GPS

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Preface

This is an introduction to some key GPS concepts. It is not an operation manual. This early sections of this document are oriented towards the ANUSC Garmin GPS 12, the later sections are more general. The author uses a Magellan Meridian GPS.

The ***Introduction*** is for people who are unfamiliar with GPS.

The most important section is on ***Waypoint Entry: Map Datum & Position Format***. It is for people who have used a GPS, and who want to manually enter waypoints into the clubs GPS but who forgot to read the manual thoroughly.

There is a section on ***Mapping software*** for those who are interested but who have not yet investigated the area. The section on ***Buying a GPS*** is for those who have spare time and money.

Links are summarised in ***GPS information on the Web*.**

Introduction

What is a GPS?

A GPS receiver is device which can calculate the current position on the surface of the earth using signals from the US military Global Positioning Satellites.

A basic GPS can:

- Display the current **3D position** (**Latitude**, **Longitude** & **Height)** to within ±15m when it is receiving good signals from **4 or more satellites**
- Display the current **2D position** (**Latitude**, **Longitude)** when it is receiving signals from 3 or more satellites
- Display current **speed** and **direction** of travel.
- Record (**mark**) the current position as a **waypoint**
- Point to a waypoint (while you are moving)
- Direct you along a **route** of waypoints
- Direct you along a previous **path** or **track** you have travelled with the GPS

The direction finding capability of a basic GPS requires the GPS to be moving.

Introductory guides to GPS include: Garmin's What is GPS, Garmin's GPS Guide for Beginners, Magellan's About Satellite Navigation and Trimble's Shockwave gps tutorial.

Accuracy

A GPS receiver requires a clear view of the sky for accuracy. Accuracy is not affected by clouds, glass or plastic, but is affected by solid objects like trees, buildings, mountains, people & cars. GPS receivers do not work under water, underground, or in many buildings.

Currently, the optimal civilian signal accuracy claimed by GPS vendors is about ±15 metres in Australia. Until 2 May 2000, the US degraded the civilian signal using "**Selective Availability**" (SA), which introduced errors of around 100 metres. Be wary of waypoints recorded before 2 May 2000, as 100 metres is a very long way underwater! See Jennifer Mehaffey's page for a comparison of SA on and off.

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A GPS receiver can improve its accuracy by **averaging** when it is stationary by recomputing the current location every second and taking the average. To find out how to do this when taking a mark using the club GPS see the Garmin GPS 12 manual p17. Newer models average automatically when stationary.

GPS accuracy may be enhanced by correction signals transmitted from a known location. Two correction systems are currently available. The older one is Differential GPS (**DGPS**) which uses a terrestrial base station at a known location to output correction signals, giving an accuracy of 3-5 metres. Unfortunately a extra bulky beacon receiver is required to pick up these signals. In the US DGPS is run by the US coast guard. In Australia DGPS is run by the Australian Maritime Safety Authority who have a map showing Australian DGPS coverage.

A newer system is the Wide Area Augmentation System (**WAAS**), which uses ground stations linked to satellites in geostationary equatorial orbit transmitting correction signals, giving an accuracy of 3 metres. Newer GPS sets incorporate WAAS receivers. In the US WAAS is run by the Federal Aviation Agency (FAA). WAAS is available in the US, northern Pacific areas, and Europe (as EGNOS). WAAS signals may be received in north eastern Queensland, at the present they are of no benefit, and may actually degrade accuracy. There are even internet postings showing how to use undocumented features to turn WAAS reception off. See http://www.gpsoz.com.au/WAAS.htm, Magellans's page on Satellite Navigation Augmentation Systems or Garmin's What is GPS.

The GPS Standard Positioning Service Performance Standard guarantees that the civilian horizontal error should be within 13-36 metres and vertical error within 22-77 metres for 95% of the time after averaging over 24 hours with all possible satellites in view. Technically minded people may find this lengthy document interesting. The latest military 18 channel GPS-S can achieve an accuracy of 4 metres after averaging for 20 minutes, and 5 mm to 3 cm with a base station.

The Clubs Garmin GPS 12

Important features of the Club's Garmin GPS 12 include:

- Stores 500 **waypoints** with 6 letter name, symbol, and 16 letter comment which defaults to the current date & time, but can be modified.
- 9 **proximity waypoints** (gives a warning when close to dangerous places like rocks)
- 20 reversible **routes** with up to 30 waypoints each
- **Track log** of 1024 points, reversible using TracBack
- 107 **Map Datum**, including WGS84 & AGD66
- **12 Channel** receiver (can track 12 satellites simultaneously)
- internal patch antenna (OK for open areas like the ocean)
- **IPX7** water resistance, supposedly it can be submerged at 1 meter for 30 minutes, but **please make sure it is kept in its waterproof pouch on a boat!**
- 4 AA batteries for up to 24 hours battery life,
  so turn it off when not in use!

Read the Garmin GPS 12 manual! (The addendum mentions a power saving feature that would be available if the club upgraded the software.)

Waypoint Entry: Map Datum & Position Format

So, you've just found the coordinates for a great dive site and you want to copy this waypoint into the club GPS. You must first determine what **Map Datum** and **Position Format** the waypoint is in, and then set the GPS correspondingly. Datum and format conversions can be automatically done by the GPS.

Map Datum

The Map Datum defines the mathematical model used to approximate the shape of the earth. Datum is a cartographic term in common use.

Common Australian Map Datum	
AGD66	Australian Geodetic Datum 1966. Used in older Australian maps and charts. **Astrln Geod '66** on a Garmin GPS 12. AUS66 for Magellan GPS, Michael McFadyen & Tom Byron.
GDA94	Geocentric Datum of Australia 1994. Used in recent Australian maps and charts. Equivalent to WGS84 for all practical purposes.
WGS84	World Geodetic System 1984. The usual GPS satellite datum used by the club. **WGS 84** on a Garmin GPS 12.

Michael McFadyen's GPS datum section has more details on other Australian map datum.

Position Format

The Position Format is a Garmin term which combines the:

1. **grid** used to define a position (e.g. Latitude & Longitude),
2. **projection** (a mathematical model used to project a curved surface onto a flat surface) and
3. **format** (e.g. degrees/mins/secs vs. decimal degrees).

Magellan use the term **Coordinate System** instead.
On maps & charts look under both grid and projection for this information.

The most commonly used Position Format is based on **Latitude/Longitude**, which is widely used on charts. Another common Position Format is **Universal Transverse Mercator (UTM)**, which is the grid projection used by most Australian topographic maps like the 1:50,000 or 1:25,000 series put out by Geoscience Australia and state governments.

Garmin Position Formats	
hddd^{0}mm.mmm	Latitude/Longitude, degrees and decimal minutes
hddd^{0}mm'ss.s"	Latitude/Longitude, degrees, minutes and seconds
hddd.ddddd^{0}	Latitude/Longitude, decimal degrees.
UTM/UPS	2 digit grid zone, easting E, northing N. Also used on topological maps, includes the map number and a grid reference.

Alternatively, you could convert the coordinates of the waypoint yourself. Instructions on how to do this are on most recent Australian maps, and also on Michael McFadyen's GPS page, and on Murray Dow's GPS page, but, why bother, when the GPS will do it for you?

How Map Datum & Position Format changes the GPS Display

The club GPS has the TUNNEL waypoint near Malua Bay.

TUNNEL waypoint using different Map Datum's and Position Formats		
Map Datum	**Position Format**	**Waypoint display**
WGS 84	hddd^{0}mm.mmm	35^{0}46.758S 150^{0}14.905E
Astrln Geod '66	hddd^{0}mm.mmm	35^{0}46.852S 150^{0}14.834E
Astrln Geod '66	hddd^{0}mm'ss.s"	35^{0}46' 51.1"S 150^{0}14' 50.0"E
Astrln Geod '66	UTM	56 251183E 6036846N

Let the GPS do Datum & Position Format conversion for you!

Waypoints are stored in the GPS in an internal format which is not affected by the format in which they are displayed. The club GPS, like most GPS's, can have its Map Datum & Position Format easily changed. This lets you enter a waypoint using one combination of Map Datum and Position Format, change back to the combination you like, and the GPS looks after all the conversions for you.

The current Map Datum and Position Format setting in no way affects the recording of marks entered by pressing the mark button, it just changes the display. Is does however, affect manually typed waypoints as you enter them, so if you use the wrong Datum to manually enter a waypoint, your waypoint will be inaccurate.

To display or change the Map Datum or Position Format

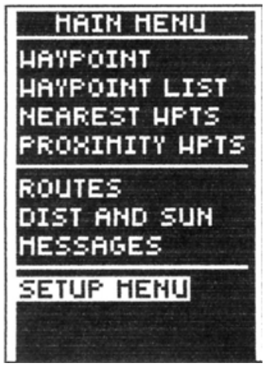
From the	**MAIN MENU**
choose	**SETUP MENU**
then choose	**NAVIGATION**

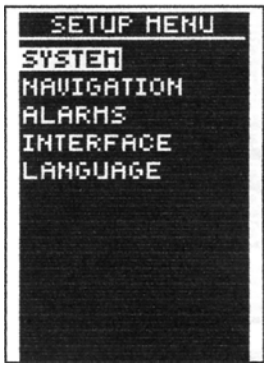
You will then see a screen entitled "**NAV SETUP**", with headings "**POSITION FRMT:**" & "**MAP DATUM:**".

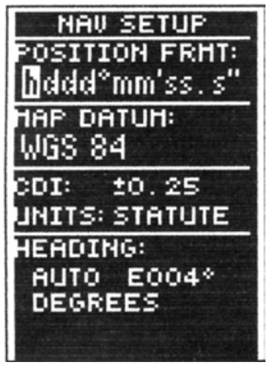
From **MAIN MENU** choose **SETUP MENU**

From **SETUP MENU** choose **NAVIGATION**

From **NAVIGATION** choose the **position format** or **map datum** you want






NAV SETUP
POSITION FRMT:
hddd°mm'ss.s"
MAP DATUM:
WGS 84
CDI: ±0.25
UNITS: STATUTE
HEADING:
AUTO E004°
DEGREES

See the Garmin manual pages 44-45 for more information.

Waypoint Conversions

GPS to GPS

Copying a waypoint from one GPS to another is simple, all you have to do is make sure that their Map Datum & Position Format match exactly. Unfortunately, different brands of GPS use different names for the same thing. Luckily, everyone uses the term Datum. The rest is just common sense, see above for some corresponding names under the headings Map Datum & Position Format.

Chart to GPS

Going from a paper marine chart to the GPS is usually simple, as charts have their Position Format already in Latitude/Longitude, so all you have to do is change the Datum (most Australian charts still use AGD 66), and ensure that the display formats of the Latitude/Longitude match. If the Datum is not shown on a NSW chart, it is probably AGD 66, unless of course it was produced before 1966.

Topographic map to GPS

See also Using a Garmin GPS with Paper Land Maps.

Typing a position derived from an Australian topographic map into a Garmin GPS is a bit more complicated, as Garmin's UTM Position Format looks different to the UTM format usually seen on maps. Most people just use a 6 digit grid reference, or the map sheet number appended to the front of the 6 digit grid reference. For example, UTM 1:25,000 map reference **56H 637 677** corresponds to Garmin UTM Position Format **56 263700E 6067700N**.

Again, the Map Datum is important, as most older Australian topographic maps use AGD 66, while more recent ones (often with an aerial photograph on the reverse side) use GDA 94, which is equivalent to WGS 84. Recent Australian topographic maps will state very clearly what datum, grid, and projection they use, and how to convert to AGD 66. Unfortunately, this information is usually only required for older maps, which may not display any information at all.

Why would an ANUSC member want to use a topographic map? Surprisingly, 1:25,000 & 1:50,000 topographic maps often have more coastal detail: like boat ramps, islands, and ocean depth than the smaller scale marine charts, so they do come in handy. Besides, ANUSC members have been known to participate in activities other than scuba diving.

If you are *really keen,* get a topographic map, write down the grid reference of some spot, enter it into the GPS, then check it by taking the GPS to that point, take a mark there, and compare it with what you entered.

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Example: Obtaining GPS waypoint coordinates from a topographic map

Using the latest NSW Land information Centre 1:25,000 map of Kioloa, 8926-1N, enter the grid reference for the Gantry at Bawley Point.

The Map Datum is GDA94 (equivalent to WGS84) and the Position Format is UTM.

Map grid references usually consist of 6 digits, the first 3 digits are the **eastings**, and the second 3 are called the **northings**. The first 2 easting digits are derived from the number of the nearest vertical grid line to the west of the point and the third one is estimated in a west-east direction. The first 2 northing digits are derived from the nearest horizontal grid line south of the point, the third is estimated going in a south-north direction. See the map for more details.

The 6 digit map reference of the Gantry is 637 677.

Looking at the top or bottom of the map you see a small **2** preceding some eastings, and looking at the left or right hand edges of the map you see a small **60** preceding some of the northings.
This gives you an extended grid reference of **2**637 **60**677.
Add 2 zeros on the right of both easting and northing you get 2637**00** 60677**00**
The "Grid Zone Designation" in the grid references area of the map says "**56**H", ignore the H.
The UTM format for the GPS is the 2 digit grid zone, easting E, northing N.
Putting all this together you get **56 263700E 6067700N**.
If you take the GPS to the Gantry, you may find that the GPS reads 56 263764E 6067789N, or something similar, although this may change slightly over time.

To see what the grid reference of the Gantry is on an old map swap the GPS Datum to AGD66, the GPS now displays 56 263661E 6067598N.

Switch the Datum to WGS 84 and Position Format to hddd^{0}mm'ss.s", to see the more familiar 35^{0}30' 9.0"S 150^{0}23'43.0"E.

Note the apparent discrepancy between the N at the end of the UTM grid reference, and the S at the end of the Latitude. The S at the end of the Latitude indicates that we are in the Southern hemisphere, as opposed to the Northern hemisphere, while the N at the end of the UTM position indicates that it is a Northing, as opposed to an Easting.

Calculating the distance between waypoints

To calculate the distance between waypoints, just put them on a route, and read off the distance.

Where to get Dive Site Waypoints?

Michael McFadyen's website

Michael McFadyen’s excellent diving web site has GPS coordinates which seem to be accurate, certainly the couple I have tried were good. He uses Map Datum **AUS66** and position format of degrees/minutes/seconds (**hddd°mm’ss”**). He has a page of New South Wales Shipwreck Marks and GPS Readings, and a GPS page, as well as lots of other stuff.

Tom Byron's books

Tom Byron’s scuba diving books are an interesting read, but the ones I have do not specify any map datum or position format. Coordinates given look like 99.99.99, which would usually be interpreted as dd.mm.ss, however, some of the seconds are greater than 60, so *I guess* he uses a position format of degrees and decimal minutes **dd.mm.mm** (like Garmin’s hddd°mm.mmm). The latest edition of his Scuba Diving in Northern NSW book comes with a CD that specifies the map datum used as **AUS66**, and a list of waypoint corrections now that SA has been turned off. These corrections do seem to be an improvement, for example, *my interpretation* of his updated location of the wreck Nerong is now only 1.42 km from the clubs waypoint, the one printed in the book is 120 km distant (the clubs Nerong waypoint is spot on).

GPScape

Ole Moller Nielson’s GPScape is a searchable database of GPS coordinates together with name, description, who made the point and other metadata. The idea is that one should be able to search for locations in a 100km radius, say, of any location. Ole uses position formats of DD.DD, DD:MM.MMM or DD:MM:SS.SS formats and the **WGS 84** datum.

Copying many Waypoints from one GPS to another

An easy way for bulk copying of waypoints is to use a program like OziExplorer. It can download waypoints from one GPS to a computer, edit them and upload them to a different brand GPS. OziExplorer knows about many brands and models of GPS. A useful demo version is available free. A data cable is required for each type of GPS. While the ability of individual programs vary, most do implicit datum conversions for you. However, generic programs like OziExplorer may have a few glitches when used with newer GPS which have extra database features (like inbuilt databases of cities, roads, navigation aids and coastlines in addition to user entered waypoints).

Mapping Software

Manually typing many waypoints into a GPS is extremely slow, tedious, error prone, and best avoided. A better way is to use a mapping program which can create waypoints with the click of a mouse, with the name typed in from a computer keyboard.

Mapping programs designed for use with a GPS can be used to plot waypoints and routes on a digital map on a computer. These waypoints and routes can be uploaded to a GPS, and waypoints, routes, and tracks on a GPS may be downloaded to the computer. Databases of Points of Interest and Navigation Aids may also be uploaded. Some digital maps can also be loaded into a compatible GPS.

Raster maps

Raster digital maps are basically scanned images of paper maps that may be **geo-referenced** (have details of location, datum, grid and projection for a viewing program). Examples include NATMAP Raster 250K Mapsheets 2002 which covers all of Australia at 1:250,000 on 2 CD's for $99, and the expensive Royal Australian Navy Australian Hydrographic Service's Seafarer GeoTIFF, and the Endeavour LEX. Natmap provides maps of Australia, a viewing program, but no GPS interface. OziExplorer provides a GPS interface and viewing program, but no detailed maps.

The free version of OziExplorer will only use bit maps (.bmp) which take up lots of disk space, and do not have geo-referencing information in them, although you can geo-reference the map yourself, using two reference points, and OziExplorer will store the geo-referencing information for later use. The full version of OziExplorer allows more than two reference points for geo-referencing, and will read many formats of scanned images, including GeoTIFF, which takes up less disk space than bit map.

GeoTIFF is a raster image format that is used for charts, aerial photographs, and other images which have a location on the Earth's surface. GeoTIFF is a extension of the TIFF (Tagged-Image File Format) image standard. It consists of image data, and a series of tags, which contain cartographic information about the image, allowing the user to tie the image to a known chart projection and for various GIS packages (such as MapInfo and ArcInfo) to display raster images in their correct location on the earths surface.

Raster digital images are often used in PC based mapping software, especially nautical navigation systems, and are available for some Personal Digital Assistants (e.g. Endeavour LEX).

Vector maps

Vector digital maps are more flexible, compact and are the usual format loaded into a handheld GPS for display. Vector maps enable the user to change the scale and level of detail viewed over a wide range, for example, from a map of the world, down to detail typically seen on a 1:25,000 map. Simple vector maps comprise of a series of straight lines with a length, direction and a starting position. GPS units with vector mapping ability built in include the Garmin GPSMAP 76S and the Magellan Meridian Platinum. Many vendors have PDA/GPS products that display vector maps (or occasionally raster maps). Vector maps are by their nature already geo-referenced.

The size of vector maps which can be loaded into a GPS is determined by the memory size of the GPS, the size of your SD card, and software size and compatibility limitations.

For example, Magellan's Meridian can currently only upload a maximum of 4 blocks of at most 16,364 Kbytes each per file to a SD card (giving a maximum size of 64Mb per file). However, depending on the size of your SD card, you can load more files, and use Menu | Card Utilities | Change Map to select which detailed map file you want to use. Currently (November 2003) DiscoverAus Streets & Tracks covers all of Australia using 235Mb, which would fit comfortably on a 256Mb SD Card using 4 x 64 Mb files. The level of detail here includes all roads, tracks, cities, towns, rivers, creeks, lakes and a comprehensive list of points of interest, but no contour lines.

If you want to also use Magellan's Mapsend BlueNav Marine Charts, which uses different software on your PC, you must load the marine chart into a different file on your SD card than the Streets and Tracks file.

Using the Magellan serial data line to transfer map data to the SD card in the Magellan Meridian GPS can take hours, while a USB SD Memory card writer can do the data transfer in minutes. Map preparation also takes quite a few minutes on a Pentium 4.

In contrast, with the Magellan SporTrak Pro GPS you load the same MapSend vector map directly into the GPS, so its 23 Mb memory is the main size limit, and you have no choice about serial line speed as yet.

Vector maps can have disadvantages too. Many have proprietary formats only compatible with a particular GPS brand and its mapping software. Due to competitive pressures, several companies seem to be hastily duplicating the same mapping task, resulting in some vector maps with many errors, typically in the most detailed layer. It appears that some vector maps have been prepared manually from raster maps by someone just clicking on what they felt were significant points. Parts of some maps appear to come from different sources with different scales and reliability. One vendors' Australian roads are accurate, but many roads, and even whole towns appear in the sea due to a very inaccurate coast line! Parts of the coastline are even missing. Unfortunately, errors in the coast line in this brand's GPS base map cannot be fixed by uploading corrections from their land based software, even though that coastline has less errors. However, if you load up their marine charts, you get accurate coastlines.

The ability for users to correct GPS base maps and compatible vector maps varies widely from vendor to vendor, an important point to consider.

Vector maps provide good coverage of North America and Europe, and there are now some for Australia, however most of the rest of the world is not covered in great detail. World maps are available, like Garmin's world base map that comes with their mapping GPS receivers, or Mapsend World Basemap from Magellan, with more detail like contour lines, at an additional price.

Layers, scale & Level of Detail

Digital maps consist of multiple layers. For example, OziExplorer can display a scanned map image, with waypoints and a route. The waypoints and route are superimposed above the map image, and can also be removed without affecting the underlying map.

Vector maps have several layers which are associated with the scale and the level of detail selected for display. This stops names from cluttering up your map, also it is computationally infeasible to use highly detailed information to draw a map of the entire planet in real time. Discrepancies between layers can and do arise!

Chart Plotters

Chart plotters use the NMEA output from a GPS to accurately plot the current position and route on a digital map on a computer screen. Many of these systems use raster maps, there are also vector systems. These systems usually have more functionality than maps loaded into a GPS, and the larger colour screen on a PC is far clearer than a handheld GPS screen. Mariners notes and many other features can be found in the more expensive systems.

Computer Navigation Systems

Automatic road routing GPS navigation systems can tell you how to get from A to B turn by turn. One example is the Garmin GPS V. Alternatively, there is the RACQ's travel Planner on the internet.

I want to buy a GPS – what should I consider?

Different people look for different things in a GPS. Are you going to use it mostly for diving/fishing on a boat, hiking, in a car or flying? Do you want a light hand held, or is it going to stay in a fixed location on a yacht next to a chart plotter? How much money and time do you have? How good is your eyesight at night in rough conditions?

If you want a light portable unit for hiking, you may want lots of extra features, like the ability to display vector maps, while if the GPS is in a fixed location on a large yacht, then a basic model will do, as maps are better viewed on the larger screen of a chart plotter hooked up to the NMEA output of the GPS. Motorists may want a fixed GPS with integrated street navigation software. Scuba divers and fishermen often do not have room or suitably dry conditions for a computer next to a fixed GPS, so one with an integrated depth sounder and mapping facilities might be best, or maybe from a maintenance point of view, it is better to keep the GPS and depth sounder separate …

Accessories include: a waterproof pouch for using a handheld in a small boat at sea, a DGPS receiver and antenna for use with a yacht, an antenna and mounting bracket for use in a car, or even a mounting bracket for use on a bike. Also, a GPS can be very heavy on batteries, especially when the backlight is used at night, so a power cable is very handy for use in a car or boat. If you are going to transfer waypoints to a computer, then a data cable is required. Combined power/data cables are available. If you want lots of mapping information handy, you may need a memory card (e.g. SD card), and then you find that a USB memory card writer is a lot faster than a serial data cable.

A basic hand held GPS can set you back $300, add in vector mapping and the price goes to around $600. Add more memory, a slightly larger display, a magnetic compass and barometer, you will be up for $1,000+ for a hand held. For a really large display, depth sounder and navigation software and you could easily spend $3,000, not counting the accompanying computer. Computer programs to view maps and waypoints typically start at around $200. Then there are the digital maps and charts, which start at $50-$200, but then you may need to buy several if you are travelling very far. Also, you may need to buy memory cards to put your maps and charts on, different brands have very different prices, GPS vendors seems to charge the most. SD memory card writers are $30-$200. PDA's incorporating a GPS are becoming more popular due to their high screen quality. A small change in configuration may save you $500 and yet give you similar features. (Prices current as at January 2003, prices and features change quickly).

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GPS features to consider include:

- Number of channels (number of satellites it can simultaneously track)
  - 12 is the standard (like the clubs Garmin GPS 12)
- Sensitivity of the antenna:
  - Quadrifiler helix antenna (currently the most powerful for handhelds)
  - Patch antennae (cheaper, clubs Garmin GPS 12 uses this)
- Water resistance, how much water can it withstand?
  IPX2 – light mist, do not immerse.
  IPX4 – rain, splashing water, do not immerse.
  IPX7 – submerged to 1 meter for 30 minutes (GPS 12).
- Display colour, size & resolution – how good is your eyesight?
- Size
- Weight (especially when hiking)
- Power consumption (battery life & number of batteries)
- Alarms for:
  - proximity waypoints (dangerous places like rocks)
  - dragging anchor
  - approaching destination
- Integrated Magnetic Compass for telling direction when stationary or slow moving
  - do you need to hold the unit perfectly level for the magnetic compass to work?
  - does the magnetic compass automatically cut out at higher speeds, or is this manual?
- Integrated barometer & thermometer
- Fish/depth Sounder
- Output log for plotting path on suitable mapping software in real time (NMEA)
- Memory size (for waypoints, routes, paths, maps, points of interest database)
- Availability of additional memory (memory cards)
- Computer cable interface, slow serial port or faster USB (only relevant for mapping).
- Integrated database products (e.g. Points of Interest, Navigation Aids)
- Vector map display
- Availability of compatible mapping & navigation software
  - do they have contour lines, how accurate, can you modify them, what gets uploaded?
- Ability to receive WAAS position correction signals (improves accuracy to ±3m)
  NOT applicable for Australia. Currently only in the US, northern Pacific & Europe.
- Button position:
  - above the display so your hand obscures it, below display for better view
  - on the sides to allow 1 handed operation
- Personal Digital Assistant (PDA) integration
  - If you have a PDA, you can get a GPS add on and use vector or raster maps.
  - If you don't have a PDA, you can get an integrated PDA/GPS!
- Lap Top integration
  - Have a lap top? Get a cheap GPS with no display that plugs into the USB port.

For recreational use the basic functionality found on the Garmin GPS 12 is probably sufficient. However, mapping facilities are very nice, especially when you notice that the dive site you've just manually entered appears to be 120 km inland, or when you didn't bother to put in a route before the night dive trip, dense fog moves in, and you suddenly notice the phosphorescence of waves breaking on rocks dead ahead. A magnetic compass is also nice when you are going very slowly while finding the exact place to anchor with the depth sounder. At very slow speeds the arrow of the GPS does not point accurately towards the goto waypoint, unless the unit has a magnetic compass that cuts in at low speeds.

However, for recreational purposes, most of these features are not essential, if you plan ahead, take a map or chart, and have a magnetic compass handy. Also, the electronic magnetic compass and vector map in a GPS has no legal status, and will usually not be as accurate as a normal fluid filled compass and paper chart.

In contrast, for serious navigation in ocean going vessels, a real time display of position using an ECDIS electronic chart on a computer would be extremely useful.

Legal Status of GPS navigation

A GPS does not satisfy the legal requirement for carrying a chart where this is required in Australian waters. A navy paper chart with all appropriate “notices to mariners” applied is the only legal chart for maritime navigation, except for the extremely expensive Navy Australian Hydrographic Service ECDIS system.

GPS Signals

See http://www.trimble.com/gps/signal.html & http://www.trimble.com/gps/amplify.html.

Carriers

The GPS satellites transmit weak 50 watt signals on two carrier frequencies, L1 & L2. The L1 carrier is 1575.42 MHz and carries both the status message and a pseudo-random code for timing. The L2 carrier is 1227.60 MHz and is used for the more precise military pseudo-random code.

Pseudo-Random Codes

There are two types of pseudo-random code. The first pseudo-random code is called the C/A (Coarse Acquisition) code. It modulates the L1 carrier. It repeats every 1023 bits and modulates at a 1MHz rate. Each satellite has a unique pseudo-random code. The C/A code is the basis for civilian GPS use, providing the Standard Positioning Service, which may be subject to selective (time & location) signal accuracy degradation according to US military requirements.

The second pseudo-random code is called the P (Precise) code. It repeats on a seven day cycle and modulates both the L1 and L2 carriers at a 10MHz rate, providing the Precise Positioning Service. This code is intended for military users and can be encrypted. When it's encrypted it's called "Y" code. Since P code is more complicated than C/A it's more difficult for receivers to acquire. Many military receivers start by acquiring the C/A code first and then move on to P code. As the military "P-code" is ten times the frequency of the civilian C/A code it is potentially much more accurate, and much harder to jam. Also, being modulated on two carriers allows for corrections to be made to help eliminate errors caused by the atmosphere.

Navigation Message

There is a low frequency signal added to the L1 codes that gives information about the satellite's orbits, their clock corrections and other system status.

Why a Pseudo Random Code?

The Pseudo Random Code is a fundamental part of GPS. It is just a very complicated digital code (i.e. a complicated sequence of "on" and "off" pulses). The signal is so complicated that it almost looks like random electrical noise, however, it is generated according to a predefined pattern. Hence the name "Pseudo-Random."

There are several good reasons for that complexity: First, the complex pattern helps make sure that the receiver doesn't accidentally sync up to some other signal. Each satellite has its own unique Pseudo-Random Code so this complexity also guarantees that the receiver won't accidentally pick up another satellite's signal. So all the satellites can use the same frequency without jamming each other. And it makes it more difficult for a hostile force to jam the system. In fact the Pseudo Random Code gives the DoD a way to control access to the system.

The complexity of the Pseudo Random Code also makes GPS economical, as it enables the use of information theory to amplify the GPS signal, which is why GPS receivers don't need big satellite dishes to receive the GPS signals.

The Future

Over the next 15+ years additional signals are planned to enhance the ability of GPS to support civil users and provide a new military code. The first new signal will be the C/A code on the L2 frequency (1227.60 MHz). This feature will enable dual channel civil receivers to correct for ionospheric error. A third civil signal will be added on the L5 frequency (1176.45 MHz) for use in safety-of-life applications. L5 can serve as a redundant signal to the L1 frequency (1575.42 MHz) with a goal of assurance of continuity of service, potentially to provide precisions approach capability for aviation users. In addition, a secure and spectrally separated Military Code (M-Code) will be broadcast on the L1 and L2 frequencies enabling the next generation of military receivers to operate more fully in an electronic jamming environment. At least one satellite is planned to be operational on orbit with the new C/A on L2 and M-Code capability no later than 2003. Initial operating capability (IOC) (18 satellites on orbit) is planned for 2008 and full operational capability (FOC) (24 satellites on orbit) is planned for 2010. At least one satellite is planned to be operational on orbit with the new L5 capability no later than 2005, with IOC planned for 2012 and FOC planned for 2014. US Federal Radionavigation plan

The EU Galileo system of 30 satellites is to be launched in 2008 to give world wide accuracy of 1 metre at cost of £550 million. The proposed Japanese Quasi-zenith satellite consisting of 3 satellites will give a high elevation coverage that penetrates into city street canyons in Japan and Australia.

GPS information on the Web – a *very brief* selection

Garmin Guides

What is GPS? http://www.garmin.com/aboutGPS/index.html
GPS guide for Beginners
http://www.garmin.com/manuals/GPSGuideforBeginners_Manual.pdf.
Using a Garmin GPS with Paper Land Maps
http://www.garmin.com/manuals/UsingaGarminGPSwithPaperLandMaps_Manual.pdf

Magellan: About Satellite Navigation

http://www.magellangps.com/en/products/aboutgps/
http://www.magellangps.com/en/products/aboutgps/howworks.asp
Explains sources of GPS error and augmentation systems like WAAS, DGPS.

Trimble's Shockwave gps tutorial.

http://www.trimble.com/gps/

Michael McFadyen

Home Page	http://www.michaelmcfadyenscuba.info/
GPS page	http://www.michaelmcfadyenscuba.info/articles/gps.htm
NSW Shipwrecks	http://www.michaelmcfadyenscuba.info/articles/nswwrex.htm

Tom Byron's scuba diving books

http://tombyron.customer.netspace.net.au/index.html
If you buy the book, check the CD for updated GPS marks!

Ole Moller's GPScape

GPScape http://datamining.anu.edu.au/~ole/gpscape_work/gpscape/
Add your favourite waypoints here!

CLUB GPS Manual (GARMIN GPS 12)

Manual is at http://www.garmin.com/manuals/GPS12_OwnersManual.pdf,

Mark accuracy improvement by averaging	pp 17
Position Formats	pp 44
Map Datum use	pp 44-45
Map Datum list	pp 56-57

The page numbers quoted are the printed page numbers, not the PDF page numbers.
(The addendum at http://www.garmin.com/manuals/104_GPS12,12XL,48,80Addendum.pdf, is not relevant for current operation of clubs GPS.)

Some GPS Manufacturers & Retailers

Delorme	http://delorme.com/
Eagle	http://www.eaglegps.com/
Garmin	http://www.garmin.com/
Garmin agent in Australia	http://www.gme.net.au/garmin/index.html
GPOZ (Excellent Oz Web site)	http://www.gpsoz.com.au/index.htm
Lowrance	http://www.lowrance.com/
Magellan	http://www.magellangps.com/en/
Magellan Australia	http://www.magellan.com.au/

Trimble	http://www.trimble.com/
Silva	http://www.silva.se/

Some Cartographic products

Australian Hydrographic Service	http://www.hydro.gov.au/
C-MAP	http://www.c-map.com/
Fugawi	http://www.fugawi.com/index.html
Garmin Cartography	http://www.garmin.com/cartography/
hsa	http://www.hsa.com.au/products/electronic_navigation/index.html
Magellan Software	http://www.magellan.com.au/accessories/?acc_group=Software
Maptrax	http://www.maptrax.com.au/
Natmap	http://www.ga.gov.au/nmd/products/maps/raster250k/
Navionics	http://www.navionics.com/Usa/Index.asp
OziExplorer	http://www.oziexplorer.com/
Public Sector Mapping Agencies	http://www.psma.com.au/
RACQ Travel Planner	http://www.nowwhereroute.com/RACQ/RoadTravelPlanner/Default.aspx
Trimble	http://www.trimble.com/geoexplorerce.html
Sensis	http://www.sensis.com.au/
UBD	http://www.ubd.com.au/

Royal Australian Navy

Australian Hydrographic Service http://www.hydro.gov.au/

Electronic Chart Display and Information System (ECDIS) & the legal status of other electronic navigation systems for maritime navigation
http://www.hydro.gov.au/eproducts/echarting/explained.htm

Approved navigation system vendors
http://www.hydro.gov.au/seafarer/rnc/system_manufacters2.htm

hsa's explanation of ECDIS & ECS
http://www.hsa.com.au/downloads/Info_ECDIS.pdf

Australian Maritime Safety Authority

AMSA DGPS page	http://www.amsa.gov.au/ns/dgps/dgps.htm
DGPS Coverage of Australia	http://www.amsa.gov.au/ns/dgps/coverage.htm

Global Positioning Satellite Systems

GPS (US, 24 satellites giving civilian users 15m accuracy)

US Coast Guard Navigation Center	http://www.navcen.uscg.gov/,
Interagency GPS Executive Board	http://www.igeb.gov/
Navstar Global Positioning System Joint Program Office	http://gps.losangeles.af.mil/
GPS Standard Positioning Service Performance Standard	http://www.igeb.gov/SPS-2001-final.pdf
Federal Radionavigation plan	http://www.igeb.gov/FRP2001.pdf
GPS-S	http://army-gps.robins.af.mil/UE/gpss.htm

GLONASS (Russia) http://www.glonass-center.ru/frame.html
(Currently 8 of 10 orbiting satellites are operational out of 24 required, civilian users are supposed to get a horizontal accuracy of 57-70m with 99.7% probability.

GALILEO (EU) http://europa.eu.int/comm/dgs/energy_transport/galileo/index_en.htm

(£550 million for 30 satellites to be launched in 2008 to give world wide accuracy of 1m with signals that penetrate buildings.)
US position on Galileo http://www.state.gov/r/pa/prs/ps/2002/8673.htm.

Quasi-zenith satellite (Japan) http://www2.crl.go.jp/ka/control/efsat/index-e.html
(Proposed 3 satellite high elevation system that will cover Australia too)

GPS Links & Reviews

http://gpsinformation.net/
Murray Dow's GPS Intro http://anusf.anu.edu.au/~mld900/walks/gps.html

GeoTiff format for raster map geo-referencing

http://www.remotesensing.org/geotiff/geotiff.html

Disclaimer

The information presented here is intended for Australian National University Scuba Club members and is for illustrative purposes only. Omission or inclusion of a product does not imply anything about the quality of that product. No warranty is made about the currency, correctness or completeness of the information provided. Prospective users and purchasers of navigational products should do their own research. Specific brand related GPS questions should be directed to the GPS vendor. RTFM!
Constructive criticism welcome.
Ron Henry, November 2003.