Satellites 12,000 miles away can pinpoint our position to within two metres – or even a millimetre

GPS update

Where are we? Where are we going? Duncan Wells reports from a seminar at the Royal Institute of Navigation

GPS is based on time. A satellite 12,000 miles up in space sends a signal, which is picked up by our GPS receiver and the time it takes the signal to arrive tells us how far away the satellite is. When our receiver has this information for another three satellites – we need four satellites to get a three-dimensional position – it uses a process called 'trilateration' to work out our position to within 10m.

Can we improve on this accuracy? Yes we can. Potential errors include:

- Delays to the signal as it passes through the atmosphere
- Shading (satellites are too close together).
- Satellite position reporting errors
- Receiver clock errors – satellites have atomic clocks; our receivers don't
- Signal multipath, where the signal bounces off buildings or land features and so takes longer to get to us.

All of these can be ironed out by a process called 'augmentation', which compares the satellite position we've been given with the satellite position of known objects and provides our receivers with the offset to improve our position accuracy to within 2m.

There are two main augmentation systems: Differential GPS (DGPS) and Wide Area Augmentation System (WAAS). DGPS transmits error corrections on AM radio, while WAAS does it from geostationary satellites.

Then if we apply Real Time Kinetic, another time comparison system, to our GPS signal we can get a position accuracy to within a centimetre. Maritime pilots use this when they take their own GPS receivers onto big ships. Further augmentation refinement can get position to within 1mm, the sort of accuracy needed to measure continental drift. It is all based on time. The more accurate our clock, the more accurate our position.

Global Navigation Satellite Systems (GNSS) is the generic term for all satellite positioning systems, the main ones being:

- GPS, run off the US Navstar satellites, is what our GPS sets receive
- GLONASS, the Russian version, hasn't been reliable in the past. Recently spruced up and now reportedly on a par with Navstar

And then we have:

- Beidou, the Chinese system, which currently only covers China but is expected to be operational globally by 2020
- Gallileo, the much-promised European system, is still not operational. Just 12 of the 30 satellites are up and full operational capability has been put back to 2019. Expect further delays if the past is anything to go by and expect Beidou to be globally available before Gallileo.

At the Royal Institute of Navigation's 'Innovation in Marine Navigation' seminar, a man from the Ministry of Defence talked about using differences in gravity to measure position. That's next, apparently.

What does all this mean for us? Our GPS sets are chipped to receive from Navstar but in future, Raymarine tells me, new GPS receivers will use both Navstar and GLONASS satellites, which are interoperable, so our receivers will use a mix of both to fix our position. Hopefully as new systems come on line we will be able to receive their signals, too. The more satellites, the more accurate our position.

PHOTO ABOVE: NOAA

PHOTO: DUNCAN WELLS

Augmentation systems improve GPS accuracy by comparing our position with that of known objects and applying an offset

Accuracy to within two metres is all very well, but how does that match up with charts? New charts are being drawn to 2m accuracy, but prior to the mid-1990s, the degree of accuracy required was to 1.5mm at chart scale. On a chart with a scale of 1:100,000 a rock, or indeed land, could be 150m away from where it is shown on the chart.

Then we have the thickness of the pencil. If this is 0.5mm, it represents an area 50m wide on a 1:100,00 scale chart. So we can never plot our position on a chart as accurately as the position given to us by our GPS.

We are achieving an extraordinary degree of GPS accuracy, but we must be careful when we relate this to charts. Remember, it is generally accepted that no one ever ran aground by following the established route.

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