7

Foundations of Navigation

"Sometimes knowing where you are not is just as important as knowing where you are."

The new Coast Guard Auxiliary crewmember may not be fixing positions, planning routes and giving courses to steer, that would be the job of the vessels' navigator or captain. Yet it is imperative that everyone on board the rescue vessel is able to use their eyes and charts, along with the electronic nav aids to monitor the safe track of the vessel.

Every CCGA crewmember shall be able to recognize when their vessel is standing into danger and they shall know how to react quickly and assertively in the interest of the vessel when they recognize a risk.

Foundations of Navigation
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Royal Majesty

Excerpt from *GPS Instant Navigation* by Kevin Monahan & Don Douglass

On June 10, 1995, at about 2230, while transiting from Bermuda to Boston, the Panamanian cruise ship Royal Majesty ran aground on the Rose and Crown Shoals near Nantucket Island, Massachusetts. On board were over 1500 people, including crew. Luckily, the weather was fine at the time and no injuries or deaths resulted from the grounding. However, weather conditions worsened. The passengers, who were forced to remain on board while the ship was refloated, were not able to disembark in Boston until 48 hours later. The incident resulted in a nasty repair bill and a great deal of embarrassment on the part of the navigation officers. The Royal Majesty had deviated 17 NM off course at the time of the grounding!

The ship was fitted with an Integrated Navigation system, with positioning information provided by GPS and Loran C receivers. This type of equipment bears the same relationship to the average consumer GPS Navigator as the space shuttle does to a bicycle. The Integrated Navigation system was of the type that takes inputs not only from positioning devices, but also from a gyrocompass and a Doppler speed log; it is programmed with waypoints and the manoeuvring characteristics of the individual vessel. It was capable of being connected to an autopilot and steering the ship in reference to a predetermined track, automatically compensating for gyrocompass error, wind, and current.

The Integrated Navigation system was capable of calculating a dead reckoning position based on course steered and speed through the water. It was programmed to sound an alarm if it detected a difference of more than 200 metres between its DR position and the GPS or Loran C position.

At the time of the grounding, the Integrated Navigation system was in operation, but for some reason it failed to keep the ship on course. Afterward, many people wondered how this happened. An investigation by the United States National Transportation Safety Board revealed the cause: a frayed wire and a duplicated function in the GPS that provided position data to the Integrated Navigation system.

As is common with many older satellite-based positioning systems, the GPS unit on board the Royal Majesty was programmed to default to a DR position when satellite signals became unavailable. Rather than freezing up and displaying the last satellite-based position available, it applied data from the gyro-compass and speed log to project the position along its course steered. (When the unit was manufactured this was an intelligent choice, because in the early days of GPS there were frequently not enough satellites available to provide an adequate fix.) When the GPS itself reverted to DR mode, it sounded an alarm, but this alarm was not very loud.

At some time prior to the grounding, the shielding on the GPS antenna wire came loose from the antenna itself. The GPS could not derive a position, so it defaulted to DR mode. Because the GPS was mounted behind a bulkhead, both its alarm and visual fault-indication display went unnoticed. Since it continued to supply position data to the Integrated Navigation system, the system did not automatically switch to Loran C positioning, but the GPS Navigator was supplying DR positioning based on the courses steered and the speed logged since the last valid position fix.

The Integrated Navigator was using the same gyrocompass and speed inputs as the GPS to derive a DR position, so the two positions never differed by more than 200 meters; consequently, the Integrated Navigator never sounded an alarm. It "assumed" that the position data it was receiving was a GPS-derived position, not a DR position, since the data came from the GPS Navigator itself.

Meanwhile, current and winds forces were slowly pushing the Royal Majesty off her Intended Track until the time of the grounding when the vessel was 17 NM off course. For this amount of Cross Track Error to accumulate, the antenna shielding must have separated several hours before. The NTSB report noted that at no time were the bridge officers aware that the ship had strayed from her course, even though they had numerous other means at their disposal to determine their position, or at least to realise they were no longer following their Intended Track.

Complacency seems to be the main cause of many accidents; navigators must constantly guard against placing their trust where it might not be due. Though there were valid reasons for the failure of the Integrated Navigation system, the report indicates that the officers neglected to monitor the ship's progress by other means at regular intervals.

In this case, the marvellous accuracy and ease of use of GPS and its derivative systems may have lulled the navigators of the Royal Majesty into the habit of using the GPS/Integrated Navigation system as their sole means of establishing position. Although not categorically affirmed, this is implied by the NTSB report. At some point, according to Murphy's Law, if you depend on it, it will fail, and it will fail at the most inconvenient time. Hopefully we can all learn a lesson from this incident.

Introduction to Navigation

Navigation is the system that vessel operators use to plan and travel along a sea route, including determining a vessel's position and avoiding hazards. The art of navigation embraces two basic concepts and four basic disciplines. The concepts are location and direction. The disciplines are dead reckoning, piloting, celestial navigation, and electronic navigation. Celestial navigation is not used by small coastal rescue craft so it will not be covered.

Dead Reckoning

Dead reckoning is the determination of position by course and distance from a last known position without regard for current or other external influences. It is arguably the most basic discipline, yet without it, none of the other disciplines would be possible.

Pilotage

"Sometimes knowing where you are not, is more valuable than knowing where you are." Pilotage involves determining a vessel's position relative to known objects, such as landmarks or aids to navigation. In some cases, all that's needed for navigation by pilotage is sound knowledge of the area, including local weather, tides and currents, hazards to navigation such as shoals, aids to navigation and traffic and of course, your chart.

Eyes and Chart

Your vessel may be equipped with the latest GPS and chart plotter, an integrated, stabilised radar and a colour depth sounder, but the only truly reliable navigational aids found on onboard your vessel **are your eyes and your chart**.

The most important skill required of navigation by pilotage, is that of observation. For pilotage in particular, the good navigator will make use of all his or her senses to determine a vessel's position relative to hazards, and guide it to its destination.

Observation skills can't be taught by this book. All of us already use such skills to a certain extent anyway. The goal here is to point out how valuable some of the skills you already have can be in navigation. Awareness and practice are the best methods for honing these skills.

Eyes

Buoys, beacons, ranges, day marks, landmarks such as peaks or breaking surf are just a few of the visual clues you can use to tell you where you are. By lining up two recognisable man-made or natural objects you can create transits that tell you where the safe water is and how the tide is affecting you.

The good navigator, no matter how skilled in the use of navigation instruments and techniques, will always use all the information available, and never rely on just one source of information, when others are available. This is very important to remember with some of the navigation instruments available today. While GPS and electronic charts have greatly simplified some aspects of navigation and are now available on the smallest boats, these systems may and can fail, or even worse, give false or misleading information. More traditional aids to navigation, such as buoys can also fail or give false or misleading information if they drift off position. The consequences of over-reliance on any one system can be disastrous.

Some available means for checking position are:

1. *Eyes for visual references*
2. *Hydrographic Chart*
3. *Boat Compass*
4. *Radar*
5. *GPS*
6. *Electronic Chart*
7. *Local Knowledge*
8. *Hand Compass*
9. *Depth sounder*
10. *Smell and Hearing*

7.1 Navigation Monitor

As a crewmember in the navigation monitor position you may not actually be navigating the vessel. Rather, your primary responsibility will be monitoring the position of the vessel in relation to the paper chart, electronic chart and radar. You must be aware of the intended path defined by the coxswain/captain and routinely checking that the vessel's position is on that path, using all available means.

A crewmember will be in constant communication with the captain or coxswain during the vessel's advance. It is the navigation monitor's primary responsibility to watch for dangers regarding the vessel's path, yet all crew shall be on the lookout for the following situations and all crew will take these actions.

You must STOP the vessel in event of:

- An unknown object in close proximity is detected by sight or radar ahead of the beam
- A major unexpected departure from the course line
- Another vessel turning or veering into your vessel's path
- Uncertainty of your vessel's general position
- Impending landmass detected by sight or radar
- When in close proximity to dangerous submerged objects (rocks, shoals or wrecks) charted or sighted
- Depth sounder consistently reading depths not expected

Note: *All crew are responsible for the safety of the vessel at all times.*

You must notify the coxswain if:

- Moving in or near conditions of reduced visibility due to rain, snow, sleet or fog
- There are aids to navigation previously unreported
- Any new vessel traffic comes into view by sight or radar
- Any fixed hazards come into view by sight, radar, or electronic chart
- If there are any differences between what you should see (according to paper/electronic charts) and what you actually see
- There is any malfunction of any electronic device
- There is any uncertainty in your operation of any device
- Any information available to you is not fully understood (chart symbol, radar image, GPS data, or instruction or request from the coxswain)
- The scale of any electronic navigation aid is changed (GPS or Radar)

Courteous and Professional Vessel Operation

- Vessel operators shall always proceed with caution to ensure that their vessel's wake and wash does not adversely affect other vessels, shoreline, docks, floats or wetlands, swimmers and divers, bathing beaches and anchorages
- Vessel operators shall always use courtesy and common sense to avoid creating a hazard, threat, stress or irritant to themselves, others, the environment or wildlife
- Vessel operators shall stay well clear of swimmers and properties
- Vessel operators shall follow *Collision Regulations*
- Vessel operators shall know that a craft moving at high speed requires more stopping distance in an emergency and therefore be more attentive because the operator has less time to act

7.2 Publications

These publications may be useful for learning:

Canadian Tide and Current Tables: Tidal and current information specific to coastal areas.

Chart # 1, Symbols and Abbreviations Used on Canadian Nautical Charts: Legend covering the symbols and abbreviations used on navigation charts published by the Canadian Hydrographic Service.

Collision Regulations: The international rules for the prevention of collisions at sea. This is your most important navigational safety publication, as it outlines the rules of right of way, lights and signals.

List of Lights, Buoys, and Fog Signals: This publication details the characteristics and descriptions of lights and navigation aids, and their positions.

Notices to Mariners: A monthly publication that contains navigational notices concerning changes in aids to navigation, hazards to navigation, chart corrections, and new charts. The Annual Edition of the Notice to Mariners should also be available.

Radio Aids to Marine Navigation: Information concerning radio weather broadcast messages and radio aids to navigation.

Sailing Directions: A book that supplements navigational charts by providing listings of associated charts related to the area; detailed geographical data; aerial photographs; and other information specific to the area.

The Canadian Aids to Navigation System: This publication details all of the different navigational aids and the Canadian/International Association of Lighthouse Authorities' buoyage system.

High Speed Doom

(A discussion paper addressing high-speed navigation associated with Fast Rescue Craft)
Written By Tyler Brand, Canadian Coast Guard (1999)

Many Coast Guard Auxiliary rescue vessels are high performance/high endurance craft capable of moving at speeds of up to 50 knots. This new speed of advance has pushed the realm of navigating these vessels into a new class with new requirements. This class of skills and knowledge is closer to the world of aviation than nautical science. In order to stay safe with these vessels, special measures must be taken with regards to training high-speed vessel crews. These platforms have evolved over the past several years and they are now being deployed.

The navigation systems that these boats are being fitted with (electronic chart plotter coupled with DGPS and radar) are in some cases more advanced than those on some large ships. These systems now allow an operator to create a route, using waypoints over the background of a digital chart. The navigator could run this route without consulting a paper chart or even slowing down for the transitions from one leg to another. The performance level of this equipment is deceiving. Most of these navigation systems were not designed to travel at this speed, and give an impression that the information that they are displaying is more current and accurate than it really is.

The new technology has surpassed the training level of the crews. An enthusiasm for the electronics coupled with a lack of formal navigation training can translate into a heads down style of navigation. At high speed this can result in catastrophe. The problems of high-speed navigation are not easily solved by our present adjustments in RHI training and an updated approach is required.

New Performance Levels

Crews are using the vessel to its maximum performance level to carry out SAR, and with an appropriate sense of urgency. Many Auxiliary Crews are becoming skilled operators of their new electronic navigation systems and when the call comes from rescue centre the crew can activate a pre-programmed route and blast off into the night following the GPS navigation screen or even the waypoint lollipop flashing on their radar screens. So far, all the vessels have returned, the incidents get resolved and the crews chalk up successful calls.

What's the problem?

The problem is that the difficulty of this type of navigational feat is not obvious to those who have been doing small boat rough navigation for years. Very gradually as the speed of the vessel has increased along with the addition of radar and GPS, so has the "safe speed" of navigation in reduced visibility. Now with the advent of the electronic charting system a fluid high-speed route makes it seem unnecessary to slow down or stop for paper chart orientation. As the navigator gives helm commands to the driver who cannot see any targets or objects, the crew must now react immediately to any dangers or unseen hazards. This feat is comparable to driving your car at 80 km per hour through downtown traffic blindfolded, while the guy in the back seat tells you to "turn right, left, watch out for the bus!" We now have the navigational equipment that allows us to do this but is it safe? The high-speed platform has arrived by virtue of its humble descendants (the little zodiacs we used to drive). The boat's performance level has exceeded the crew's standard of training. At some point we crossed that line into a whole new realm of high performance navigation.

Safe Speed Means Safe Speed

If rescue vessel operators are following the collision regulations and always moving at *safe speed* then why would we need special navigation training? Ideally, this would always be the case but safe speed is a matter of judgement and judgement can vary. FRC navigators can overestimate their abilities to detect and avoid objects at these speeds. If your vessel's range of speed is 0-15 knots then the range of judgement for a safe speed will vary with conditions and confidence, and span from 7 knots to 12 knots. If the vessel is capable of 50 knots then the range of safe speed will also vary with conditions and confidence, and span from 18 knots for some operators but 40 for others.

Communication is the key to safely operating these vessels. The navigator who, is looking at the charts and the radar must be able to clearly communicate with the driver. At 50 knots or 25 metres per second a mixed-up message can mean you can travel a tenth of a nautical mile before you have time to sort out the confusion. This danger is not readily apparent to the average small boat coxswain and therefore not taken into account when adjusting for the safe speed equation. High-speed navigation requires special consideration. The solution is not to put smaller engines on the vessels or take off the electronic navigation equipment. It is simply to pay special attention to the training of these crews and have some standard of performance on the navigational level while always allowing a margin for error.

7.3 Aids to Navigation

7.3.1 Buoys and Beacons

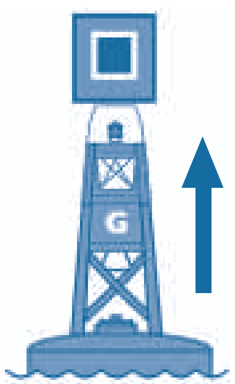
Always consult the chart to confirm placement of bouys.

The Canadian Aids to Navigation system is a combined Lateral-Cardinal system. It is important for vessel operators to know the characteristics of each of these systems to ensure safe navigation on our waterways.

Lateral Aids to Navigation

Lateral aids may be either buoys or fixed aids. They indicate the location of hazards, and of the safest or deepest water, by indicating the margins of the channel. The general rule is: **Red, right when returning**.

Lateral means "side." The lateral system is a convention, which tells the mariner on which side to leave a buoy to ensure the buoy is between the vessel and the danger it protects against (in channels, the buoys protect against the danger of grounding in shallow water). In North America we use IALA system B, which means red to right when returning (coming in from sea). But not all channels lead in from the sea. IALA System B is a convention that has established in-from-the-sea to be a clockwise flow around N. America, down the East coast (red buoys to starboard when heading south), across the Gulf coast (red to starboard when heading west), and up the West Coast of the Canada (red to starboard when heading north). In-from-the-sea on the Great Lakes is generally northerly and westerly except Lake Michigan, where it's southerly (leading toward the port of Chicago). The rule is to keep red buoys to starboard when returning to harbour. Obviously, then, green buoys are kept to port.



Port Hand Bouy

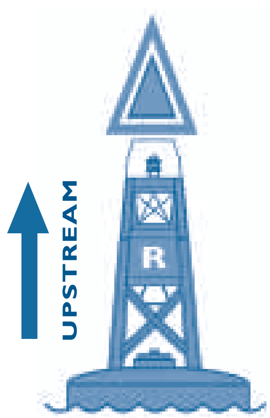
The colour of the bouy tells you where to go, ie., green (port) – go to starboard of it.

Keep the starboard hand (red coloured) markers/buoys/lights to the starboard side when your vessel is:

- Returning from sea
- Heading in an upstream direction
- Entering a harbour or
- Heading North on West Coast, or South on East Coast

Keep the red markers on your port side when:

- Proceeding out to sea
- Heading in a downstream direction
- Leaving a harbour or
- Heading South on West Coast, or North on East Coast



Starboard Hand Bouy

Lateral Day Beacons

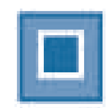
Although the majority of fixed aids to navigation support and display a light for night navigation, a limited number do not. These unlit aids are known as day beacons, and are used primarily to assist the mariner during daylight hours, where night navigation is negligible or where it is not practical to operate a light.

Colour, shape, and sometimes a number, are used to identify the purpose of a day beacon. Reflective material is applied to day beacons to improve their visibility and identification at night for mariners equipped with a searchlight.

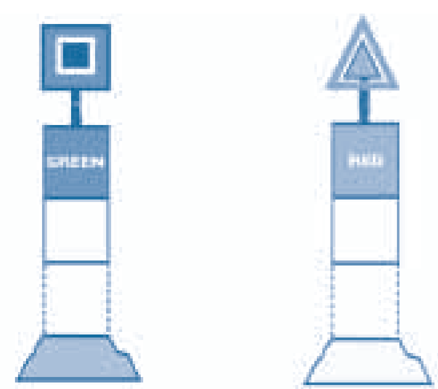
Starboard Hand Day Beacon:

A starboard hand day beacon is triangular, with a red triangular centre on a white background, and a red reflecting border. It may display an even number made of white reflecting material. It marks the starboard side of a channel or the location of a danger in daylight and must be kept to the right when proceeding upstream.

Port Hand Day Beacon:

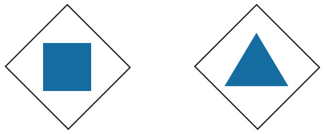


A port hand day beacon is square, with a black or green square centre on a white background, and with a green reflecting border. It may display an odd number made of white reflecting material. It marks the port side of a channel or the location of a danger in daylight. It must be kept to the left when proceeding upstream; a port hand day beacon must be kept on the vessel's port (left) side.



Port Hand Day Beacon   Starboard Hand Day Beacon

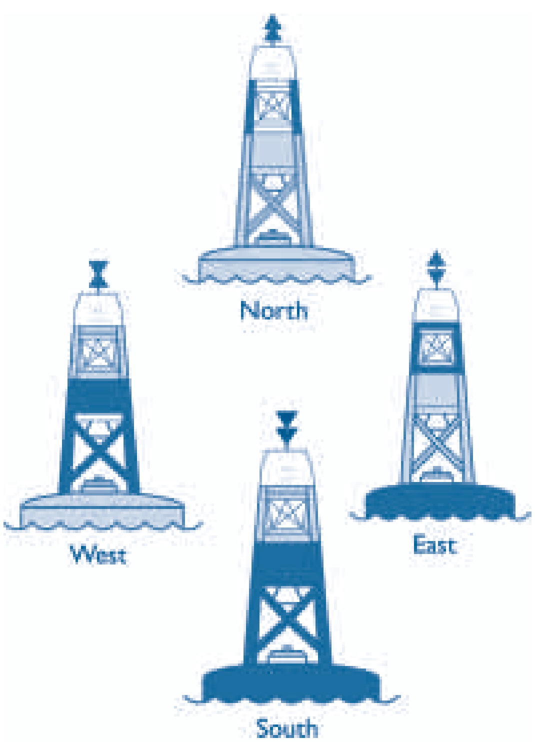
Bifurcation/Junction Day beacon



A bifurcation/junction day beacon marks a point where the channel divides and may be passed on either side. When proceeding in the upstream direction, a bifurcation/junction day beacon displaying a red reflecting triangle on a white diamond with a red border indicates that the preferred route is to the left. Similarly, a green reflecting square on a white diamond with a red border indicates that the preferred route is to the right. When proceeding downstream, the positions and meanings of these day beacons are reversed.

Cardinal Aids to Navigation

Cardinal buoys, marked in yellow and black, indicate the location of the deepest and safest water. The North, East, South and West cardinal buoys are distinguished by their colour pattern, and by their top marks. Pass to the named side of the buoy.



North is Up

The North Cardinal Buoy is black on top and yellow on the bottom. The safe water lies to the North of this buoy. Flashing White Light: (Q) 1S (VQ) .5S

Diamonds Are in the East

The East Cardinal Buoy is black with a yellow band. The safe water lies to the East of this buoy. Flashing White Light: Q(3) 10S or VQ(3) 5S

South is Down

The South Cardinal Buoy is yellow on top and black on the bottom. The safe water lies to the south of this buoy. **Flashing White Light:** Q(6) + LF1 15S or VQ(6) + LF1 10S

Time Is In The West (Hour glass shape)

The West Cardinal Buoy is yellow with a black band. The safe water lies to the west of this buoy. **Flashing White Light:** Q(9) 15S or VQ(9) 10S

Special Buoys

For areas that are designated for special purposes and activities we have buoys that mark these areas and give information about the area. Usually an area used for swimming or an area where boats are prohibited is listed in the boating restriction regulations for the area. These regulations allow signs or buoys to be posted to mark the restriction. Regardless of the colour of reflective material, all special buoys, where lighted, will display yellow lights, and will flash regularly at intervals of 4 seconds each.

Cautionary Buoy

This is a buoy that marks an area where mariners are to be warned of dangers such as firing ranges, race courses and under water structures. This buoy may be fitted with a single yellow X as a top mark.

Cautionary Buoy

Diving Buoy

This is a buoy that marks an area where diving activity is present. The flag is a common red and white diagonal stripe.

Diving Buoy

Control Buoy

This is a that marks an area where boating is restricted or controlled

Control Buoy

Keep out Buoy

Used to mark an area where boats are prohibited

Keep Out Buoy

CHARACTERISTICS OF LIGHTS

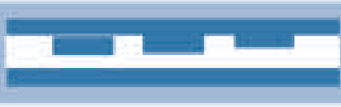
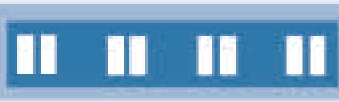
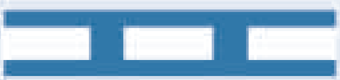
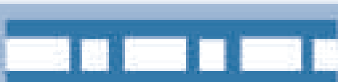
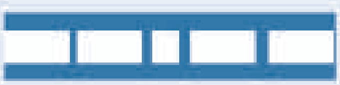
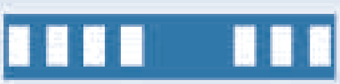
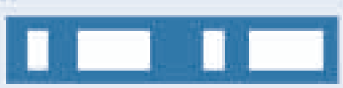
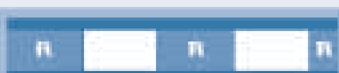
Flashing pattern and period (|-----|)	Type	Description	Abbreviation
	Fixed	A light showing continuously and steadily	F
	Fixed and flashing	A light in which a fixed light is combined with a flashing light of higher luminous intensity	F Fl
	Flashing	A flashing light in which a flash is regularly repeated (frequency not exceeding 30 flashes per minute)	Fl
	Group flashing	A flashing light in which a group of flashes, specified in number, is regularly repeated.	Fl (2)
	Composite group flashing	A light similar to a group flashing light except that successive groups in the period have different numbers of flashes	Fl (2+1)
	Isophase	A light in which all durations of light and darkness are equal	Iso
	Single occulting	An occulting light in which an eclipse, or shorter duration than the light, is regularly repeated	Oc
	Group occulting	An occulting light in which a group of eclipses, specified in number, is regularly repeated	Oc (2)
	Composite group occulting	A light, similar to a group occulting light, except that successive groups in a period have different numbers of eclipses	Oc (2+1)
	Quick	A quick light in which a flash is regularly repeated at a rate of 60 flashes per minute	Q
	Interrupted quick	A quick light in which the sequence of flashes is interrupted by regularly repeated eclipses of constant and long duration	IQ
	Group quick	A group of 2 or more quick flashes, specified in number, which are regularly repeated.	Q(3)
	Morse code	A light in which lights of two clearly different durations (dots and dashes) are grouped to represent a character or characters in the Morse code.	Mo (A)
	Alternating	A light showing different colours alternately	Al RW
	Long flashing	A flashing light in which the flash is 2 seconds or longer	LFl

Figure from Chapman Piloting (seamanship and small boat handling) 62nd edition, p516.

Information Buoy

This is a buoy that displays information by words or symbols information of importance to mariners.

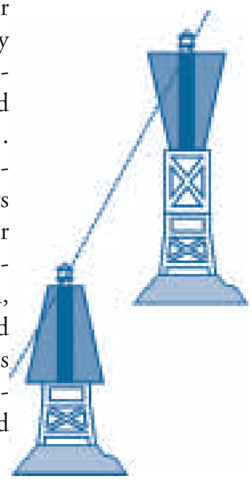
Swimming Buoy

This buoy marks the perimeter of a swimming area.

Isolated Danger Buoy

This is a buoy that marks random hazards such as rocks, shoals or submerged objects.

7.3.2 Ranges and Transits



A range consists of two or more fixed navigation day marks or lighted marks situated some distance apart, and at different elevations. Ranges provide a recommended track for navigators when in line, and may or may not be lighted. The colour of the range day beacon, as well as the colours and characteristics of the lights are detailed in the appropriate List of Lights, Buoys and Fog Signals publication.

7.3.3 Sector Lights

A sector light consists of a single light whose total luminous beam is divided into sectors of different colours to provide a warning or a leading line to mariners. The colours and boundaries of these sectors are indicated in the appropriate List of Lights, Buoys and Fog Signals publication and on nautical charts.

When only a red sector is used within a white luminous beam, the red sector marks obstructions such as shoals. A combination of red, white and green sectors in a luminous beam is used to provide a leading line to navigators. When proceeding upstream, the red sector indicates the starboard hand limit, the white sector indicates the recommended course, and the green sector indicates the port hand limit.

7.3.4 Fog Signals

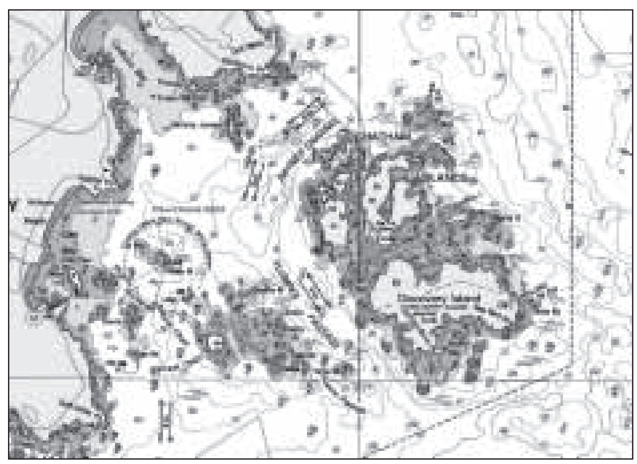
Fog signals are audible aids to navigation that warn of dangers when visual aids are obscured by weather conditions.

Fog signals are normally operated when weather conditions reduce the visibility to less than two nautical miles. While most fog signals are operated manually, or automatically by fog detection equipment, some fog signals may be operated continuously.

The mariner can identify fog signals by their distinctive sound and signal characteristics as detailed in the appropriate List of Lights, Buoys and Fog Signals publication.

7.4 Hydrographic Charts

A chart is a paper representation of your three-dimensional environment. To read a chart, you have to be able to translate the information found on the chart to your actual surroundings, and then you have to be able to identify these surroundings on the chart.

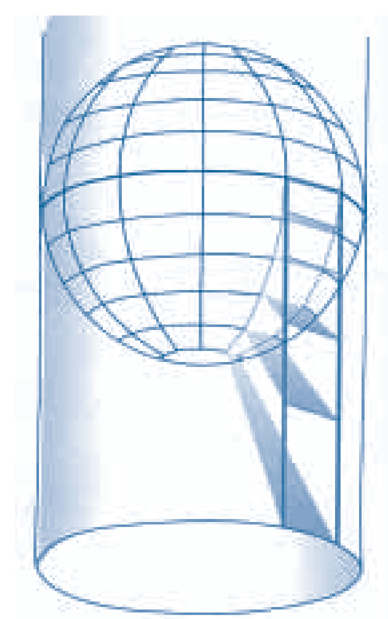


Your chart must be up to date and the correct scale for the area.

Hydrographic charts allow mariners to see graphic representations depicting water areas, including the depths, underwater hazards, traffic routes, aids to navigation and adjacent coastal areas.

Topographical maps are for use on land. Some mariners use topographic maps when there are no hydrographic charts printed for an area. They do not depict the depth of the water areas, underwater hazards, marine traffic routes, or the aids to navigation.

7.4.1 Mercator Projection Chart

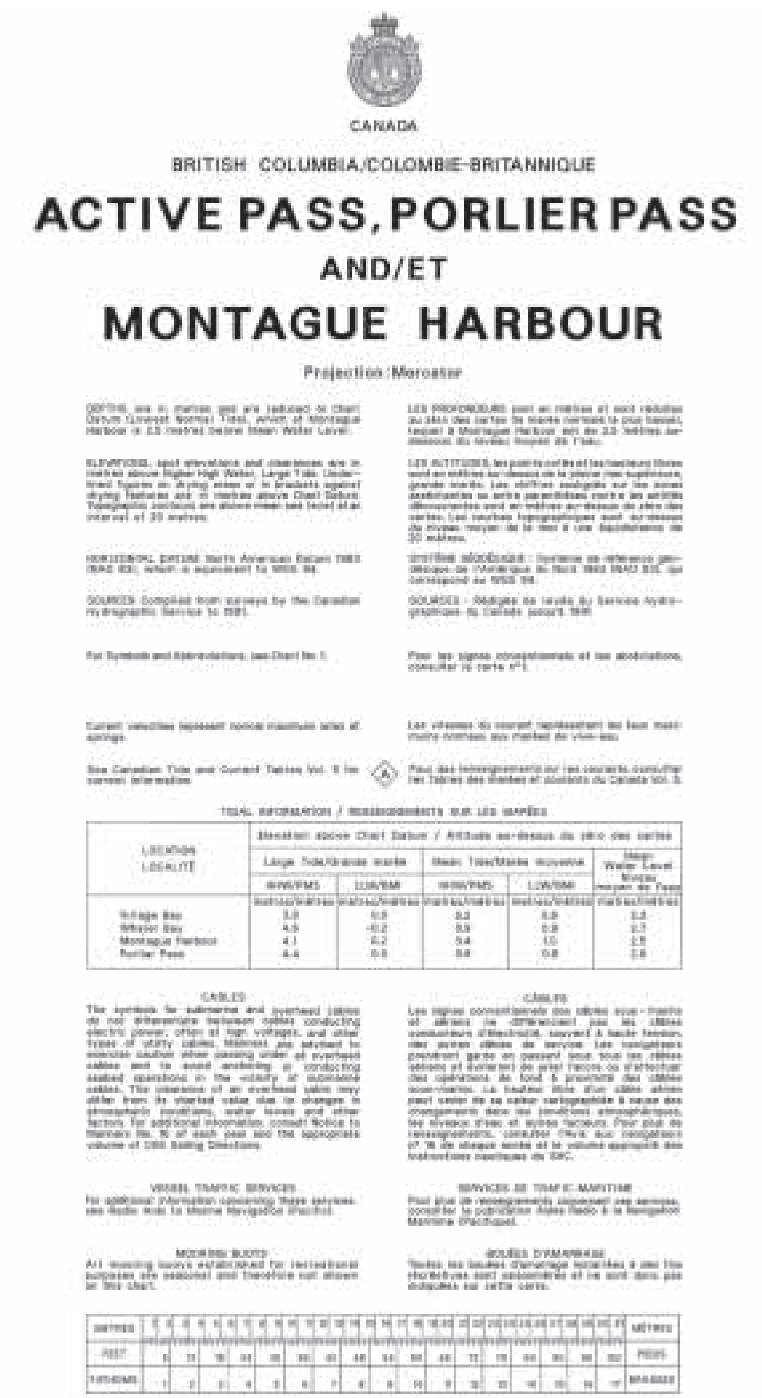


Mercator charts are the most widely used type of charts for marine navigational purposes. Mercator charts stretch the surface of the earth to lie flat on a chart table. This will alter the image so that landmasses that are in the north will appear larger than they really are.

Title Block

The title block includes the projection and scale of the chart, sounding information, and notes and cautions. This data is very important and is provided to ensure the accurate interpretation of the information contained on the chart.

The height above and below objects is taken from a reference water height, or datum. The measurement of depth is indicated by the purple border on Canadian charts are in metres or fathoms. In addition, the most important part of the block is the title itself, which defines the geographical area covered by the chart. The chart's margins indicate a number, which is the identification number provided to that version of the chart.



7.4.4 Chart Symbols

These symbols are just some of the many found on the Canadian Hydrographic Services charts.

- rock awash
- rock which covers and uncovers at drying height
- dangerous underwater rock
- submerged wreck
- current symbols/arrows
- boat ramp
- lifeboat station

7.4.5 Chart Check

Your charts should be of the appropriate scale and up-to-date.

- **Scale:** Use the best scale chart for your area. Small-scale (large area) charts won't necessarily show all the detail needed.
- **Up-to-date:** Make sure your chart is up-to-date. The date of the last update is usually stamped in the chart border. Update information is available from Notices to Mariners and Notices to Shipping. It may be part of your duty to update the charts regularly.

7.4.6 Distances and Positions

Measuring Distances

Distances can be taken from the latitude scale nearest the area measured. This distance will be in nautical miles and cables (tenths of a nautical mile).

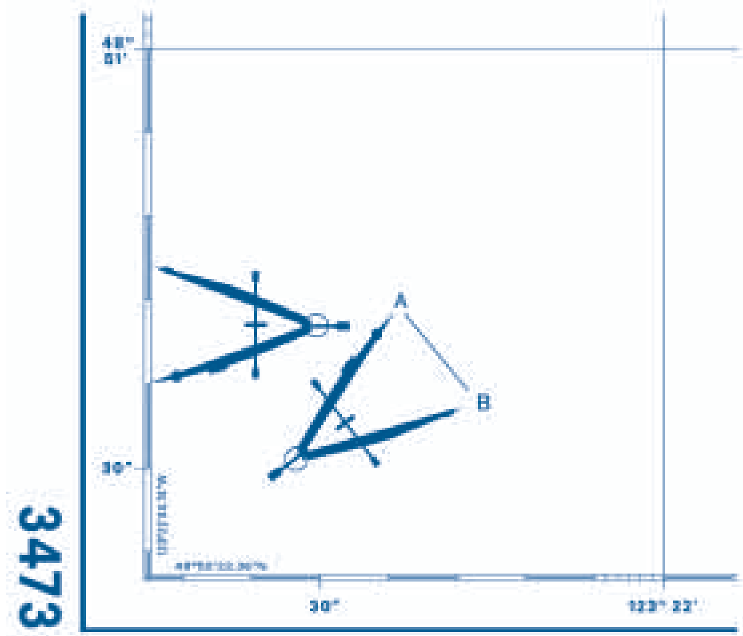
Plotting Your Position

Latitude and Longitude provide us with a co-ordinate system that can pinpoint any position on the globe. By using a set of co-ordinates, we can find that position on a chart simply by lining up the intersection of the latitude and longitude.

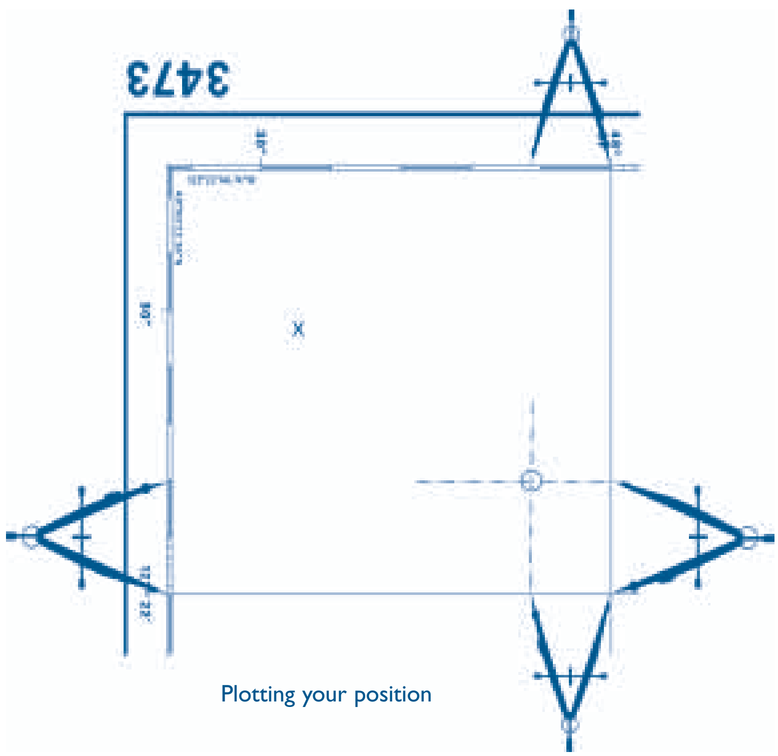
Latitude and Longitude

The latitude scale at the side of the chart divides the earth into even slices cut like potato chips parallel to the Equator, from the middle to the top and bottom. These slices are measured in degrees, minutes and seconds. Because the slices are even, one minute of latitude is also equal to one nautical mile (6080 ft.)

The longitude scale is made up of meridian slices cut like an apple through the center. Each of these lines goes through the poles, cutting the earth in half. These lines are also measured in degrees, minutes and seconds. Since they intersect at the pole, the closer to the pole we get, the closer these lines are together. One degree of longitude is 60 nautical miles wide at the equator, but converge at the North Pole. This is why we only use latitude for measuring distances

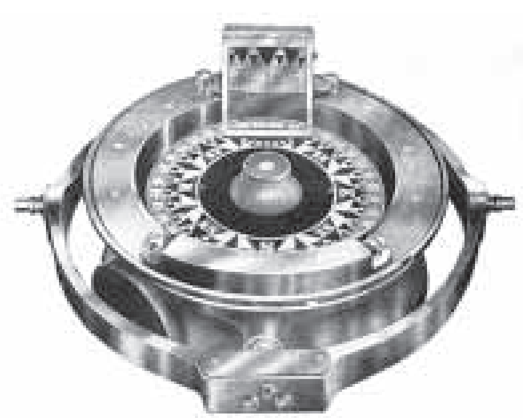


Measuring a distance on latitude



Plotting your position

7.6 The Compass



The compass is an essential tool of navigation. It is not a complex device, but it can confuse an operator, sending a vessel off in the wrong direction. The compass card always points towards magnetic north, thus the boat actually spins around the compass rose as the course is altered.

When you observe your mounted ship's compass from the helm, you should see a lubber's line. The lubber's line is a line marked on the standing part of the compass' clear cover. It shows the direction in which your bow is pointing. The compass course that is directly below the lubber's line is your boat's heading. The compass will only point directly towards magnetic north when there are no other magnetic fields around to misdirect it. Unfortunately, almost all boats have magnetic fields generated by the metal on the boat. This error, called compass deviation, can be measured and applied to the compass heading.

The compass is a magnet. It aligns itself with the natural magnetic field of the earth, pointing towards the north magnetic pole. The magnet is attached to a card that is divided into 360 degrees.

The small boat navigator uses the compass primarily to indicate the direction in which the boat is headed. As for the information gathered by the navigator's senses, it may be used by itself or in conjunction with landmarks or a chart.

On its own, the compass can guide you home at night, or in poor visibility. Some preparation is required though – take note of the course(s) you steered on your way out. Bear in mind though, that your drift and compass deviation may make your return courses different than the reciprocals.

If you're steering on a landmark, make a note of the compass course. If you're still steering on the landmark, but the compass heading changes, you know you're being pushed off course.

When using a chart, a good practice is to lay out the compass courses along your intended route.

Most small boats are equipped with a steering compass. While not primarily designed for taking accurate bearings of objects, the small boat navigator can still get a reasonably accurate bearing by pointing the boat towards an object and noting the compass heading.

True bearing: (North Pole)

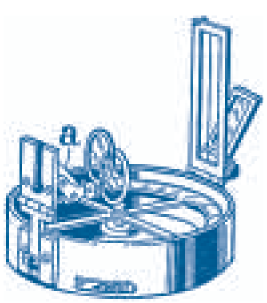
Variation: the difference in degrees between magnetic north and the North Pole

Magnetic: The direction of the magnetic pole

Deviation: The degrees of error that the magnetic fields on your vessel give your compass at different headings.

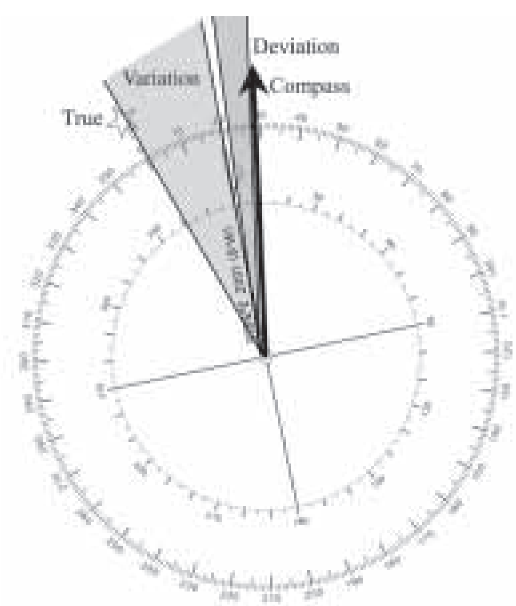
Compass/ships course: The course that you vessel is steering according to your vessels compass

Steering Compass



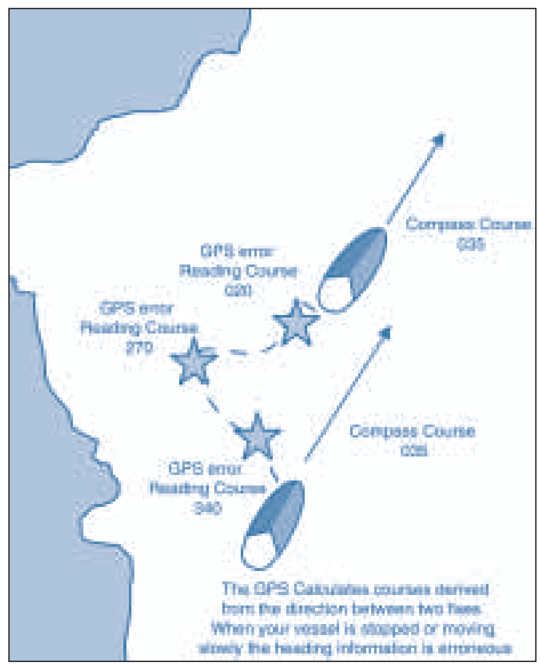
Compass Error

If your compass is a standard magnetic compass then it will try to point in the direction of magnetic north. This is not the same direction as the North Pole (True North). The angular difference between the North Pole and magnetic north is called variation. The other compass error occurs when your vessel's magnetic field pulls the compass in different directions as your vessel swings around the compass card. This error is called deviation.



GPS heading information is often displayed on the navigation screen of your GPS. This readout is derived from the GPS tracking the movement of the vessel from one point to another and calculating the direction from the last co-ordinate to the present position. This has nothing to do with a compass and navigators must remember that anytime other than when the vessel has been moving in a straight line for a while and not affected by wind or current this information will be misleading.

DO NOT use the GPS as a compass



Steering by compass

If you are supposed to be heading in a certain direction, then you must line up the lubber's line with your intended heading on the compass. If your intended heading is North, and North is to the right side of your lubber's line, then you would steer towards the N, or to the right. If your intended heading is a number of degrees, then you would steer toward that number. As the number gets closer, slow your turn. Once you are close, use small helm movements to keep the two lines together. You are now on course.

Choose a landmark

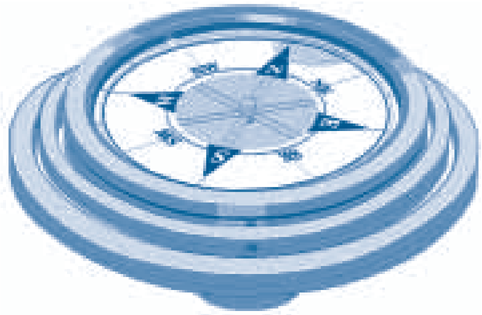
Once you are on course, you can look ahead and select a landmark (mountain or rock) off your bow. Steering on this landmark will be a more accurate way to hold your course. Remember to check the course on the compass regularly. Any change in course towards the landmark will indicate set off of original track.

High-speed compass turns

When moving at speed, the compass can have trouble keeping up with your turns. If the boat turns quickly, the compass can over-swing and mislead you. This can result in your vessel chasing the compass through its swaying motion. To turn while underway, look over the compass card to the general direction of your next intended course, and pick a landmark. Start your turn and steady up on the landmark. Once the compass has recovered from the swing, you can use it to do final course corrections.

Compass Check

Many metals (primarily steel), some live electrical wires, and all magnets will affect the compass, as will a radio or speaker. To avoid errors from false readings, keep them away from the compass. A good rule of thumb is about 1 metre. If you're not sure if the object is affecting the compass, move it around while watching the compass at the same time. If the compass heading changes (assuming of course that the boat isn't also), then the object is too close.

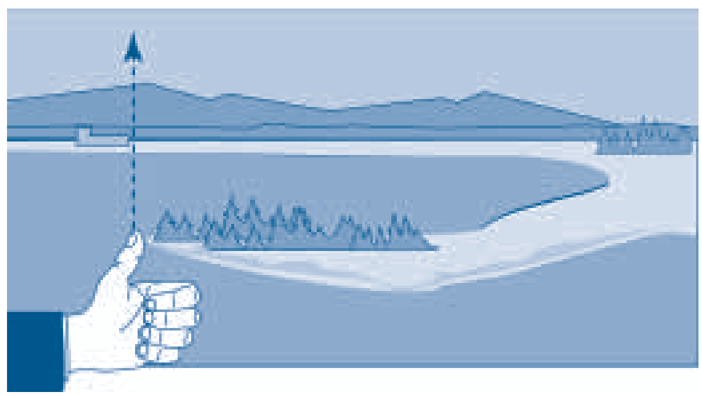


Periodically check your compass against known transits on a variety of headings. Compass error can vary, depending on your heading. Also, check your compass whenever a new piece of metal or electronic gear is added, removed or changed.

Check to make sure the compass bowl is full of liquid. A bubble in the bowl means the compass may need repair.

7.6.2 Using your Eyes and Chart in Pilotage

This chapter cannot begin to provide all the information necessary to becoming a navigator. Any one who is operating a rescue vessel should attend a formal navigation course. However, there are some tips and tricks that may be used to estimate your position relative to landmarks and land masses.



As your vessel progresses, the navigator and/or navigation monitor will be comparing the chart with what can be seen visually and by radar. There is no substitute for a tangible paper chart to get your bearings. By watching landmarks, points, islands and rocks one can make visual lines that can keep you out of trouble and in safe water.

7.7.3 Transit Lines

A line that touches two points is called a transit line. Transits are used to establish many things but the most important are: lines of position, exact bearings, and boundaries or clearing lines. By lining up two objects and keeping your vessel to one side of the line up one can keep the vessel in safe water. This transit is called a clearing line and it sets a boundary to let your vessel clear a danger.

By steering on a transit line one can obtain a true bearing from the chart and compare that with the compass course to determine compass error. While steering on a transit line it is easy to estimate the set of the current (or cross track error) by watching which direction you move off of the transit.

Terms for Current

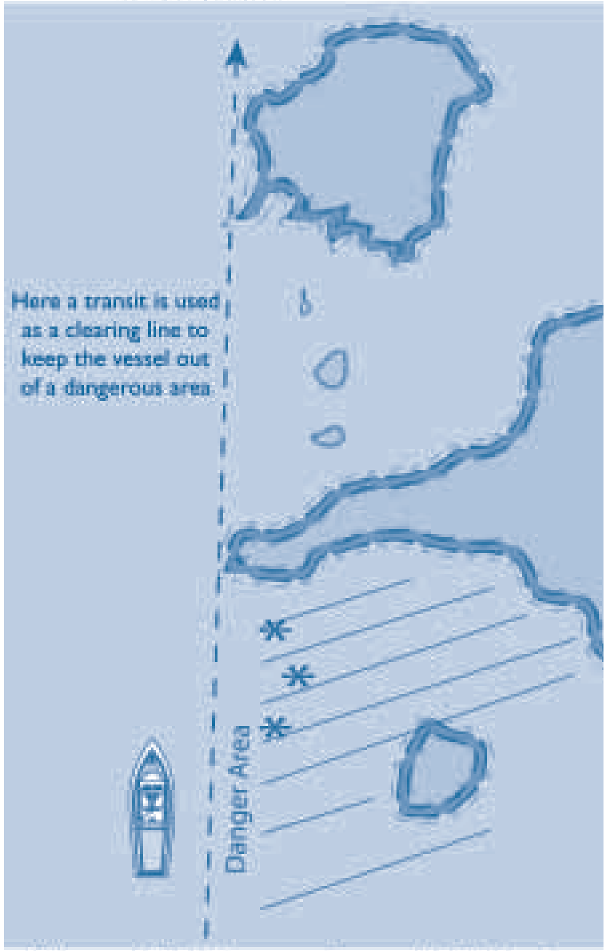
Set: *direction of current flow affecting your vessel.*

Rate: *speed of the current.*

Drift: *distance that you have been pushed off course over a period of time.*

Many metals (primarily steel), some live electrical wires, and all magnets will affect the compass, as will a radio or speaker.

Clearing Line



As long as the island does not disappear behind the point then you are in safe water

By steering on a transit it is possible to estimate set (sideways movement) from current

NOTE: If landmasses on the chart do not appear to match the land around you, then you should notify the coxswain immediately.

7.7 Collision Regulations

This chapter only gives a brief summary of the collision regulations as they pertain to small vessels in Canadian waters. These regulations are comprehensive and many books are devoted solely to explaining and interpreting them. Each Auxiliary crewmember should own a copy of the regs and study them carefully.

The collision regulations are comprised of:

- Steering and sailing rules
- Navigation lights
- Manoeuvring and warning signals
- Fog signals
- Legal responsibilities

7.7.1 Fundamentals of Collision Prevention

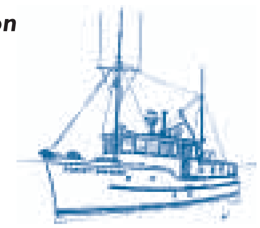
The **"Rules of the Road"** ensure order and safety on the seas. To navigate and ignore them is to put many lives in danger. Every confident and competent mariner must learn them.

The International Regulations for Preventing Collision at Sea define the rules that vessels must follow when they are:

- At risk of collision
- Operating at night
- Displaying lights
- Using distress signals, or
- Operating in conditions of restricted visibility.

All mariners are responsible for having a comprehensive knowledge of the Collision Regulations, and operating their vessels in accordance with these rules.

Some General Definition



Power Driven Vessel: Any vessel propelled by machinery.

Sailing Vessel: Any vessel under sail, provided that propulsion, if fitted, is not in use.

Under Way: Not tied to a dock, aground or at anchor.

Making Way: Moving through the water with machinery engaged.

Two terms are of paramount importance in a crossing situation:

Stand On: The stand on vessel is the vessel that is required by law to maintain course and speed (unless it is apparent that the other vessel has not taken the appropriate action in time to avoid a collision) and is not required to take early and substantial action to keep well clear.

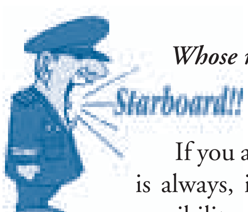
Give Way: The give way vessel shall yield to the stand on vessel by taking early and substantial action, sounding the appropriate signal, and making a readily apparent alteration to course in order to pass well clear.

Responsibility

Rule 2 of the collision regulations states:

Nothing in these Rules shall exonerate any vessel, or the owner, master or crew thereof from the consequences of any neglect to comply with these Rules or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstance of the case.

In construing and complying with these rules, due regard shall be had to all dangers of navigation and collision and to any special circumstances, including the limitations of the vessel involved, which may make a departure from these rules necessary to avoid immediate danger.



Whose responsibility is it to avoid trouble? Yours!!

If you are the operator of a vessel, it is always, in every situation, your responsibility to avoid a collision. When an approaching vessel is required to give way but doesn't you must take action to avoid a collision.

The rules are not there to replace good judgement and practice of good seamanship. You should not put your vessel in any danger by blindly following the rules.

You must consider all factors pertaining to navigation (water depth, wind, traffic, current, and manoeuverability of your vessel etc.) when complying with the Rules.

Two Key Rules of the Road

If everyone followed rules five and six of the Collision Regulations, collisions at sea would be greatly reduced. Always keep a lookout and never go too fast.

Traffic on roads and highways would be chaos without laws to regulate the right of way. On the water, where movement is less restricted, rules of the road are even more important. This is particularly true of crossing situations.

Rule 5 Lookout states:

Every vessel shall at all times maintain a proper lookout by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision.

In other words, you should always have at least one person designated as a lookout when you are on-board. Under no circumstances should your vessel be underway without someone on lookout duty. This rule may seem quite obvious, but, remember, that on a SAR case, everyone on-board may be doing something (looking at charts, taking care of casualties, talking on the radio or cellular phone, etc.) and the lookout position may be overlooked.

All mariners are responsible for having a comprehensive knowledge of the Collision Regulations, and operating their vessels in accordance with these rules.

A lookout is someone who is watching over the path of the vessel and reporting any objects, oddities, land masses or vessels that may present a danger to the vessel or be relevant to the safe navigation of the vessel. Lookouts may use all available means to determine the safety of the navigation path. The lookouts' secondary duty is to identify objects, targets, or details that may prove relevant to the vessel's mission.

Suggested Roles and Responsibilities for Lookout

- ✔ Performs constant visual scans of the vessel's path and reports all objects forward of the beam
- ✔ Routinely looks aft for overtaking vessels
- ✔ Maintains communications with the Helm and Captain/ Coxswain
- ✔ Uses all available means to keep a lookout (hearing, sight, smell, night vision goggles, binoculars)
- ✔ Reports the positions and estimated heading of vessels approaching using a designated sighting system (See commands and signals for lookout)

- ✔ Reports conditions of visibility and changes in weather
- ✔ Protects eyes from wind and spray and sunlight by using appropriate eye wear

Commands and Signals for Lookout

Communications between lookouts, the helm and the Navigation watch are critical for vessel safety. Two way loud and precise messages allow quick exchange of information. The captain should establish a reporting method (see below) before getting underway).

Five ways to call a sighting

Every Vessel shall at all times maintain a proper lookout by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision.

Clock Method – The search vessel is at the centre of a clock face. The bow of the boat is 12 o'clock, with the hour hand pointing at the sighted object. An object at 9 o'clock means the object is abeam to port; an object at 3 o'clock means the object is abeam to starboard.

Degrees of the Compass – The search vessel is at the centre of an imaginary circle, divided into 360 degrees, with the bow at 000°. The spotter will indicate a bearing by calling out the number of degrees that the object is bearing at. 090° means the object is abeam to starboard; 270° means the object is abeam to port.

Colour and Degrees – The search vessel is at the centre of an imaginary circle, in which the centre line of the vessel divides the circle into two equal parts. The port side is designated Red, and the starboard side is green. Each half circle is divided into 180 degrees, with the ship's head being 000°. Reporting would go like this:

Red 090° degrees means the object is abeam to port

Green 090° means the object is abeam to starboard. This method is customary when giving radar bearing.

Points – The vessel is divided in 32 imaginary "points," with 16 points on each side of the vessel. Each point equals 11 and 1/4 degrees, in the same manner as the points of a compass. Thus:

8 points to starboard means the object is abeam starboard;

8 points to port means the object is abeam to port;

4 points on the starboard bow is 45 degrees to starboard.

Hand/Arm Point – This last method is very simple, and suitable for use by even the most novice SAR crew member. The spotter is instructed to call out and point directly at the object until the vessel master sights it.

Rule 6 Safe Speed states:

Every vessel shall at all times proceed at a safe speed so that she can take proper and effective action to avoid collision and be stopped within a distance appropriate to the prevailing circumstances and conditions.

The speed at which you navigate must be adapted to the prevailing circumstances and conditions. For example, a safe speed in plain daylight may not be safe at night or when visibility is restricted by fog. Operators must use good judgement to determine safe speed. In low visibility, it is good practice to be able to stop your vessel in one-half the visibility distance. The rules go on to provide a list of the factors that should be taken into account in determining a safe speed.

- *The state of visibility*
- *The traffic density, including concentrations of fishing vessels or any other vessels*
- *The manoeuvrability of the vessel with special reference to stopping distance…*
- *Turning ability in the prevailing conditions*
- *At night, the presence of background light such as from shore lights*
- *Back scatter of her own lights*
- *The state of wind, sea and current, and the proximity of navigational hazards*
- *The draught in relation to the available depth of water*

In addition to the international rules, some modifications apply in Canadian waters.

Safe speed - Canadian modifications

In the Canadian waters of a roadstead, harbour, river, lake or inland waterway, every vessel passing another vessel at work, including a dredge, tow, grounded vessel or wreck, shall proceed with caution at a speed that will not adversely affect the vessel or work being passed, and shall comply with any relevant instruction or direction contained in any Notice to Mariners or Notice to Shipping.

Where it cannot be determined with certainty that a passing vessel will not adversely affect another vessel or work described in that paragraph, the passing vessel shall *proceed with caution at the minimum speed at which she can be kept on her course.*

Rule 7 Risk of Collision

Every means available must be used to determine if a risk of collision exists. **If in any doubt,** assume the risk exists. If fitted with radar, a systematic plot should be maintained to detect any risk of collision. **Proper use of radar** is required in clear daylight as well as at night.

How do you know when to worry?

If you are watching a vessel approach, and its compass bearing or reference point on your vessel does not appreciably change, then you are at risk of collision. Two vessels that remain on a steady bearing or a bearing that does not change significantly, and decreasing range are at risk of collision. Both vessels should do everything necessary to determine if there is a risk, and then follow the rules to avoid a collision.

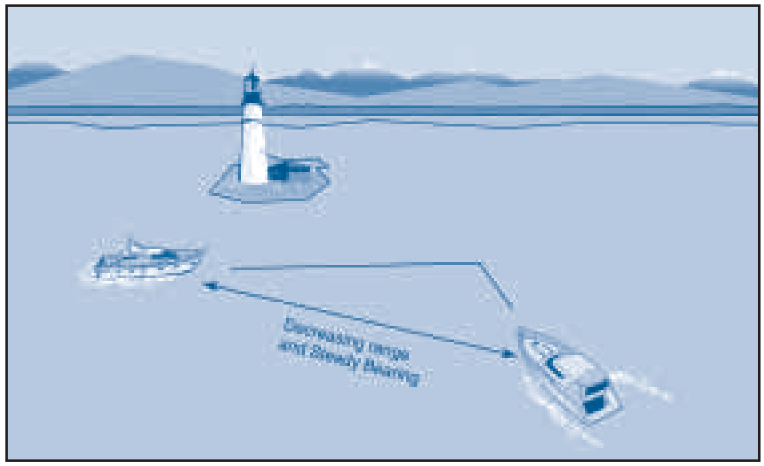
Rule 8 Action to Avoid Collision

- Make positive action in **plenty of time**, well in advance of any potential meeting, in order to give the other vessel time to asses their situation adequately
- Any action taken should be **large,** so that it is immediately apparent to any approaching vessel by sight, as well as by radar
- If you have sufficient sea room, altering course is usually the best action, as long as it does not result in another close quarters situation
- A succession of small alterations of course **should be avoided**
- Pass at a safe distance, and monitor the effect of the action until finally **past and clear**
- **Reduce speed or stop** if more time is needed to assess the situation or to avoid collision
- Have full regard for the actions you are taking
- The stand on vessel must still comply with the rules

7.7.2 Conduct of Vessels in Sight of One Another

Before you leave the dock, the vessel operator must know the basic rules of safe navigation; who has the right of way, and how one should behave in a crossing situation.

Navigation, like vehicle driving has its own set of rules of the "road." The problem is that not *everyone* using the "road" knows the rules. As a SAR crewmember, you may have to manoeuvre at high speed among people that are familiar with the rules



and among people that know nothing about them. Knowing the rules is part of a professional attitude.

You MUST know all the rules presented in the following pages, and there is no magical way to learn them. This is a difficult subject, but always remember that your safety and the safety of other vessels may depend on your knowledge of these rules.

The problem is that not everyone using the "road" knows the rules.

With power vessels, operating when in sight of one another, one vessel has right of way over the other in three situations.

Meeting, Crossing and Overtaking

There are three situations which the regulations deal with directly: meeting head on, crossing each other's paths, and one vessel overtaking and passing another.

"Two vessels that have come to a complete stop cannot collide."
– Brian Sylvester

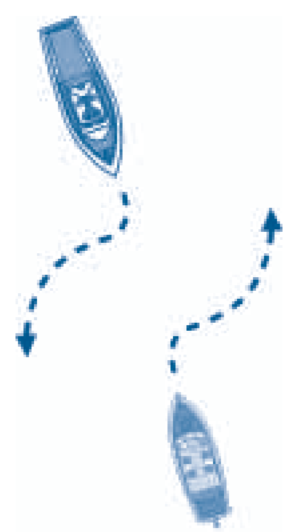
Meeting

Neither boat has the right of way, so each should swing right, then straighten course to pass left side to left side, as vehicles on the road do. Meeting situations would almost never involve risk of collision if all boats adopted this practice.

If you must change your boat's heading to avoid collision, then give one blast on your horn to indicate you are changing course to your starboard, or two blasts to signal that you are changing course to your port.

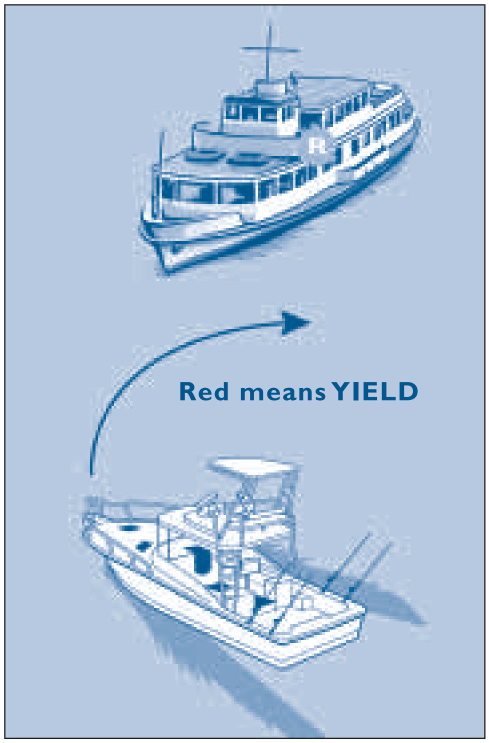
Meeting Head On

When two vessels are meeting in a head on situation, both vessels shall take early and substantial action by sounding one short blast of the horn and altering to starboard. They shall pass port to port and be well clear.

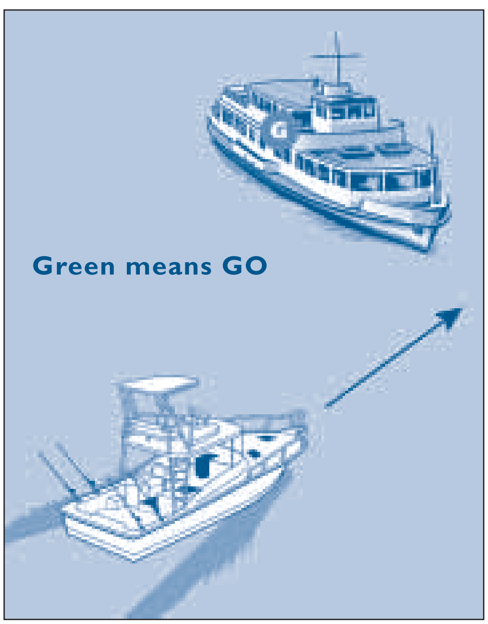


Crossing

When two boats are approaching each other at an angle, they may be in danger of colliding. To help determine whether the two vessels are on a collision course, visually align some vertical part of your boat -a flagstaff or antenna, for example -with any point on the other boat. If this bearing remains the same over a period of time, keeping speed constant, then a danger of collision exists.



A memory aid that may help is:
Green means Go and Red means Yield



When two power-driven vessels are crossing, the vessel that has the other on her starboard side shall give way in a manner that is consistent with the practice of good seamanship (don't try to outrun the boat and cross their bows). A helpful memory aid that is appropriately used in normal situations is: if you are looking at his red sidelight, then give way. If you are looking at his green light, then you are the stand on vessel (Red means Stop and Green means Go). This is only true if the give way vessel takes action.

Overtaking

The boat being overtaken always has the right of way. Both should use the proper manoeuvring and warning signals. Pass safely, the passing boat must be clear ahead of the other vessel before the passing situation is ended.

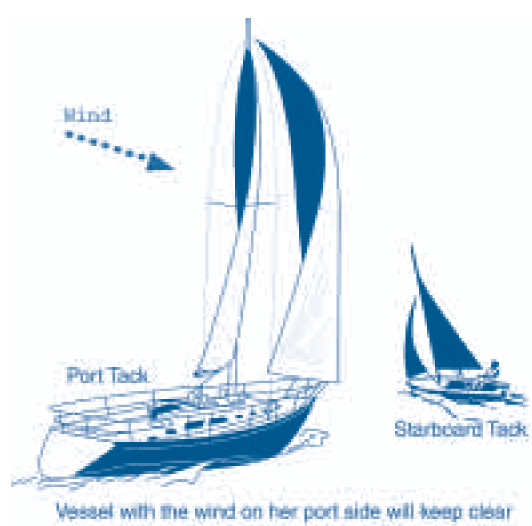
Actual rules for crossing situations can be found in Section **II** of the Collision Regulation booklet.

The vessel travelling at high speed requires increased stopping distance if the operator has to stop in an emergency and requires that the operator be more attentive because the operator has less time to react to changing conditions. If any vessel meets a vessel not under command, that vessel must give way.

Sailing Vessels

Sailing vessels have special rules regarding right of way when they encounter other sailboats. They determine right of way by the wind direction and tack. A sailboat is said to be on a starboard tack when the wind is coming from the starboard side and pushing the sail out over the port side.

Sailing Vessels Approaching While on Opposite Tacks



When two sailboats are approaching on different tacks, the boat on a starboard tack (wind on the starboard side) shall be the stand on vessel, and the sailboat sailing with the wind crossing the port side, a port tack, shall take early and substantial action to keep well clear.

Sailing Vessels on the Same Tack

When two sailing vessels are approaching while on the same tack, the vessel that is to windward (up wind; opposite to the side where the mainsail is carried) shall keep clear of the vessel to leeward.

When the sailing vessel on a port tack is not sure of the tack of another sailboat, she shall assume that the other vessel is on a starboard tack and take early and substantial action to keep well clear.

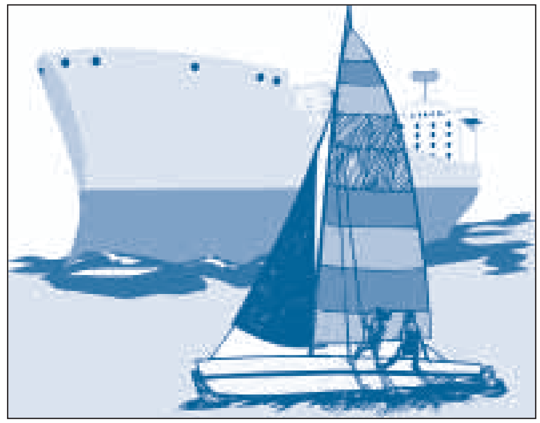
7.7.3 Narrow Channels and Traffic Separation Schemes

Except when overtaking, small boats not under power and sailboats under sail have the right of way over power-driven vessels. If a power driven vessel comes across a canoe or a sailing vessel, then the power-driven vessel should take early and substantial action to keep well clear. If a sailboat has its motor engaged, then they become a power-driven vessel and should be treated as such.

All vessels, including those operating for special purposes, are ranked with respect to right of way:

Rule 9 Narrow Channels

When travelling in a narrow channel or fairway, one should navigate as close to the starboard-hand side of the channel as practical. IA vessel traffic lane (marked purple on a chart) should be crossed as if crossing a channel. Cross at right angles, not at long shallow angles. Small sailing vessels shall not impede larger vessels in a narrow channel or fairway. This keeps small vessels out of the way of big ships and traffic. If in a narrow channel or traffic lane, you must give way to larger vessels that cannot manoeuvre easily in that area. It is the small vessel's responsibility to keep clear, and not impede the passage of large vessels in narrow channels or traffic lanes.



Keep right and keep clear.

Rule 10 - Traffic Separation Schemes

- All vessels are still required to follow the other rules in the collision regulations
- Generally keep to the starboard side, and clear of the separation zone. If you must join or depart the scheme, use as small an angle to the direction of flow as is possible
- Avoid crossing the traffic lanes, except at right angles to the general flow
- Avoid any conduct that may impede a power driven vessel using a traffic separation lane, such as sailing, anchoring or fishing in a Traffic Separation Scheme
- Vessels that are required to work in traffic zones, (i.e., buoy tenders, etc.), are exempt while carrying out their operations, but are required to participate in the MCTS Vessel Traffic Services

Responsibilities Between Vessels

Definitions

- **Vessel** - anything on the water capable of being used for transportation
- **Power driven vessel** - a vessel propelled by machinery
- **Sailing vessel** - a vessel being propelled solely by sail
- **Vessel engaged in fishing** - while the fishing gear is in use, the vessel is hampered by her gear

- **Seaplane** - any aircraft designed to operate on the water
- **Vessel not under command** - a vessel that is unable to manoeuvre due to some exceptional circumstance such as engine or steering failure
- **Vessel restricted in ability to manoeuvre** - a vessel that is unable to manoeuvre due to the nature of her work, such as having divers down or having an awkward tow
- **Vessel constrained by her draught** - a vessel with too much draught to deviate from the channel she is following

Rule 18 General Pecking Order

The vessel at the bottom of the pecking order shall give way to all the vessels above when in sight of another vessel.

Note:
An Auxiliary vessel that is towing is not usually considered restricted in her ability and therefore is considered a power driven vessel.

- Not Under Command (NUC)
- Vessels Restricted in Their Ability to Manoeuvre (RAM)
- Vessels engaged in fishing
- Sailing vessels
- Power driven vessels

The vessel lower on the list must stay clear.

7.7.4 Navigation lights for Small Vessel

Things can get confusing on the water at night or when fog, mist, rain or snow restricts visibility. To ensure safe vessel operation, a system of lights and sound signals has been established to enable vessels to communicate their actions and intentions.

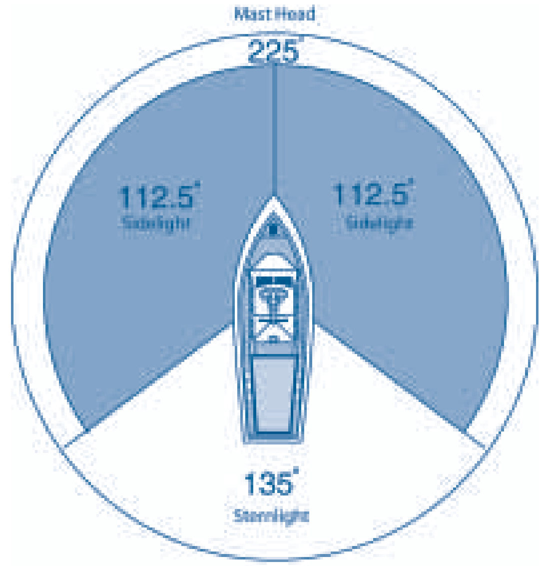
Every vessel must possess the correct lights and sound signalling equipment

Every vessel must possess the correct lights and sound signalling equipment. Collision Regulations require that vessels be able to identify themselves, indicate their manoeuvres, and their activities engaged in.

Vessels must be equipped with the proper lights. All vessels underway shall, from sunset to sunrise, exhibit sidelights and a sternlight as described in the Collision Regulations, rules 20 and 23.

The required lights and arcs of visibility for power-driven vessels are:

Masthead Light (WHITE)	225°
Port Light (RED)	112.5°
Starboard Light (GREEN)	112.5°
Stern Light (WHITE)	135°
All Round Light/Anchor Light (WHITE)	360°
Towing Light (YELLOW)	135°



Sailing Vessels

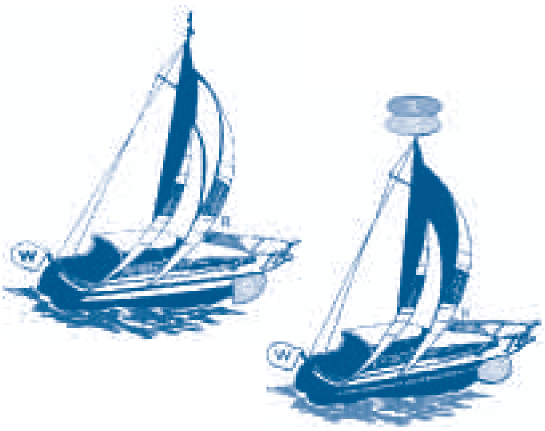
Rule 25 - Sailing Vessels Underway and Vessels Under Oars

A sailing vessel underway exhibits:

✔ sidelights
✔ sternlight

If the sailing vessel is under 20m (65 ft) the sidelights and sternlights may be combined into a single tri-coloured lantern carried at the top of the mast where it can best be seen.
Optional: two all round lights in a vertical line, the upper being red and the lower being green (these two all round lights cannot be used in conjunction with the combination tri-lantern)

Options for sailing vessels



Sailing vessels less than 20m long can display a combined red, green and white lantern (sidelights and sternlight).

Less than 20m
optional configuration

Small sailing vessels less than 7m long have a fourth option for navigation lights while underway.

Vessel under oars may exhibit:

- ✔ sidelights
- ✔ sternlight; if not, a flashlight or lantern showing a white light

There are two options for a vessel under oars to exhibit navigation lights while underway.

Power Driven Vessels

Rule 23 - Power Driven Vessels Underway

When **underway** a power driven vessel shall exhibit a masthead light, sidelights and a sternlight.

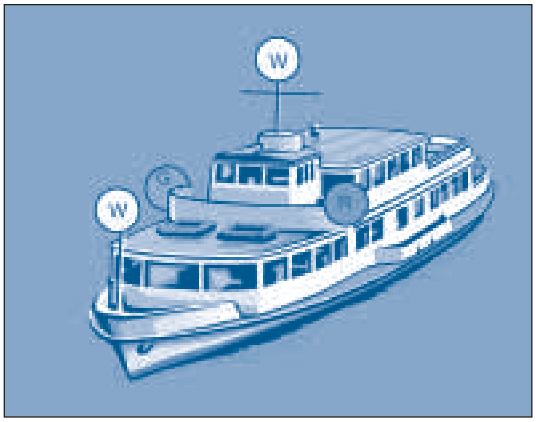
- If over 50m (164') a second masthead, light abaft and above the first masthead light, is required.
- A vessel under 50m does not require a second masthead light but may exhibit one.
- Hovercraft require an all round flashing yellow light as well as lights for a power driven vessel when operating in the non-displacement mode.
- If the vessel is under 12m, it may exhibit an all round white light in lieu of a masthead light and sternlight.
- If the vessel is less than 7m, and the maximum speed is less than 7 knots, it may exhibit an all round white light in lieu of masthead, side and stern lights. If it is practical, sidelights also will be exhibited.

Power-driven vessels that are less than 20m long have the following navigation light options when underway.

12 - 20m optional configuration

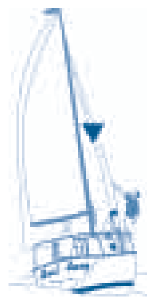
Power-driven vessels that are less than 12m in length have a third option while underway

Less than 12m



Power driven vessel over 50m underway

7.7.5 Day Shapes Basic

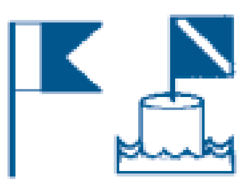


Sailing vessels proceeding under sail, and also being propelled by machinery, must exhibit a cone shape (apex downward), by day. At night, and during periods of restricted visibility, these vessels are required to exhibit the lights indicated for power-driven vessels of a similar length

A vessel under 50 metres while at anchor must exhibit a black ball in the rigging where most visible.

Signals for Diving

All vessels engaged in diving must display the blue and white Code Flag "A." A red and white flag carried on a buoy is used to mark areas where diving is in progress. If you see either flag, keep well clear of the vessel and diving site, and move at a slow speed. Power driven vessels are required by the collision regulations to take early and substantial action to keep well clear of vessels engaged in underwater operations.



Radar Reflector

Vessels under 20m in length, and all non-metal craft are not easily detected on radar. Such vessels must be equipped with a radar reflector when operating in an area frequented by shipping. Reflectors should be mounted at least 4m above the water.

Vessels that are less than 20 metres in length or which are constructed primarily of non-metallic materials shall be equipped with a passive radar reflector as described in the *Collision Regulations,* rule 40:

- Mounted or suspended at a height of not less than 4 metres above the water, if practicable
- Unless in limited traffic conditions, daylight, and favourable environmental conditions and where compliance is not essential for the safety of the vessel
- Unless the small size of the vessel or his/her operation away from radar navigation makes compliance impracticable

Navigation Lights for Larger Vessels

Not Under Command (NUC)

Rule 27 - Vessels not Under Command

At night:

✔ two all round red lights in a vertical line

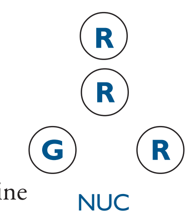
If making way:

✔ sidelights

✔ sternlight

During the day:

✔ two black balls in a vertical line



Vessel restricted in ability to manoeuvre

At night:

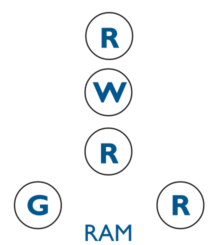
✔ Three all round lights, the highest and lowest being red, and the middle being white

If making way:

✔ masthead light(s)

✔ sidelights

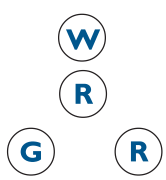
✔ sternlight



During the day:

- ✔ three shapes in a vertical line, the highest and lowest being black balls, and the middle being a black diamond.

A vessel towing that is severely restricted in her ability to deviate from her course exhibits towing lights and shapes as well as the above.



Fishing vessel

Vessels Engaged in Fishing

When engaged in fishing other than trawling:

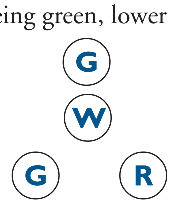
- ✔ two all round lights, the upper being red the lower being white,

When making way fishing vessels shall also exhibit:

- ✔ sidelights
- ✔ sternlights

Trawling – when engaged in trawling and underway:

- ✔ two all round lights, upper being green, lower white
- ✔ masthead light(s)
- ✔ sidelights
- ✔ sternlights
- ✔ Anchor lights, if at anchor.



Trawling

Towing Vessels

If the length of the tow is less than 200m (measured from the stern of the towing vessel to the stern of the last vessel or object being towed):

- ✔ two masthead lights in a vertical line
- ✔ sidelights
- ✔ sternlight
- ✔ towing light above the sternlight

If the length of the tow exceeds 200m:

- ✔ three masthead lights in a vertical line
- ✔ sidelights
- ✔ sternlight
- ✔ yellow 135° towing light above the sternlight

From astern

Pushing or Towing Alongside

If the vessel is engaged in pushing ahead or towing alongside, and the two **are rigidly connected:**

- ✔ masthead light(s)
- ✔ sidelights
- ✔ sternlight (i.e. same lights as a power driven vessel)

If the vessel is engaged in pushing ahead or towing alongside **and not rigidly connected**:

- ✔ two masthead lights in a vertical line
- ✔ sidelights
- ✔ sternlight

The vessel or object being towed shall exhibit:

- ✔ sidelights
- ✔ sternlight

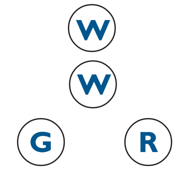
Towed object

A number of vessels towed alongside or pushed as a group shall be lighted as one vessel:

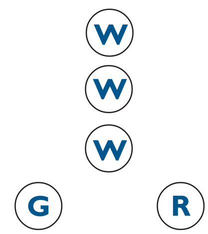
- ✔ not part of a composite unit pushed ahead - sidelights
- ✔ towed alongside - sidelights
- ✔ sternlight

If the length of the tow exceeds 200m:

- ✔ If the tow is inconspicuous or partly submerged (difficult to see)
- ✔ If less than 25m (82 ft) in breadth - two all round white lights, one forward and one aft
- ✔ If more than 25m (82 ft) in breadth
- ✔ four all round white lights, to mark its length and breadth



Tow < 200m



Tow > 200m

Note:
Trolling vessels are not considered vessels engaged in fishing with regards to the collision regs.

- ✔ More than 100m (328 ft) long additional all round white lights so that the distance between lights never exceeds 100m (328 ft)

During the Day

- ✔ A black diamond shape where it can best be seen
- ✔ A black diamond shape at or near the aftermost extremity

If it is impracticable to show the proper lights and shapes, all measures are to be taken to indicate its presence.

Note:
A yellow 135° towing light is used above the stern light only when the tug is towing something behind it.

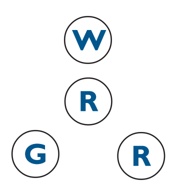
Note: The towing lights are not required if the towing vessel does not normally tow, is engaged in towing another vessel in distress, or in need of assistance.

Any light to attract the attention of another vessel shall be such that it cannot be mistaken for any aid to navigation

All possible measures are to be taken to indicate the relationship between the towing vessel and the vessel being assisted. A searchlight may be used to illuminate the tow or towline

Pilot Vessels

Rule 29 - Pilot Vessels



Pilot vessel

When underway:

- ✔ sidelights
- ✔ sternlight
- ✔ two all round lights in a vertical line, the upper being white and the lower being red

When anchored:

- ✔ anchor lights
- ✔ two all-round lights in a vertical line, the upper being white and the lower being red

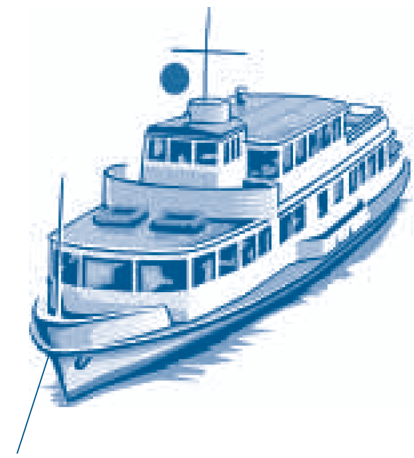
If the pilot vessel is not engaged in pilotage duties, she will only display the lights and shapes for a power driven vessel of her size.

Vessels at Anchor

Rule 30 - Anchored vessels and Vessels Aground

A vessel at anchor shall exhibit:

- ✔ in the fore part an all-round white light at night
- ✔ a black ball
- ✔ at or near the stern an all-round white light, lower than the forward light



If the vessel is less than 50m in length:

- ✔ an all-round white light where it can best be seen

A vessel aground shall exhibit:

- ✔ in the fore part an all round white light at night
- ✔ at or near the stern an all round white light lower than the forward light, where they can best be seen
- ✔ two all-round red lights
- ✔ three black balls in a vertical line (during daylight hours)

Seaplanes

Rule 30: Seaplanes, while on the water, are considered to be vessels so should exhibit lights and shapes as closely similar to those laid down for vessels.

Special Lights

Signals to attract attention

If necessary to attract the attention of another vessel, any vessel may make light or sound signals that cannot be mistaken for any signal authorised elsewhere in these Rules, or may direct the beam of her searchlight in the direction of the danger, in such a way as not to embarrass any vessel. Any light to attract the attention of another vessel shall be such that it cannot be mistaken for any aid to navigation. For the purpose of this Rule the use of high intensity intermittent or revolving lights, such as strobe lights, shall be avoided.

Special Flashing

"Special flashing light" means a yellow light flashing at regular intervals at a frequency of 50 to 70 flashes per minute, placed as far forward and as nearly as practicable on the fore and aft centreline of a vessel and showing an unbroken light over an arc of the horizon of not less than 180 degrees nor more than 225 degrees and so fixed as to show the light from right ahead to abeam and not more than 22.5 degrees abaft the beam on either side of the vessel.

Flashing

"Flashing light" means a light flashing at regular intervals at a frequency of 120 flashes or more per minute.

Blue Flashing

"Blue flashing light" means a blue all-round light flashing at regular intervals at a frequency of 50 to 70 flashes per minute.

A "government ship" means a ship or vessel that is owned by and in the service of Her Majesty in right of Canada or of a province and any ship that is owned or operated by a federal, provincial, harbour, river, county or municipal police force.

Any **government ship** may exhibit as an identification signal a blue flashing light where it:

- Is providing assistance in any waters to any vessel or other craft, aircraft or person that is threatened by grave and imminent danger and requires immediate assistance, or
- Is engaged in law enforcement duties in Canadian waters.

White Flashing

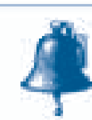
Manoeuvring and warning signals by flashing light

7.7.6 Sound Signals

Sound Signalling Equipment

The Collision Regulations (Rule 33) requires that vessels of 12 or more metres in length be provided with a whistle and a bell, which conform to the specifications detailed in Annex III of the regulations. Vessels in excess of 100 metres in length shall also be provided with a gong, the tone and sound of which cannot be confused with that of the bell.

Vessels less than 12 metres in length shall not be obliged to carry the sound signalling appliance outlined above, but must carry some other means of making an efficient sound signal.

Legend of Sound Signals		
Whistle	Any sound signalling appliance capable of producing loud blasts as specified in Annex III of the Collision Regulations.	
Short Blast	A blast of approximately one second's duration.	
Prolonged Blast	A blast of approximately four to six second's duration.	
Rapid Ringing of Bell	Ringing the bell rapidly for approximately 5 seconds in the forward part of the vessel.	
Rapid Sounding of Gong	Banging the gong rapidly for approximately 5 seconds in the aft part of the vessel.	

The Signals Defined The Collision Regulations define sound-signalling terms as follows:

Manoeuvring and Warning Signals

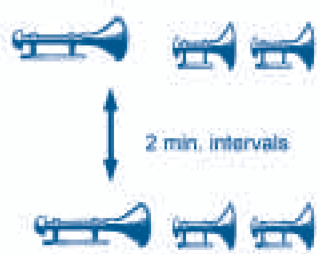
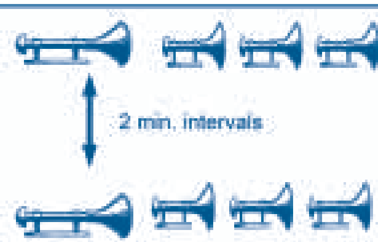
Rule No.	Vessel or Situation	Signal Required
34a	Power-driven vessels in sight of one another: ***"I am altering course to starboard."***	
34a	Power-driven vessels in sight of one another: ***"I am altering course to port."***	
34a	Power-driven vessels in sight of one another: ***"I am operating astern propulsion."***	
34c	When vessels are in sight of one another in a channel or fairway, a vessel intending to overtake another: ***"I intend to overtake you on your starboard side."***	
34c	When vessels are in sight of one another in a channel or fairway, a vessel intending to overtake another: ***"I intend to overtake you on your port side."***	
34c	When vessels are in sight of one another in a channel or fairway, the vessel about to be overtaken shall indicate agreement with the following whistle signal:	

Manoeuvring and Warning Signals
(continued)

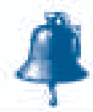
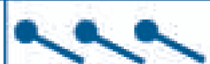
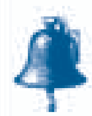
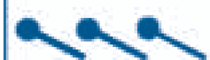
Rule No.	Vessel or Situation	Signal Required
34d	Vessels in sight of one another are approaching each other, and from any cause either vessel fails to understand the intentions or actions of the other, or is in doubt as to whether sufficient action is being taken by the other to avoid collision, the vessel in doubt shall make the following whistle signal:	
34e	A vessel nearing a bend or area of a channel or fairway where other vessels may be obscured by an obstruction, shall sound the following signal:	
34e	A vessel nearing a bend or area of a channel or fairway where other vessels may be obscured by an obstruction, shall upon hearing a prolonged blast, answer with the following signal:	

Restricted Visibility Signals

In or near an area of restricted visibility, whether by day or night, the signals outlined below shall be used as follows:

Rule No.	Vessel or Situation	Signal Required
35a	A power-driven vessel making way through the water.	
35b	A power-driven vessel underway, but stopped and making no way through the water.	
35c	A vessel not under command; a vessel restricted in her ability to manoeuvre; a vessel strained by her draught; a sailing vessel; a vessel engaged in fishing; a vessel engaged in towing or pushing another vessel; or a vessel restricted in her ability to manoeuvre while carrying out her work.	
35e	A vessel being towed, or the last vessel of a tow, if manned.	

Restricted Visibility Signals
(continued)

Rule No.	Vessel or Situation	Signal Required
35g	A vessel of under 100 metres in length at anchor.	 1 min. intervals
35g	A vessel greater than 100 metres in length at anchor.	 Forward  1 min. intervals
35g	Vessels at anchor may also choose to use an additional warning signal.	
35h	A vessel aground.	  Three (3) distinct strokes on the bell; rapid ringing of the bell, followed by three (3) distinct strokes on the bell.  1 min. intervals
35h	A vessel aground may also choose to utilize the optional whistle signal.	
35i	A vessel of less than 12 metres in length that has run aground shall not be required to issue the above signals, but if she does not, shall make some other efficient sound signal.	 2 min. intervals
35j	Pilot vessel – optional in addition to 35(a), (b) or (g).	

7.8 Electronic Navigation

Electronic Navigation embodies the basic traditional navigation methods used by the ancient mariners – the principle of "Fix-to-Fix" with a few modern twists.

Essentially, electronic navigation uses three basic tools, although any single one can provide some information.

The three basic components are:

- (D)GPS – (Differential) Global Positioning System
- RADAR – Radio Detection and Ranging
- Gyro or Fluxgate Compass

Supplementary information is also provided by electronic charts, depth sounders, thermal sensors and other technological wizardry. No single piece of equipment can replace a good watchkeeper; and extreme caution must be used when employing any electronic aids. Even now, in the 21st century, there is no replacement for an alert watchkeeper with good eyes and reliable chart.

7.8.1 Radar

RADAR is an acronym for **RA**dio **D**etection **A**nd **R**anging.

When at sea it is essential to know your position in relation to near by land and to other vessels in the vicinity. Your radar will give you this information rapidly and in any sort of visibility. Your radar is a navigational aid enabling you to fix your position by means of reflected radar signals from recognisable features such as headlands, harbour entrances and buoys.

Your radar is also an anti-collision aid enabling you to determine the range and relative bearing of other vessels in the vicinity, both in good and bad visibility.

How Radar Works

Radar, as designed for marine navigation applications, is pulse modulated. Pulse-modulated radar is used to determine the distance to a target by measuring the time required for an extremely short burst or pulse of radio-frequency energy to travel to the target and return to its source as a reflected echo. Directional antennas are used for transmitting the pulse and receiving the reflected echo, thereby allowing determination of the direction of the target echo from the source.

Radio-frequency energy travels at the speed of light, therefore, the time required for a pulse to travel to the target and return to its source is a measure of the distance to the target. Since the radio-frequency energy makes a round trip, only half the time of travel determines the distance to the target. The round trip time is accounted for in the calibration of the radar.

It should be obvious that in measuring the time of travel of a radar pulse or signal from one ship to a target ship, the measurement must be of an extremely short time interval. For this reason, the MICROSECOND (μsec.) unit of time is used in radar applications. The microsecond is one-millionth part of one second, i.e., there are 1,000,000 micro-seconds in one second of time.

The radio-frequency energy transmitted by pulse-modulated radars consists of a series of equally spaced pulses, frequently having durations of about one microsecond or less, separated by very short but relatively long periods during which no energy is transmitted. The terms PULSE-MODULATED RADAR and PULSE MODULATION are derived from this method of transmission of radio-frequency energy.

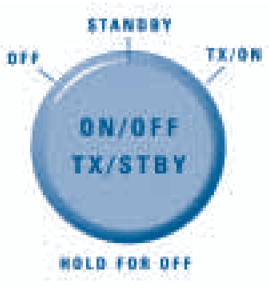
If the distance to a target is to be determined by measuring the time required for one pulse to travel to the target and return as a reflected echo, it is necessary that this cycle be completed before the next pulse is transmitted. This is the reason why the transmitted pulses must be separated by relatively long non-transmitting time periods. Otherwise, transmission would occur during reception of the reflected echo of the preceding pulse.

Because radar is a technological aid to navigation, it's important to remember that:

- Equipment can fail;
- Operators can make mistakes; and
- Environmental conditions or improper handling can affect equipment performance.

Key Concept:
*The small vessel radar regularly provides scanty information; at high speed there are only two navigational aids that you can trust on your vessel. These are your **EYES** and your **CHART!***

Radar Operating Controls



Power Switch

This switch has the OFF, STANDBY, and Transmit (TX/ON) positions.

At the OFF position there is no power supplied to the radar and the radar cannot be operated.

In the STANDBY position, the radar is in a state of immediate readiness and can be brought into use whenever required. In the ON or TX position waves are being transmitted and any echoes from targets that are received are amplified and displayed on your screen. If the switch is turned directly from the OFF to OPERATE positions, there is a warm-up period of about three minutes before the radar set is in full operation.

Brilliance Control

Also called INTENSITY or BRIGHTNESS and is similar to the brightness control on the television set. It varies the background illumination against which amplified echoes appear on the screen, but does not affect the degree of amplification. The brilliance control is adjusted to make the trace of the rotating sweep visible but not too bright.

Gain Control

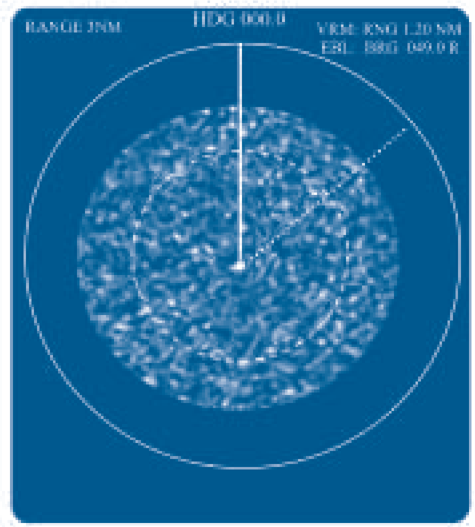
The gain control is the same as a volume control. The gain control varies the amplification of the radar receiver and thus the strengths of the echoes as they appear on the screen. The gain control is adjusted until a speckled background appears on the display. With too little gain, weak echoes may not be detected; with excessive gain, strong echoes may not be detected because of the poor contrast between echoes and the background of the display. When adjusting the gain, the radar should be set on one of the longer-range scales (6 NM) because the speckled background is more apparent. Generally the gain should not be re-adjusted throughout the other range scales.

Rain Clutter Control

Rain, hail and snow all return echoes on the radar as a blurred or cluttered area. The rain clutter control shortens the echoes on the display, reducing clutter. When used, the rain clutter control has an effect over part of the display and generally tends to reduce the receiver sensitivity and, thus, the strengths of the echoes as seen on the display.

Sea Clutter Control

Sea return or unwanted echoes that are received from waves may clutter the display, especially at short ranges. The sea clutter control is used to suppress sea clutter out to a limited distance from the vessel. Its purpose is to enable the detection of close targets which otherwise might be obscured by sea clutter.



Rain can cloud your screen

This control must be used carefully along with the receiver gain control. Generally, one should not attempt to eliminate all sea clutter. Otherwise, echoes from small close targets may be suppressed also. Normally the sea clutter should be placed at the minimum setting or off in calm seas.

Tuning Control

If the radar does not have an automatic tuning control to keep it tuned for optimum performance, the manual tuning control must be adjusted to obtain the best reception of echoes. The tuning control enables the receiver to be tuned to the same frequency as the transmitter. The tuning should be checked periodically to insure that the radar is operating properly. The radar may be tuned by adjusting the tuning control for maximum return on the echoes from the vessels wake. When sea clutter is used for manual tuning adjustment all anti-clutter controls should be off. Tuning may need adjustment with a change of range scale.

Pulse Length (Range)

The longer the pulse length, the greater the range capability of the radar because of the greater amount of energy transmitted. At shorter-range scales, a shorter pulse length provides better target resolution. Generally, long pulse for long range and short pulse for short range. However, short pulse can be used to separate targets that blend together.

Relative Motion Display

Most small vessel radars provide relative motion displays in which your own vessel is always at the centre of the display and the motion of the contact is *relative* to your own vessel. What this means is that in order to determine the direction and speed of the target, you must consider your own position in relation to that target. On relative motion display, fixed objects such as land masses move at a rate equal to and in a direction opposite to the motion of your own vessel. The relative motion display can either be heading-up or in North-up.

Heading-up

Where your own vessel's heading is always at the top of the screen. The contacts are displayed at bearings relative to your own vessel's bow. In this mode the Radar operator has no idea which objects are moving and which are stationary. It is very easy to become disoriented when operating the Radar in this mode at slow speeds and variable courses (such as during a shoreline search at night).

In North-up

The picture is gyro or flux gate stabilised and north is always at the top of the screen, the heading line wanders according to your own vessel's heading, and contacts are displayed relative to north or magnetic north.

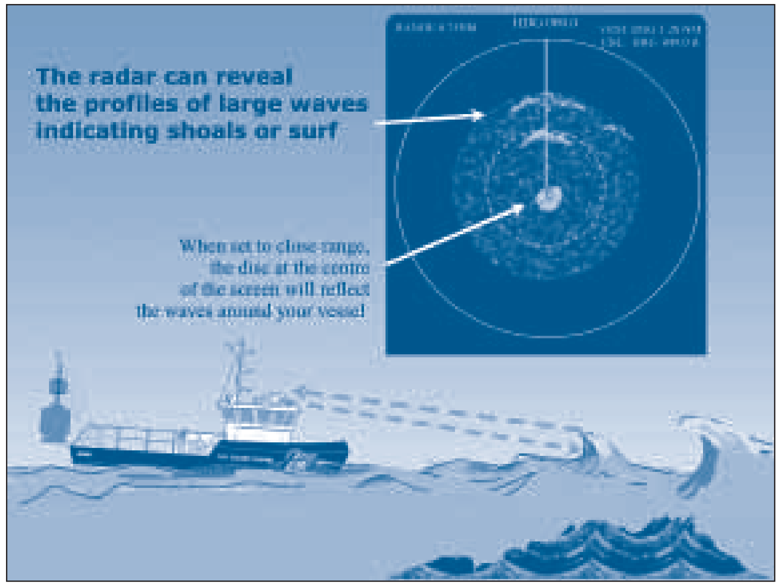
The heading-up display is most suitable for collision avoidance in crowded coastal areas or narrow channels. The North-up display is often preferred on the high seas, and simplifies plotting because target bearings appear in degrees true. The north-up mode requires that the radar unit be connected to a gyrocompass or a fluxgate compass.

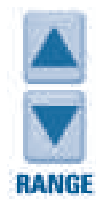
Range Scale

The likelihood that a radar unit will detect a target depends as much on the size, shape, material, height and angle of the target as it does on the range of the radar. Ranges beyond 15 miles are of limited use on small vessels except for coastwise navigation. The use of a high range scale makes the picture of the more important close-range areas smaller, and makes targets in that area much smaller and less likely to be noticed. Important changes in close range targets are obscured when larger scales are used.

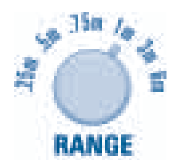
Most small vessels use a 6 to 12 mile radar range when running in the open and a smaller range as the circumstances may dictate. For manoeuvring close to targets, the range is usually reduced to the smallest range that will show the area of interest. A good rule of thumb is to keep objects of interest in the outer 1/3 of the display.

In the open sea, however, care should be taken not to neglect the longer distance ranges in conditions of reduced visibility, when another vessel could get dangerously close without being noticed if short ranges are used exclusively. The radar should not remain on a set range scale. The range scale should be increased to give advance warning and detection of long-range targets and reduced to a smaller scale to monitor close in targets.





Control Type 1: Both up and down arrow buttons with range below them



Control Type 2 curved numbers around button

WARNING

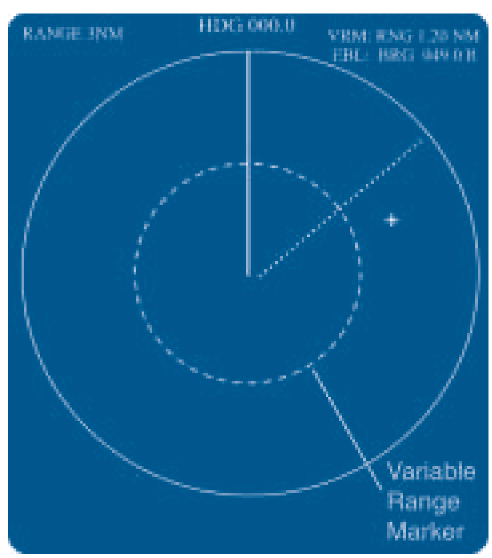
The navigator should not rely solely on radar or GPS information, and should never make assumptions based on scanty radar information.

Navigators must be able to navigate without the help of electronic navigational aids.

Variable Range Marker

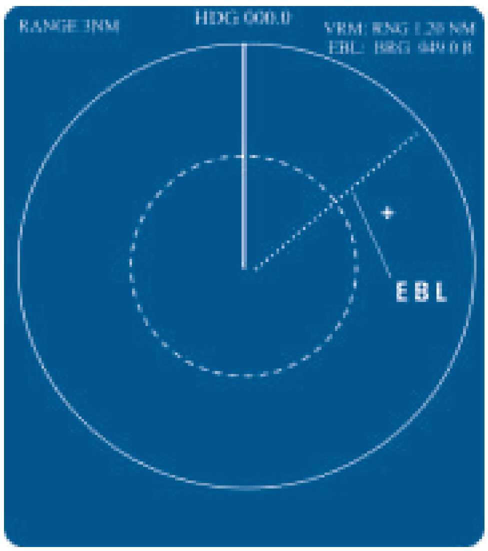
The Variable Range Marker (VRM) is used to measure the range to a target. Generally there are two ways of measuring range; fixed range rings which appear on the display and the variable range marker, which can be moved inward or outward so that it touches the leading edge of a target and indicate its range on a digital readout.

The radar should not remain on a set range scale



Electronic Bearing Line (EBL)

The bearing cursor or electronic bearing line (EBL) is used to measure the bearing of a target. The EBL is a movable straight line that pivots around the centre point of the screen, which can be placed over the image of a detected object. The display will then digitally read out the relative bearing from the vessel to the object. There are two ways of measuring bearings, a mechanical cursor and electronic bearing line.



Collision Avoidance

The moment an echo appears on the screen, its range and relative bearing should be measured and its range and true or magnetic bearing noted. A risk of collision can be ascertained by careful watching the true or magnetic bearing of an approaching vessel. If the bearing does not appreciably change such risk should be deemed to exist. You should then act in accordance with the Regulations for Preventing Collisions at Sea. If using a relative bearing, ensure that you are on a constant heading.

The target has a steady bearing and a decreasing range. The Electronic Bearing Line or EBL is used to track the target's advance.

Constant Bearing/Decreasing Range

A basic method of collision avoidance is the use of the radar cursor or EBL to give an early warning of collision. When a target appears on the screen, rotate the EBL to put the line directly on top of the pip. If the target stays on this line as it gets closer, you're on a collision course. This is known as constant bearing/decreasing range. If you already have the cursor on one target and another appears, you can note the bearing on the ring around the radar screen, or, if the target is in sight, you can take a visual sight and observe whether the angle between your vessel and the target changes or remains constant. If the angle remains constant as range decreases, you're on a collision course. For example, if you see lights in line with the bow chock and they stay right there as they get brighter, you know you've got a problem.

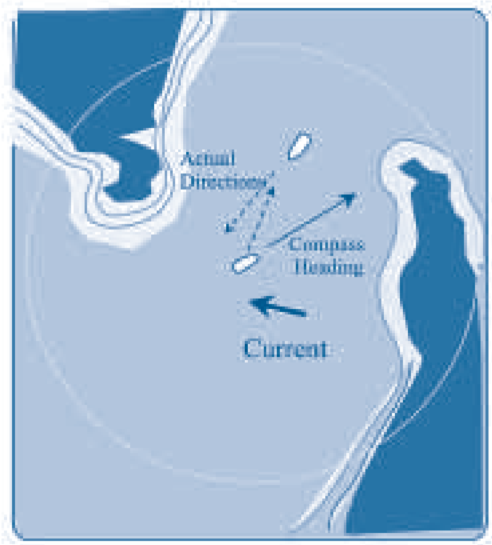
Radar Safety

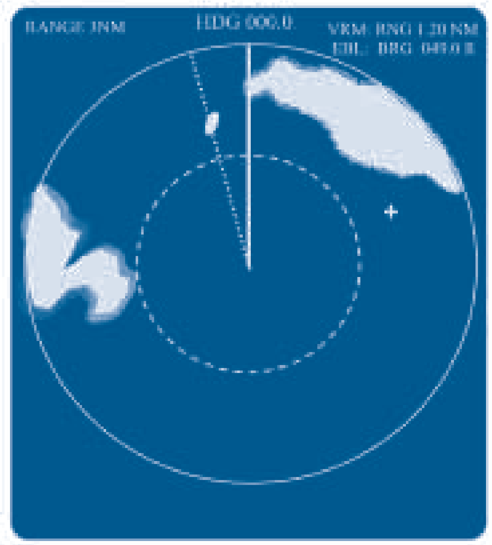
Radars can cause harm if you are not cautious and follow some basic safety guidelines

- Radar must be installed according to the manufacturer's instructions.
- Antennas rotating: **stay clear of transmitting radar**. The microwaves being transmitted are the same ones that cook your food in a microwave oven. In open boats stay below the rotating antennae level.
- When servicing you can de-activate the radar from the display and make sure that no one transmits while your are working on it by activating the lock out switching and post signs on the set, if possible.
- Electromagnetic energy may cause harmful radiation.
- When operating in close quarters with other vessels, or coming alongside a vessel, ensure that the Radar is in Standby and not transmitting.

How Things Look on Radar

The radar only receives signals from objects that reflect microwaves. The picture that you see on the screen is only a representation of a reflected waves direction and the distance to where it was reflected. There are many things in the world that do not reflect microwaves very well.



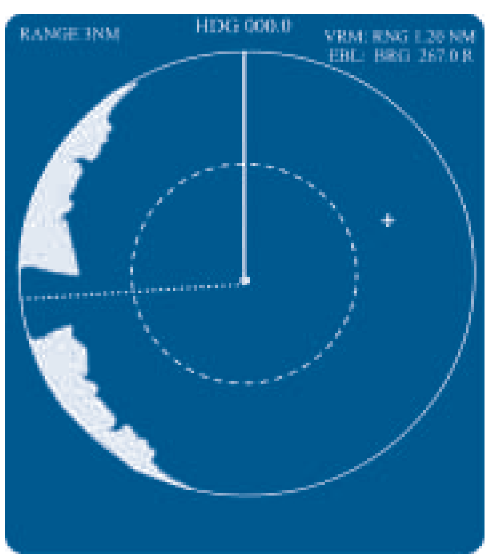


This drawing shows how a vessel can be pointing in a direction away from you, yet still presents a risk of collision. The radar will help you determine this.

Small vessels are particularly susceptible to blind spots because of lower energy radars and low height antennae

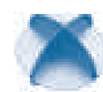
Bad Reflectors

- Trees or vegetation
- Low beaches
- Low smooth rocks
- Non metal vessels (Fibreglass, Inflatable boats etc.)
- Metal vessels that have shallow angled house works (look like stealth bombers)



Low valleys or wet lands can appear as channels or inlets. A common mistake is for navigators to be expecting to see an opening and turn when the radar screen looks like this (this is actually a beach with a valley behind it).

Good Reflectors



- Tall steel ships
- Rocky cliffs
- Flat sided fishing vessels
- Square flat surfaces at right angles to the antennae (Radar Reflectors)
- Wave crests breaking at close range

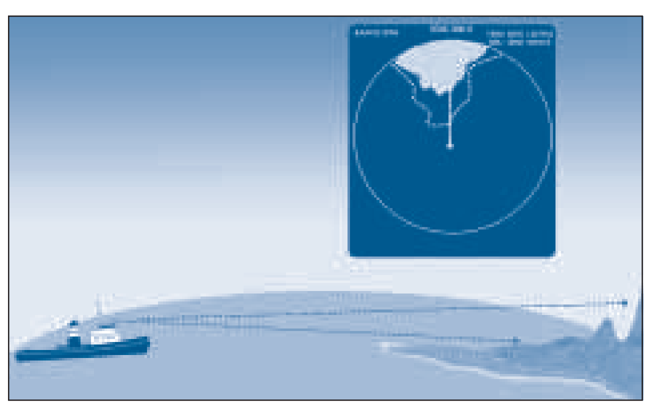
The Radar will deceive you!

Sea returns:

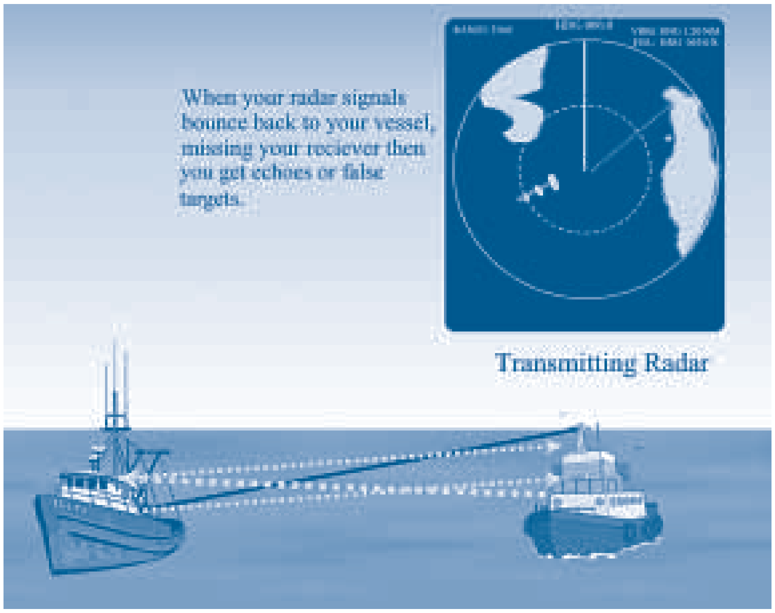
In heavy weather, irregularities in the water surface may appear as a dense background of clutter forming the shape of an almost solid disc right in the centre of the display. This disc can obscure targets that are close in.

Precipitation Returns

Echoes from rain, snow, etc. appear as countless small echoes continuously changing in size, intensity and position. These returns can also appear as large hazy areas, depending on intensity of storm cell.



The dotted line indicates the land not seen by radar



False targets

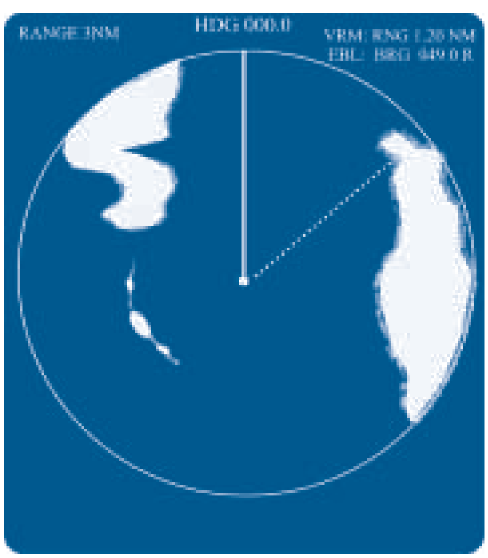
Blind sectors, shadow effect:

Your radar can be obscured and subsequently blinded in areas of return. This means that because of your vessel design and antennae size there are areas on your radar display that will not show a vessel even when one is there. Small vessels are particularly susceptible to blind spots because of lower energy radars and low height antennae. When objects on your vessel are in the direct path of the antennae then you can get a ghost image. This is a large contact that follows you at a constant distance and matching speed.

Reflected Images and Ghosts

Whenever radar waves behave badly, (reflect from somewhere other than the real target), you will see contacts on your display that are not there or you will see nothing where there is something. An object can appear on you display in two different places.

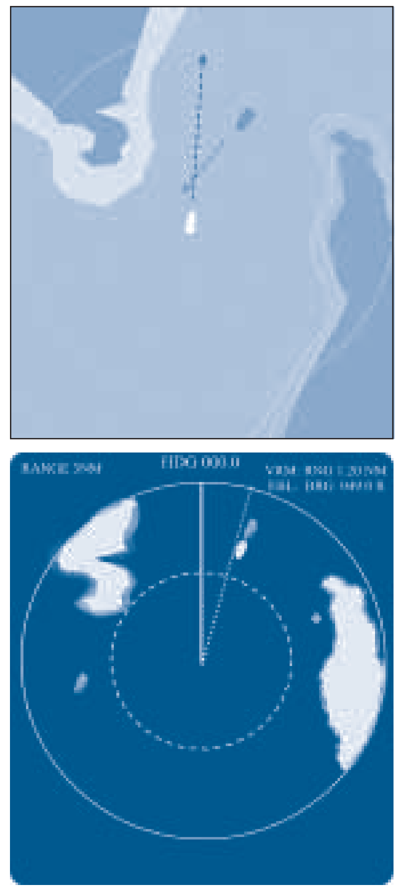
Never use your radar as the sole information source for navigation.



Side Lobe Error. This is caused by the beams side lobes reflecting off the target at short range.

Ghost images:

- Similar in appearance to real echoes, but intermittent and poorly defined, with a tendency to smear.
- Sometimes caused by targets nearby with wide smooth surfaces.
- Retain a fixed relationship with true images.



Ghost images appear in the area away from the actual target.

False echoes:

May appear when a large target is at short range, or when a reflecting surface is nearby.

Radar line of sight:

Because of the curvature of the earth the height of your radar antennae dictates how far it can detect small objects. Line of sight limits search for distant objects. The taller the object stands up from the water the farther your antennae can detect it.
Example: In standard conditions, with 6 feet height of antenna, water level objects such as; logs, rocks, liferafts, etc. have a radar horizon of 3.01 NM a 300 foot cliff has a radar horizon of 21.3 NM.

Radar Antenna Sweep Delay:

Most small craft radar antennae turn fairly slowly, and refresh the display only about once per second. When a vessel is moving slowly on a calm sea, this is not a problem. Refresh delay, or latency, becomes a problem at speeds above 20 knots. The table below summarises the distance travelled per antenna rotation.

The display may appear to look OK but the reality is that you are hurtling along blind except during the sweep of the antennae. If you imagine driving on the highway in heavy rain, the only time that you can see clearly is just after the windshield wipers go by. Normally you would turn up the speed of your wipers, thus fixing the problem. Also when you shorten the time between sweeps on your radar you increase the range; looking farther ahead gives you more warning to avoid oncoming vessels. Yet the disadvantages are at long range the objects close to you are obscured. If you decrease your range then you wait longer between sweeps. This is not safe if you are travelling at 28 metres per second. Imagine driving at 100 Km/h in heavy rain and having your wipers on low speed. The solution for your vessel is to slow down. And you should secure other means of fixing your position and spotting hazards ahead.

Radar Summary

Radar is a useful tool when used to assist a small craft navigator to detect some objects in the area of operations. The radar only shows you objects that reflect and there are many objects out there that do not reflect but will still damage your boat. Use your **EYES** and your **CHART**. Never use your radar as the sole information source for navigation.

7.8.2 Global Positioning System (GPS)

Excerpts taken from *GPS Instant Navigation* by Kevin Monahan and Don Douglas

The Global Positioning System (GPS) is a worldwide 24-hour navigation positioning system operated by the US Department of Defence. It consists of a Ground Control Segment, a Space Segment, and User Equipment Segment. The User Equipment Segment is what is commonly known as a GPS receiver.

How GPS Works

24 earth-orbiting satellites in six different orbits form the Space Segment (there are also 3 or 4 operational spares in orbit at any one time). Each satellite circles 10,900 nautical miles above the earth in orbits inclined at an angle of 55 degrees to the equator. Each satellite transmits precision timed signals (derived from onboard atomic clocks) on two frequencies, L1 and L2. A separate channel on each frequency is dedicated to each satellite.

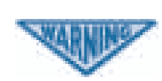
The civilian GPS can resolve positions to approximately the same level of accuracy as the military system (within 20 metres). The difference is that the civilian service is subject to Selective Deniability, whereas the military system is not. The single largest contributor to GPS error is interference with the broadcast signals caused by the ionosphere (a shell of electrically charged particles that surrounds the earth).

Never rely solely on a navigational aid!

Each satellite also broadcasts "Almanac" and "Ephemeris" messages. Your earthbound GPS receiver uses the almanac to determine which satellites are above the horizon and what channels they are broadcasting on. The receiver then locks on to the most appropriate satellites for fixing a position. Given the exact time the navigation message was broadcast, and knowing the time it was received, the GPS receiver determines the amount of time it takes for the coded signal to travel from the satellite to your antenna. From there, it is a simple computation to determine the actual distance between the satellite and your GPS antenna. From this point, the GPS receiver calculates a position in the same way as a human navigator using radar ranges.

The single largest contributor to GPS error is interference with the broadcast signals caused by the ionosphere

The ephemeris message tells the receiver the exact location of the satellite when the message was broadcast, and since the receiver now knows the distance to the satellite, it calculates that it must be on the surface of an imaginary sphere, centred on the satellite. Where that sphere intersects with the surface of the earth, a Circle Of Position (COP) is formed.



The high levels of GPS accuracy should not be cause to reduce your vigilance in navigation or your margin of error.

From two satellites, the receiver calculates two COPs, which cross at two possible positions. To determine which position is the correct one, a third satellite range is needed. Thus, for a receiver at sea level, a minimum of three satellites is needed to determine a two-dimensional position. For aircraft, and vehicles on land, which operate above sea level, a fourth satellite is needed to determine a three-dimensional position (including altitude).

Satellite timing signals are subject to small errors, so each orbiting satellite is closely monitored from five sites around the world (The Ground Control Segment). The main control facility at Falcon Air Force Base, Colorado, makes minor adjustments to keep the system within its prescribed limits of accuracy (20 metres.)

GPS Accuracy

Since the inception of the system, GPS has become the driving force behind an enormous civilian economy. In 1996, US President Bill Clinton recognised this fact and directed the United States Department of Defence to develop other methods of ensuring national security—Selective Deniability. The result of this new technology is that *civilian users of the Global Positioning System can now expect their receivers to provide positioning accurate to within 20 metres* (instead of the 100 metre accuracy available prior to May 1, 2000).

In a practical sense, it is now possible to determine your position anywhere in the world within the length of a medium sized boat. The accuracy of GPS far exceeds even the theoretical repeatable accuracy of Loran C.

As a result, your GPS may be more accurate than your nautical chart—especially if the chart edition is more than 20 years old. Chart errors now comprise the signal greatest source of error (except for human error) in the navigational equation. However, other possible sources of error may be present as well, such as:

- Inherent chart inaccuracies
- Mistakes in transferring positions from the chart
- Temporary periods of degraded GPS performance due to ionospheric activity, electrical interference and other shipboard causes
- Sudden GPS failure
- Mistakes in entering co-ordinates into the GPS receiver/navigator

The arrangement of the satellites in the sky, as seen from the GPS receiver, can also have a significant effect on GPS accuracy. The ideal arrangement of satellites is to have one overhead and three more equally spaced around the horizon, but high enough in the sky not to be affected by atmospheric interference. Any other arrangement results in a horizontal dilution of position (HDOP), which further degrades GPS accuracy beyond the basic 20 metres. However, there are generally 6 or more satellites visible at any one time and since modern GPS receivers monitor up to 12 satellites simultaneously, HDOP effects are rarely critical.

Other factors, such as the vessel's own metal masts and rigging, large structures, and high mountains can also interfere with signal reception, degrading GPS accuracy.

Chart Datum

Cartographers and Hydrographers use precisely defined "datums" to determine the geographic co-ordinates of positions on the surface of the earth. With the advent of satellite positioning systems and satellite assisted surveying techniques, cartographers discovered that the assumptions they made regarding the shape of the earth were no longer valid. Consequently, the latitude and longitude grids on the maps they drew were offset from their true locations so a new worldwide datum system was developed. This is known as WGS84 (the North American version is NAD83). The result is that positions of geographic features taken from older charts (drawn to an earlier datum – NAD27) cannot be reconciled with their positions on charts drawn to NAD83.

Most GPS receivers can calculate the difference between the two datums and thus compensate for the datum shift. **But you must make sure that your GPS receiver is set to the datum of the chart you are using;** otherwise errors of up to 200 metres (in Canada) can be introduced into your position fix.

Since electronic charts are normally corrected to WGS84 (or its equivalent – NAD83), you should make sure that your GPS receiver is set to fix positions in one of those datums when using electronic charts.

Many Canadian charts are still drawn to NAD27, so check the datum of each chart when you intend to use it with GPS positioning. The information you need can be found in a paragraph named "Horizontal Datum," located in the title block of the chart.

Differential GPS (DGPS)

It stands to reason that if you have surveyed your position with great accuracy, using some other means than GPS, then you can compare it to the GPS position of the same location, and discover the amount of error in the GPS position. This is the function of a DGPS reference station. The error information is then broadcast over separate radio frequencies to DGPS receivers at sea. A built-in computer in the DGPS receiver uses the corrections to enhance the accuracy of the GPS fix. The result is accuracy in the order of two to ten metres, depending on your distance from the reference station.

This differential process eliminates the errors that are the same at both locations, such as selective availability and atmospheric effects. The greater the distance between the ship and the reference station, however, the greater the likelihood that atmospheric effects will be different at the two locations. Therefore, high order DGPS accuracy is limited to areas that are within a few tens of kilometres of a reference station. In the near vicinity of a reference station, residual errors may be as little as two metres. But as you move further from the reference station, the accuracy diminishes and errors get steadily larger.

When GPS Fails

Failures of GPS can be roughly classified into the following categories:

Total failure

The GPS receiver/Navigator display either dies completely or freezes up. This could be due to a power failure, corrupted software, faulty antenna connections, or failure of some component in the onboard equipment. It could also be due to the failure of one or more satellites.

Partial failure

The most dangerous failure is when the receiver/Navigator continues to operate but gives erroneous information. This could be due to overloaded memory, corrupted software, faulty antenna connections, improper antenna placement, or external or onboard interference.

Human error

Usually due to improper data entry, the receiver/Navigator operates on the wrong instructions and provides information that is not appropriate for the situation.

A total failure of the equipment is easiest to detect, but when the display is out of sight and the unit is providing data to another navigation instrument, you must continuously verify that the data source (the GPS receiver) is functioning properly.

Old Data

If your set is equipped with an "old data" alarm, stay alert for the alarm indication. An "old data" warning appears whenever the receiver loses contact with the satellite signals. This indication may not be audible, so make sure you can recognise it immediately, because the display will freeze at the moment the GPS signals were lost. An "old data" alarm is the surest way to determine if you have suffered a complete GPS failure.

The most likely cause of lost signals is a faulty antenna connection, so as soon as the indication appears, check the connection. Look for cracked insulation or pinched antenna wires. And finally, check the antenna itself. Small cracks in the covering can allow water to penetrate to the wire-wound core and corrode the fine wires inside.

An old data warning may appear when you carry a hand-held unit inside the cabin of a boat where it cannot sense any satellite signals. The warning may even appear when a large amount of rigging obstructs the satellite signals or when you are moored close alongside large steel buildings or a high cliff. Whatever the cause, the best solution is to place the GPS where it has an unobstructed view of the sky—hold it up in the air if you must. If you determine the cause is tall buildings or cliffs, there is not much you can do except wait a little and hope that, as the satellites move through the sky, enough satellites will become visible for the receiver to calculate a fix again.

DGPS is earth-based, and the correction broadcasts are subject to being blocked by high mountains and by atmospheric interference

An "old data" alarm is the surest way to determine if you have suffered a complete GPS failure.

Using your GPS

As a crewmember you may be using the GPS to monitor the vessel's progress or even to guide the vessel along an intended track. The GPS is a remarkable navigation aid and it has taken much of the mystery out of fixing your position. Yet in a coastal environment the GPS system error can vary and this error combined with operator error can easily place your vessel in the wrong spot. The GPS may indicate that you are in safe water while in reality; you are heading into the rocks.

WARNING

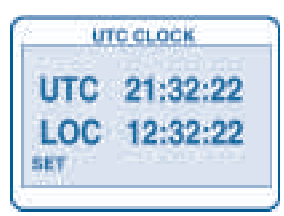
GPS receivers are subject to errors and therefore positions should not be solely based on one source of information. When underway do not fall into the trap of following the GPS arrows, look up and use your eyes, your chart, and the radar to constantly monitor the progress of your vessel.

This section outlines some of the features that most GPS receivers have in common. Generic menus are used as examples for the different features so that a new user can read this section then practice using the functions on their own GPS.

GPS receivers come in different shapes and sizes and recently many companies are making inexpensive portable models that can be used on land or sea. Every make and model is different, therefore the only way to become a skilled GPS user is to spend a few hours with the owner's manual and the machine itself pushing buttons and practicing the menu routines.

Initialize the Receiver

Each receiver has a specific set up routine outlined in the owners manual. These steps should be followed carefully for mistakes in the set-up can induce errors in the system.

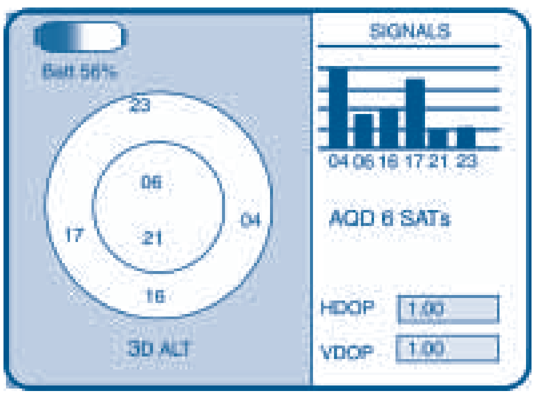


When the GPS is new or has been moved more than 500 miles since its last use it will need time to initialize. It may prompt you to enter an approximate position and a country code. You may be asked to enter the time and your time zone. The GPS system relies on the science of measuring small amounts of time difference so it is a good idea to ensure that the clocks are set correctly.

During initialization the receiver is gathering ephemeris (schedule) information from the satellites and storing that information in the memory for the next time you use it. The next start up will acquire a position much faster from now on.

The Satellite Page

This page gives you an idea of what satellites are acquired and how strong the signals from them are. The receiver requires three strong signals for a two dimensional position and four signals for a three dimensional position. The circles represent the altitude (angular height from the horizon) of each satellite. The middle of circle is higher and the outside of the circle is lower on the horizon. There will be some measure of position accuracy on this screen. This will indicate the quality of the position information based on a few factors. Satellites can become masked (obstructed) or lose their signal strength, and the receiver may not have strong enough signals or geometry to maintain an accurate position.



Six satellites have been acquired

Position Errors

HDOP

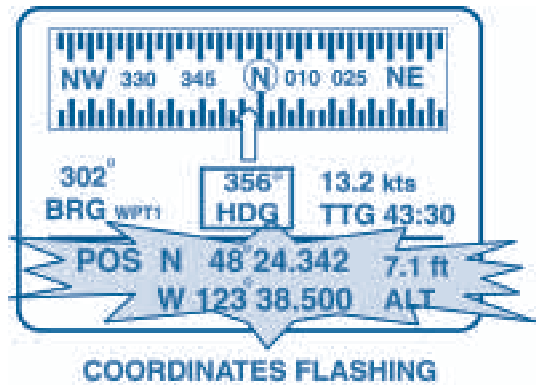
Horizontal Dilution of Position or HDOP is a measure of the quality of geometry. Signal geometry is good if you have satellites that are received from high and low altitudes. If the satellites are grouped too close together then your position accuracy becomes diluted, and HDOP goes up. Ideal reception occurs at an HDOP of 1.0 that's three satellites at 120° and one directly overhead. Questionable positions are at anything over 3.0 and when HDOP reaches over 5.0 the receiver will alert the user that the position is unreliable.

Geometric Quality (GQ) and Estimated Position Error (EPE)

These are two other measures of position accuracy found in many receivers and they usually will indicate the position accuracy within a range of metres.

If a GPS is getting bad data then it will do one of two things:

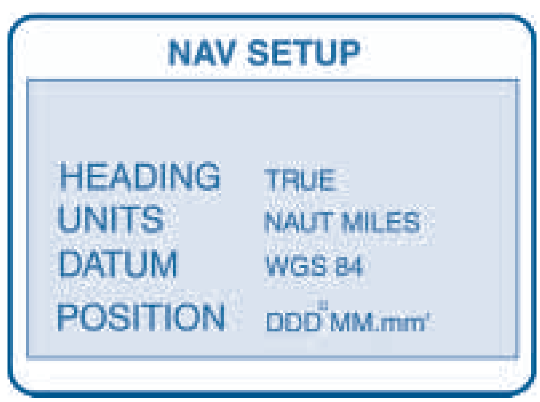
1. Sound or flash a warning alarm and switch to DR (dead reckoning) mode. This is when the receiver guesses your new position based on your course and speed from your old position. As the Royal Majesty (see story p. 120) discovered, a GPS in DR mode can be a dangerous thing if you do not know that it is guessing.
2. Most GPS receivers, when given old data will simply stop updating the position and start to flash or sound an alarm. Every crewmember should be familiar with the receiver's method of indicating an inaccurate position.



Flashing coordinates can indicate old data or an inaccurate position

Navigation Set-up:

Getting the right datum is a critical step that can't be overlooked when setting up your receiver. If your chart is based on NAD 27 and your GPS is set for WGS 84 then the GPS will indicate you are in the wrong spot on the chart. Most receivers will be set on WGS 84 as a default but have over a hundred different datums in the memory bank. Read your owners manual and follow the steps to setting the receiver to the correct datum and as you change charts don't forget to check your new chart for the datum it uses.



The owner's manual will guide you through setting up the proper datum and units.

Using Common GPS Features

Waypoints and Routes *(The specific menu routines for these functions can be found in the GPS owner's manual)*

Waypoints are positions entered into the memory of a GPS receiver or chart plotter. A string of waypoints that is used to get somewhere is called a route. The individual paths between waypoints are the legs of the route. Most functions of the GPS are based around these three features.

Entering Waypoints

Most systems allow the user to enter waypoints using a few methods. Here are three common methods.

- Name the waypoint and enter the latitude and longitude of the desired spot
- Enter your present position and name the waypoint
- Use a cursor on an electronic chart or plotter display to mark a spot and enter it as a waypoint.

NOTE: When naming waypoints, use geographical references to identify that position instead of numbers and letters (if your machine will allow this). This makes the waypoints easier to recognise in the memory and easier to place logically into routes (e.g. Henry Point ; Lama Pass East).

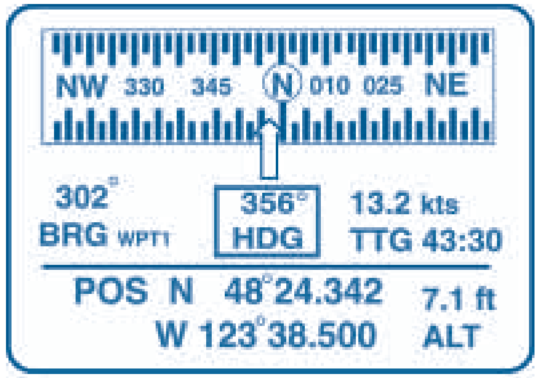
Routes

Routes can be used for regular trips that the vessel makes or for planning a passage in which you need to follow a specific path. A route is simply a list of linked waypoints that connect together. If you have a bank of stored waypoints in the memory then you can create a route by stringing them together and naming that route (e.g. Masset to Triple Island). The GPS will mathematically calculate the distances and courses to follow for each leg of the route, even without a position fix. You can use this list of leg courses and distances to verify your chartwork and make notes for your passage plan.

Underway

Position Screen

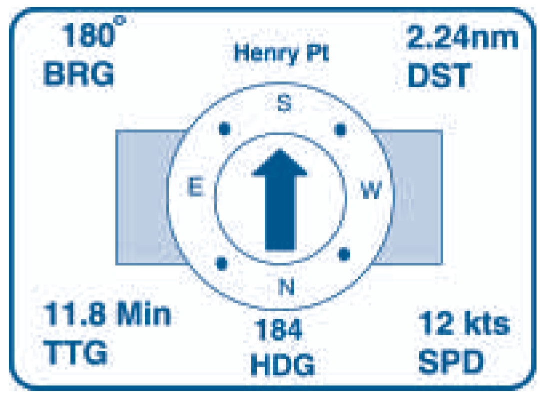
The position screen is the main screen that can be used to steer, fix your position and check the general status of the system. All the essential navigation information is here. Not all systems have the compass graphic but they will list your heading information somewhere on this screen.



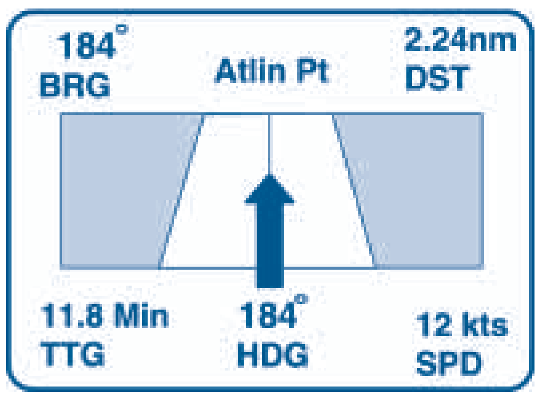
Position Screen

Navigation Screens

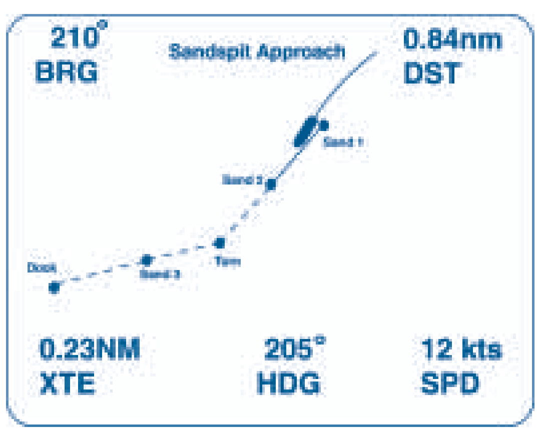
Most GPS systems have a few navigation screens to choose from, they are usually variations on the same three themes, compass screen, road screen and plotter screen. When following a route, going to a waypoint or fixing your position you can toggle back and forth to each of these screens to get the information that you need.



Compass



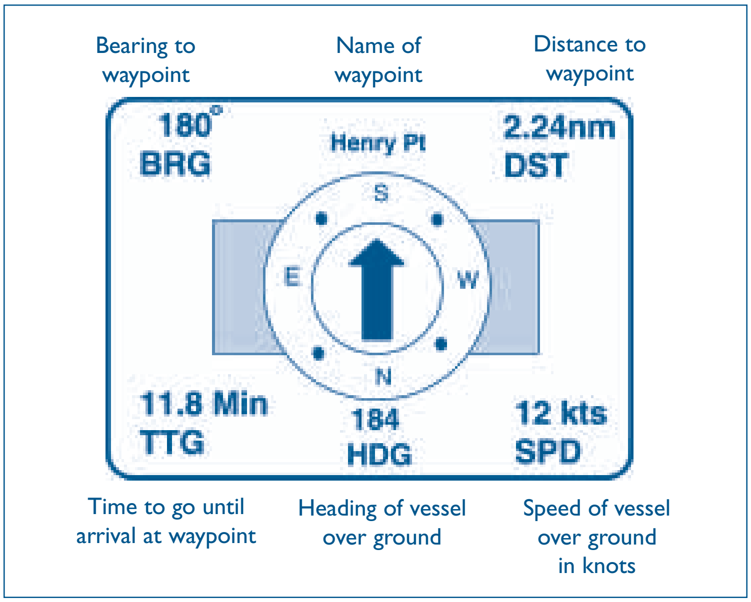
Road



Plotter

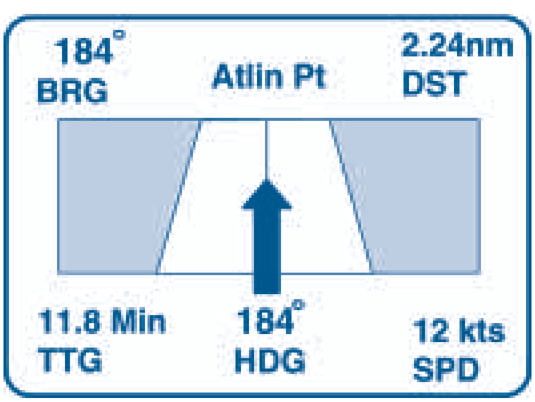
1. Compass Screen

This screen displays your course in reference to the cardinal points of the compass and an arrow will indicate the direction of your waypoint. This screen is easy to see and the large arrow in the middle makes it a useful quick reference while steering. It will give you the direction of your track over ground and this can be compared to your magnetic compass or gyro-compass heading.



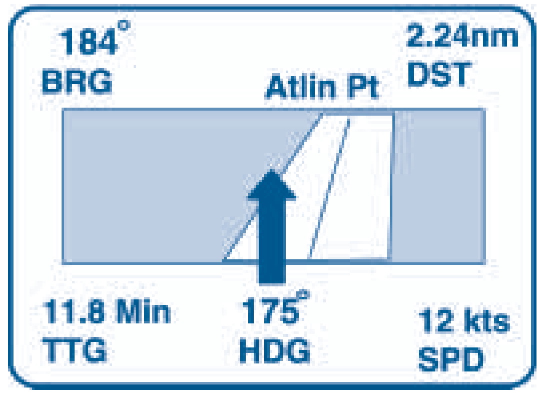
2. Road Screen

The road screen is designed to give the navigator an idea of how far the vessel has strayed off of the intended track (XTE or cross track error). The width of the road can be set to any desired value. The waypoint is indicated at the end of the road and the BRG is the course to steer to the waypoint. SPD and HDG are speed and heading calculated over the ground and the vessels movement through the water may be different. The road screen is effective in determining exactly how much you are being pushed off of your course.



Cross Track Error

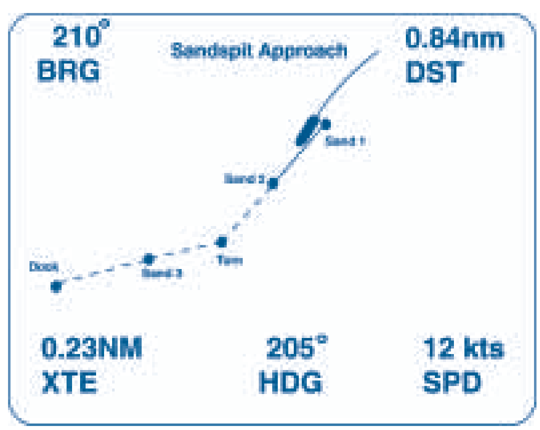
Wind, current or an unplanned course alteration can put you off of your intended track. When your vessel is being set off track, the road will move sideways and the end of the road indicates the direction in which you must steer to get back on the track to your waypoint. Not all screens have an arrow to indicate your heading but you can use this arrow to estimate a course to swing back to your track and then steer to the waypoint.



If the road width is set at 1 mile, then this vessel is 1/4 mile off of the track, and heading in the wrong direction.

3. Plotter Screen

The plotter screen is great for seeing where you have been. When following a course, searching a shoreline or running an open water search pattern, the plotter will show your path over the ground. The plotter will also display your route or string of waypoints and provide a graphical reference of where your vessel is on the route. This screen can also be helpful when estimating your cross track error and let you steer back to your intended track.



GPS Drill: Accuracy and System Check

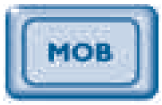
Checking the accuracy of your system is part of a routine of constant vigilance. Before getting underway and while underway, crewmembers can practice the accuracy check by following these steps:

- *Switch to the position page and write down the position coordinates and compare those with the other position information at hand. (Radar, Compass bearings, Loran C).*
- *Call up the satellite page and check your position error (EPE,GQ, or HDOP). How many satellites are you tracking?*
- *Call up the nav set-up page and check the system's chart datum and compare that with the datum used on your chart.*

GO TO

This function allows the user to set a direct path to a position manually entered by coordinates, a plotter or a stored waypoint.

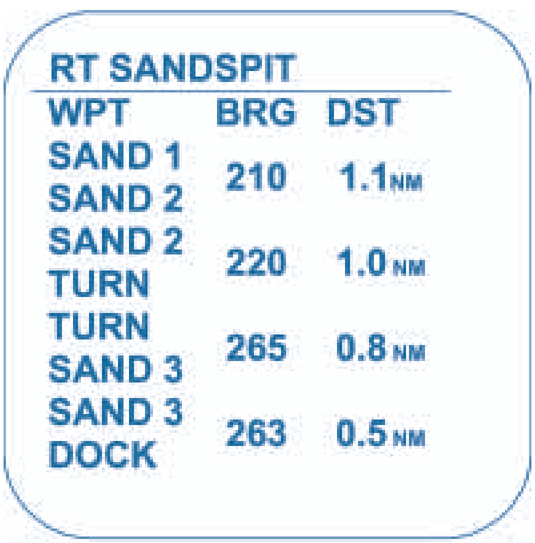
MOB (Man Overboard Board)



If someone falls over the side or you just need to mark a spot quickly and steer back to it then the MOB button will set your system to focus on that spot and provide a course to steer, distance to and time to go before you get there.

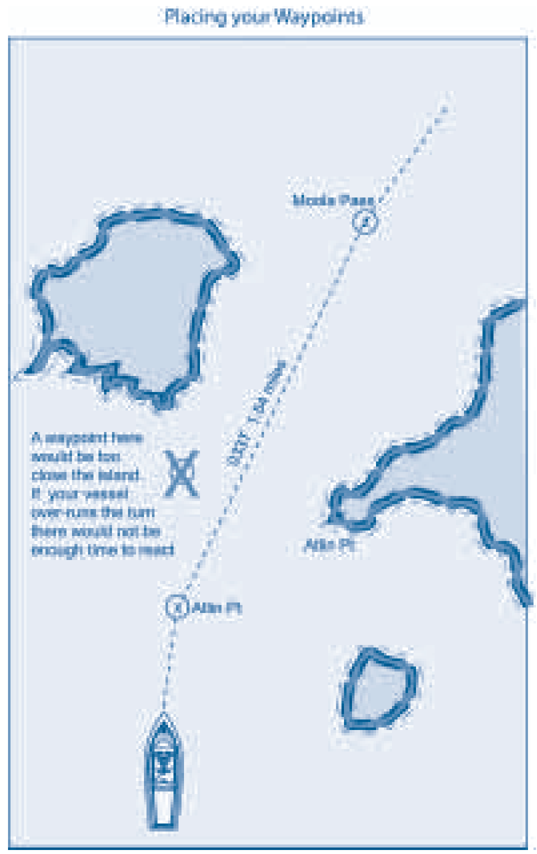
Creating a Route

Once you have waypoints in your systems memory you may wish to use them to create a route or make an entirely new route from different waypoints. When you select a string of positions and link them together the system will calculate the courses to steer between them and the distances of the legs. You can select and change the waypoint order and follow this route in either direction. Sometimes you may wish to delete or add a waypoint in a route.



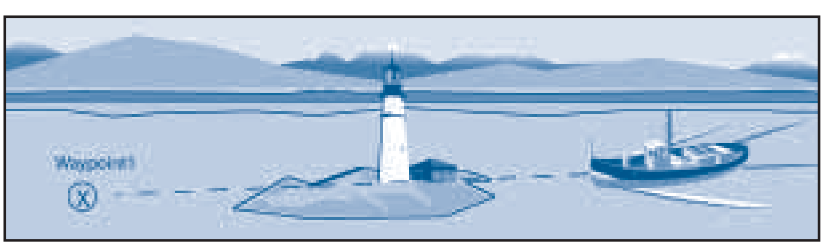
Route Planning

When you plan your routes, place the waypoints in open clear water to make sure that your course lines for the legs of your route pass through safe water. When planning turns at the beginning of the next leg, place the waypoint in a spot that will forgive position or operator errors See diagram). If you over-run your turn you do not want to find yourself up on the beach.



The waypoints are placed in clear water and named using a geographical reference not a number of letter

GPS systems can be very accurate but not very smart:



Remember that the GPS will steer you directly to your waypoint regardless of obstructions

The GPS only knows mathematical differences between coordinates on a sphere and it uses that and your position information to steer you to those points. The machine does care if there are rocks, islands or continents in your way. It will quite happily steer you through the middle of these things.

GPS Drill: Routes

The buttons and menu routines can be complex when working with a GPS routes. Remembering the sequences takes time and practice.

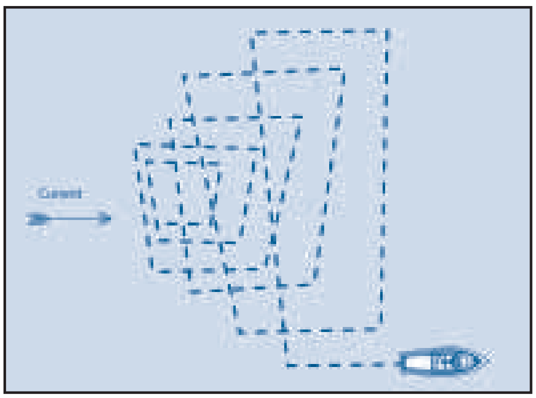
Therefore, each crewmember should sit down with the owner's manual and practice the following procedures:

- *Create and name a route*
- *Select and add previously stored waypoints into you route*
- *Enter and new waypoint and add it to your route*
- *Delete a waypoint from your route*
- *Activate and follow the route from first leg to the last*
- *Activate and return along that route (reverse route) from last leg to the first.*
- *Skip the current leg and advance to the next leg manually*

Using the GPS in searches

The GPS can be used in many ways during a search. If the JRCC provides the coordinates of a vessel in trouble or the commence search point for a search you can enter that position as a waypoint and hit the GOTO button for a direct line to that spot, provided the path is clear of dangers. In islands or along a shoreline, you can create a route with that position as the end of your last leg.

Using the GPS to run open water search patterns may not be good idea. The GPS does everything in reference to the ground and not the surface of the water. When searching for a person or object on the water you want your search pattern moving with the water surface and not staying with the ground. By using a stopwatch and timing your search legs, you will keep your pattern on the surface, and when you look at your GPS plotter your ground track will be skewed in the direction of your current. If you use the GPS to guide through the pattern the pattern will stay still while your search target may be drifting away.



Common GPS Symbols & Abbreviations

Abbreviation	Meaning
ALT	Altitude
AQR	Acquiring
BRG	Bearing to a position
DST	Distance to a position
ETA	Estimated time of arrival
EPE	Estimated position error
Ft	Feet
GQ	Geometric quality
HDG	Heading of vessel over ground
Kts	Nautical miles per hour
M	Metres
MAG	Magnetic
NM	Nautical mile
SAT	Satellite
SPD	Speed of vessel over ground
TRK	Track of vessel over ground
TRU	True
TTG	Time to go until arrival at position
WPT	Waypoint
XTE	Cross Track Error

7.8.3 Electronic Charting Systems and Chart Plotters

The electronic charting system is comprised of three components designed to fulfil each of the three basic functions of the system:

- Input – provided primarily by the GPS, although some systems incorporate fluxgate compasses, speedometers and depth sounders to verify information.
- Processing – generally this is also performed by the computers built into a GPS, but functionally this component allows for the storage of Waypoints, computes ETAs, determines relative bearings, and calculates a host of other information. Some more recent systems actually take input from a (D)GPS and process the data on a dedicated laptop computer.
- Output – The most common output device for charting systems is a raster display (similar to most computer displays), although LCD (Liquid Crystal Display) screens, Plasma Panels, and CRTs (Cathode Ray Tube) are also available. Sometimes output also takes the form of a servo control system such as an Auto Pilot.

Electronic Chart Display

Some basic definitions of the output displays need to be applied at this point:

Chart Plotter – a plotter which has the capability of displaying rudimentary charts;

ECDIS – (pronounced “ek dis”) an Electronic Chart Display and Information System combining a GPS, computer, navigation software, and electronic charts that allow an operator to view the position of the vessel in real-time against a background chart.

Electronic Navigation Charts (ENC)s

These are electronic charts that are fully compliant with the international IHO-S-57 standard for ECDIS. These charts are electronic versions of the National Hydrographic Survey or NOAA charts, use the standard hydrographic symbols, are updated regularly, and are complete compilations of the same information contained in Notices to Mariners, List of Lights, Radio Aids to Marine Navigation and other official publications. These are very comprehensive databases in electronic form and are rarely found on Fast Response Craft, but are increasingly common aboard large commercial craft, military and Canadian Coast Guard vessels.

Vessel Icon

This mark on a chart display, ECDIS, or ENC comes in various shapes, styles and colours. The purpose of the vessel icon is to show the operator where the electronic input thinks the vessel is situated, according to the most recent electronic data available to it. Some icons are shaped like a vessel and can orient themselves against a North Up background to indicate bearing and relative position to hazards. On some displays the icon (or a bearing line attached to the icon) becomes elongated as the vessel speeds up and gets smaller as the vessel slows down.

7.8.4 Depth Sounder

Under-rated and often overlooked as a Navigation tool by pleasure craft operators, Depth Sounders are invaluable for inshore or near-shore Search and Rescue work. Consider the altimeter in an aircraft – when coupled with a pilot's eyes and a reliable chart – an altimeter lets a pilot know exactly where he is. Depth sounders can be used in exactly the same manner – only the visual references (rocks instead of mountain tops) can sometimes disappear with a tide.

Depth Contours in Shoreline Search

The most common application of a depth sounder in SAR activities is when a vessel is called upon to perform shoreline searches. A coxswain may typically instruct a helmsman to follow a depth contour while other crewmembers are engaged in maintaining lookouts.

Cautionary Notes

Depth sounders, as with other electronics, use echo locating of radio signals to operate. Sometimes these radio signals have frequencies which are very close to the frequencies of other electronics, and the instruments may interfere with each other yielding false readings which may be assumed to be accurate. When depth sounders on small craft tend to flash on/off, their reliability becomes questionable. When this happens, there are always the old standbys: **Eyes and Chart.**

7.9 Navigation: When in doubt stop or slow down

The single most dangerous act in Search and Rescue is transiting to scene. You as a crewmember must constantly be vigilant and on watch. High-speed rescue craft require that all on board excluding victims must play an active role (lookouts) in the safe passage of the vessel. The communication between the Captain/Coxswain and the helm must be fluid, clear and regimented. If anyone is in doubt as to the safety of the vessel that person shall be able to stop the vessel for an assessment of position and direction. A prudent Skipper will realise that a vessel that moves that quickly can afford an orientation stop or two.