



The Global Positioning System, the world's first global utility, has become a proven innovation and a marvel of modern technology. Over a few short years, GPS has changed many of the traditional ways we do things and in a growing number of ways, has changed human kind forever. GPS is now such an integral part of many otherwise 'ordinary' everyday maritime situations, that we are already starting to take this extraordinary satellite-based system for granted. But according to GPS systems analyst Kerry Matthews, the best is yet to come.

# GPS

## Navigation In The 21st Century

### Part Three: How Accurate Is Your GPS ?

**GPS Accuracy – what is it, how to define it, how has accuracy changed and what does it mean to the majority of boating users?**

Minimum performance standards that an SPS user can expect are outlined in the *Global Positioning System Standard Positioning Service Performance Standard* of 2001. This standard defines the levels of performance the U.S Government makes available to civil users through the GPS Standard Positioning Service (SPS) since Selective Availability was discontinued in May, 2000.

SPS performance standards are based on Signal-In-Space performance. GPS being a space-based dynamic worldwide system, these specifications outline global average and worst-case conditions at a level the U.S Government has some control. The affects of ionosphere, troposphere, receiver design, multipath or other

interference including the "users contribution" to the overall performance are not included.

*Selective Availability* was the largest single factor that until recently affected ALL civil positioning performance. With SA now discontinued, there are now many other factors and variables, which have become much more pronounced. The primary factors that can contribute to overall SPS performance are

- Satellite Availability
- Satellite Signal-In-Space (SIS) ranging errors
- Constellation geometry
- Receiver and antenna design
- Type of solution determination
- Atmospheric effects

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- Signal reception – user's terrain, local interference

GPS control operations are required to maintain Service Availability, Service Reliability and Accuracy within defined parameters and conditions.

Of most interest to the average recreational user with a single frequency GPS receiver is Positioning Accuracy.

*Positioning Accuracy represents how well the position solution, over a specified time interval conforms to "truth", being any specified location where the position is accurately known with respect to an accepted coordinate system.*

System accuracy and other performance standards are now defined at the Satellite level, referred to as

Accuracy Standard	Conditions & Constraints
<b>Global Average Positioning Domain Accuracy</b> <ul style="list-style-type: none"> <li>● 13 metres 95% All-in-View Horizontal Error (SIS Only)</li> <li>● 22 metres 95% All-in-View Vertical Error (SIS Only)</li> </ul>	<ul style="list-style-type: none"> <li>● Defined for position solution meeting the representative user conditions</li> <li>● Standard based on a measurement interval of 24 hours averaged over all points within the service volume</li> </ul>
<b>Worst Site Positioning Domain Accuracy</b> <ul style="list-style-type: none"> <li>● 36 metres 95% All-in-View Horizontal Error (SIS Only)</li> <li>● 77 metres 95% All-in-View Vertical Error (SIS Only)</li> </ul>	<ul style="list-style-type: none"> <li>● Defined for position solution meeting the representative user conditions</li> <li>● Standard based on a measurement interval of 24 hours averaged over all points within the service volume</li> </ul>

Signal-In-Space (SIS). As there is no 100% absolute guarantee, all performance standards are defined as a percentage probability relative to certain conditions and constraints.

In meeting these positioning accuracy standards the Operational Control Segment must also maintain standards within defined statistical relationships for Service Availability and Service Reliability. With Selective Availability (SA) now discontinued, these relationships are defined in the context of a dynamic space based system rather than a fixed terrestrial system as previous.

Horizontal accuracy less than 13 metres 95% (global average) is certainly an improvement compared to the 100 metres 95% when SA was active. However remember that these new performance specifications are SIS (Signal-In-Space) based on a 24-satellite constellation with the worst 2 satellites removed.

Without Selective Availability (SA) there are many more factors that jointly affect the performance specifications, which in conjunction with other variables contribute to the overall user accuracy. Some of these factors that now affect GPS accuracy and performance were probably "clouded" by the blanket affect of SA, when active.

With so many factors now affecting the performance a user experiences, a single set of performance standards is unable to represent the service expected by all users under all circumstances. This is further

complicated as some of the factors affecting user performance are outside the control of the U.S Government.

SPS standards do not include other possible sources of error or how the user applies the basic positioning and timing services provided. The effect by the ionosphere as the signals travel to

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the user is one possible source of error, while multipath is highly dependent on receiver and antenna design.

Adopting generally accepted values for ionosphere/troposphere delay, multipath and general receiver noise affects in addition to the defined SPS standards, the global average positioning accuracy that a user within

the terrestrial service volume might "expect" could be around 25 metres or less 95% of the time. In GPS terms the "terrestrial service volume" covers from the surface of the earth up to an altitude of 3,000 kilometres, a true global utility. Under "normal" worst site conditions, accuracy could be around 50 metres or less, 95% of the time.

Yes, accuracy could be that much. In fact, accuracy could be much worse than that, especially the other 5% of the time, especially as this other 5% is a complete unknown.

But fifty metres! Isn't Selective Availability supposed to be discontinued? Don't we now have military type accuracy? Don't manufacturers quote accuracy

much less than that? Isn't GPS accuracy predominately less than 10 metres? What's the answer? To all these queries the simple answer is "Yes", however some require further explanation.

GPS performance has certainly exceeded established service levels but these service levels have a substantial margin introduced between performance committed and performance observed. GPS on-orbit spare satellites are included as part of the operational constellation as satellite lifespan is not determined by being available or not. GPS being a dynamic global system, the performance a GPS user experiences will vary widely due to many factors, unique variations can be a result of a user's location, even the user's application of the technology.

To gain maximum performance from their GPS all users need to be aware of the limitations and operation of their equipment, including understanding the underlying behaviour of the system. This includes how performance could be affected by many different environmental and system factors including themselves, the user.

There are many documented events, which highlight some of the errors that have occurred and certainly could probably occur again. Some like clock failures, resulting in positioning errors of hundreds of kilometres can be explained. Others of smaller proportions might be a result of sun spot activity or geo-magnetic storms or could be multipath at one specific