from the satellite. In order to determine its accurate position, the receiver must accept signals from at least four satellites.

We now all have access to a certain level of navigation should we require it. The number of applications for satellite navigation is growing significantly, new applications are being found every day and the list already includes:

- Road;
- Agriculture;
- Fisheries;
- Environment;
- People with disabilities;
- Civil protection;
- Time referencing;
- Science;
- Leisure;
- Pilot projects;
- Rail;
- Aviation;
- Public transport;
- Maritime;
- Military;
- Safety;
- Energy;
- Telecommunications;
- Finance/Insurance; and
- Civil Engineering.

Let's now look in more detail at the regional satellite navigational systems that are being developed in Asia.

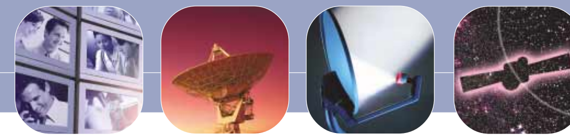
China

The 'Big Dipper' satellite navigation system has its roots in 1983 when a proposal was made to make a Twinsat regional navigation system using just two geostationary satellites. Subsequent tests on the satellites showed that its capabilities were on a par with those of the United States' NAVSTAR GPS system so, ten years later, in 1993, the Beidou programme was officially launched.

The first two experimental satellites went into orbit in 2000 and the plan was to launch a further two satellites so that two remained in operation and two served as in-orbit spares. The fourth satellite was launched in early 2007.

The two satellites continuously broadcast signals to the entire Asian continent and the user terminals would then transmit the signal back up to the satellite which then sent the signal back down to earth to the control centre. The system did work very effectively but

Marine satnav. Photo courtesy of Garmin.



there were two major operational constraints. Firstly, the user had to emit a signal from their handset to find their location and secondly, there was a single control centre that, if targeted by an enemy, would bring the entire system crashing down. That said, it cannot be denied that Beidou was an incredible achievement for only two satellite launches in comparison with the other systems such as GLONASS, NAVSTAR and Galileo that require many satellites to operate.

BD Star Navigation was formed to render the system suitable for civilian applications and commercial operators. The project was approved in 2003 and the development and marketing of receivers began. In December 2005, the system was tested and approved for the use of Chinese fishing vessels.

However, despite all the advancements, there was still a reliance on NAVSTAR signals for some applications and, as a result, the Beidou-2 or COMPASS system development was announced in 2006. This supplementary Medium Earth Orbit (MEO) constellation would use the same principles as NAVSTAR or Galileo or GLONASS in order to achieve highly accurate readings. Once completed, the public will have access to a free service with 10 metre accuracy. The licensed military service will be more accurate and will also provide additional information and services such as status and communication abilities.

India

In 2006, the Indian government approved plans to go ahead with the Indian Regional Navigational Satellite System. It is a developmental autonomous regional system that will be constructed and controlled by the Indian government. It is hoped that, once completed, the system will give the user an accuracy of less than 20 metres throughout India. Implementation is expected within 6-7 years. It is unknown whether the Indian government will be assisting the Russian government in the restoration of the GLONASS system.

The IRNSS will comprise seven satellites and ground support segment. Three satellites in the constellation will be placed in geosynchronous transfer orbit and the remaining four in geosynchronous inclined orbit of 29 degrees relative to the equatorial plane. This will mean that all seven satellites will have continuous radio visibility with the control stations. The signals will use the S-band frequency to transmit.

The ground segment is expected to consist of a master control centre and several ground stations so that the integrity of the system may be easily maintained. It is envisaged that the first satellite will be ready for launch in 2008-9. The entire IRNSS system will be under Indian control. The space segment, ground segment and user receivers will be built in India.

The Department of Space (DOS) is the nodal agency for all matters connected with satellite navigation. ISRO/DOS has identified Satellite Navigation as an important thrust area and a large investment in this programme is slated for the 11th Five Year Plan.

ISRO and AAI are implementing a satellite based navigation system over the Indian air-space for civil aviation called GAGAN, which consists of a space-segment and a ground segment. The space segment is a dual frequency (L1 & L5) GPS compatible payload on GSAT-4 under the Technology Demonstration System (TDS) Phase. The ground segment consisting of eight Indian Reference Stations (INRESs), one Indian Master Control Centre (INMCC), one Indian Land Uplink Station (INLUS) and associated navigation software and communication links has been installed and a Preliminary System Acceptance Test (PSAT) has been just concluded. The position accuracies available are good.

In this programme, which is extremely challenging technologically, India will take a major step towards providing an infrastructure for provision of PNT services throughout India and the neighbouring areas. The technological challenges include:

- Satellites;
- Atomic Time Standard;
- Establishment of Earth Stations;
- Establishment of Master Control Stations;
- Establishment of critical, safety and verification subsystems;
- Navigation software written to DO-178B standards;
- GNSS user receiver manufacturer; and
- Time transfer technology and much more.

Japan

The Quasi-Zenith Satellite System (QZSS) is a constellation of several identical satellites, with at least one satellite positioned near zenith over Japan at anytime. Users can receive the communication and positioning signals from one of the QZSS satellites near zenith position without obstruction in urban and mountainous area. As a result of the satellite's position, people in moving vehicles and using mobile phones can speak and send and receive high-quality content without interference. In addition, the system is expected to significantly improve the accuracy of positioning.

QZSS programme is a joint government-private section programme. Four governmental ministries, the Ministry of Public Man-

SpectraTime wins Rubidium Space Clocks contract from IRNSS

Spectratime, a company of the Orolia group, has announces that it has won a contract valued at approximately four million euro to supply Rubidium Space Clocks to the Indian Regional Navigational Satellite System IRNSS

With this new contract, SpectraTime confirms its position as the world-leading supplier of space atomic clocks, and is on the way to having the largest number of atomic clocks on board satellites.

The Indian Regional Navigational Satellite System (IRNSS), developed by the Indian Space Agency (ISRO), will consist of seven satellites. Three of the satellites will be placed in geostationary orbit, with the other four in geosynchronous orbit. The constellation will also comprise a ground segment consisting of a Centre of Principal Control and ground stations, in order to follow the satellites and to guarantee the system's integrity. The Indian Regional Navigational Satellite System, whose first satellite could be launched in 2009, will be able to provide an absolute position with an accuracy of 20 metres across the whole of India and to a distance of about 2,000km beyond its borders.

SpectraTime atomic clocks will be at the heart of the system. The principle of navigation by satellite is based on the transmission of signals coming from at least four satellites to the users. To get very precise location data, these signals must be perfectly synchronized. The extremely precise measurement of time on board each satellite, achieved through embarked atomic clocks, is thus a central condition for the positioning performance of the system. In the framework of the IRNSS programme, each satellite will have four SpectraTime Rubidium atomic clocks on board to reach a stability of less than 10 billionths of a second per day.

"To give a point of comparison, our clocks are 10 million times more precise than a watch made of quartz," says Pascal Rochat, Chief Executive Officer of SpectraTime.

With this new contract, awarded to SpectraTime just four months after Giove-B – the second experimental satellite of the Galileo European Global Navigation Satellite System (GNSS) – was successfully launched, SpectraTime is strengthening its competitive position on the fast-growing GNSS market. "A worldwide satellite navigation constellation consists of 20 to 30 satellites, each embarking three to four atomic clocks. Within five years, we expect to have the largest number of space-borne atomic clocks of any company," underlines Pascal Rochat.

agement, Home Affairs, Posts and Telecommunications (MPHPT), Ministry of Education, Culture, Sports, Science and Technology (MEXT), Ministry of Economy, Trade and Industry (METI), and Ministry of Land, Infrastructure and Transport (MLIT), will conduct research and development on critical advanced technologies and orbital demonstrations, while JAXA (Japan Aerospace Exploration Agency) is serving as an integrator in a joint research project with relevant research institutes on the High Accuracy Positioning Experiment System.

Unlike geostationary satellites, QZSS can transmit signals without obstruction from urban or mountains because one satellite remains overhead. Users can therefore enjoy interference-free communications when they are walking in urban or mountainous areas. In addition, the system, used together with the Global Positioning System (GPS), will provide much more accurate positioning information than before.

High Accuracy Positioning Experiment System

The proposed High Accuracy Positioning Experiment System consists of onboard instruments capable of generating and transmitting positioning signals and ground tracking stations responsible for estimating the time and orbital position of the satellite.

The system is aimed at improving availability of GPS signals for relevant users through QZSS, which is equipped with instruments capable of generating and transmitting signals compatible with modernised GPS signals. In addition, QZSS is designed to transmit not only these positioning signals but also their correction signals and information of GPS availability in order to enhance the accuracy and reliability of the positioning signals. A future plan calls for the acquisition of technologies necessary for the development of a next generation satellite positioning system through orbital demonstration conducted with experimental signal and onboard equipment designed to improve positioning accuracy.

Space-based positioning systems have played an important role in wide area and diverse fields from land survey to car navigation, and have become critical to our lives. Research on the Positioning Experiment System is expected to improve benefits for GPS users and to increase the sophistication of an advanced future satellite positioning system.

A Critical Design Review of the QZSS was conducted in August and the team is now involved in manufacturing a test model as well as working on the ground systems. Potential applications for the system are also being discussed with industry and research institutions. The project consists of two different phases. The first is a technology demonstration and application demonstration. The second phase involves the testing of the round-the-clock system with three QZ satellites including the first one launched in the test phase. At present, JAXA is concentrating on achieving a good result with the first satellite. JAXA is responsible for the system development and operation in the first phase in which three technology demonstrations will take place. The first is focused on improving GPS availability. A satellite will be launched that can transmit GPS-like signals. The satellite will be used as the fourth GPS satellite with a round-the-clock view. JAXA also assumes responsibility for high precision time management. The second technology demonstration will enhance accuracy and reliability. The aim is to achieve one metre accuracy for high speed vehicles. The third technology demonstration is to establish next generation positioning technology in Japan using Japan's own frequency signal thus giving Japan its own, original system and self sufficiency when required.

Regions with ambition

Considering the difficulties that the European Galileo system has run into, it will be interesting to see how the Asian systems progress. What is not in doubt is the fact that the world is not happy to rely upon the American NAVSTAR constellation and regions are really pushing themselves to develop their very own systems that will be able to cope with the next generation demands that will be put on them. Location based services are the future and will be used more and more in coming years as features are built into the devices that we use everyday such as mobile phones. Therefore, countries want to be prepared. The regional services will be capable of working independently but will also be interoperable with other regional systems enabling more accurate positioning. As Asia asserts itself in terms of navigation technology it will further improve services and help to take these systems to the next level. ■

Photo courtesy of Garmin.