An Introduction to G.P.S.

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Introduction

The information contained in this document together with the practical exercise is designed as an introduction only. By the end of the session the student should have a rudimentary knowledge of how a GPS receiver operates and how it can be used to navigate from point to point. In addition a number of limitations will be understood.

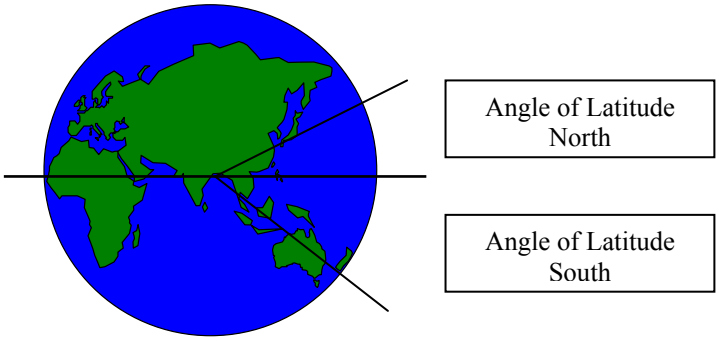
It is recommended that before any real reliance is placed on a GPS the user should thoroughly familiarise him or her with the equipment being used in a practical environment.

Latitude and Longitude

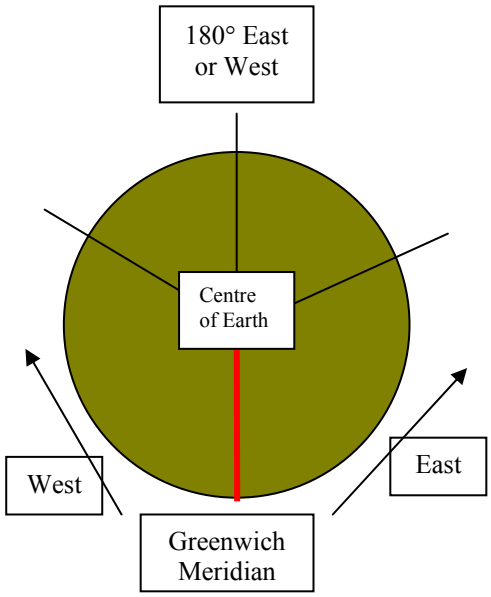
For safe navigation it is essential that a passage can be planned and that the vessel follows the planned track. To do this the chart is the main tool.

In order to define a position there is a grid superimposed on all charts, which is made up of lines of latitude that run parallel to the equator and lines of longitude that run parallel to the line between the two poles. Positions are expressed as angles from the centre of the earth: -

Angle of Latitude - This is the angular distance either North or South of the Equator. An angle of latitude can never be more than 90°. One minute of latitude at the Earth's surface equals one nautical mile.



Angle of Longitude – This is the angular distance East or West of the Greenwich Meridian. An angle of Longitude can never be more than 180° East or West as there are only 360° in a circle.



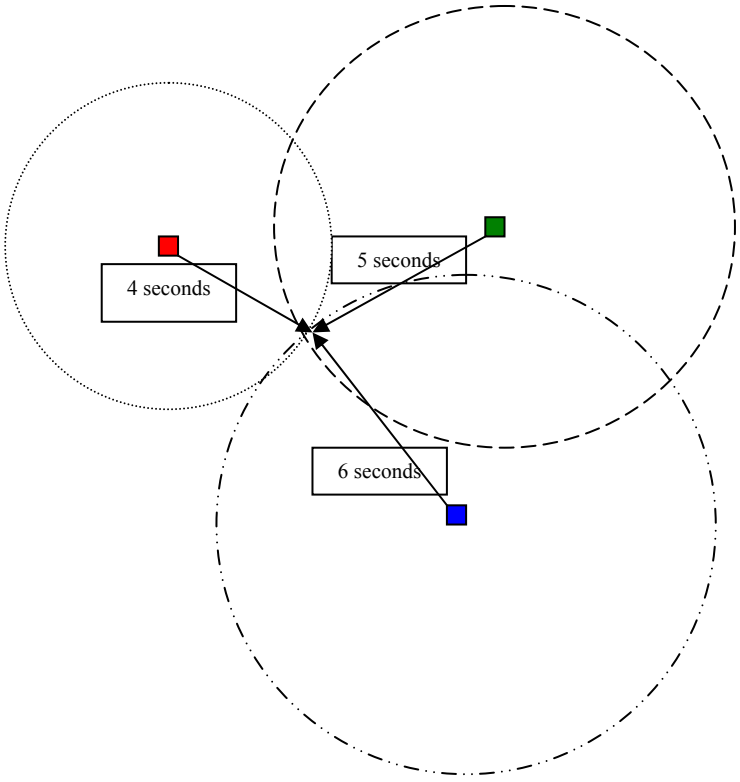
An example of a Lat/Long Position is - 50° 01'.4N 004° 06'.9W

Global Positioning System

Funded by the US Navy the worldwide Global Positioning System (GPS) was set up for military applications. Initially, for security reasons, standard commercially available sets only had an accuracy of about 100 metres as a result of a random error being introduced into the system. During the Gulf War in 1992 the error was switched off which means that a reasonable receiver today will give an average accuracy of 10 metres.

A GPS receiver calculates it's position velocity and time by tracking signals sent from GPS satellites. Time is obtained from four atomic clocks, which are so accurate that they will gain or lose only one second in 50,000 years. The satellites have an elaborate control system. There are five ground control-monitoring stations located around the earth to receive technical telemetered data. The master control station sifts all the information and transmits to the satellites their own true position in space and the satellites in turn transmit this to the GPS receivers on earth. Each of the 24 satellites circles the earth twice a day in a very precise orbit and constantly transmits information. In order to determine a position fix a receiver needs to see at least three satellites.

Because a GPS receiver can only see satellites above the horizon it needs to know what satellites to look for at any given time. It uses an in built almanac to do this. From each satellite it receives the satellite's position, its number and accurate time. The GPS receiver then calculates the satellite range by measuring the time of receipt of the signal and multiplying the time taken for the signal to come from the satellite by the speed of radio waves in air. The GPS receiver has thus located itself on a position sphere of known radius. If it does this for the signals received from three or more satellites it can produce an accurate position, which is displayed as a lat/long position. Ongoing monitoring can identify course and speed.



Navigation Options

GPS units usually provide four ways to navigate to a destination. GOTO, MOB, TracBack and route navigation.

- The most basic of method of selecting a destination is the GOTO function, which lets you choose any stored waypoints as the destination and quickly sets a direct course from your present position.
- The MOB or "man overboard" function allows the operator to mark the point at which a person or object has been lost overboard, once activated it will direct the boat back to the position marked (it does not however take account of wind or tide).
- The TracBack function allows you to quickly and easily retrace your path using the track log automatically stored in the receiver's memory. The advantage of the TracBack feature is to eliminate the need to mark waypoints along the way and manually create and activate a route back to where you began.
- Route navigation simply links a number of waypoints together in a sequence determined by the operator to form a route; this allows navigation around obstacles or through channels etc.

Entering Data into a GPS Receiver

Having seen how a GPS receiver can identify its position, speed and course, it is now possible, by providing the receiver with information in a recognisable format, to give it a destination. The receiver is then able to work out the direction to the destination, the distance to travel and from the vessel's speed its estimated time of arrival.

The most common method of data entry is by using latitude and longitude to put a waypoint into the memory.

All receivers are slightly different but this is generally the input format:-

N or S XXX° XX.XXX'
E or W XXX° XX.XXX'

Once data has been entered it is possible to use the "goto" function to activate the waypoint. The GPS receiver will then display the necessary information to navigate to the desired position.

The GPS receiver's display can be customised to provide information in a number of ways including a rolling road, course and direction and actual verses planned track

System Limitations

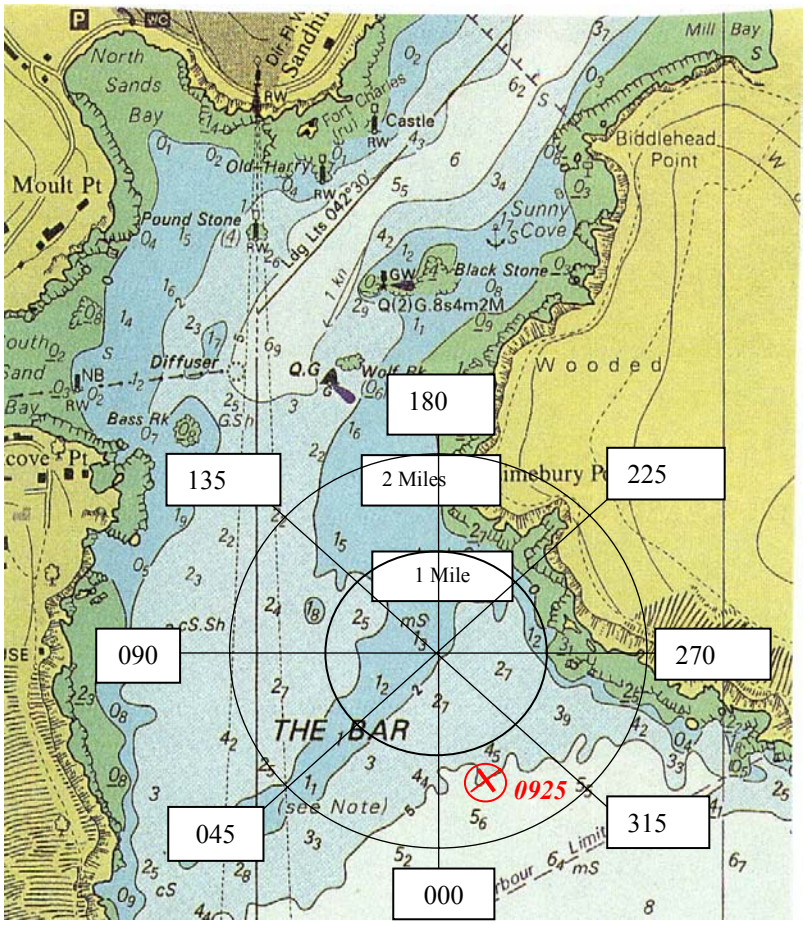
Whilst The Global Positioning System is one of the best navigational aids available it does have some practical limitations of which the user should be aware: -

- Using a GPS is not a substitute for knowing the vessel's location on a chart.
- A GPS cannot see and therefore does not recognise hazards between its current position and any waypoint.
- A GPS can help navigation in fog but cannot see obstructions or other water users. It is not a substitute for keeping a good lookout.
- A GPS will take you where you tell it – always check the data entered into a GPS
- If the exact coordinates of a mark are entered then be aware of the risk of collision with that mark when visibility is poor e.g. at night

Practical Position Location.

There are several conventional ways of plotting a position on a chart including taking bearings from two or more fixed positions, using a running fix and plotting bearing and distance. GPS additionally allows the user to read off Latitude and Longitude and plot a position directly onto the chart. This however is difficult in an open boat that is moving. An alternative method is to choose a waypoint on the chart and draw concentric circles at convenient distances from that waypoint (say every mile). Having done that draw a compass rose again centred on the waypoint that is a mirror of a normal compass. By using the "Goto" function on the GPS it is possible to get a bearing and distance from your chosen waypoint.

Your position can then be accurately estimated and marked on the chart without the use of instruments.



For example if the waypoint bears 340° at 1.4 miles it is possible to plot the vessel's current position. Adding the time to the chart means that the navigator knows where the boat was at a certain time. This can be important if there is subsequently need to estimate a position as a result of equipment failure etc.

Glossary of Terms

Almanac Data
Satellite constellation information (including location and health of satellites) that is transmitted to your receiver from every GPS satellite. Almanac data must be acquired before GPS navigation can begin.

Bearing
The compass direction from your position to a destination.

Course Made Good (CMG)
The bearing from the "active from" position (your starting point) to your present position

Crosstrack Error (XTE)
The distance you are off a desired course in either direction.

Desired Track (DTK)
The compass course between the "from" and "to" waypoints.

Differential GPS (DGPS)
An extension of the GPS system that uses land-based radio beacons to transmit position corrections to GPS receivers.

Estimated Time of Arrival (ETA)
The time of day of your arrival at a destination.

Estimated Time Enroute (ETE)
The time left to your destination at your present speed.

Grid
Coordinate system that projects the earth on a flat surface, using square zones for position measurements. UTM/UPS and Maidenhead formats are grid systems.

Ground Speed
The velocity you are travelling relative to the ground position.

Latitude
The north /south measurement of position perpendicular to the earth's polar axis.

Longitude
An east/west measurement of position in relation to the Prime Meridian, an imaginary circle that passes through the north and south poles.

Navigation
The process of travelling from one place to another and knowing where you are in relation to your desired course.

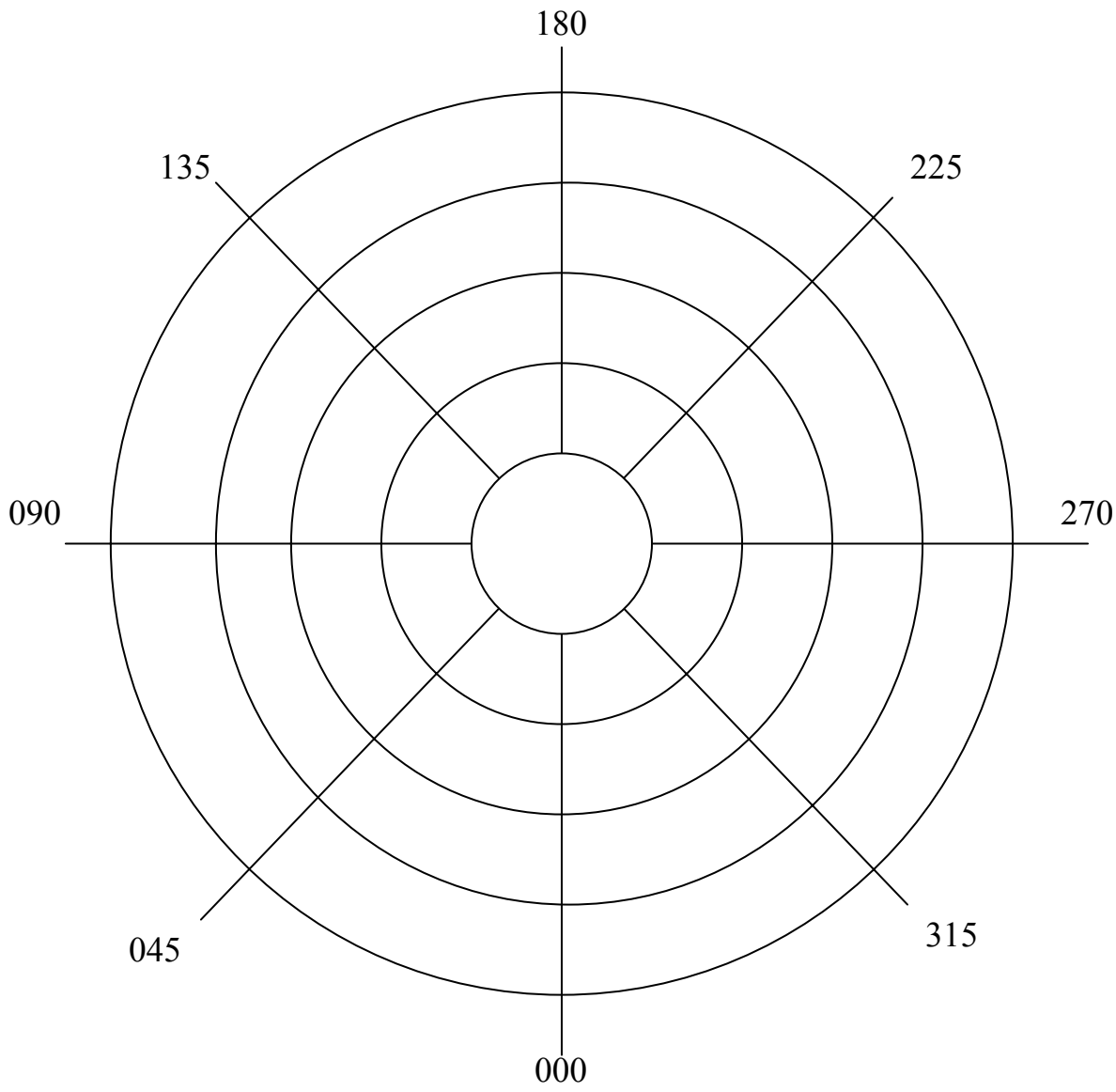
Position
An exact, unique location based on a geographical coordinate system.

Track (TRK)
The direction of movement relative to ground position.

Universal Transverse Mercator (UTM)
A grid coordinate system that projects global sections onto a flat surface to measure position in specific zones.

Velocity Made Good (VMG)
The speed you are travelling in the direction of the destination.

Waypoint
A specific location saved in the receiver's memory.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