Water Awareness and Charge Certificate Manual

Module 61: Chart Work

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Module Contents

Module Title	Comments	Rev No	Revision Date
Module 61: Chart Work	Initial Release	1.0	11 Jan 2013
Module 61: Chart Work	Text update and additions	1.1	8 Sept 2013
Module 61: Chart Work	Outcomes Added	1.2	14 Jan 2018

Outcomes

After completing this module, the certificate holder will:

- Be able to recognize chart symbols and abbreviations.
- Be able to plot their location on a chart
- Be able to plan a course using navigator’s tools

1 Introduction

The primary tool for any navigator is a chart. This course does not aim to turn you into a qualified navigator, but rather to introduce you to the principals of chart work. Chart work is very difficult on small vessels as the limited space does not lend itself to using a full size chart.

What follows far exceeds the requirements of the Category R and even Category E certificates, but will provide you with a base to further your studies on chart work.

2 Projections

Because the earth is round and charts are flat sheets of paper representing sections of the earth's round surface, you will get distortions of the vertical and/or horizontal axis. To overcome this, there are several techniques in the make-up of a chart, and these result in different styles of charts known as 'Chart Projections'.

Sailing in polar regions involves the use of 'Gnomonic Projection' charts and sailing in low and mid-latitude areas (up to 60° latitude; where most of us do all our sailing) requires the use of 'Mercator Projection' charts. The illustrations in Figure 1 show the idea behind the make-up of these two types of charts. The Mercator projection is the projection we will be dealing with, as it will get us from the equator around Cape Horn to the south or to Norway in the north. Notice how the horizontal 'Scale' taken from the equator remains constant and how the vertical scale of the Mercator projection increases the greater the distance from the equator.

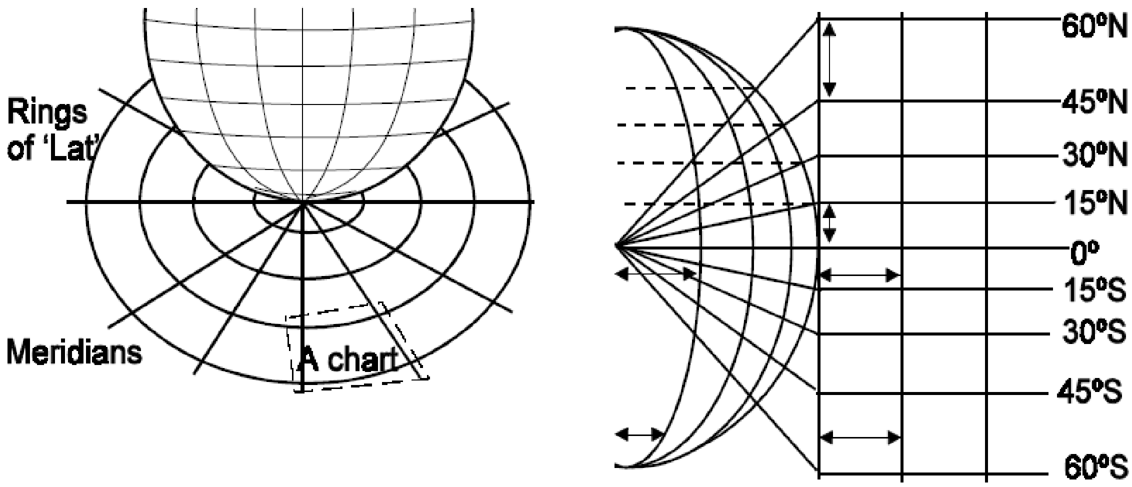


Figure 1: Gnomonic and Mercator Projections

A chart's scale may be shown to be, for example, '1:100 000' (one in one hundred thousand) meaning one unit of length on the chart (let's say one centimetre) represents one hundred thousand units (centimetres) of the land. A '1:50 000' scale chart is regarded as a very big scale chart as it shows a small area in great (big) detail, but a '1: 250 000' is a small scale chart as it shows a large area and can therefore only show small detail. REMEMBER: Big scale, big detail (small area); small scale, small detail (big area)

We measure distances on a Mercator chart using the side vertical scale only - horizontally opposite the area of interest. This is to ensure we get the right proportion of scale depending on the distance from the equator:

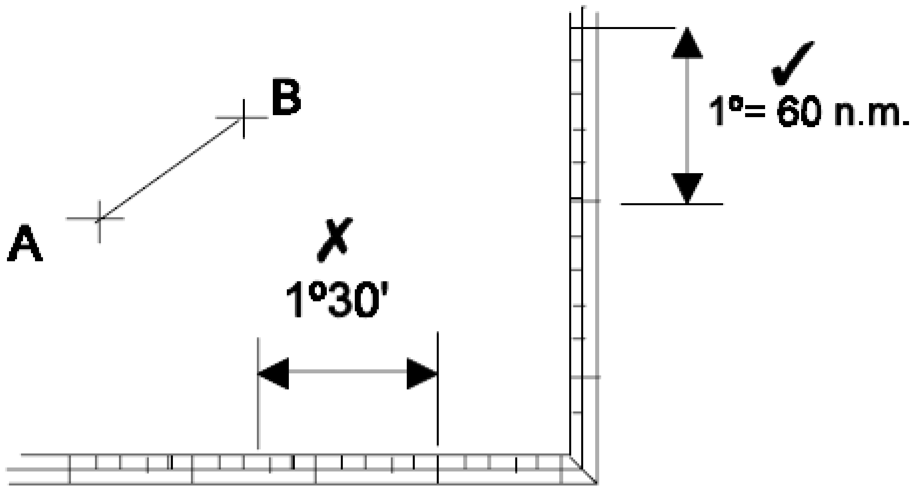


Figure 2: Mercator Scale

A Nautical Mile is the length of an arc of a Great Circle (the e.g. equator) subtended by an angle at the centre of the earth of one minute. It is 1 852 metres long

3 Markings on the Charts

Charts are framed by a black ruled border. Outside the border, at the top left and bottom right hand corners, is the Chart Number. Outside the bottom edge starting at the left corner is the record of corrections to the chart. Corrections to charts are made as a result of amending instructions being published in 'Notices to Mariners' - notices are serially numbered from '1' upwards from the start of each year, so the chart is marked with the year and notice number to indicate that the correction has been done to the chart. For example, '1990.14.39' would mean that 'Notices to Mariners' numbers 14 and 39 of 1990 had correcting instructions for this chart AND that they have been applied to this chart. The third and last piece of information outside this black margin is the detail of printing showing when it was printed, who printed it, the date of the latest edition, etc. SAN indicates that the chart is printed by the South African Navy

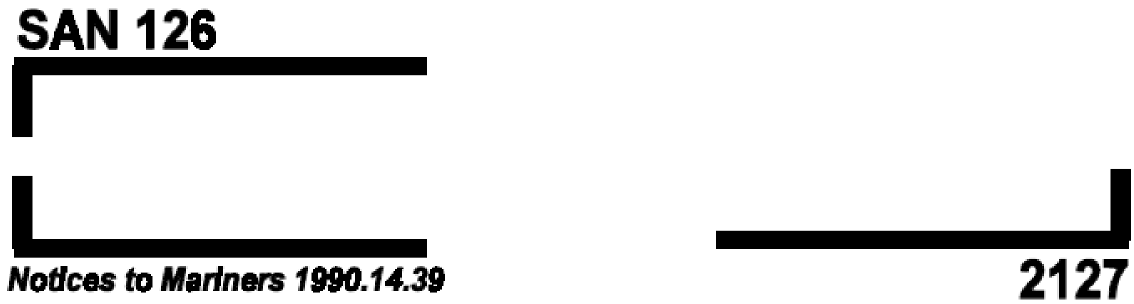


Figure 3: Chart Markings

The black framing margin contains the longitude scale and longitude angle (with reference to the Greenwich Meridian to give the actual longitude) along the top and bottom horizontal margins, and the side vertical scale shows the latitude scale and latitude angle (with reference to the equator to give actual latitude. Notice how distance is only measured on the vertical latitude scale - each 1º = 60' or 60 n.m. and each 1' is 1 n.m., and the length of line for 1' is subdivided into five (or ten) equal parts representing 0,2 n.m. (or 0,1') each. If it is 0.2', we must interpolate for odd numbers of decimals.

Remember, we only work to one decimal place of a mile. Compare the actual length of 1' on the vertical, Latitude, scale with the equivalent length on the horizontal scale for Longitude. The further one is away from the equator, the bigger the difference.

Inside the framing margin, usually over land areas so that it does not obscure any relevant land, coast or sea area, we find the Chart Statement which comprises most of:

1. The publishing authority's crest.
2. The title of the chart e.g. 'Approaches to San Diego Harbour'
3. The type of 'projection' used in the make-up of the chart e.g. 'Mercator Projection'.
4. The scale of the chart.
5. The reference or datum from which all heights above sea level are measured, and the units of measurement used e.g. feet, or metres.
6. The reference datum from which all depths are measured, and the units of measurement of depth e.g. feet, fathoms, or metres.
7. 'Notices', 'Warnings' and/or 'Cautions' applicable to navigating in the area depicted by the chart.
8. A table headed 'Tidal Levels Referred to Datum of Soundings'.
9. Reference to the Ellipsoid of the chart. Most modern updated charts are referenced to the World Geodetic System 1984, commonly referred to as WGS84. CAUTION: - Be aware that transferring GPS derived latitude and longitude data onto a non WGS84 chart may result in significant errors in assumed position. This error is most likely to be found in remote islands where accurate determinations of longitude were not necessarily done at the time of survey, and where inaccurate data has been transferred from old charts onto new charts.

3.1 Chart Symbols and Abbreviations

Charts representing large areas do not have enough space to fit in all the detail and names, explanations, descriptions, etc. Therefore a universal system of symbols was accepted by the world's maritime nations, and these, together with the abbreviations used on English language charts, enable the charts to remain relatively uncluttered yet contain a wealth of information. A full list of all chart symbols can be found in The publication SAN HO-6 (Symbols and Abbreviations used on South African charts)

Unless you are a professional navigator, do not try to learn them all - there are too many, but do remember the symbols for dangerous wreck, rock awash, and rock of unknown depth considered dangerous to all vessels.

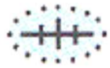
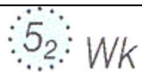
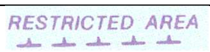
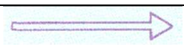
	Wreck showing hull or portion of superstructure above chart datum		Dangerous wreck – depth unknown
	Wreck – least depth known by depth sounding		Foul area, with rocks or wrecks. Dangerous to navigation
	Dangerous underwater rock at uncertain depth	12 Rk	Dangerous underwater rock at known depth
	Rock awash – height unknown		Rocks surrounded by shoal or reef at known depth
	Limit of restricted navigation area		General Maritime limit
	Mandatory direction of traffic		Radio call in point
	Anchorage		Major lighthouse

Table 1: Chart Symbols

3.2 Electronic charts

Electronic chart systems are fast becoming the de facto standard charting systems available to the navigator, and are now legally replacing the requirement to carry paper chart folio's depending on the ship meeting certain backup system requirements. The greatest advantage to using electronic charts is that they allow for the integration of other navigational information onto the charts display. Information such as GPS position, ships heading, AIS data, waypoints, courses and radar is commonly incorporated today.

Chart displays (repeaters) can also be strategically mounted where the navigator can best use them effectively. It can remove the requirement for the navigator to move from his conning position to a chartroom below decks to do whatever navigational work is required.

The chart information can either be stored as Raster information or Vector information.

Raster information data storage is cumbersome as it is basically just like a picture. Zooming in close will result in pixilation errors, and zooming out will not increase important font size so text and symbols may be difficult to read on large scale settings.

Vector information basically stores all information as lines, arcs curves, colour filled areas, text and symbols. Changing the scale of the chart viewed on the display, automatically changes the generation of for example, shore outlines or harbours, and displays the relevant symbols and text (such as depths) in readable character sizes. Detail which becomes too small to generate graphically is automatically hidden.

The prudent navigator of small craft should if possible always carry some paper charts of the areas in which he will be voyaging, in case of failure of his electronic systems for what ever reason.

3.3 The Compass Rose

A Compass Rose usually appears in either two or three places on a chart. Look at a typical compass rose from the south-west of Cape Point, South Africa, on chart SAN 3002 (shown below

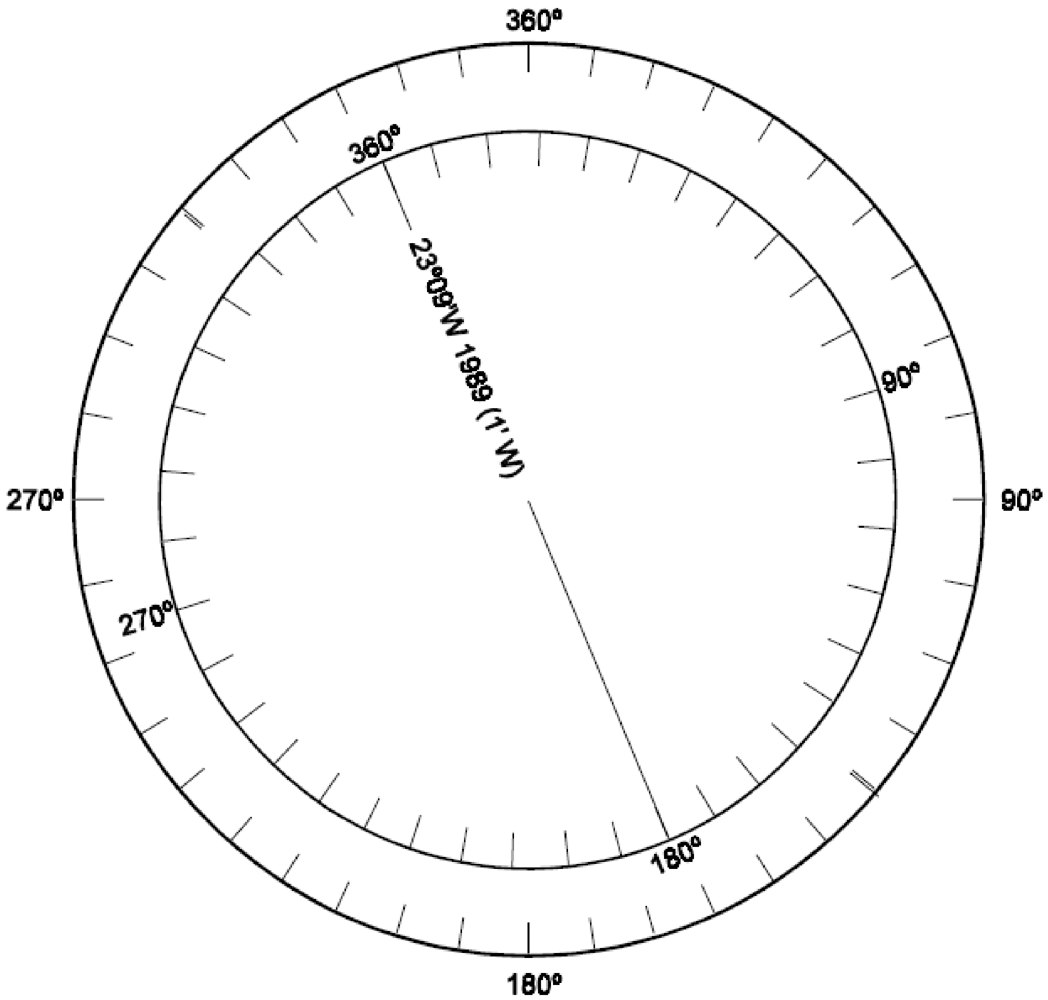


Figure 4: The Compass Rose

Notice that the outer ring showing the 360º graduations of a circle is orientated towards the North Pole, or to 'True North'. It is then called '360ºT'. The inner ring also shows 360º but it is orientated to point its 360º mark in a different direction. The direction it is pointing is towards the magnetic North Pole or 'Magnetic North as it appears from the centre of the circles. As the influence of the earth's magnetic field varies according to the place on earth, the difference in directions to the true and magnetic north poles will differ depending on where it is measured.

3.3.1 Variation

The compass roses on a large scale chart are there to inform the navigator of the magnitude of the magnetic effect on the compass, or 'magnetic variation', in the vicinity of those compass roses. The navigator uses the information from the compass rose nearest to the relevant area. At the centre of the compass rose is a statement of what the angle difference is, between the directions 'True North' and 'Magnetic North', as measured at that place. This direction towards the Magnetic North may be east or west of the direction to True North. (In the Atlantic and Indian Oceans it is west; in the Pacific Ocean it is east.) In Figure 4 it is '23º13'W (1989)'. The year is stated because the magnetic field of the earth is not stationary - it is moving, albeit very, very slowly. The annual rate of change to the magnetic variation appears near the centre of the compass rose. In Figure 4 it is shown as 1'W so to calculate the current declination is

2009 – 1989 = 20 years

* 1’W per year

= 20’W

So the current declination is 23º29' W

3.3.2 Declination

The nautical navigator must clearly understand the possible confusion that may arise when conversing with people versed in land based navigation and when using land based maps.

Land based navigators conventionally refer to the difference between Magnetic North and True North, measured in the horizontal plane, as Declination. Strictly speaking this is incorrect.

Magnetic declination is the difference between the horizontal plane of the observer and the magnetic line of force measured in the vertical plane. Declination is measured with a DECLINOMETER which is really just a normal compass turned on its side.

The resulting magnetic vector observed at the compass, which is a combination of the Earths magnetic field declination and effects of the ships structure is compensated for by the ships compass adjuster by use of vertically placed soft iron bar compensators known as Flinders bars.

Magnetic declination effect on the compass card is greatest in high latitudes, where the vertical component of the Earths magnetic field is dominant. The compass card becomes sluggish and difficult to use in a seaway.

3.3.3 Deviation

The course steered according to the ship's compass is not always the Magnetic direction. Every vessel has some amount of ‘magnet-affecting metal’ in its make up, such as the engine, tanks, mechanical and electronic equipment on board, tools, etc. These metallic objects affect the compass, and they affect the compass by differing amounts depending on whether the vessel is facing north, south, east or west - or any other direction. The effect is called deviation.

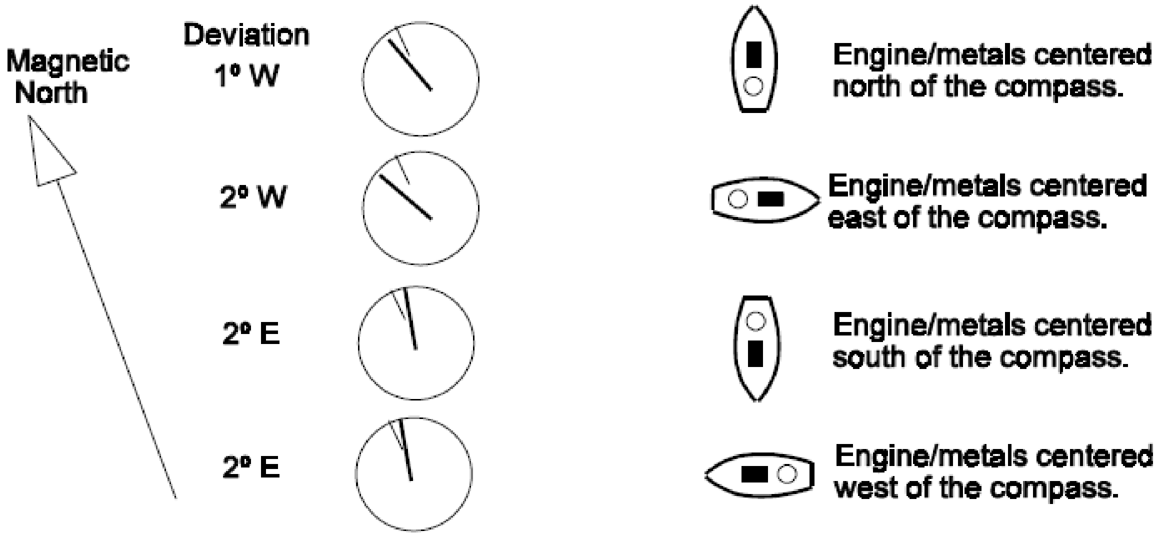


Figure 5: Compass Deviation

3.3.4 Swinging the Compass

To establish what the deviation of a compass is on any particular ship's heading, the first step is to obtain the services of a qualified 'compass adjuster' who will 'Swing the Compass'. This process of swinging the compass involves sailing the vessel away from the immediate surrounds of other metals into 'open' water, then slowly turning the vessel through 360º and checking the compass readings against known calculated values of what the compass should read. Transits and conspicuous objects on land are used for this check. Any difference is the deviation, and the compass adjuster will attempt to adjust the compass's 'compensating magnets' to get the deviation to a minimum on all headings. Once the adjusting process has minimised the deviation, any remaining deviation is reported to the vessel's skipper in the form of a Deviation Card.

TABULAR DEVIATION CARD Ship's Name Name and Type of Compass .... (e.g. Plastimo, Steering), Date:					
Compass	Deviation	Magnetic	Compass	Deviation	Magnetic
360°°	1 ° W	359°	180°	2° E	182°
022,5°	2 ° W	020,5°	202,5°	3 ° E	205,5°
045°	3 ° W	042°	225°	3 ° E	228°
067,5°	3 ° W	064,5°	247,5°	2 ° E	249,5°
090°	2 ° W	088°	270°	2 ° E	272°
112,5°	1 ° W	111,5°	292,5°	1 ° E	293,5°
135°	0°	135°	315°	1 ° E	316°
157,5°	1° E	158,5°	337,5°	0°	337,5°

Figure 6: Deviation Card

A compass should be readjusted (re-swung) every three years or additionally whenever major 'metallic' changes to the vessel are made. Or when significant changes in the ships normal operating latitude is made..

3.3.5 Calculating Compass Course

First we change the True direction to a Magnetic direction by adding the westerly variation or subtracting easterly variation. Then we change the Magnetic direction to a 'compass direction' by adding westerly, or subtracting easterly, deviation. Remember:

'Error west, compass best (bigger); error east compass least'.

If a vessel is sailing south, 180º T (True) where magnetic variation is 23º W (West), the magnetic course will be:

T + V (Var W) = M

180ºT + (v is west) 23º W = 203ºM

and the compass course, using the Deviation Card at Figure 6, will be:

M - D (Dev is E) = C

203ºM - (D is east) 3º E = 200ºC

We can put it all in one line:

T V M D C

180ºT + 23ºW = 203ºM - 3ºE = 200ºC

Each number of degrees has a letter behind it so that there can be no confusion as to what each is. This is most important when any one number is written on its own. For example, to write in the log book that the ship's course was '275º' is ambiguous - is it 275º True, Magnetic, or Compass

4 Speed

In marine terminology, the speed of a vessel at sea is measured in knots, which is one nautical mile per hour. As 'speed' (knots) is determined by distance (n.m.) per time (hour), if we know any two of these values we can calculate the third using the equation.

Distance = Speed X Time. D = T x S

So, if a vessel has to cover a distance of 30 n.m. and it sails at 6 knots, it will take 5 hours to do the trip. Also, if a vessel covers a distance of 15 n.m. in 2 hours, its speed is 7.5 knots. Similarly, a vessel travelling at 5 knots for 4 hours will cover a distance of 20 n.m.

5 Location

5.1 Lines of Position

The navigator may wish to take a magnetic bearing from the vessel to a landmark using the vessel's Hand-Bearing Compass.

The magnetic reading that is obtained is converted to a True direction by subtracting the westerly (or adding the easterly) variation. By orientating a ruler along the True direction calculated and compass rose centre-point line, then 'walking' it to the landmark on the chart so that one edge of the ruler lies on the middle 'dot' of the landmark symbol, a pencil line can be ruled from the landmark to seaward, representing a line along which the vessel's position was located at the time the bearing was noted. This line is called a Line of Position, (or L.O.P.).

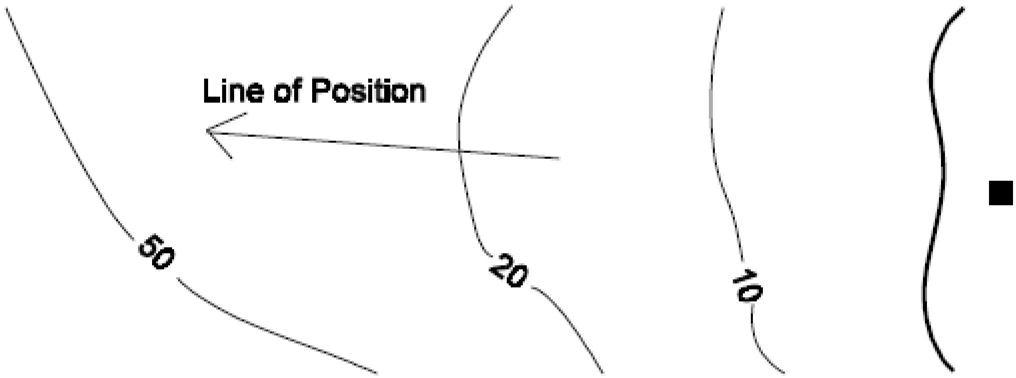


Figure 7: Line of Position

5.2 Fixes

Multiple lines of position can be used to determine a vessel's location, known as a fix.

A fix can be made from 2 lines of position lines, but the disadvantage is that if there is an error, you have no way of knowing. However, if you plot three position lines, when there is an error it will show up, because the lines will cross in a triangle. This is known as Cocked hat, the size of the cocked hat giving an indication of the level of accuracy of that fix.

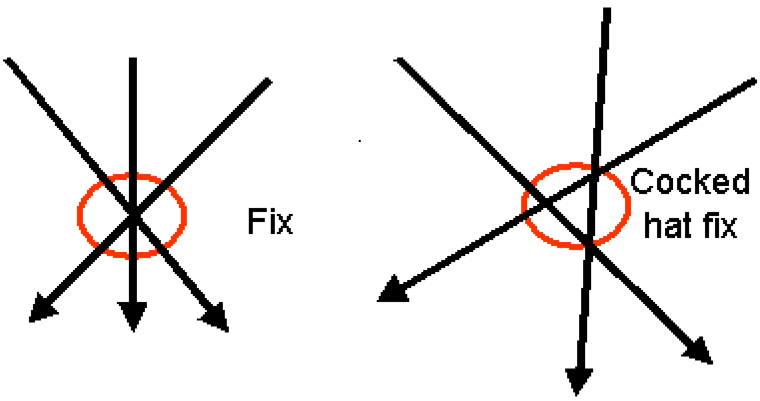


Figure 8: Fixes

Whilst it is possible that the vessel could be inside the cocked hat, it may also be outside of it. Most navigators assume they are in the centre of the triangle provided it is not too large and there are no hazards near by. If your fix results in a large cocked hat, it is probably better to try again, perhaps by using different features.

The standard symbol for a fix is to draw a circle around the area and write fix next to it. You should also record the time and the log reading when you take the bearings. This information is normally written next to the fix on the chart. Something to remember when you plot a fix is that it is where you were when you took the bearings-you will have moved since then. If you recorded the time and the log reading at the time of taking the bearings, you will be able to deduce where you are now, and more importantly whether where you are going is safe. Remember that at 6 knots a vessel will have covered one mile if you take 10 minutes to plot the fix.

When you plot a fix using a hand-bearing compass, it is not certain that you are at that spot. A prudent skipper would assume they are in that area, and if there were any hazards, would consider the vessel to be near to them.

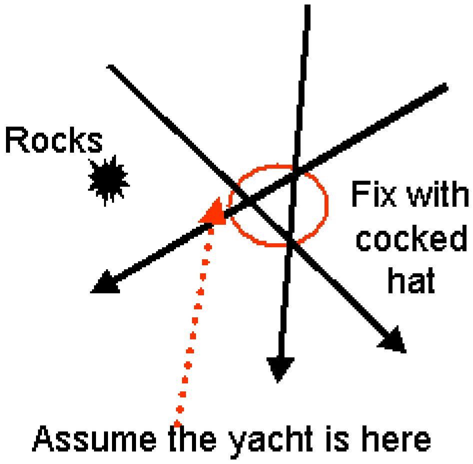


Figure 9: Assumed Position in a Cocked Hat Fix

6 Navigators Tools

Navigators have a variety of everyday and specialised items to help them with their chart work

6.1 Navigation dividers

Navigation dividers are designed to be used one handed and to be opened with the points crossed. Do not be frightened of pressing the points in to the chart, this will help you to hold them steady and to measure distances more accurately, just do not press them in so hard you damage the chart.

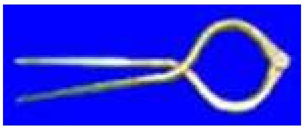


Figure 10: Navigation dividers

6.2 Plotter

You will need some sort of navigational plotter. By far the most popular tool for this is a Breton or Portland Plotter; they are essentially the same thing. A rectangular ruler with a rotating compass rose fixed in the centre. They are used for plotting and measuring directions on nautical charts.

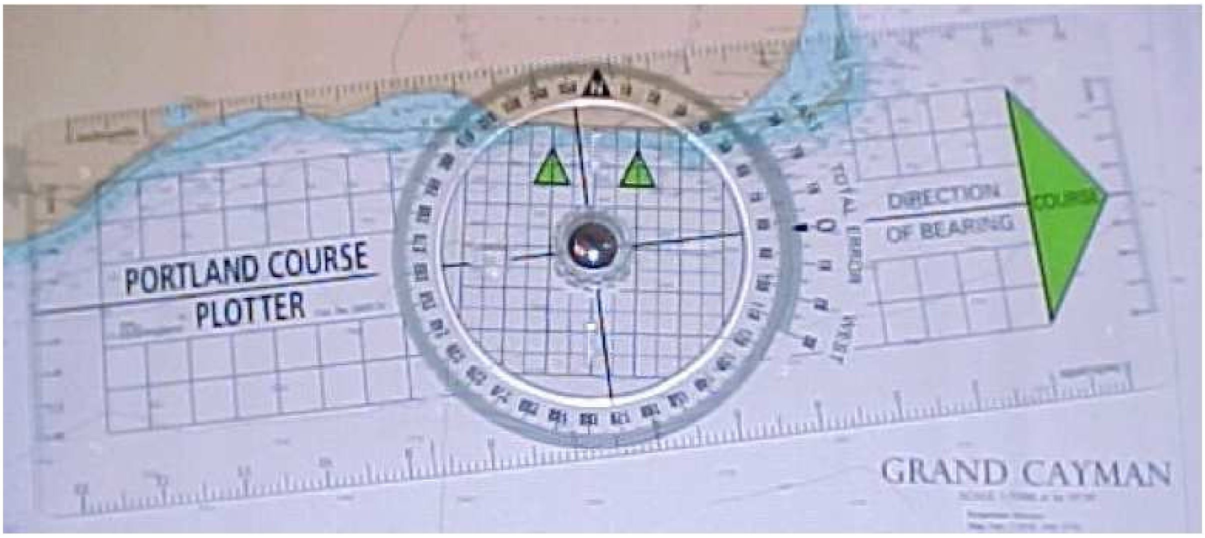


Figure 11: Portland Plotter

There are many other tools for plotting such as Parallel rules, a Douglas Protractor, or two set squares, but a plotter is acknowledged to be the fastest way to work

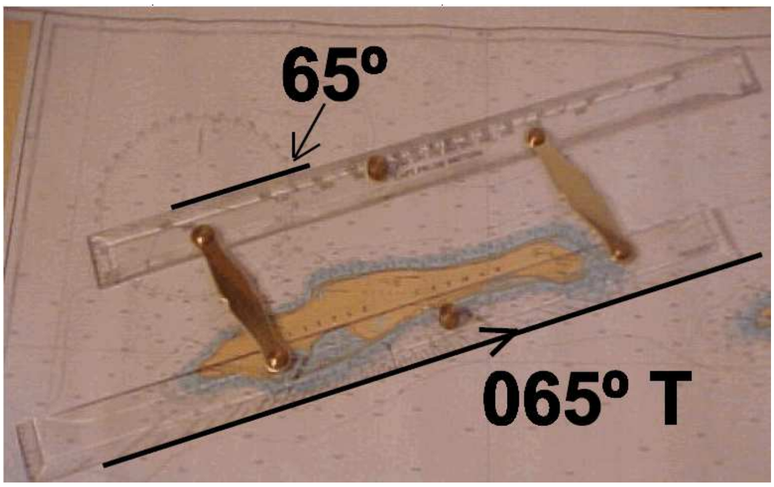


Figure 12: Parallel rules

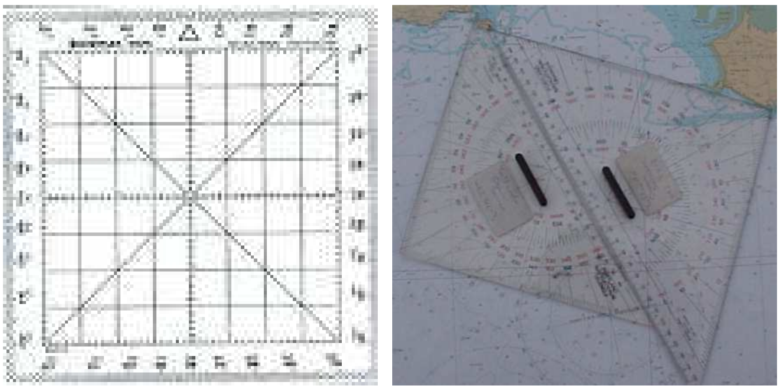


Figure 13: Douglas Protractor and Set squares

6.3 Pencils

A good supply of 2B pencils are essential. 2B pencils are soft enough so they do not damage the chart and will keep a point for a reasonable period.

6.4 Eraser

Choose an eraser that is soft and will not remove the chart surface, there are some that are slightly crumbly when used and they can be ideal.

6.5 Pencil sharpener

As it will be used frequently, select one that retains the sharpening debris and dry to keep it dry. In the salty atmosphere on a yacht, the blades frequently rust and do not last long.

6.6 Calculator

A basic calculator that can be purchased for a couple of Rands can be useful for calculating the time of a passage. Your cell phone usually has a calculator application these days.