GPS smoothing – removing discrepancies in received positions

Introduction

There is an age-old saying that "Navigation is the precise art of knowing where you were". Not so much nowadays it would seem – with the advent of GPS and ECDIS we are very close to knowing precisely where we are, all the time. However, the continuing trend to rely solely on this means of navigation rather than to cross-check with other independent and reliable navigation techniques introduces a significant risk.

CHIRP Maritime published reports in Maritime FEEDBACK (MFB) issue 54 which were *inter alia* related to discrepancies in positions between a marine pilot's PPU, (Portable Pilot Unit), and the vessels ECDIS position. It was determined at the time that the discrepancy was due to settings of the GPS – specifically the smoothing.

CHIRP subsequently received further reports of a similar nature and, as reported in MFB 56, we engaged with GPS manufacturers in order to study the subject in further detail. In this Insight article, we provide a simple explanation about GPS smoothing and good practices to follow in this regard.

What is GPS smoothing?

The accuracy of a GPS position obtained on board a vessel can be affected by the quality of satellite signals received at the GPS receiver's antenna. In addition, the accuracy may be affected by satellite geometry, satellite system errors, and other factors such as signal blockage, atmospheric conditions, and receiver design features/quality. The shipborne marine GPS receiver computes the ship's position several times per minute. Each of these positions is affected by these errors to varying degrees and thus, if all were plotted, the track might appear erratic.

Erratic position and speed data from the GPS receiver can lead to errors in determining the ship's speed and ship's course. GPS smoothing is embedded as software within the GPS receiver and is utilised to overcome this problem. The basic principle of smoothing techniques is to reduce erratic data points used for providing the ship's GPS position. Thus, the smoothing settings can affect the GPS display for speed over the ground, course over the ground, and course made good since all of these are computed from the positional data being received.

GPS receivers employ a filtering algorithm to compensate for data points beyond known variances and provide a stable position display output and position output signal for other navigational aids / navigational instruments. The filtering algorithm uses a series of position measurements over time to provide position outputs that tend to be more accurate than individual position measurements for navigational use.

If all obtained positions (several times a minute), on a stationary vessel, were to be plotted on an ECDIS chart of appropriate scale, the plotted position would appear scattered around an extremely small area of the chart, however, they are unlikely to overlap. When the receiving conditions at the shipborne marine GPS receiver are unfavourable, the GPS fix obtained may change significantly even if the vessel is stationary. Appropriate adjustment of the Latitude and Longitude GPS smoothing setting in the GPS receiver can reduce this phenomenon.

If we now consider the ship to be moving at sea speed, the position plots would appear to be more scattered. The shipborne marine GPS receiver directly measures the ship's speed over the ground (SOG) and ship's course (COG) during the position fixing process. If every position fix that is obtained is utilised to directly derive SOG and COG, both these values would appear to be changing randomly depending on receiving conditions and other factors. Appropriate adjustment of the Speed and Course GPS smoothing setting in the GPS receiver can reduce this apparent random change of SOG and COG.

Should the GPS smoothing be adjusted?

The shipborne marine GPS receiver's GPS smoothing setting can be adjusted appropriately by the shipboard navigator. The GPS will have reduced accuracy of displayed position, COG and SOG output if the shipboard navigator does not set the GPS smoothing setting correctly for the actual navigation environment of the vessel. The onboard manual for the shipborne marine GPS receiver provides steps for conducting this adjustment. In general, the correct setting depends upon the expected dynamics of the vessel. If a ship is

highly dynamic (i.e. moving rapidly), it should be set to a lower value since the filtering window needs more frequent input, resulting in a more responsive measurement. However, if a vessel is less dynamic and has much more resistance to change in its motion, this value can be increased to reduce measurement noise.

The advice from the manufacturers that ***CHIRP*** Maritime contacted is that SOG and COG smoothing should only be adjusted if the operators know what they are doing. If the operator is not sure, then the specific GPS manufacturer and the manufacturer's instruction manual should be consulted. The smoothing settings are (in general) entered by the attending service technician when the GPS unit is installed on the vessel, and it seems they are seldom adjusted thereafter. Considering the problems highlighted in Maritime FEEDBACK 54, perhaps a change of mindset is needed.

Ask yourself the question - *On the current leg of the passage, is my vessel on a steady course and speed for a long time?* If the answer to the question is affirmative, the smoothing setting needs to be applied to ensure that the COG and SOG outputs derived from GPS positions do not seem to change erratically.

Precautions

- The shipboard navigator should be aware that LAT/LONG smoothing and COG/SOG smoothing parameters can be adjusted by the user to adjust the level of responsiveness of the shipborne marine GPS receiver. The ship's GPS User Manual should be consulted on how to adjust the GPS smoothing setting. The smoothing setting of shipborne marine GPS receivers should be correctly adjusted according to the expected dynamics of the vessel.

    - *If the vessel is navigating near harbour entrances, harbour approaches and coastal waters,* where the passage plan requires the vessel to frequently change course and/or speed, *the GPS smoothing settings should be set low* so that small changes in the vessel's course/speed over the ground (COG/SOG) and position (LAT/LONG) are tracked closely by the GPS.

    - *If the vessel is navigating in ocean waters*, where the passage plan requires the vessel to maintain a steady course and speed for relatively long periods of time, the *GPS smoothing settings should be set around mid-range* so that scattered positions obtained by the GPS receiver are smoothed to obtain a stable course/speed over the ground output (COG/SOG) and a steadily changing position (LAT/LONG).

- Failure to appropriately adjust the GPS smoothing settings, as above, can lead to situations where there is a significant offset (reported to be as high as 160 metres) between the displayed position on the ECDIS and the ship's actual position derived from visual observations (bearings/distances) or from radar overlay.

- Whenever a ship's passage plan is being prepared, choice of position fixing methods to be used for each leg of the passage must take into consideration that prevailing IMO performance standards for a marine GPS receiver (without differential GPS capability) require, in ocean waters, that the system should provide positional information with an error not greater than 100 metres with a probability of 95%. *Such a position fixing system should not be chosen as the primary position fixing system near harbour entrances, harbour approaches and coastal waters*, where the latest IMO standards prescribe that the positional information error should not be greater than 10 metres with a probability of 95%.

- Where the ECDIS on board provides a radar overlay facility it must be used at every available opportunity to verify the GPS position. *If there is a discrepancy between the radar overlay picture and ECDIS display it must be recognised as an indication of an underlying inaccuracy in the GPS position received.* This is also the reason why good seamanship suggests that we should cross-check the GPS position against the radar by means of LOPs and visual bearings during coastal navigation.

- The shipboard navigator must not abandon the basic tenets of navigating by sight and sound. Where available, maintain visual verification of the vessel's position to ensure situational awareness and safe navigation.

Conclusions

From the above it can be determined that there are two distinct issues, namely the accurate knowledge of where the vessel is, and the adjustment of GPS smoothing to compensate for inaccuracies. It should also be noted that this discussion is related to GPS units and not DGPS (which should automatically correct the errors that have been discussed in this article).

CHIRP Maritime has repeatedly highlighted the importance of traditional navigation and keeping a good lookout. It is imperative that critical sections of every passage are carefully planned and executed. Transits, wheel over positions, turning curves, visual bearings supplemented by radar ranges, and parallel indexing are just a few of the tools available to the navigator.

In today's electronic age it seems that far too much reliance is being placed upon GPS derived positions displayed on ECDIS with reluctance, in some cases, to use other available and reliable means of navigation to verify the ship's position. This being the case, it is imperative that the information being displayed is correct. Clearly, as we highlighted in FEEDBACK Issue 54, this is not always the case.

It seems to ***CHIRP*** that there is a case for having two distinct settings for GPS smoothing, (perhaps one for deep-sea and another for port arrival). The manufacturers that we spoke to stated that there are no general recommendations in this respect and pointed out that it is up to the operators, dependent upon the dynamics of the vessel in question. They also highlighted the importance of traditional navigation. Whilst it is disappointing that the manufacturers were unable to provide specific advice, it is understood that a particular marine GPS model may be fitted on a variety of tonnage from fishing vessels, to high-speed ferries, large tankers, container vessels, general cargo ships and yachts. Nevertheless, the potential problems have been discussed and the question for bridge teams and company management is simple – are we going to do something about it?