Should you trust your GPS?

Where is here? How accurate is GPS – and more importantly how accurate are the charts we take for granted. As Duncan Wells discovers, when you get down to it, there's reason to be cautious.

Of course these days we all rely on GPS and every member of the crew has their own portable plotter, so unless someone switches off the signal you should always know where you are to within a few metres. There are currently two GPS systems in operation, the American Navstar which works well and has good coverage, and the Russian Glonass, which doesn't and hasn't. Galileo, the European system, is due to become operational in 2013 but has suffered a number of delays, so don't hold your breath, and the Chinese are due to go live with their version in 2015. In the meantime we rely on the US who, since 1 May 2000 when they switched off Selective Availability, have been giving us the correct positional information. So GPS is extremely accurate. It's true that it can be affected by significant ionospheric, or tropospheric interference. but I've never experienced it myself.

On the other hand, one evening, when the aircraft carrier USS *Enterprise* was blocking the eastern Solent and I was in the Beaulieu River, my GPS suddenly went down. The indicator showed that the batteries were OK and it performed all its functions, except to tell me where I was. I immediately suspected foul play and contacted VTS (Vehicle Traffic Service) the following day to find out what had happened – but they were totally unaware of any problems. So was it suspicious? Was Big Brother ganging up on me or had my GPS simply been playing up?

In fact, it's prcisely because GPS is so brilliant and so accurate that we need to be a bit careful (Pic 1). In the old days, sailors were well aware that their geographical position could be at least a nautical mile out because their positions were derived using celestial observations and, for that reason, would give a wide berth to charted hazards.

Even with the advent of electronic instruments such as Loran they were cautious. There was a general acceptance that the charts were more accurate than the clever navigational techniques currently available. But now that's no longer the case and GPS is pretty much spot on. We know from our in-car sat nav that if we don't have the correct maps in the system the GPS will quite happily show us driving over fields, when in fact we're using the new bypass. And so, on the boat, we need to know that the GPS is talking the same language – using the same datum – as the paper chart onto which we're plotting our position. GPS defaults to the WGS84 datum (World Geodetic System 84). Therefore unless your chart says that WGS84 positions can be plotted directly onto the chart, you will either have to make adjustments according to the chart's instructions for satellite derived positions or you must set your GPS to read the datum that matches the chart, which might be Ordinance Survery Great Britain 1936 or European Datum 1950, or indeed any of hundreds of datums which have been produced for charts around the world. Most GPS sets allow you to use different datums but not all. Then of course we have the question of the accuracy of the GPS itself.

GPS gives us a basic accuracy of 21 metres, according to the NGIA (National Geospatial Intelligence Agency) in the USA, which is an accuracy of 0.01 minutes of latitude. The Admiralty say this is actually 33 metres, or around 0.02 minutes of latitude, but I suspect they're being picky because the Americans got there first, on this occasion. By using Differential GPS, which takes a reference station with a known position and compares the differential between that and its GPS position, to give a 'correction' which it sends to your GPS, we can increase the accuracy to between 2 and your set is equipped with WAAS (Wide Area Augmentation Service) which was originally developed for aircraft (and most sets these days are) then you'll be getting the 2 to 7 metre accuracy. This is the positional error at your GPS aerial. Something you need to be aware of if your vessel is 300m in length!

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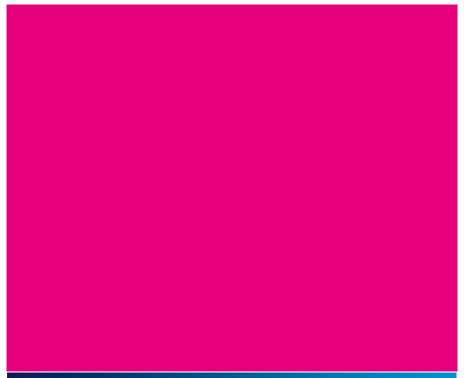

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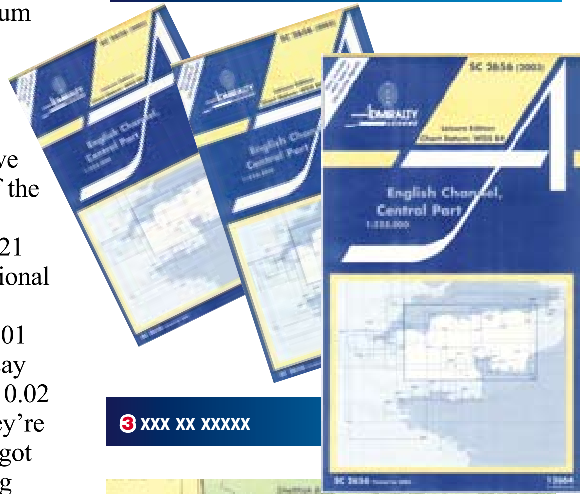

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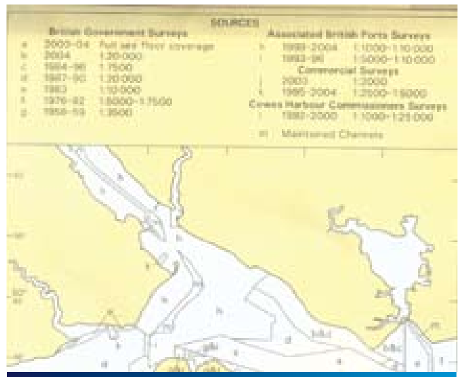

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5 On this chart of 1:20,000 scale this 1mm pencil line is 20 metres wide

6 On this chart of 1:500,000 scale this 1mm pencil line is 500 metres wide.

MEASURING GPS ACCURACY

So how do we know how accurate our GPS is (Pic 2) when it gives us our position? Well, of course, it will usually tell us on the main screen to the nearest foot or metre. And this is where it will probably show us the HDOP (Horizontal Dilution of Precision), also know as DOP. Now, just as a standard three point fix requires the charted marks to be spread evenly – too close together or too far apart and you build in inaccuracy – so the GPS needs the satellites to be spread evenly as well. A DOP of 1 or less is ideal. A DOP higher than this and the fix becomes less accurate until we reach a DOP of 20 or more when we'll incur an inaccuracy of at least 50 metres. Of course if you're in How accurate are the charts and can we rely on the fix we place on them? Since electronic charts, Raster (a direct copy from the paper chart) and Vector (interactive charts) are derived from the paper chart, we can treat electronic and paper charts the same (Pic 3). The obvious benefit of the electronic chart on a GPS linked chart plotter when you're sailing is that it shows you where you, are all the time, whereas the paper chart which requires you to plot the fix shows you where you were.

However, charts often rely on data which was collected when survey methods were considerably less sophisticated than they are today (Pic 4). The printing process, plotting techniques and even the thickness of a pencil can affect their accuracy. To put all this into context, a pencil line of 1mm equates to a distance of 20 metres on a chart of 1:20,000 – a large scale scale chart (small area) of a harbour (Pic 5) – and 500 metres on a smaller scale chart (larger area) of 1:500,000 (Pic 6). On my North Atlantic chart with a tiny scale of 1:10,000,000 a pencil line of 1mm equals 10 kilometres!

ARE YOU CONFIDENT?

The accuracy of the chart itself varies enormously depending upon the quality of the source data and the International Hydrographic Office are working on

CATZOC TABLE

The Classification of source data accuracy at present

ZOC	Position Accuracy	Depth Accuracy	Seafloor Coverage	Survey Type
A1	+/-5m	10m +/-0.6m 30m +/-0.8m 100m +/-1.5m 1000m +/-10.5m	Full seafloor sweep	Controlled high accuracy Survey using WGS 84 datum, DGPS with multibeam channel sweep system
A2	+/-20m	10m +/-1.2m 30m +/-1.6m 100m +/-3.0m 1000m +/-21.0m	Full seafloor sweep	Controlled systematic survey using echosounder with sonar and mechanical sweep
B	+/-50m	10m +/-1.2m 30m +/-1.6m 100m +/-3.0m 1000m +/-21.0m	Full seafloor coverage not achieved. Uncharted features hazardous to surface navigation are not expected but may exist	Controlled systematic survey to standard accuracy
C	+/-500m	10m +/-2.5m 30m +/-3.5m 100m +/-7.0m 1000m +/-52.0m	Full seafloor coverage not achieved. Depth anomalies may be expected	Low accuracy survey or data collected an an opportunity basis such as soundings on passage
D	Worse than ZOC C	Worse than ZOC C	Full seafloor coverage not achieved. Large depth anomalies may be expected	Poor quality data

a standardization of 'Categories of Zones of Confidence', or Catzocs into a scale of Fitness For Use - FITUSE - by which navigators can judge the quality of the data on any given chart. Having programmed the route into the computer using Electronic Navigational Charts (ENC) based on the Electronic Chart Display and Information System (ECDIS) and having supplied details about the ship (Pics 7 & 8) such as draught and desired under keel clearance (UKC), the navigator will then be advised by a system of traffic signals – Green for go, Red for stop – if he can rely on the chart data for the route chosen (Diag 1).

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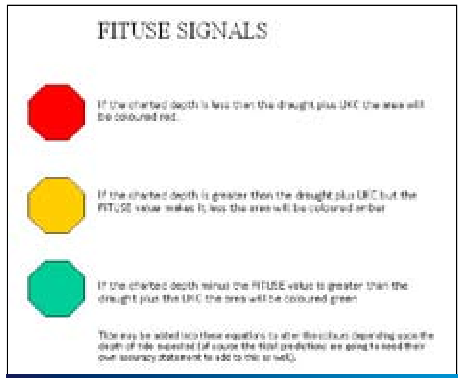
8 xxxxxxxx



Diag 1 xxxxxxxx

While detailed large scale charts of major ports and approaches will conform to a Catzoc of A1 and be highly accurate (Pic 9), small scale charts that cover a larger area will comprise a variety of Catzocs from A1 to D and you will need to check the chart Source Data to find out which is which (Pic 10). So when your GPS with WAAS capability shows you in a position that's only likely to be up to 7 metres adrift, the mark that you're looking at on the chart could possibly be as much as 100 metres out of position. Added to which high accuracy aerial photography has revealed serious discrepancies between the true shoreline and the charted shoreline. So 'cutting the corner' in fog – not that anyone would be daft enough to do it – could turn out to be disappointing! It's therefore important to bear in mind these inaccuracies when planning our pilotage and give a wide enough berth to any obstructions. It is also worth reminding ourselves not to get confused by the 'Zoom in' facility on the chart plotter (Pic 11). Zooming in does not alter the accuracy of the chart (Pic 12), it just means that we're getting a closer look at it (Pic 13) and what we might be looking at could well be based on a lead line and sextant survey from 1890 which sampled only a small percentage of the ocean floor!

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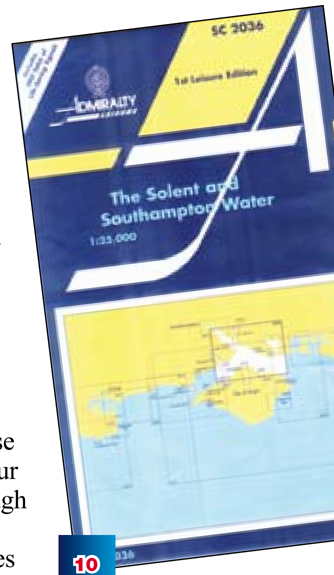

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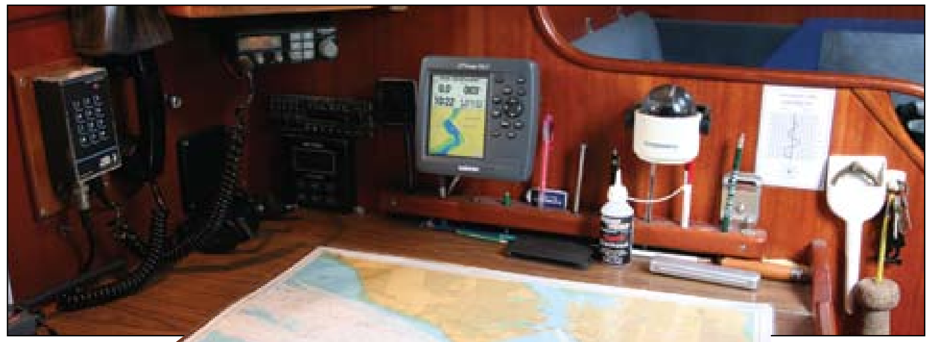
BEWARE HUMAN ERROR!

Finally, the greatest error with GPS is human, so check that you've entered the correct co-ordinates for marks, buoys and waypoints and make sure that you always give a cable or so offset when plotting buoys. No one will ever forget the story of the Fairline on its delivery journey to the Channel Islands when it struck Bridge West Cardinal by the Needles channel and sank. Had they plotted the precise co-ordinates of the cardinal? And was this an occasion when the chart was 100per cent true and the GPS was operating at its 2 metre accuracy?

One day in the future, when the charts and GPS are both accurate to within a couple of feet and technology has come down in price, we should be able to look forward to a fully integrated boat. A boat with DSC (Digital Selective Calling) Radio hooked up to the GPS, with Radar and AIS (Automatic Identification System) all linked to the plotter to give us a true picture of the sea area and the land, night and day – and, a true picture of the shipping around, plus a look at the water ahead through Sonar on the bow, and from accurate vector charts, to give us information about the seabed and likely hazards, combined with instant weather information. That, surely, would be the perfect navigation system. In fact it's more or less with us today. The only thing is that when these systems are installed on every boat, we'll probably feel much safer than we ought to. We may even may lose our basic skills as seaman and our ability to use or indeed to believe the 'mark one eyeball'. Finally, don't you just love the caveat that pops up each time you turn on your GPS plotter (Pic14)?



11 At 0.8nm...

12 Zoomed into 500ft...

13 Zoomed in to 300ft, the accuracy hasn't changed we are just getting a closer

14 No one can afford to take responsibility for anything these days!