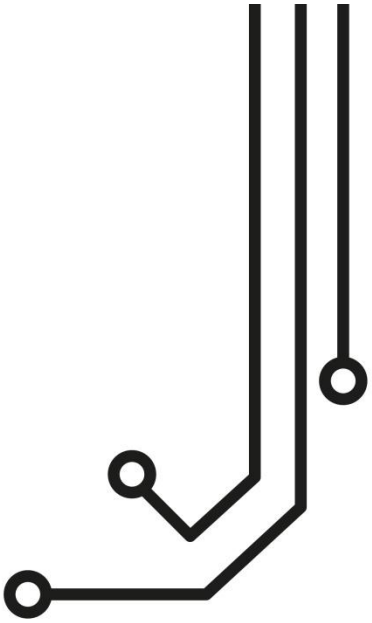
DIGITAL YACHT



DualNav™ GPS+GLONASS White Paper

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1. Background

Knowing your position whilst at sea is key to safe navigation. What we now take for granted, was extremely difficult, time consuming and inaccurate. Then, in the latter half of the 20th century, came the electronic positioning systems – Decca, Loran, Transit and in the 1990s, the global positioning system, GPS. Over 20 years have passed since the first GPS receivers were commercially available and in this time the whole world has come to rely on this US funded technology. Now every boat, plane, car and train that we travel on has GPS navigation and even your smart phone can give a GPS position accurate to within 10m, anywhere in the world, at the touch of a button.

Decca Receiver

Transit Display

Much political discussion has taken place over our reliance on GPS technology, to the point where both Europe (Galileo) and China (Compass) are developing their own satellite based navigation systems, which are scheduled to be fully operational by 2020. However, whilst GPS was being developed in the 1980s, there was another competitive system developed in Russia called GLONASS. This system was very much over shadowed by the American GPS system and due to the secrecy surrounding the technology and the difficulties for non-Russian companies to license this technology, it never achieved wide spread commercial use outside of Russia and surrounding countries.

During Russia's difficult financial period between 1989-1999, government spending on their space program was cut by 80% and launching of new GLONASS satellites stopped. With relatively short life spans the GLONASS satellites soon started to fail and by 2001 there were only 6 satellites still operational and the GLONASS service effectively ceased.

Most observers at the time thought this would be the death of GLONASS but in 2000, with the Russian economy recovering, President Vladimir Putin took a special interest in GLONASS and made the restoration of this service a high priority. Between 2002-2011, a large investment was made and at the end of 2011 GLONASS was fully restored and now offers worldwide coverage (with 24 operational satellites) and accuracy almost as good as GPS. In areas of high Latitudes (North and South) GLONASS is more accurate than GPS due to the orbital position of the satellites.

2. How a Global Navigational Satellite System Works

GPS, Galileo, GLONASS and Compass are collectively known as Global Navigational Satellite Systems (GNSS) and all reply upon their own constellation of satellites. Although each system works slightly differently and on different frequencies, the basic method of calculating your position is the same for each system.

Accurate calculation of your 2D (Lat/Lon) or 3D (Lat/Lon/Alt) position relies upon the ground equipment (receiver) processing the signals from 3 (2D only) or more satellites. Each signal is accurately time stamped as it is transmitted and by measuring the time each signal takes to reach the receiver and knowing the position of the satellite it was sent from, it is possible to very accurately "triangulate" the receiver's position.

Accurate and synchronised timing is achieved with atomic clocks in each satellite and the position of each satellite is tracked and calibrated by base stations to minimise positional errors and allow modern GNSS receivers to achieve typical accuracies of less than 5m.

The most accurate positions are achieved by using signals from satellites that are as high as possible in the sky and not dipping towards the horizon when atmospheric conditions can affect signal strength and timing. Therefore the larger the number of satellites in view, the better the positional accuracy as the receiver has more satellites to choose from and can pick the strongest/best positioned ones to use for navigation.

As the way in which these different GNSS systems work is very similar and the frequencies used are relatively close to each other, it has been possible for manufacturers to develop GNSS receivers that will read the signals from multiple systems.

3. DualNav™ - New Technology

Now with the GPS150 DualNav™ technology, boat owners can have a single sensor that will automatically read satellite data from both GPS and GLONASS constellations, choosing the best signals from over 50 satellites. Wherever you are in the world you now have twice the satellites to choose from resulting in the GPS150 receiver having much better coverage, time to first fix and positional accuracy. Add to this the new high sensitivity receiver design, selectable baud rate and 10Hz position update rate and you have a GPS receiver that is significantly better than every previous marine GPS receiver on the market.

DualNav

The GPS150, Digital Yacht's compact marine GPS & GLONASS positioning sensor using DualNav technology

The new performance is particularly noticeable if the receiver is mounted below deck/inside the wheelhouse where the high sensitivity receiver still gives a good position fix. Even in ideal installations where the antenna is mounted outside, older GPS systems could often lose fix, if there were any obstructions blocking the view of the sky or when sailing in tree lined rivers or close to cliffs. With DualNav™ technology you have almost twice as many satellites to choose from, giving a much more reliable and accurate fix in all conditions.

On larger boats, it is now possible to have two completely separate position sources, not just two GPS units but two different positioning systems so that you can compare and validate your actual position. Set one GPS150 to GPS mode and another GPS150 to GLONASS mode and you have dual redundancy and two independent positioning systems.

The GPS150 also supports SBAS (Satellite-Based Augmentation System) which is the generic name given to the differential signal transmitted by various local geo-stationary satellites. SBAS allows the GPS150 receiver to remove errors in the position due to environmental conditions and improves accuracy down to <1m. Using WAAS in the US and EGNOS in Europe the GPS150 will automatically switch to differential SBAS mode when available.

4. What Data is Transmitted ?

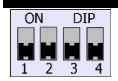
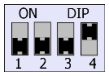
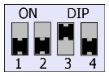
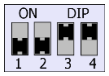
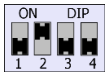
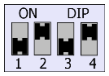
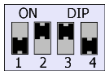
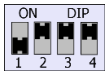
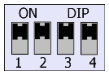
All GNSS systems calculate your;

- Position (Latitude/Longitude/Altitude)
- Speed Over the Ground (SOG)
- Course Over the Ground (COG)
- Date and Time (UTC = Coordinated Universal Time)
- Quality of Fix
- Satellite positions and signal strengths

The GPS150 outputs all of the above data as a series of NMEA0183 data sentences. All of the popular sentences are output; **GGA, GLL, RMC, VTG, GSA, GSV, ZDA**

The GPS150 can be configured to operate in various modes to suit different applications or ensure compatibility with different equipment that it is connected to. The default mode just uses the GPS satellites and outputs all of the above sentences, once every second at the standard NMEA0183 baud rate of 4800baud. For many applications, particularly connecting to existing or legacy systems, this configuration will provide maximum compatibility.

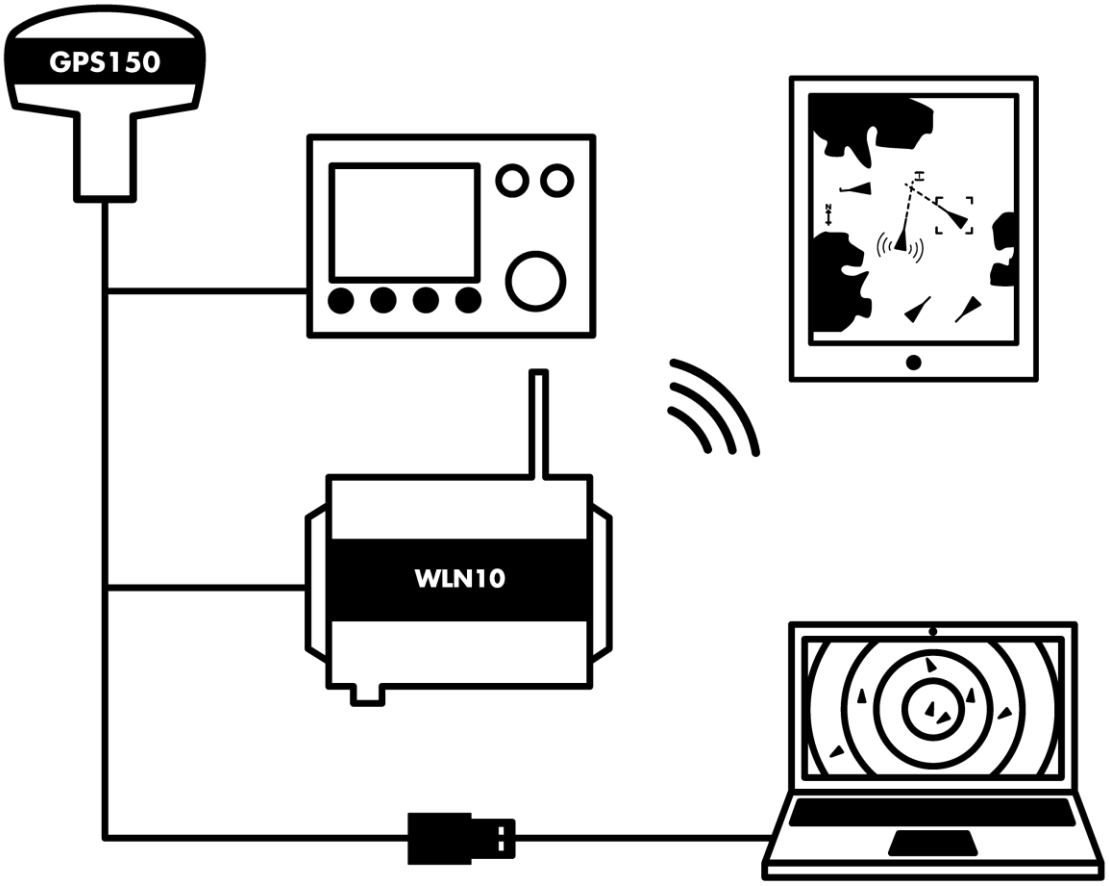
Mode selection is via four small DIP switches inside the unit and we currently have 9 modes defined but more can easily be added at customer request.

Switches 1234	MODE	SATELLITES	BAUD	RATE	NMEA DATA
	GPS 105 Mode (default)	GPS	4800	1 HZ	GGA/GLL/RMC/GSV/GSA/VTG/ZDA
	GPS 6Hz Mode 4800 Baud	GPS	4800	6 HZ	RMC
	GPS+GLONASS Minimum Sentences	GPS+GLONASS	4800	1 HZ	RMC/GSV/GSA
	GPS+GLONASS All Sentences 1Hz	GPS+GLONASS	38400	1 HZ	GGA/GLL/RMC/GSV/GSA/VTG/ZDA
	GPS+GLONASS All Sentences	GPS+GLONASS	38400	6 HZ	GGA/GLL/RMC/GSV*/GSA*/VTG/ZDA*
	GPS+GLONASS Standard Sentences	GPS+GLONASS	38400	10 HZ	GGA/RMC/GSV*/GSA*
	GLONASS 1Hz All Sentences	GLONASS	4800	1 HZ	GGA/GLL/RMC/GSV*/GSA*/VTG/ZDA*
	GLONASS 6Hz Minimum Sentences	GLONASS	4800	6 HZ	RMC
	Full "Turbo" Mode	GPS+GLONASS	115000	10 HZ	GGA/GLL/RMC/GSV*/GSA*/VTG/ZDA*

* These sentences output at 1HZ

5. Applications

There are many applications for GNSS data aboard a modern boat or ship and it is not unusual for a boat to have 2, 3 or even more position systems. As well as devices that need to know your position, your course and speed over the ground is important data that many devices can use and with reliance on this data, comes the need to have a suitable backup system, should the primary device fail.



One of the benefits offered by DualNav technology, is that the GPS150 can be configured to work exclusively from the GLONASS satellite constellation and this provides a completely separate backup solution that will work even if there is a problem with the GPS system, which can and does happen.

As far as the equipment that the GPS150 is connected to is concerned, the NMEA0183 messages that it receives from a GPS150 configured for GLONASS only operation, are identical to those from a normal GPS and so in most cases switching can be automatic/seamless and many ECS Systems already have this functionality.

As well as providing a backup to the primary positioning system, other applications for a GPS150 GNSS sensor include;

- Position Input to a DSC VHF Radio
- Position Input for a Class A AIS Transponder
- 10Hz rapid Course over the Ground input for a Chart Plotter or Radar (MFD)
- Replacement GPS antenna for a failed older unit
- Connection to a Wireless NMEA converter to provide GPS data to Tablets and Smart Phones
- Position Input for Yeoman plotter

- Position Input for AIS Receiver Display

The 10Hz update rate that we mention above allows many Multi-Function Displays (MFDs) to have much smoother chart rotation if they have the Course Over the Ground updated ten times every second. Also the plotting of the vessel is almost continuous with no noticeable lag or jumping and the radar overlay alignment is more accurate and responsive.

Finally for high performance race navigation software or instrument systems, the GPS150 has a “Turbo” mode (115K baud) that can provide combined GPS and GLONASS position, course and speed data at 10Hz and this provides the ultimate in real time data where every meter or 0.01 of a knot can make the difference between winning and losing.

6. Useful Links

If this White Paper has encouraged you to learn more about GNSS or even purchase a GPS150 system for your boat, then the links below should be of interest…

- Digital Yacht’s Website where you can find the latest information on our GPS150 products.
- Digital Yacht’s Blog for all of the latest news and articles on GNSS
- Inside GNSS website for all the latest information on GNSS systems
- Wikipedia article on GNSS
- GPSWorld website the original and still one of the best websites on all things GNSS
- US Coast Guards website which includes lots of good info about GPS
- United Nations Committee for GNSS website