GPS and GIS technology trends

by G. Loganathan

Experts in the field of telecommunications had their opportunity in Bangalore, India, on 9th-10th September to exchange their views on the advancement and future trends of global positioning systems (GPS) and geographic information systems (GIS), during a two-day seminar organised by the IEE Bangalore Branch. IEE Past President Prof. John Midwinter (University College London), currently researching in the area of optical communications, inaugurated the seminar by the traditional lighting of a lamp. This was followed by his inaugural address.

Bangalore, once known as Garden City, is now popular as 'electronic city', where Prof. Midwinter interacted with some telecomms companies and research organisations, and also had a press interview. This brought out some major issues of potential concern:

- 'The emerging technology and research in modern telecommunication, based on optical fibre system is well ahead of market demand. Research is heading towards marketing wave-length reconfigurable networks on the super-capacity highways. But industry is unable to engineer research into products. Lack of investment in telecomms companies and a worldwide trend'
- While the world shortage of optic-fibre cable, that was a worry even in India, around the same time last year, no longer holds good, 'an increase in cable-manufacturing companies, and the consequent drying out of the market has resulted in a surplus', reports *Times of India*, as Prof. Midwinter's observation

The keynote address was delivered by Dr. Aatre (Scientific Adviser to Defence Minister & Secretary, Department of Research & Development, Government of India) during the inauguration. He remarked that India was the first country to develop an airworthy military GSP used in tankers, aircraft and missiles. While GPS is used widely, when they see its applications, people take it for granted as a simple system. But this technology never flows into the education system and is not exposed to the general public. Dr. Aatre therefore suggested that professional Institutions like the IEE should take the lead in trying to promote the introduction of the basics of GPS and GIS at school level detailing its applications, so that the acceptance of this technology increases.

During the technical session, Prof. Paul Cross (Head of Geomatics Engineering, University College London) presented two papers on the 'Prospects for global navigation satellite systems (GNSS) in the next decade' and 'High precision engineering and environmental applications of GNSS'. Some highlights from his presentation are given here:

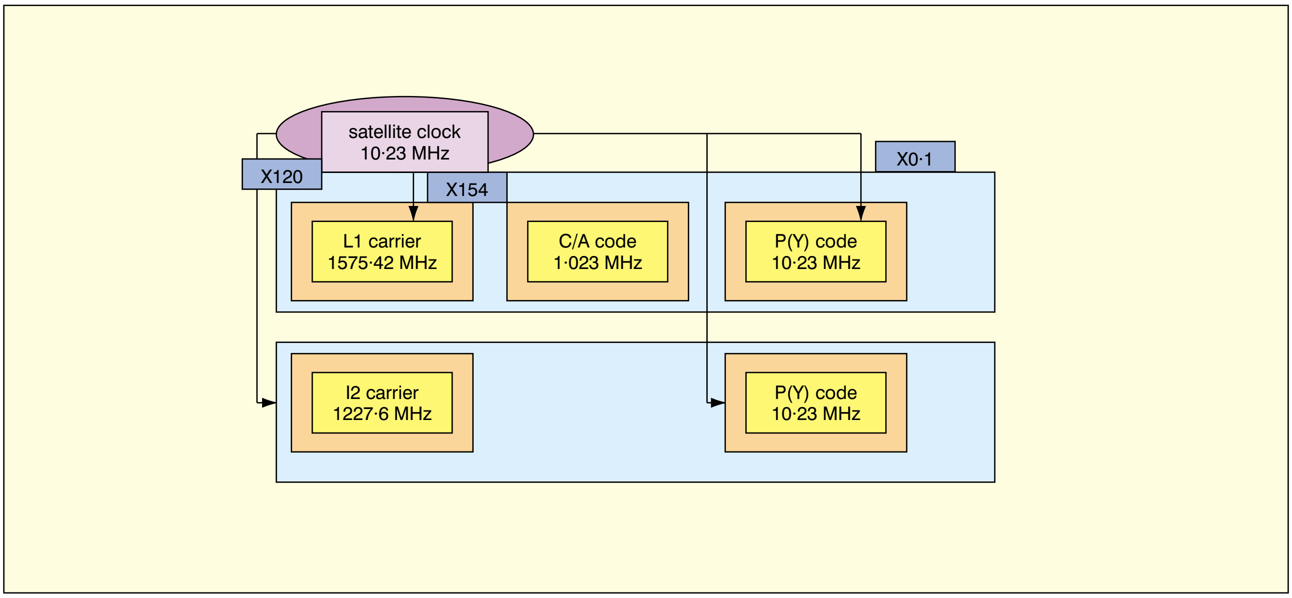

Fig. 1 GPS signal generation (courtesy of Dr Paul Cross)

One GPSS now in use is the GPS Constellation, designed for military applications and operated by the US Air Force. Nominally, the system is formed from a constellation of 24 satellites, six orbit planes, 55° inclination and 26 500 km radius. The GPS signal consists of two carrier frequencies, L1: 1575·42 MHz (0·19029 m wavelength) and L2: 1227·60 MHz (0·24421 m wavelength); two binary modulation codes: P (Y) code 10·23 MHz (29·305 m wavelength) and C/A code: 1·023 MHz (293·05 m wavelength) and 1500 bit data message 50 Hz. The signal generation is depicted in Fig. 1.

The satellites in the orbits are to be monitored. The GPS receiver in its working process measures distance using the travel time of radio signals, which needs an accurate timing device. The satellites and receivers use digital codes called pseudo-random code (PRC). Pseudo-range measurement is used to resolve any ambiguity in measurement. The replica code is corrected against the satellite code. The time offset is scaled by the speed of light to form a distance measurement. C/A distance is in the range 0–293·05 km.

Another aspect discussed was differential GPS (DGPS), which is the relative positioning using pseudo-ranges with pseudo-range corrections (PRCs). These PRCs are determined at one or more known stations and applied at unknown stations. For real time operations PRCs are broadcast. It works over a small areas (<500km by 500km), most range errors are highly correlated with an accuracy of from 0·5 to 2·0m.

The DGPS service providers are:

- *International navigation companies*, which use L-band satellite communications.
- *Free national level services*, for example, UK Trinity House (six stations, 300kHz)
- *Local services:* GSM or FM radio delivery.
- *Independent systems.*

In future, Prof. Cross explained, DGPS will have:

- General move towards a ‘wide area solution’, sometimes called a network solution
- WASS and EGNOS are US and European ‘government level’ implementations
- Modern wide-area systems can involve:

—multiple reference stations
—multiple SATNAV systems (e.g. GPS and GLONASS)
—geostationary overlay
—real-time error modelling
—monitor stations
—integrity signal (typical time to alarm <10s).

GPS technology finds general navigation application in areas such as walkers, cyclists, cars etc. and also applicable in emergency services like taxis, buses and ambulance etc. However, problems associated with GPS are:

Professor John Midwinter delivers his inaugural address

- *Signal reception:* with limited use inside, masking (topography like trees, buildings etc.), interference (especially L2).
- *Accuracy:* especially in height.
- *Integrity:* need six or satellites for fault detection and elimination (FDE).
- *Cost:* basic GPS code chips cost just a few tens of dollars, but up to $10 000 for a high accuracy receiver. Differential services can be expensive.

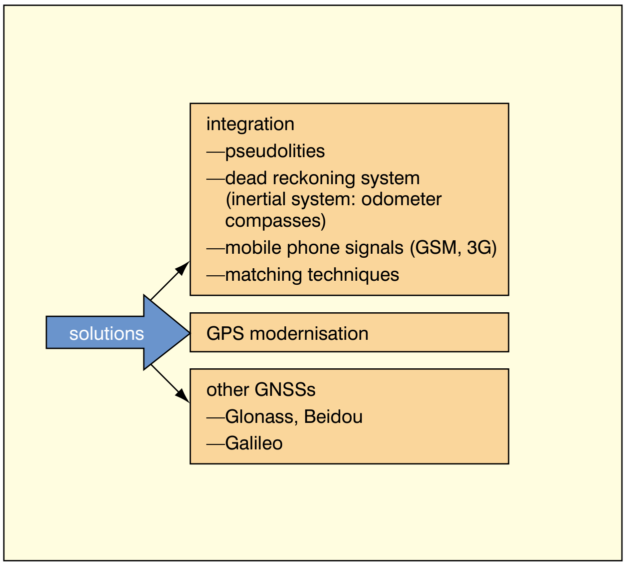

Fig. 2 Solutions to GPS problems

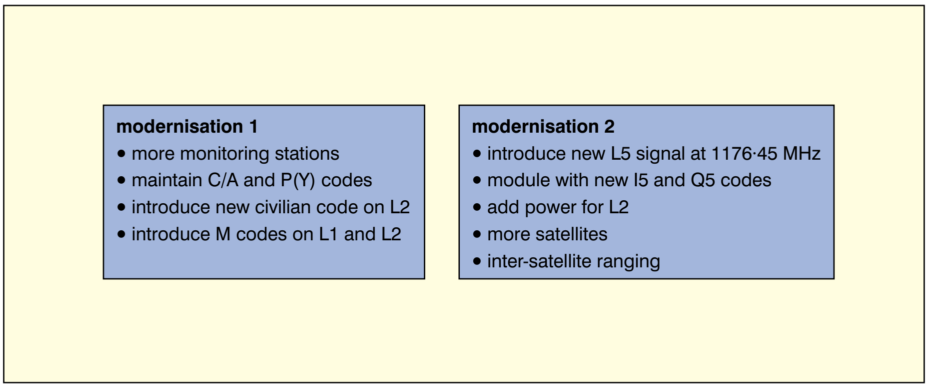

Fig. 3 Two stages of GPS modernisation

As Prof. Cross explained the solutions to these problems are illustrated in Fig. 2.

While referring to GPS modernisation, he briefly outlined what it involves, in two stages (see Fig. 3).

By 2010, Prof. Cross projected we can expect:

- 70(?) navigation satellites
- autonomous 3m accuracy positioning everywhere
- novel uses of many signals
- low-cost high accuracy positioning in virtually all developed areas
- extensive value added services
- even more applications.

Another expert, Dr. S. V. Kibe, Programme Director (SATNAV, ISRO) shared his experiences with regard to core constellations, augmentations, GPS modernisation and application of satellite navigation (SATNAV) technology in scientific endeavours. His address on the need and types of augmentation highlighted the following:

- Current GPS Constellation cannot support requirements for all phases of flight, as integrity is not guaranteed:

—all satellites are not monitored at all times
—time to alarm is from minutes to hours
—no indication of quality of service.

- Accuracy is not sufficient, even with SA off, vertical accuracy >10m.
- Availability and continuity must be met.

Dr. Kibe concluded remarks that the use of satellites in 'free flight' is a must for communication navigation surveillance (CNS).

Dr. Banerjee (Senior Deputy Director, National Physical Laboratory, New Delhi) in his presentation discussed GPS time and its applications, and correction to pseudo range and common view time transfer, and various other aspects. While reviewing online timing applications of GPS receiver, he stressed the need for calibration of GPS time receiver with respect to standard time, which is linked to UTC of BIPM. The extent of inaccuracy may be a characteristic of a particular model.

The above mentioned experts projected the future trend of Constellation as illustrated in Fig. 4.

The seminar included discussion on many other applications of GPS and GIS. A good number of professionals gave contributions during the technical sessions. The seminar was Co-Sponsored by the IEEE and the Institution of Electronic and Telecommunication Engineers (IETE).

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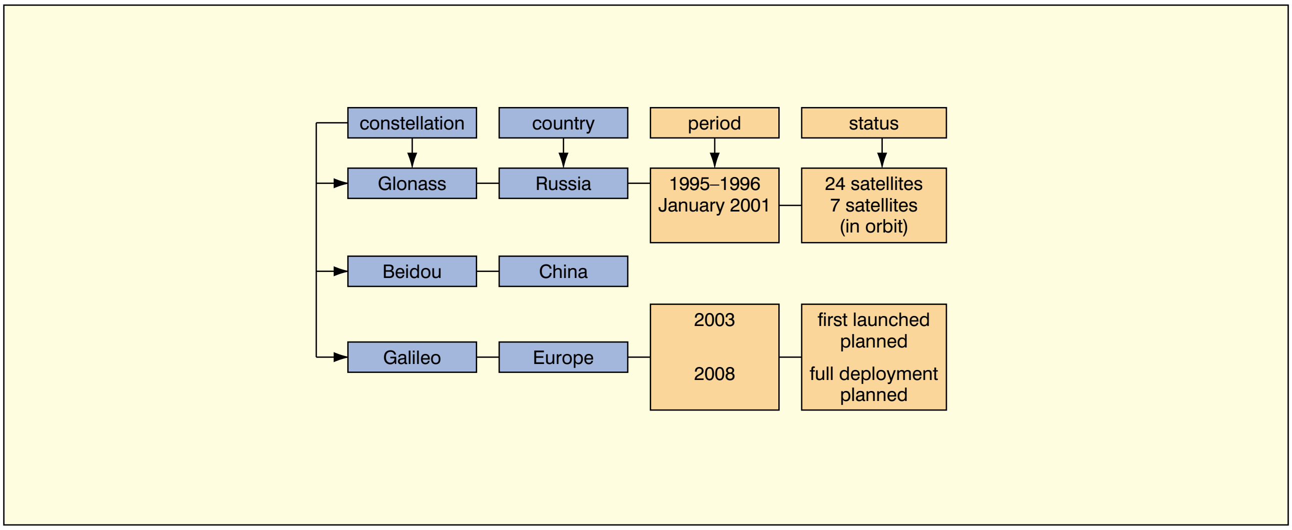

Fig. 4 Future trends for Constellation