GPS – Global Positioning System

Owen Mace

GPS is almost what its name suggests — a global positioning system. It allows those with suitable receivers to position themselves with considerable accuracy anywhere on the earth. There are three components. The Control Segment manages the entire system. The Space Segment consists of 24 satellites transmitting carefully timed radio signals. The User Segment means you and I with our receivers. It is a digital system, using spread spectrum modulation techniques, which also transmits very accurate timing information.

GPS is really two systems at once. One is for civilians and the other is for the armed forces of the United States and its allies, including Australia. The civilian system provides the Standard Positioning Service (SPS) using a Course Acquisition (CA) code, whereas the Precise Positioning Service (PPS) using an encrypted code called the P(Y) code.

SPS has an inherent accuracy of ±30 m when providing positions at a rate of one per second. Errors called Selective Availability (SA) are deliberately added to the signals, so that anywhere on earth the horizontal error is less than about 100 m. (Certain provisos can be ignored for the moment.) Errors in altitude are somewhat greater. The PPS has an inherent accuracy that is much greater, believed to be ±2 m at 10 positions per second.

Techniques have been developed to enhance SPS accuracy, but at a cost. An accuracy of 5 to 10 metres costs a few hundred dollars, but if you want a millimetre or two, you will not get much change from $100,000. Car devices costing about $3,500 will provide an electronic map to guide you to your destination. Ships have had such devices for years.

GPS measures the time a signal takes to travel from transmitter to receiver. Multiplying that by the speed of light gives the distance. If you know the position of a satellite, the distance between it and a receiver is readily calculated, but with only a single measurement it could be anywhere on a sphere of that radius. A second satellite narrows the position to a circle, and a third to one of two points. One will be near the earth's surface and the other tens of thousands of kilometres away. Since the relationship of the satellites' clocks to the receiver's clock is not known, a fourth satellite is needed for an independent position solution. Each satellite transmits what is known as ephemeris data to enable receivers to calculate exactly where it is at any time. Receivers can navigate with fewer satellites if some of the four unknowns can be established. Ships remain at sea level, so they can operate with three, as can cars if certain assumptions can be made.

Hartleigh Kelly, our oldest racing skipper, at the Twenty Year Members' Dinner. [He's the one looking at the camera.]

All this is fine, providing signals are received clearly. In built-up areas they can be blocked by buildings and even foliage, and they can be reflected from a large building to cause what is known as a multipath error. The US Department of Defense adds errors (called Selective Availability) so that, even with a perfect receiver, the accuracy of a position is 10 m for 95% of the time and 300 m for 99.99% of the time. Other errors arise if a satellite signal is shadowed and lost for a short time. A receiver may then not automatically lock back on the signal, although receivers are getting better at reacquisition. Errors can compound to as much as half a kilometre in the City of Adelaide.

Selective Availability, and indeed the design of SPS, is to deny adversaries of the United States and its allies the use of the system for targeting purposes. During the Gulf War South Australia was turned off altogether and errors of 30 m were seen. Not only did the allies have many GPS units, some servicemen bought their own, giving them an overwhelming advantage in this technology. During the Kosovo conflict South Australia remained in the system, but the rate of errors was doubled or tripled, again with the intent of denying it to the Yugoslav forces.

Differential GPS (DPGS) augments standard SPS by setting up a high quality GPS receiver in a position that is very accurately known. This measures the pseudoranges and compares them with the actual pseudoranges calculated from the known satellite and receiver positions. The differences are broadcast to other receivers to calculate positions down to millimetres. These differential corrections are broadcast by radio station JJJ on inaudible frequencies, and are to be sent by the Australian Marine Safety Authority (AMSA) on a long wave frequency. Almost all modern GPS receivers are 'differential ready' to accept differential corrections.

The result is a device that makes navigation simple and precise, but never forget that, as explained above, the system available to yachtsmen is deliberately not perfect, and that human error can readily arise if we key in the wrong numbers. SQ

●n 2 May 2000, President Clinton announced that Selective Availability (SA) was turned off GPS transmissions. This has the effect of immediately improving accuracy to about 25m.

Oberon

JKSmith

Alas poor *Oberon*! She is sold.
Our love has gone for want of gold.
No thrilling times for us remain;
Henceforth our life will be mundane.

No more to see the sea at rage,
To witness it in wild rampage.
No more to see its heavenly bliss,
When stars stoop down with tender kiss.

Lost are the days of salutary balm,
When shags skim low over its wondrous calm;
When shearwaters with their graceful flight
Return to the land for the coming night.

No more to see the dolphins play,
With their attentive eye and proud display,
Leaping clear of the water's crest
And laughing at us, though we do our best.

Good times. Yea, good times all,
And now we let her canvas fall,
And then the sails are stowed at last
To become a memory of a distant past. SQ