The Cruising Club of America

CHECKING THE GPS

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SUMMARY

Great reliance is placed on the modern GPS for navigating small boats. There are occasions however where the navigator might question and want to verify that it is operating satisfactorily.

How well the GPS is operating can be easily determined by observing the range and bearing of a waypoint one degree North or South and again, one degree East of West. If the results are close to that calculated, the unit is working as intended. In no case should the GPS range for one degree be greater than 60 nautical miles.

FOREWARD

At the worst moment, the navigator may begin to doubt the accuracy of the GPS. It can happen when the radar doesn't seem to confirm the location on the chart, when closing on a submerged outcropping or some critical waypoint where there is need for great accuracy. Even worse with a Man Overboard.

Every prudent sailor wants to ensure his vessel and equipment is sound and operating properly before casting off. This should also include verifying the accuracy of the GPS.

The way to thoroughly test these units is on a bench where the parameters can be tested with accuracy. Unfortunately, this luxury is not available while underway at the time when the accuracy is questioned.

Airplane pilots are taught to believe and rely on their instruments rather than their senses. Fortunately, piloting a boat differs since boats can usually be slowed, stopped, quickly turned around or backed up without catastrophic consequence - except perhaps to pride. Certainly, if visual observations or the depth do not correlate with the charted electronic position, the GPS should be suspect.

Restated, if what you see is not what the GPS is telling you, **believe what you see.**

There are a few notes that apply to this paper:

1. Downloading this paper to a computer running on Windows requires Acrobat Reader Version 5.0 or higher. Unfortunately, this version was released prior to Windows XP and while it will appear correct on computer's display running Windows XP, printing it out requires Acrobat Version 6.0 or higher for a legible printout. The latest Acrobat Reader version is available free at this website.

2. Margins, top and bottom, left and right have been set to:

a. Top and bottom – 1.0”
b. Left and right – 0.6”
c. Header and footer – 0.5”

3. It has been suggested that an index be added. Actually, a facility in Adobe Acrobat is available for this. Simply click on “Edit” on the Tool Bar, then “Find” and type in the reference word. The program will do the rest.

I want to thank R Steven Thing for his review and comments on the original draft of this paper.

Comments, corrections and suggestions are more than welcomed and I try to respond to each of these when received. Since we spend as much time as we can on our boat, please send them to me via email.

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SOME FACTORS CONTRIBUTING TO QUESTIONABLE GPS POSITIONS

In addition to the GPS malfunctioning, there can be other contributors to an erroneous position. They give the appearance of a malfunctioning GPS even though it is operating as intended and designed. Some of these are:

1. The chart may be in error particularly in third world countries where old surveys have not been updated and corrected. These errors are not necessarily but mostly in longitude.

2. The chart datum may differ from that selected in the GPS's program menu. Charts in other countries do not necessarily use WGS 84 nor do even old US charts that have not been updated – onboard or updated at NOAA. Imray Charts, very popular in the Caribbean and Europe have only recently switched over to a defined datum and not necessarily WGS 84.

3. With some chart packages which have been available in chandleries throughout the US, the latitude/longitude switches from degrees, minutes and tenths of minutes to degrees, minutes and seconds without warning from page to page.

For sure, these deviations can catch the fatigued navigator off guard. Any changes from that normally used to determine positions should be notated and highlighted on each chart page; if the datum is different, circle it in red.

All of these deviations can be present at the same time. The change in datum led to the loss of a 53' yacht at Mayaguana a few years ago and also a grounding (temporarily) by the author in almost the same place.

There is nothing wrong with using a datum other than WGS84 provided that the new datum is selected on the GPS when using a chart that calls for the different datum. But **not** using the proper datum means that all the GPS's calculated positions will be off by a fixed amount.

The significance of using the wrong datum can be more than trivial. A comparison between WGS 84 and European50 taken at the dock at Lefkas, Greece had our European50 position about 365 feet north and 198 feet east of our WGS 84 position. This is a difference of about 415 feet between the two chart datum without moving the boat!

None of these errors are due to the GPS's accuracy but rather, to using the wrong reference point by the navigation program. All manufacturers of these devices include a warning to not rely exclusively on these units for navigational purposes and for good reason.

The algorithms programmed into the navigation packages of the modern GPS are often derivatives of earlier products and even the same as that programmed in Loran products from several years

ago. At least one manufacturer used the same subroutines from their Loran products in their GPS products subscribing to the theory that if it works, it works and there is no point in changing it. In actual fact, the algorithm carried forward to the new products was not correct.

GPS and Loran navigation programs have a lot in common and can be treated as the same for all in the tests described below.

TESTING THE NAVIGATION PACKAGE

Two quick tests to verify if the navigation algorithms programmed into the GPS are correct. This also works while underway. They can be performed wherever you are except at or close to the North or South Pole.

The tests involve obtaining a Range and Bearing of a position to the North (or South) and secondly, a position to the East (or West). Both tests should be done to ensure that the unit is operating correctly.

Note: Not all units calculate the East/West range correctly. This is the more complicated calculation and coincidentally for other reasons, where most old charts are in error.

The first and easiest check is the accuracy north or south which is along a meridian (a great circle of the earth). The second and a little more difficult is along a parallel of latitude which are all small circles except for the equator.

The tests below exercise most of the navigational functions of the unit. If the Range and Bearing are approximately correct in both the North/South and East/West directions the unit is operating as designed.

Even though a yacht may be underway while the check is performed, the distance covered in the time to calculate is negligible unless the yacht is moving at a very high rate of speed.

SOME MEASUREMENT CONSIDERATIONS – THE THEORY

For the navigator, the earth is coordinated by a series of great circles running from the North Pole to the South Pole called meridians. Latitude is measured along a meridian north or south from the equator. Perpendicular to the meridians are a series of circles called parallels, which are all small circles except for the equator which is a great circle. Longitude is measured east or west from the meridian running through the Naval Observatory at Greenwich, England which is called the Prime Meridian.

By convention, there are 360 degrees to a circle and each degree is divided into 60 minutes. In the past, each minute was further divided into 60 seconds. In more modern usage, the minute is divided into tenths, hundreds and thousands.

For example, latitude 23 degrees, 29 minutes and 19 seconds is the same as latitude 23 degrees, 29.316 minutes.

La 23° 29'19" N = La 23° 29.316' N

It is very easy for the tired navigator to overlook this subtle difference. Charts using minutes and seconds should be highlighted.

By definition, each minute of latitude measured along a great circle is equal to one nautical mile. Restated, a minute measured on any meridian is equal to one nautical mile (a minute a mile). Similarly because it is also a great circle, each minute of longitude on the equator is equal to a nautical mile, but only on the equator.

Moving away from the equator north or south, each minute of longitude becomes increasingly less than a mile until the meridians converge at the poles and become zero. This is discussed in some detail in the American Practical Navigator (Bowditch) as well as other navigational texts.

The earth is not a true sphere because its shape is flattened at the poles. When this shape called an oblate exists, the meridians only approximate a great circle and therefore, the only true great circle on the earth is the equator. And because of the flattening at the poles, this change from a perfect sphere is more pronounced closer to the poles. Since the meridians are not true great circles and become less so as they approach the poles, measurement of a minute north or south along a meridian other than at the equator is always something less than a nautical mile and certainly never more.

This abnormality with meridians is corrected in the meridionial expansion of latitude on the vertical edges of the chart and can generally be ignored by the navigator in most cruising areas involving short distances; less than 600 miles. It does come into play however when measuring distance with a GPS.

Along a meridian or along the equator, angular distance can generally be directly converted to distance:

1 ° arc = 60 min arc = 60 nm (nautical miles)

Therefore:

1 nm = 6076.12 = approx. 6076 feet
0.1 nm = 607.6 = approx. 608 feet
0.01 nm = 60.8 = approx. 61 feet
0.001 nm = 6.1 = approx 6 feet

From a practical standpoint, it is only important to remember that one degree along a meridian is 60 nautical miles close to the equator and becomes something less than 60 nm as the poles are approached.

CHECKING ACCURACY – NORTH OR SOUTH

To test and verify North/South accuracy, enter a waypoint exactly one degree North (or South) of your current position (same longitude) and obtain the Range and Bearing. The range should be almost 60 nm and the bearing for a waypoint to the North should be the magnetic variation if the unit is set to magnetic bearings or, zero degrees if set to True.

Range	< 60 nm
Bearing	0° or Variation in degrees

CHECKING ACCURACY – EAST AND WEST

A more complicated test involving a little trigonometry is the distance of one degree east or west along a parallel. To do this, enter a waypoint at the same latitude and exactly one degree east or west of your current position. This will produce a bearing of East (90 deg.) or West (270 deg.) plus the magnetic variation if magnetic bearing is switched on.

This Range should be sixty times the cosine of the latitude.

Range	60 cos La
Bearing	90° or 270° (+ magnetic variation is switched on)

AN EXAMPLE

An example of both of these using Paris-Arsenal as a location and where the latitude and longitude are La 48° 51.088' N, Lo 02° 22.117' E follows: In these examples, the magnetic variation is switched to Auto Mag which is 002 ° at this location.

North or South:

Enter a waypoint of: La 49° 51.088'N, Lo 02° 22.117'E - one degree north, same longitude

	La - N	Lo – E
Position	48° 51.088’	02° 22.117’
Way Point	49° 51.088’	02° 22.117’
Difference	01° 00.000’ N	00° 00.000’

Get Range & Bearing:

Range = 59.9 nm
Bearing = 002°

East or West

Enter a waypoint of: La 48° 51.088'N, Lo 03° 22.117'E - one degree east, same latitude

	La - N	Lo – E
Position	48° 51.088’	02° 22.117’
Way Point	48° 51.088’	03° 22.117’
Difference	00° 00.000’	01° 00.000’ E

Get Range & Bearing:

Range = 39.48 nm
Bearing = 092°

To confirm this range, calculate the longitudinal distance:

Rng = 60 cos La

Rng = 60 x cos 48° 51.088’

Convert degrees and minutes to degrees

Rng = 60 x cos 48.8515°

Rng = 60 x 0.6580

Rng = 39.48 nm

The technical proof of this is available via email from the author at: wpaul04@attglobal.net.
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