Fisheries and Oceans Canada | Pêches et Océans Canada

Coast Guard | Garde côtière

SALUTI PRIMUM AUXILIO SEMPER

2000 EDITION

Canada

NOTE

This booklet is intended to provide mariners with a basic understanding of the Global Positioning System (GPS) and the Differential Global Positioning System (DGPS), and to assist them in choosing the most appropriate receiver for their needs.

The Coast Guard encourages mariners to learn about these systems and to take advantage of them. They will help make your voyage safer, especially when long distances and poor visibility levels make navigation difficult.

ACKNOWLEDGEMENTS

For their time, their expertise and their technical guidance, I must thank Dave Ireland, Ian Gillis, Val Smith and Monique Hupé. My indebtedness extends to a host of other people as well, so many in fact that space will not allow me to mention all of you by name. I hope you will accept this acknowledgement of my deep appreciation.

I would also like to thank the Garmin Corporation for allowing the Canadian Coast Guard to reprint some of their material.

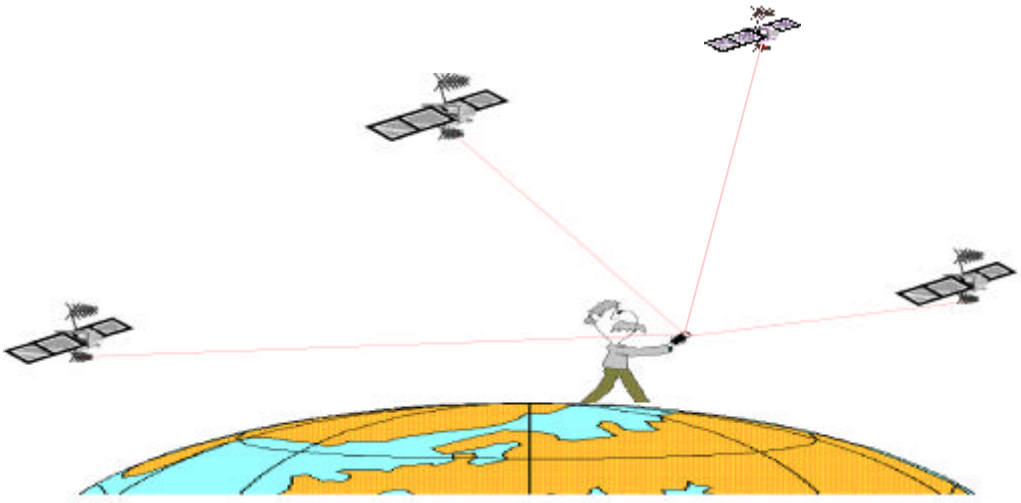
Lynn Denis
Standards Officer
Navigation Systems Branch
Canadian Coast Guard

GPS / DGPS MADE EASY

WHAT IS GPS?

The Global Positioning System is a satellite-based radionavigation system provided by the US Department of Defense. It permits users with suitable receivers to establish their position, speed and time on land, sea or in the air, at any time of the day or night and in any weather condition. The System is accurate to within 30 metres, which is equal to or better than any other radionavigation system available today.

A GPS receiver can obtain a position fix anywhere in the world.



The GPS system has 3 major segments: space, control and user.

The Space Segment consists of a constellation of 24 satellites orbiting the earth at an altitude of 20,000 kms. These satellites act as reference points from which receivers on the ground determine their position.

The Control Segment consists of 5 stations here on earth which track the satellites.

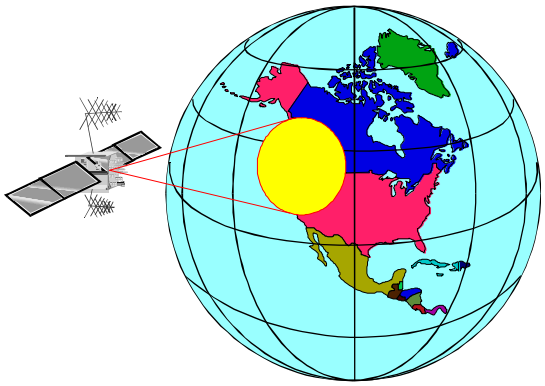
The User Segment consists of antennas and receiver-processors.

SO HOW DOES IT WORK?

GPS receivers use the principle of "RANGING". The receiver measures the distance from a location on earth to the positions of several satellites to determine the latitude and longitude of the position on earth.

GETTING A POSITION FROM GPS

Only 1 satellite



Suppose you turn on your GPS receiver and it picks up the signal of 1 satellite. The receiver tells you the location of that satellite and the distance between you and it.

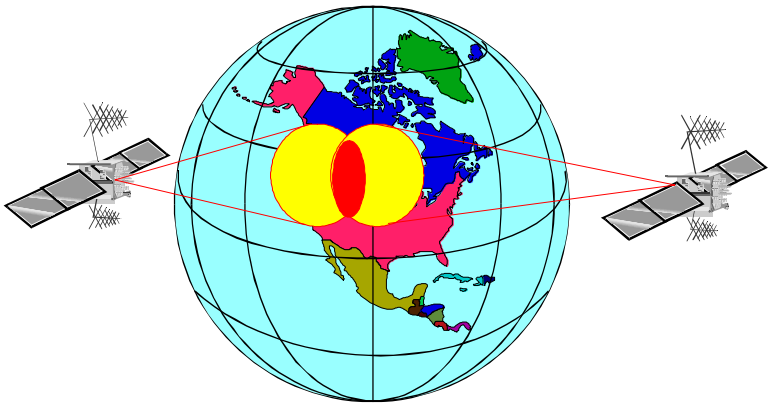
But this single measurement is not a big help. At best, you can conclude that you are within a rather large circle whose circumference is determined by your distance from the satellite.

You are still lost!

2 satellites

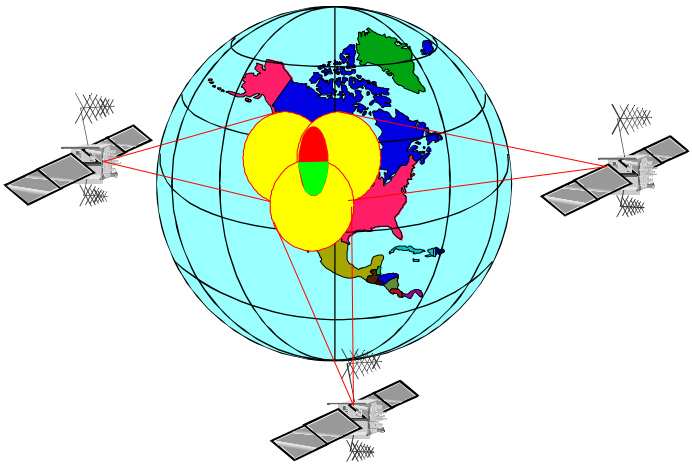
Now suppose that your GPS receiver picks up signals from another satellite. This helps to narrow down your location.

Now, you know that you are somewhere within the intersection of two large circles.



You still don't know exactly where you are, but things are starting to look better!

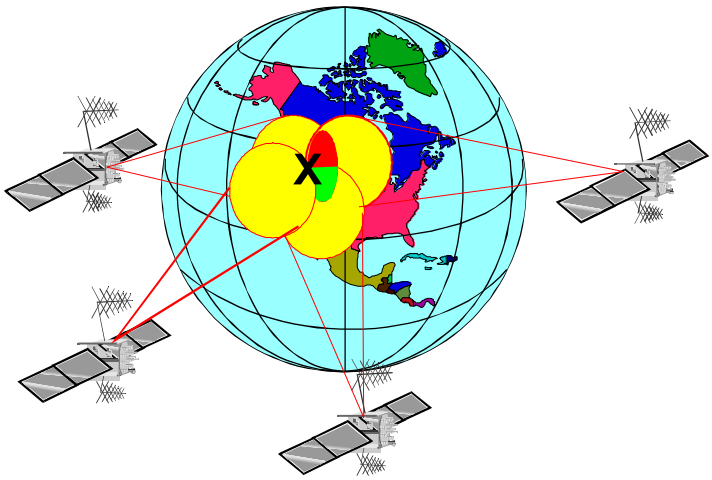
3 satellites



Let's go one better. If your receiver picks up signals from a third satellite, then you know that your position will be within the intersection of three circles.

You have a position but no check on its quality!

4 satellites



With four satellites you get a precise point for your position and you also know your elevation.

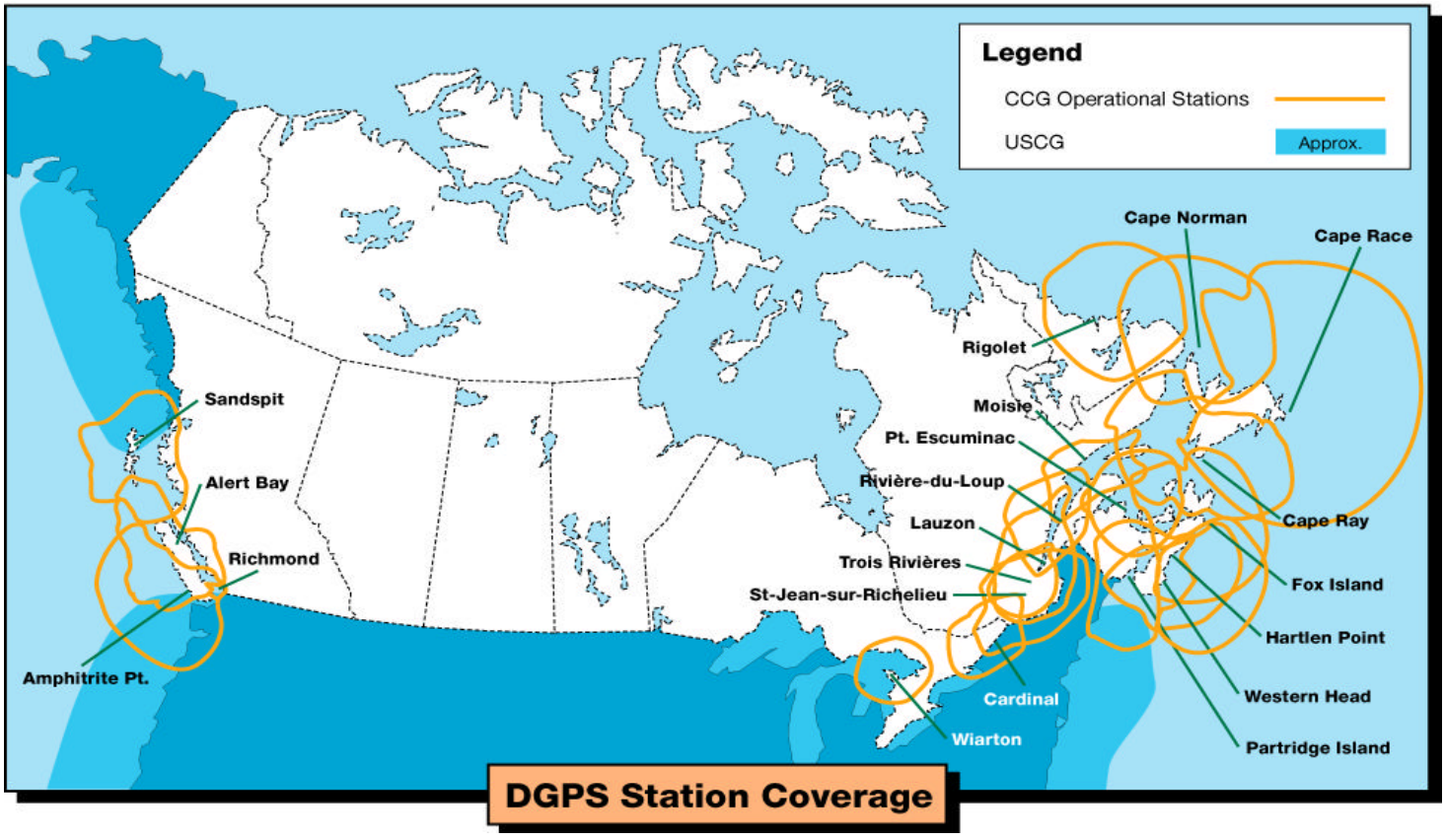
There, you have a position that is accurate to 30 metres!

WHAT IS DGPS?

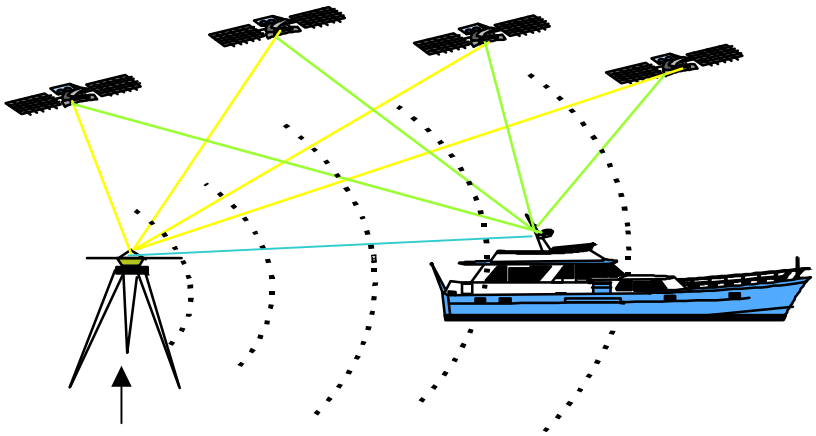
Differential GPS is a method of increasing the accuracy of positions derived from GPS receivers. With DGPS receivers, position accuracy is improved, going from 30 metres to better than 10 metres.

Canadian Coast Guard (CCG) reference stations correct most of the errors in the GPS signal and transmit these corrections to anyone within the CCG or USCG coverage area who is equipped with a DGPS receiver.

DGPS COVERAGE IN CANADA



If your receiver is designed and equipped for differential corrections, then it will apply the Coast Guard corrections to your position - making your position much more accurate.

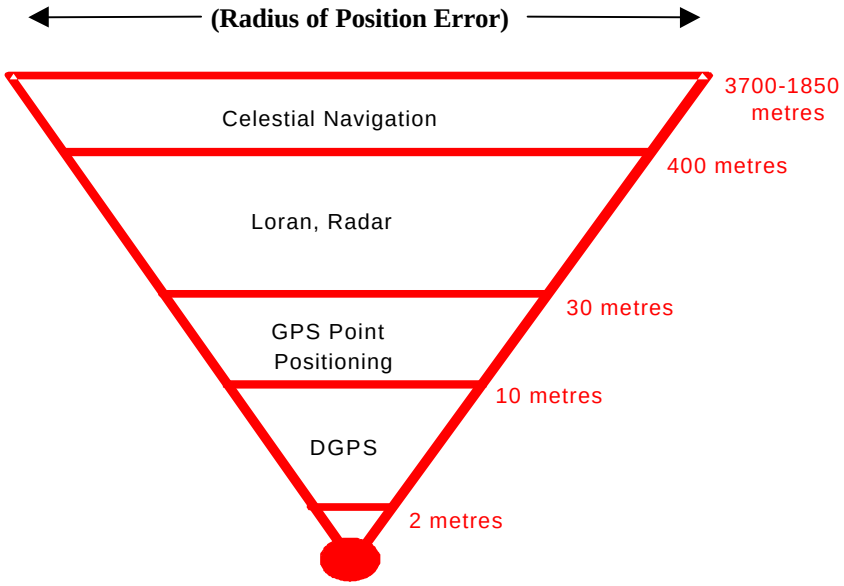


CCG Base

A GPS receiver can be upgraded to receive DGPS signals only if it has been designed as "DGPS ready." This is a useful option for those who do not need the more accurate technology immediately, but think they will in the near future. If you require 10 metre accuracy right now, you can also purchase a DGPS receiver initially.

CAUTION: While many GPS receivers are advertised as differential "ready", please note that this does **NOT** mean that the differential receiver is already built into the unit. The unit requires an additional receiver module along with a low-frequency antenna.

Here's how GPS/DGPS fits into the navigation picture.



Things just get better and better!

DGPS also provides integrity monitoring. Whenever the accuracy provided by the reference station falls below established limits, a warning signal is automatically transmitted to advise the mariner that the service is unreliable.

Should the differential signal be lost altogether, a DGPS receiver can continue to operate in the GPS mode.

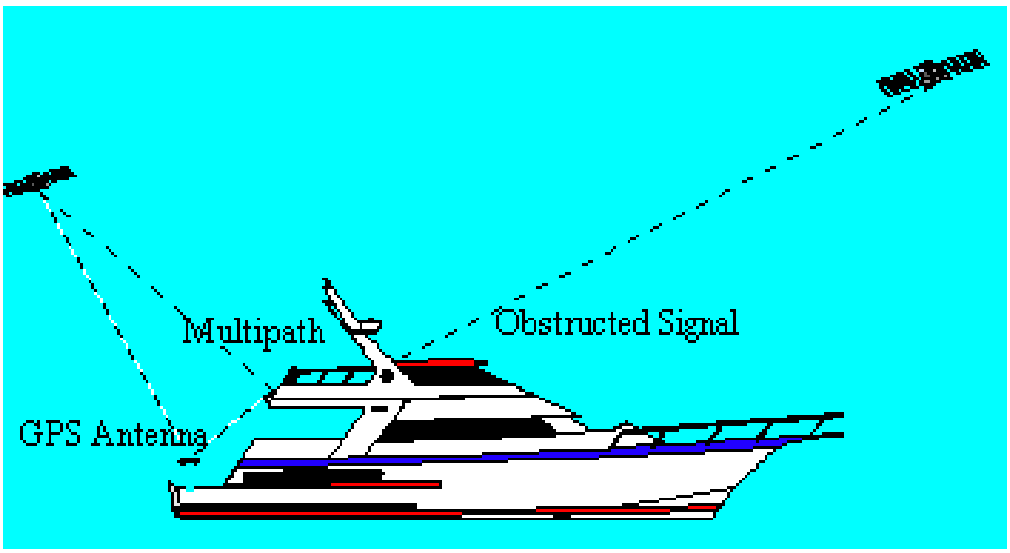
* Consult your operator's manual to verify your receiver's ability to process and display the integrity monitoring signal.

Levels of Service Standards for the Coast Guard DGPS service

- Accuracy to 10 metres 95% of the time
- Signal availability 99.0% of the time
- Broadcast reliability 99.8% of the time
- Integrity monitoring warning within 10 seconds
- Double or enhanced coverage in all Vessel Traffic Services (VTS) zones

OBSTRUCTION ERROR

The GPS/DGPS signal could be reflected from the surfaces of nearby obstructions. It that happens, the signal may reach the receiver antenna indirectly and positional accuracy may be degraded.



Obstructions can include other vessels, mountains, trees and even parts of your own vessel. Indeed, if you stand too close to the antenna, you could become the obstruction.

Remember, for GPS/DGPS to work you must have clear visibility of the full sky (meaning, line of sight?).

INSTALLATION AND MAINTENANCE

To take full advantage of this service, users should ensure that they have high quality GPS / DGPS receiver equipment which is properly installed in accordance with the manufacturers' instructions.

Remember....

** Read your manual carefully for installation instructions. **

GPS/DGPS & NAUTICAL CHARTS

NOTE: The following section describes how a mariner can make use of GPS/DGPS in conjunction with nautical charts. The same principles apply to land-based GPS/DGPS, except that land maps are used instead of charts.

If charts or maps are not available, you may relate your present position to objects around you and use this correlation to return to backtrack to previous positions. (See practical application section.)

A nautical chart, a pair of dividers or compass (divider with pencil) and a straight edge (ruler) are **ESSENTIAL** tools of **SAFE NAVIGATION**.

A nautical chart is a map of water areas and adjoining land which is intended primarily for marine navigation. It provides the mariner with a vast amount of information such as depth of water, elevation of land, Horizontal Datum, nature of the bottom and the positions of aids and dangers to navigation.

There are several scale levels of charts: a large-scale chart covers a small geographical area while a small-scale chart will cover a larger area. Larger scale charts are recommended for their greater accuracy.

These charts are produced by the Canadian Hydrographic Service (CHS). When you first look at a nautical chart, you will notice that it uses numerous symbols and abbreviations to convey important information to the user. To help you decipher these symbols and abbreviations, CHS publishes a manual called Chart 1. Information about CHS and where to obtain charts is available on the Internet at www.chs-shc.dfo-mpo.gc.ca

Another very important publication which you will require is the Notices to Mariners which advises about any changes that may have occurred with respect to navigation, and explains how to update your charts accordingly. This publication is also available on the Internet at www.notmar.com

When using GPS or DGPS you must be able to relate the position that it provides to the world around you, otherwise the information given by your receiver will have little meaning. To confirm your position, the latitude and longitude readings from the GPS or DGPS should be plotted on a chart. Conversely, the chart can provide latitude and longitude information which you can enter into a GPS or DGPS unit for trip planning.

Once you have your chart, the first step is to make sure that you have selected the right chart datum on your GPS/DGPS receiver. This information is shown in the Horizontal Datum note near the bottom of the chart's title note and looks like this: NAD 27 & NAD 83. Some receivers may show WGS 84 instead of NAD 83.

If the Horizontal Datum Note says that the chart is on North American Datum 1983 (NAD 83), then select NAD 83 or WGS 84 on the GPS/DGPS receiver. Then you may plot positions directly on the chart. Alternatively, you could input positions scaled off the chart, inputting these to the receiver as "waypoints".

If it says the chart is on North American Datum 1927 (NAD 27), you have two choices:

- You can select NAD 27 on the GPS/DGPS receiver and then either plot the positions on the chart or input the positions to the receiver. With this procedure, however, there is the possibility that, in some parts of Canada, you may end up introducing an additional positioning error of up to about 50 metres.

- You can select NAD 83 or WGS 84 on the receiver and manually follow the instructions of adding or subtracting published constants to both the latitude and longitude before plotting on the chart. To input coordinates scaled off the chart, one needs to reverse the mathematical operation before inputting the value to the GPS/DGPS receiver.

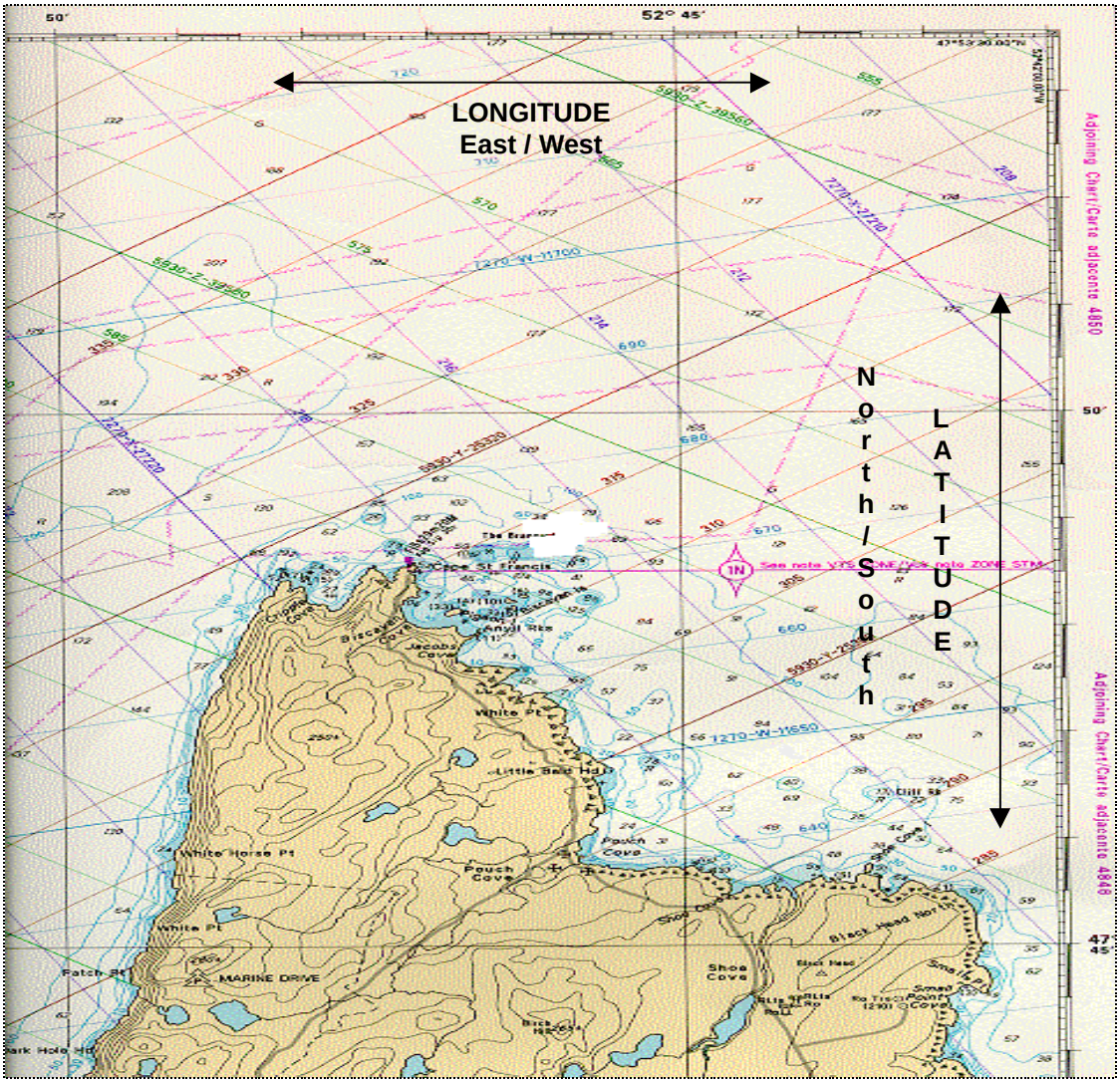
All Canadian charts are being converted to NAD 83 as new charts or new editions are produced.

Example of information found on chart:

> HORIZONTAL DATUM : North American Datum 1983 (NAD 83). Positions on NAD 27 must be moved 0.30 seconds northward and 3.59 seconds eastward to agree with this chart.

Let's start....

On the chart below are two sets of scales running along the top, bottom and sides. The scales on the top and bottom are for measuring longitude (east or west), while the sides are for latitude (north or south).



Latitude and Longitude are defined in terms of degrees, minutes and seconds (i.e. ° = degrees, ' = minutes and " = seconds)

Note: 1 degree contains 60 minutes and 1 minute contains 60 seconds and 1minute of latitude = 1 nautical mile (1852 metres or approximately 6076 feet).

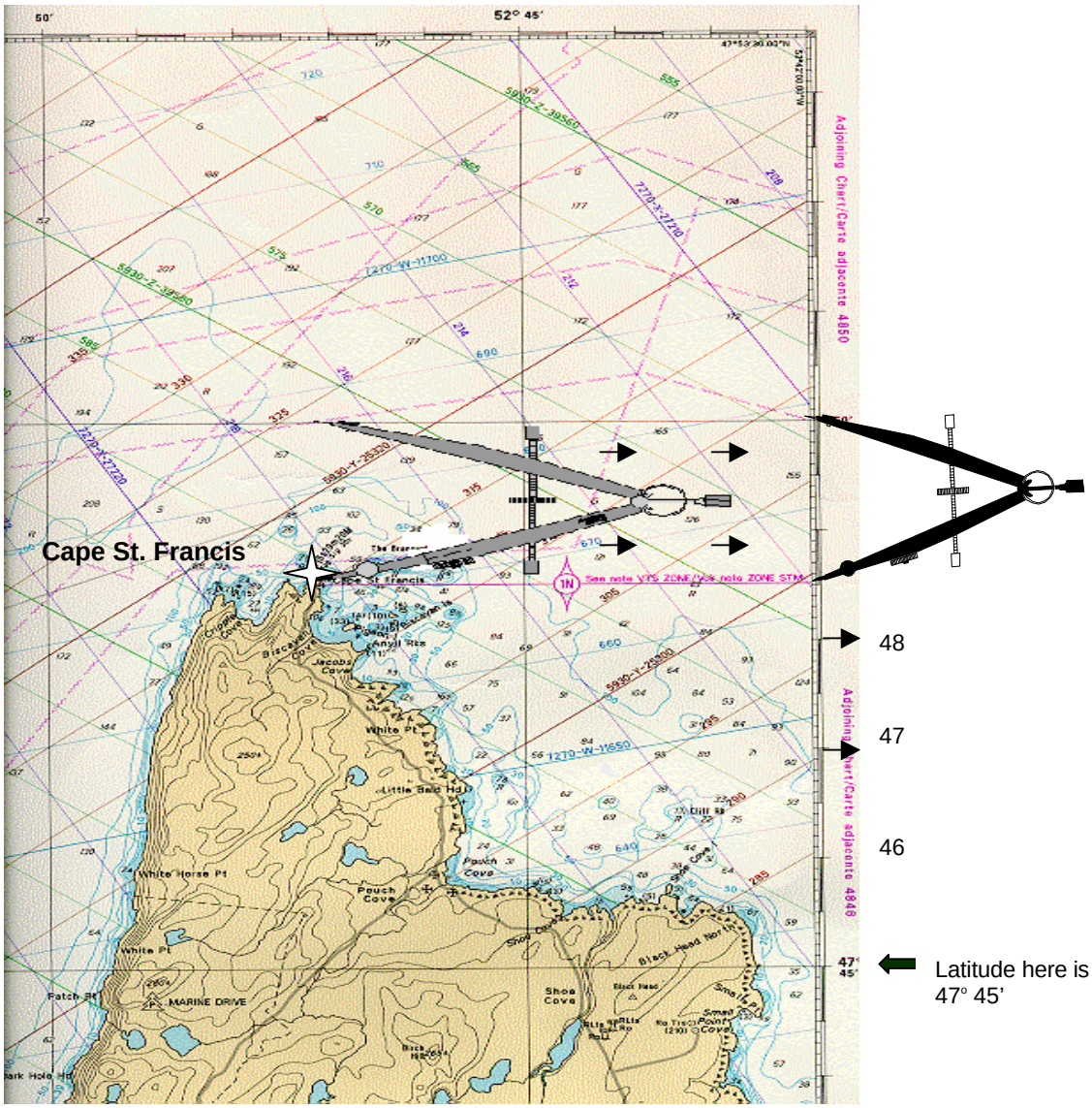
*(Please note that the Canadian Coast Guard recommends that mariners **NOT USE** aids to navigation as waypoints).*

Let's take a position from a chart (i.e. Cape St. Francis)

To find the latitude of Cape St. Francis, you need to place your dividers on the nearest latitude line.

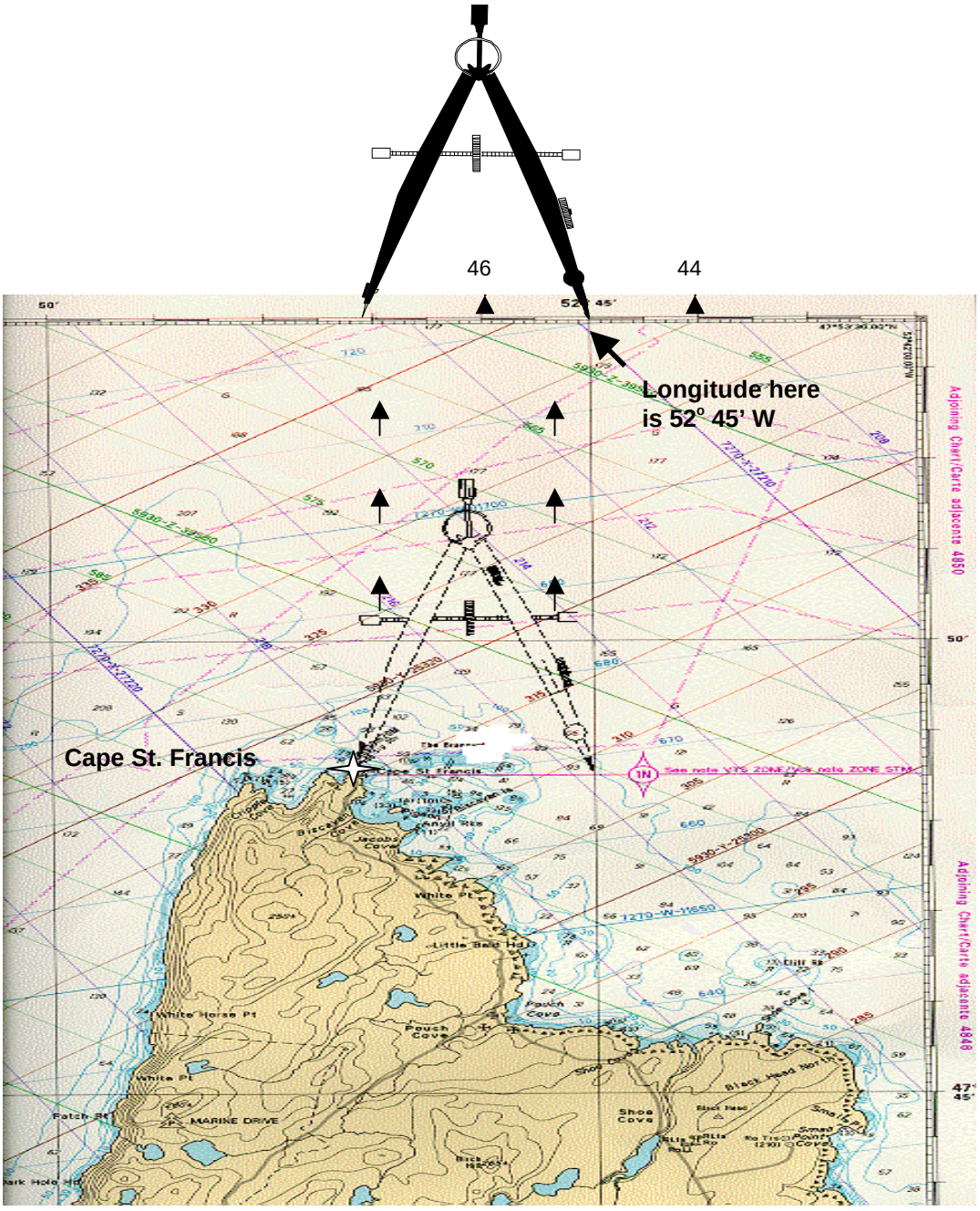
Still keeping one point of the dividers (or compass) on the latitude line, extend the other point to the position of Cape St. Francis.

Once you've done this, take your dividers and place one point on the latitude scale (on the side) and read the latitude off the scale. Please be as precise as possible because errors will come back to haunt you later.



The latitude for Cape St. Francis should read 47°48'32"N

Repeat the same process for longitude by using the longitude line and longitude scale (at the top or bottom).



The longitude for Cape St. Francis should read 52° 47' 09" W

The complete coordinates for Cape St. Francis are 47° 48' 32"N / 52° 47' 09" W.

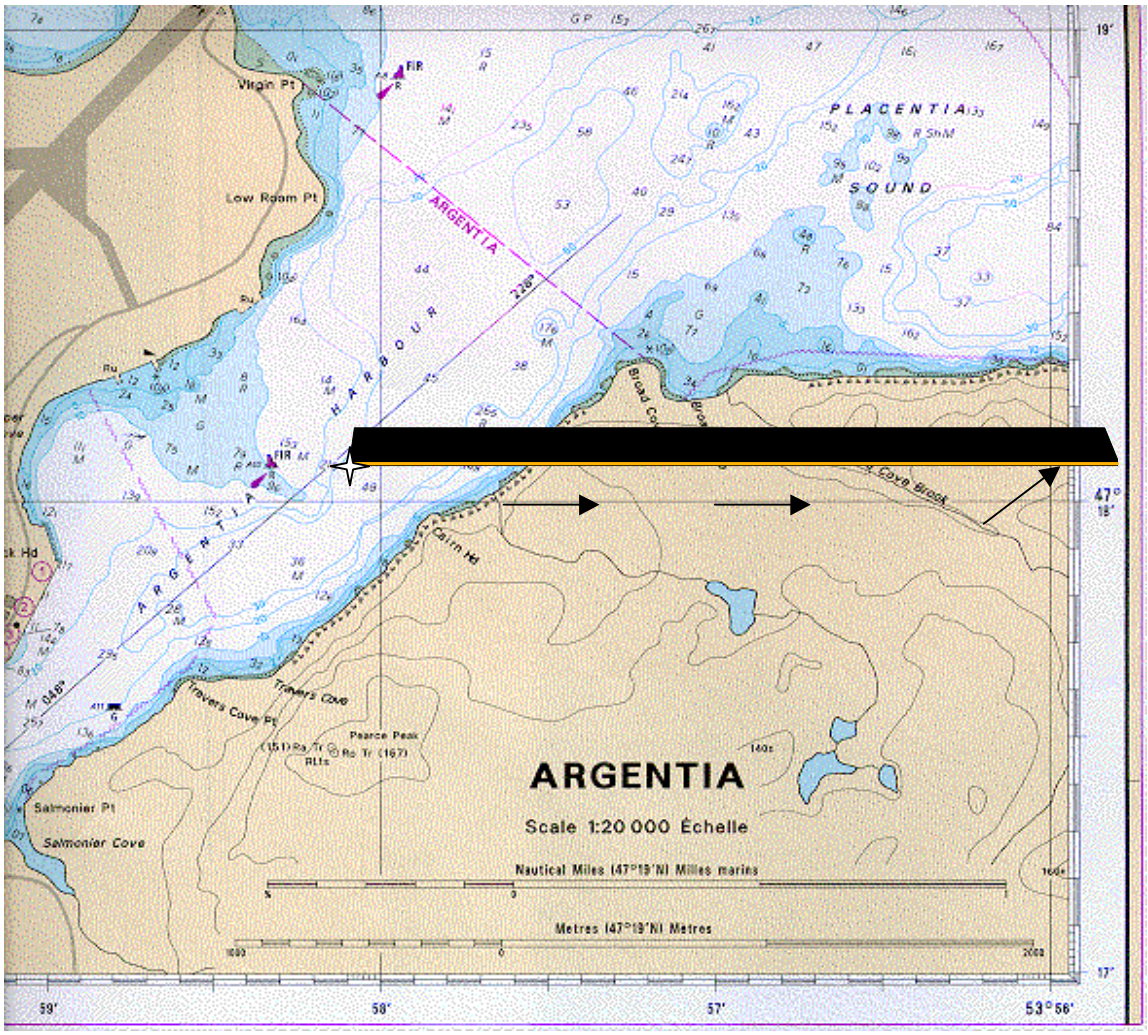
Remember...

- When taking a position, please be as precise as possible.
- Mariners are cautioned not to use aids to navigation as waypoints - due to the risk of colliding with the aid or grounding on the danger the aid is marking.

How to Plot a Position

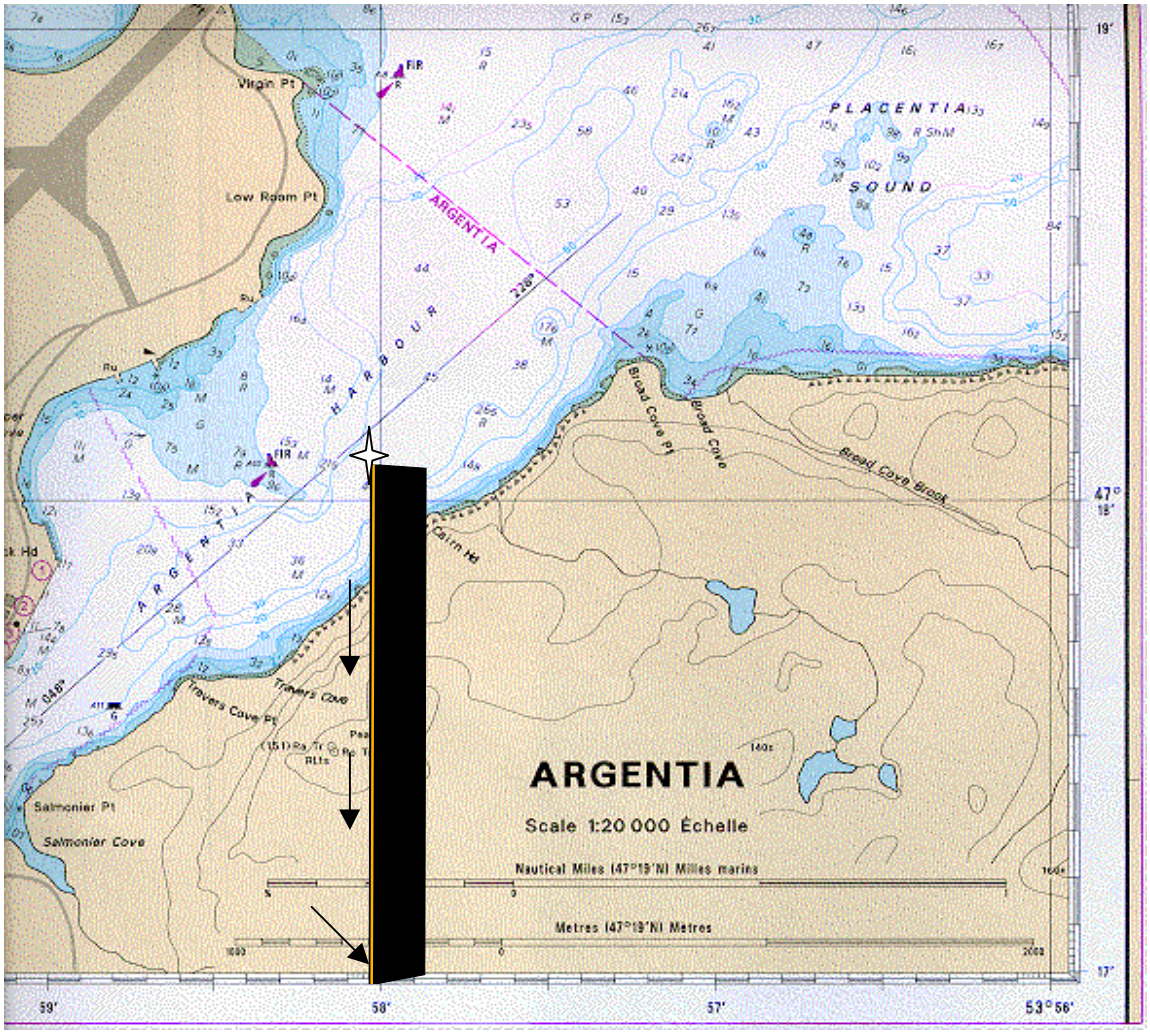
Let's say your GPS or DGPS receiver shows your position as being 47° 18' 04" N and 53° 58' 02" W.

Using your parallel rules (a ruler, compass or pair of dividers can do the trick, if you do not have a set of parallel rules), locate the coordinates on the latitude scale. *Again, be careful* to ensure accuracy using these tools. Locate the coordinates on the latitude scale. Estimate the distance and with a sharp pencil mark the location.

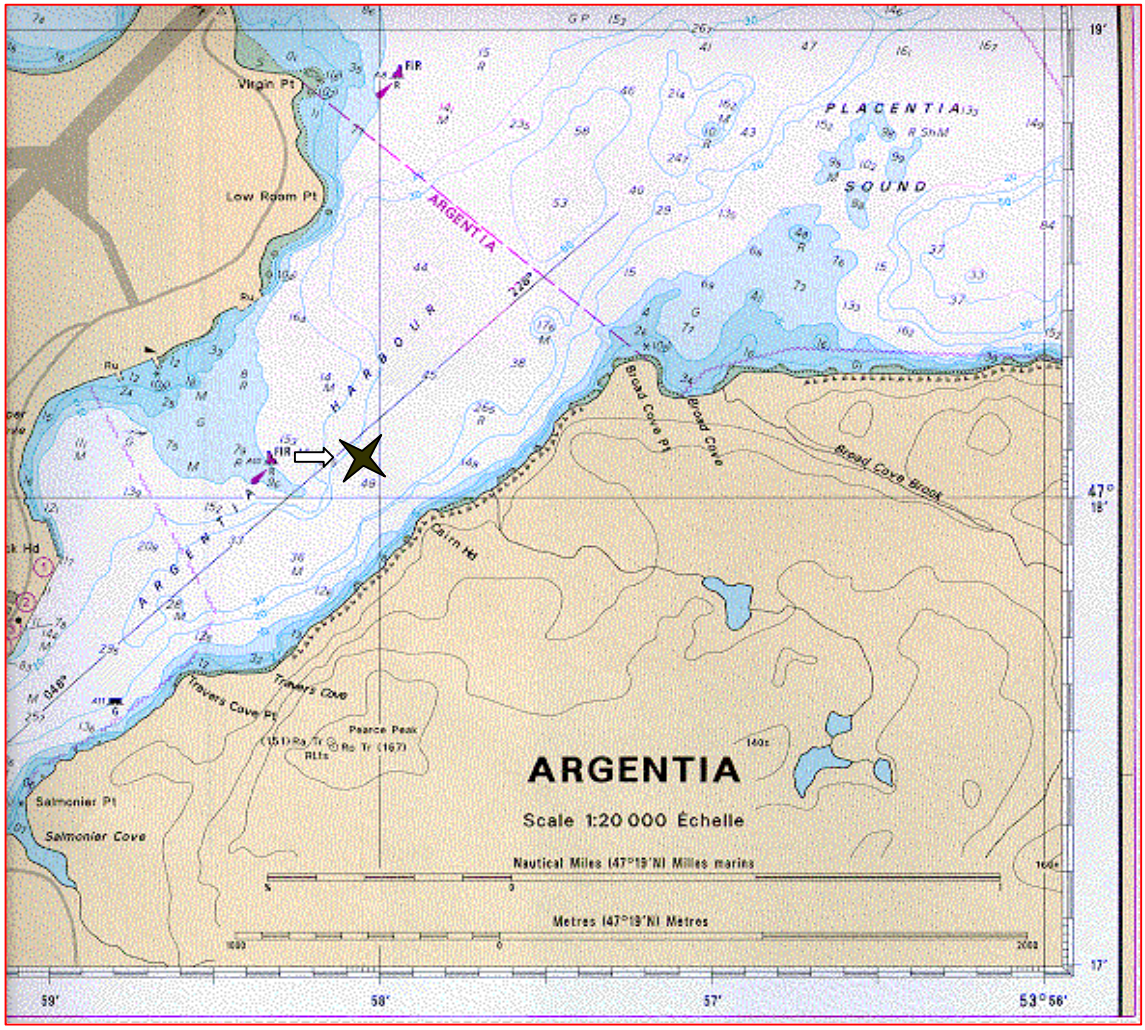


Next, take your parallel rules and place one edge on a nearby latitude line. Slide the other edge until you hit your mark and draw a line to it.

Repeat the same process for your longitude by using the longitude scale.



The intersection of these lines is your location on the chart.



In other words **X** marks the spot...

So remember...

- Use recent chart editions
- Keep your charts up-to-date using the Notice to Mariners publication
- Use the largest scale chart available which is more accurate since it covers a smaller area

For more information on purchasing charts and about other matters – (chart catalogue, charts, symbols and abbreviations), please contact your nearest Chart Dealer or CHS office, or visit the CHS web site at www.chs-shc.dfo-mpo.gc.ca

PRACTICAL APPLICATION

*** In this practical application portion, only the basic functions are covered. For more detailed functions please refer to your user's manual.**

**** Please note that the snap-shots were taken from the GPS screens of one model. The information found on other models might be displayed differently but the information remains the same.**

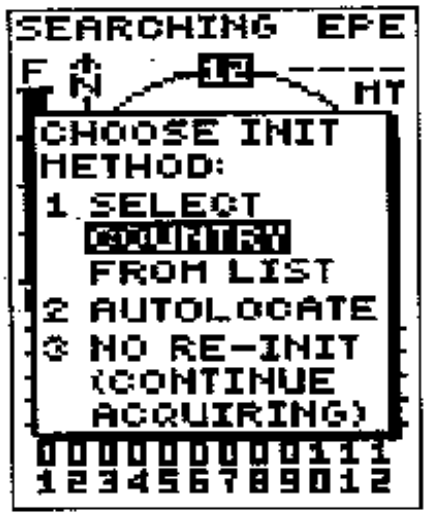
When a GPS receiver is turned on, it searches, acquires and tracks the coded satellite signals and computes a position fix, all automatically.

A new receiver right out of the box will have a completely clear memory; it won't know what time it is, what its position is or where any of the GPS satellites are.

Initialization

Before you start doing anything you must first initialize your receiver. There are various ways of doing this, so please refer to your user's manual.

When the unit is turned on it will immediately start searching for coded satellite signals. It will ask you for intialization information such as an approximate position by selecting a country and/or province from the internal list.



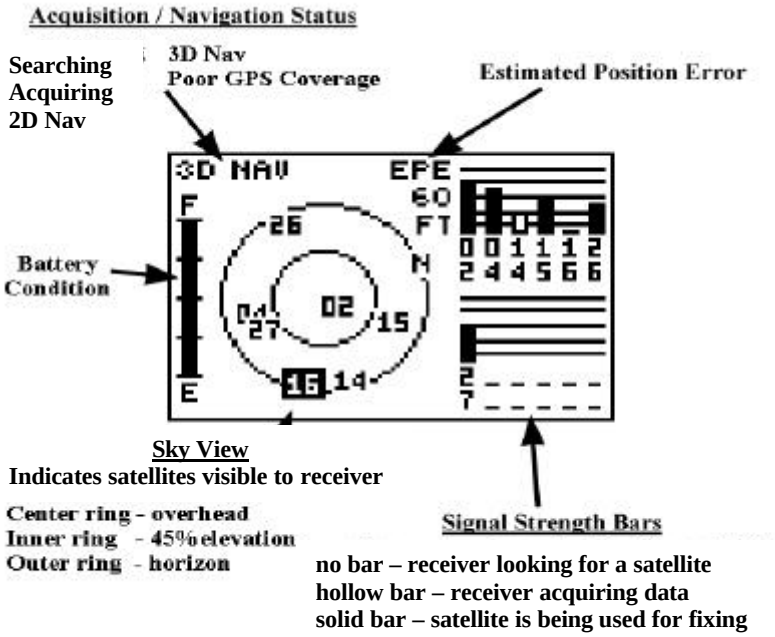
Don't forget also to enter the "time" for the area of operation and for Standard and Daylight Savings Time.

One more thing to keep in mind...

If your receiver has traveled more than 500 miles from where it was last powered up, a re-initialization is required.

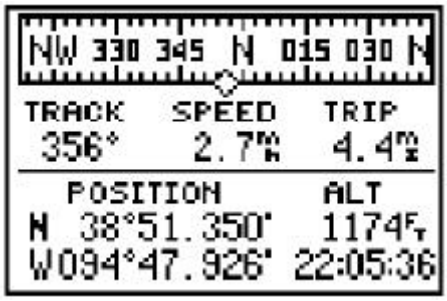
Satellite Status

The satellite status provides you with a visual reference of satellite acquisition, signal strength and position.



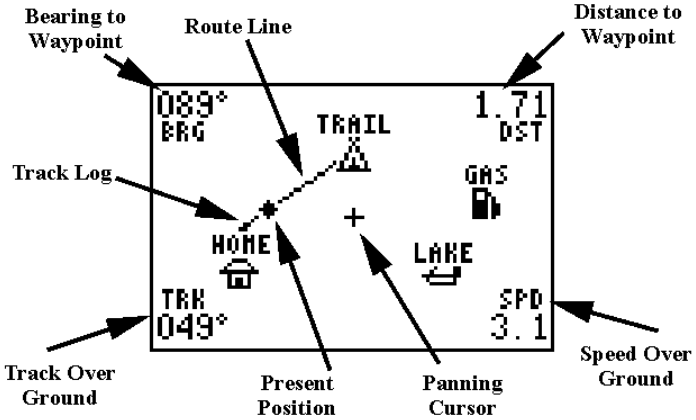
Position

Once you've acquired sufficient signals, the position page will show up. This shows you where you are, what direction you're heading and how fast you're going, and it's particularly helpful when you do not have an active destination selected.



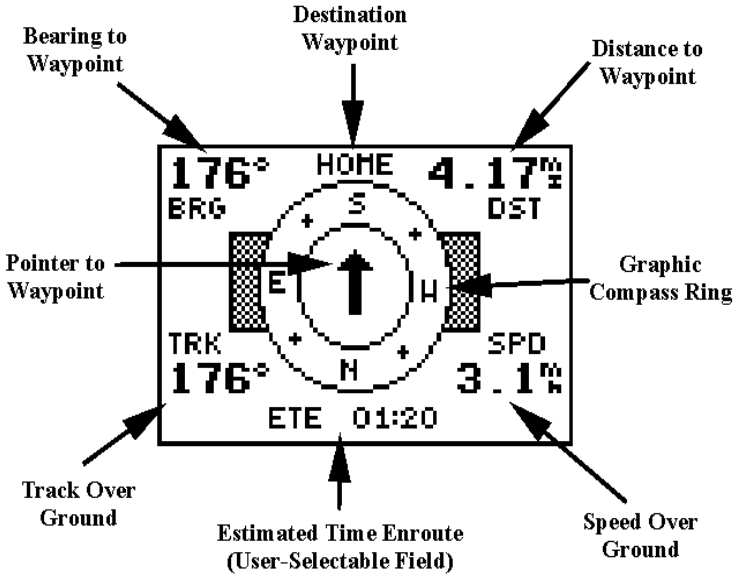
Map

The map displays allows you to view your position and provides a real time graphic "bread-crumb" display of the path you have traveled over and nearby waypoints that you have entered (see waypoint screen).

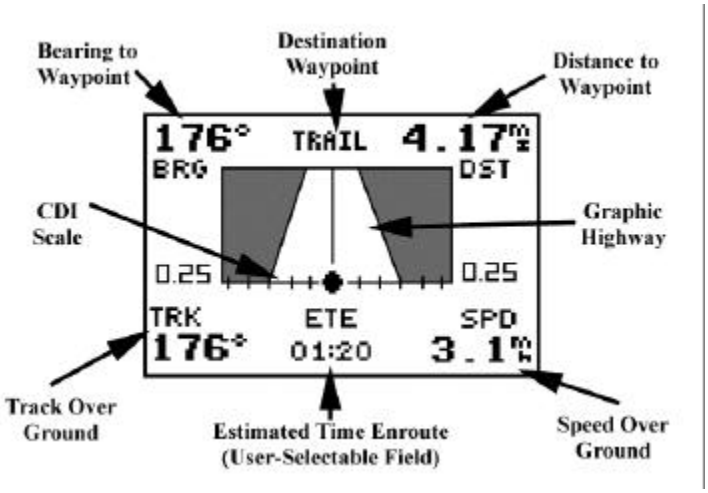


Navigation Page (Compass or Highway)

When going to a waypoint, the navigation page provides graphic steering guidance.



The highway page provides the same information as the compass page.

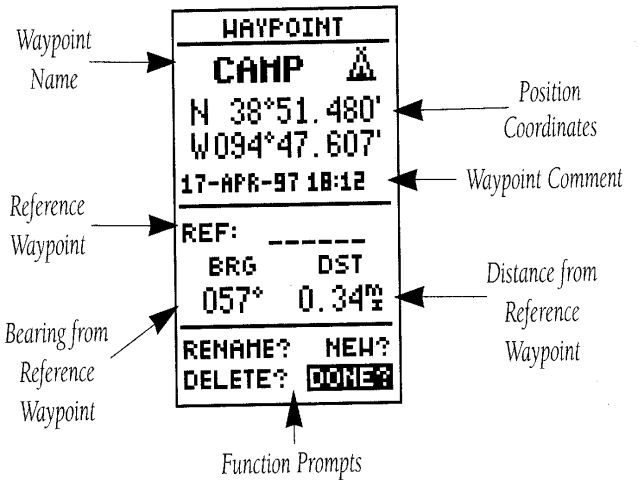


Menu

This provides access to additional pages (sub-menus) that are used to select and customize operation and navigation setup (access to the waypoint management, route, track log and setup features).

Waypoint

Waypoints serve as electronic markers that let you keep track of starting points, destinations, navaids and other important positions (e.g. good fishing spot). A waypoint position can be entered by taking an instant electronic fix or by manually entering a coordinate or range and bearing in reference to an existing waypoint.



Go To

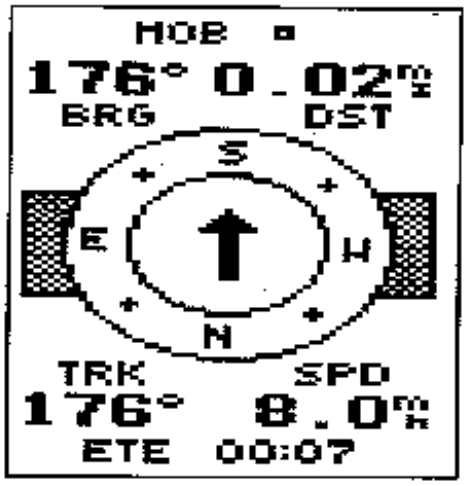
A Go To is nothing more than the receiver providing a pointer and drawing a straight-line course from your present position to the destination you've selected.

Backtrack or Traceback Navigation

The backtrack or traceback function allows you to quickly and easily retrace your path.

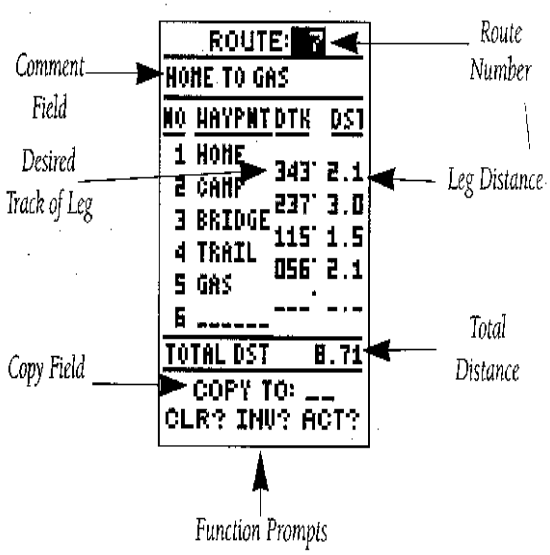
Man Overboard

The man overboard function (MOB) lets you simultaneously mark and set a course to a position for quick response to passing positions (like the spot where your hat blew overboard)



Routes

The route navigation lets you plan and navigate a course from one place to another using a set of pre-defined waypoints.



So remember....

- Setup the Chart Datum correctly and check when changing charts
- Always check your course to "go to" on the chart

SOME COMMON SENSE...

- Read your GPS receiver manual. Most manuals have a good description of the GPS/DGPS system, as well as how to enter waypoints and routes.

- GPS is a tool. Add it to your toolbox of navigation techniques, but remember:

  It only tells you where you are, and the range and bearing to where you told it you want to go. **You've still got to plan the route.**

- Due to the risk of collision with the aid, or grounding on the danger the aid is marking, mariners are cautioned not to use an aid to navigation as a waypoint.

DEFINITIONS

NAVIGATION:	The process of traveling from one place to another and knowing where you are in relation to your desired course.
DIFFERENTIAL GPS (DGPS):	An extension of the GPS system that uses land based radio beacons to transmit position corrections to GPS receivers.
GROUND SPEED:	The velocity you are traveling relative to a ground position. The speed that you are traveling over the bottom.
POSITION:	An exact, unique location based on a geographic coordinate system.
WAYPOINT:	A specific location saved in the receiver's memory that is used along a planned route.
BEARING:	The compass direction from your position to a destination.
LATITUDE:	A 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.
MULTIPATH ERROR:	Errors caused by the interference of a signal that has reached the receiver antenna by 2 or more different paths. Usually caused by one path being bounced or reflected.
TRACK:	The direction of movement relative to a ground position.

DESIRED TRACK:	The compass course between the "from" and "to" waypoints.
CROSSTRACK ERROR:	The distance you are off a desired course in either direction.
2D NAVIGATION:	At least three satellites with good geometry have been locked onto and a 2-dimensional position fix (latitude and longitude) is being calculated. "2D Diff" will appear when you are receiving DGPS corrections in 2D fix.
3D NAVIGATION:	At least four satellites with good geometry have been locked onto and your position is now being calculated in latitude, longitude and altitude. "3D Diff" will appear when you are receiving DGPS corrections in 3D mode.
POOR COVERAGE:	The receiver is no longer tracking enough satellites for a 2D or 3D fix.

LIST OF DGPS STATIONS OPERATING IN CANADA

STATION NAME	*Geographical Position Latitude Longitude*	*Frequency (KHz)*
PACIFIC REGION		
Alert Bay BC	50° 35’ N 126° 55’ W	309
Amphitrite Pt BC	48° 55’ N 125° 33’ W	315
Richmond BC	49° 11’ N 123 ° 07’ W	320
Sandspit BC	53° 14’ N 131° 49’ W	300
CENTRAL & ARCTIC REGION		
Cardinal ON	44 ° 47’ N 75° 25’ W	306
Wiarton ON	44° 45’ N 81° 07’ W	286
LAURENTIAN REGION		
St-Jean-sur-Richelieu QC	45° 19’ N 73° 19’ W	296
Lauzon QC	46° 49’ N 71° 10’ W	309
Rivière du Loup QC	47° 46’ N 69° 36’ W	300
Moisie QC	50° 12’ N 66° 07’ W	313

STATION NAME	*Geographical Position Latitude Longitude*	*Frequency (KHz)*
MARITIMES REGION		
Partridge Island NB	45° 14’ N 66° 03’ W	295
Pt. Escuminac NB	47° 04’ N 64° 48’ W	319
Fox Island NS	45° 20’ N 61° 05’ W	307
Western Head NS	43° 59’ N 64° 40’ W	312
Hartlen Point NS	44° 36’ N 63° 27’ W	298
NEWFOUNDLAND REGION		
Cape Race NF	46° 46’ N 53° 11’ W	315
Cape Ray NF	47° 38’ N 59° 14’ W	288
Cape Norman NF	51° 30’ N 55° 49’ W	310
Rigolet NF	54 ° 11’ N 58° 27’ W	299

For further information on the DGPS service or the DGPS system characteristics, contact your regional Coast Guard office.