9.0 Navigating with Radar - Part Two

9.1 Landfall and estuary navigation

In the offshore environment, radar is mainly used to pick up other vessels and determine the best avoidance action to take, should that become necessary. It can also be a key early warning aid in identifying and preparing for approaching heavy weather. When approaching landfall, it usually becomes the first reliable source of intelligence about the landmass ahead.

However, the curvature of the earth tends to be an annoying factor, distorting when and how we will see identifiable detail. Also, increased traffic, shoaling water and geographic obstacles mean that waterborne traffic can no longer be trusted to travel on steady courses.

9.2 Landfall radar interpretation

In the offshore surveillance scenario, more often than not, closing targets will maintain steady headings and speeds, simplifying the task of radar interpretation. However, transitioning from an offshore environment to that of an imminent landfall demands increased observational acuity from the radar observer. Even when the position of the boat is known "with some accuracy", the first contact paints from the coastline can be misleading at best and baffling at worst.

The key to overcoming any uncertainty is preparation. By taking the time to reconnoitre the navigation aids and geographic features around the projected landfall the process becomes more comfortable. Using a good large-scale chart of the area and your inbound DR track positions the expected sequence and relative location of initial paints can be forecast.

9.2.1 The plan position display

It is **very** important to remember that a *Plan Position Indicator* (PPI) display is **not** a presentation "looking down upon" the radar's displayed area of coverage. It **is** the presentation of the radar's view **looking out from the height of its antenna**. Therefore, as you approach landfall your radar can only see things that are **above its radar horizon**. Because of this the first paint your radar gets from the coast may very well be high ground ***some distance inland*** from the point of land nearest to your boat. To get a feel for this effect, consider the following, using the same numbers we used in Section 4.0, "The bends":

Height of antenna = 5 m (16.5 ft), distance to horizon = 4.9 NM

24 NM Radar

Remaining distance to **edge** of radar coverage 24 NM - 4.9 NM = 19.1 NM

If $d = 2.21 \times \sqrt{h_m}$, then $h_m = (19.1/2.21)^2$ or 75 m (246ft) height on the radar horizon

16 NM Radar

Remaining distance to **edge** of radar coverage 16 NM – 4.9 NM = 11.1 NM

If d = 2.21 x $\sqrt{h_m}$, then $h_m = (11.1 / 2.21)^2$ or 25 m (82 ft) height on the radar horizon

Thus, unless you are experiencing AP (ducting), to receive an echo from maximum range on a 24 NM display the object must be 75 m or almost 250 ft **above the water level at your boat.** This effect is demonstrated in Figure 9.1 which shows how the radar shadow masks objects below the radar horizon.

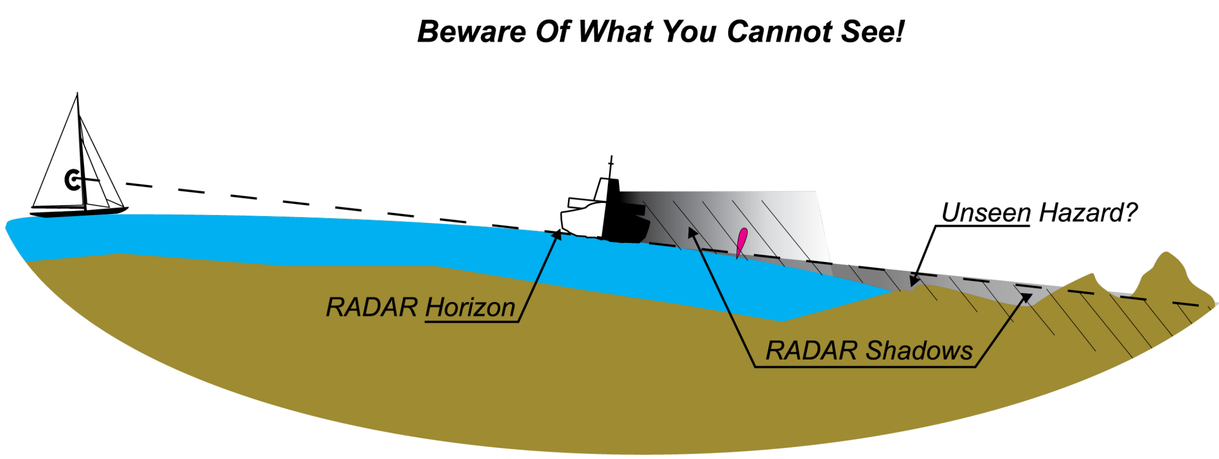


Figure 9.1 Radar horizon and shadow masking

9.2.2 Pre-planning landfall

Prudent navigators will study the chart with this in mind as they "picture" at what range and azimuth the first pickup is likely to be and when **after that** the first key navigation aid or geographic feature might appear. Always attempt to match the chart features to the radar picture, not the radar picture to the chart. Experienced navigators/ operators always caution that the human tendency is to try to fit the visual picture to match the printed chart features. Too often this leads to mistaken positioning.

The final caution to keep in mind is that, at maximum range, the radar beam-width of the popular 46 cm (18 in) antenna can smear the paint of a small object 5.2° or more, across your display azimuth. At 24 NM that is about 2 NM wide! As other features become visible they may be disguised by this effect. As long as you remember that the **centre of the nearest edge** of a **single** radar paint is the object's location. Much valuable information can be gleaned from an otherwise apparently muddy radar display picture.

9.2.3 Beam-width distortion

Figure 9.2 below, illustrates the different radar ranges (5 m antenna height, above water level) where one might expect to be able to initially identify individual features on the radar. Notice that you could be as close as 2.75 NM to the channel entrance before you can expect to see **both** sides of the channel itself.

Because the antenna beam-width is a relatively constant angle, the closer you come to an object of interest the smaller the paint of its "width" will appear on the display. This allows more detail to emerge as you approach a harbour entrance, inlet or other small objects. This improving definition is particularly advantageous in fog, feeling the way into a harbour protected by a narrow entrance channel.

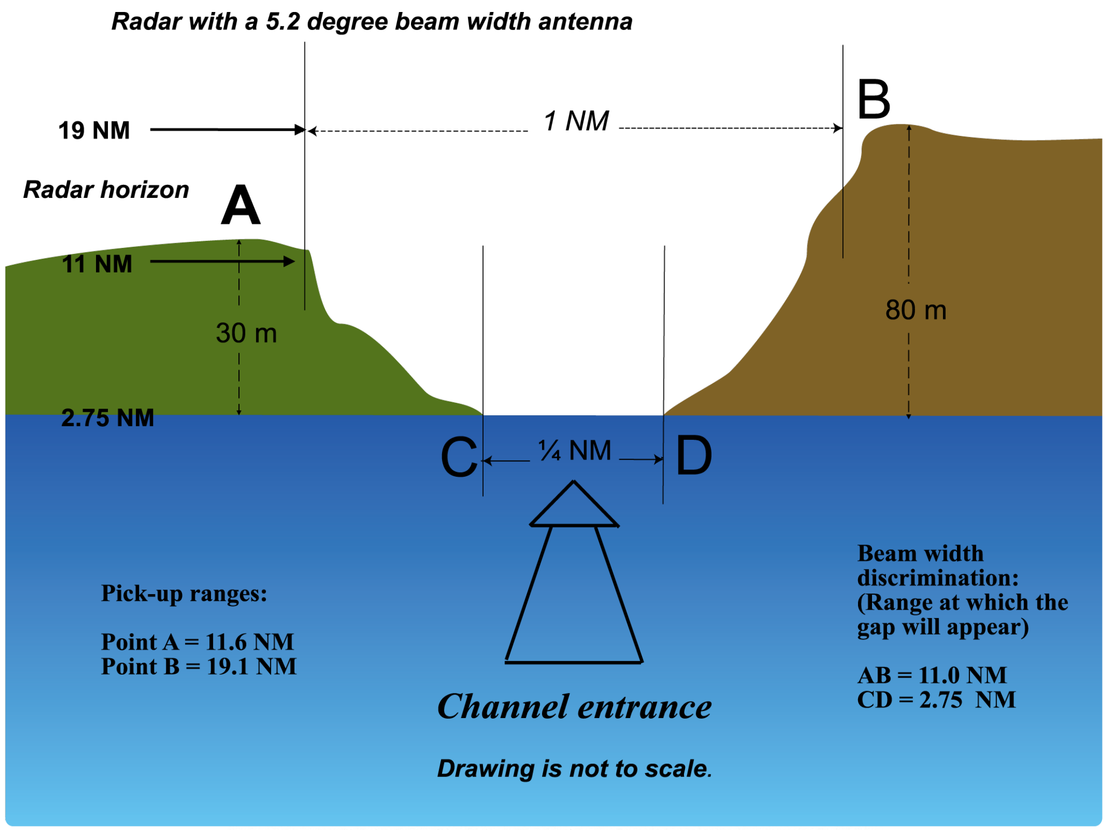


Figure 9.2 Loss of Detail with Distance

There are many examples of such harbours. St. John's, Newfoundland and St. George's, Bermuda are two examples of approaches which can be most difficult to "pin-down" on radar until you are within a couple of miles of their entrances.

9.3 Estuary or coastal radar interpretation

This is the navigating environment in which most of us do our waterborne relaxing. It can also be the most stressing and occasionally distressing! Here is where the investment in a well-founded and operated radar can prove itself invaluable.

It is also, by far, the busiest and most difficult environment in which to practise the art of interpreting a radar picture. One might find large freighters in north-south shipping channels while smaller commercial vessels and ferries are bustling east and west. Overlaid upon this traffic can be the vast range of pleasure boats of many shapes, sizes and speeds. These craft may be driven by anybody, from an expert to a neophyte!

In this environment **nothing** can be taken for granted! It would be naïve to assume that any vessel painting on your radar will maintain a steady course or speed for more than a few minutes at a time. This potential fluidity can make the results of any attempt to “measure” the progress of another vessel questionable. Here is where true familiarity with your equipment, its display and its limitations, together with good seamanship, are paramount.

The EBLs, VRMs, or cursors on your display can be your greatest allies. They can be set quickly and accurately and, most of all, they can give you the very first hint that you may be on a collision course with another vessel. It is in this environment that a GPS and fluxgate compass, integrated into your radar, will prove most valuable.

9.4 External inputs

Most of the small marine radar, designed and produced for the recreational market, have the built-in capabilities to be connected to, or integrated with, other sensors or devices such as a laptop computer. The most common inputs are GPS position messages and fluxgate compass heading data. Fluxgate compass information enables the radar display to compensate for true and magnetic headings, and true and magnetic north. The GPS provides the radar display with present position, waypoint data and the magnetic variation for the current position.

So equipped, the radar can then orient the display to show “Head-up”; “Course-up”; “North-up true”; or, “North-up magnetic” pictures. The GPS can provide the next waypoint data to the display which is superimposed upon the current radar picture as a “lollipop” (see Figure 9.3). The location of the waypoint is at the centre of the lollipop and the course to steer is in the direction of the “stick”.

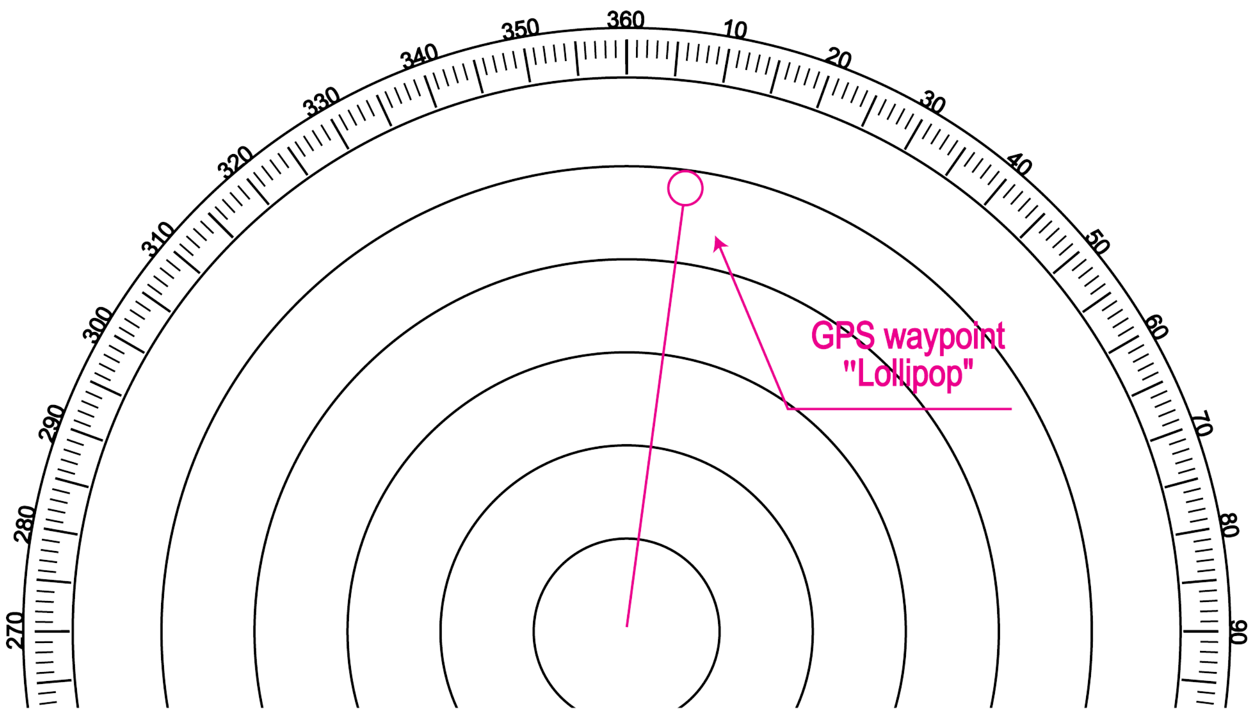


Figure 9.3 GPS waypoint display

9.4.1 Maintaining a GPS route

A carefully planned route inserted into the GPS, with the current waypoint(s) displayed, greatly assists in maintaining boat orientation and desired *course-over-the-ground* (COG). This is of particular importance when you have been forced to manoeuvre frequently to avoid traffic. Luckily, the times you are most likely to have to depend heavily upon your radar to navigate are under weather and/or lighting conditions that discourage less experienced boater from venturing forth!

Never rely upon your "right-of-way". Approaching vessels may not be aware of your presence, not interested in your presence or unable to manoeuvre themselves. "A tack in time saves mine?"

9.5 Signal boosters

9.5.1 RAdio beaCONs (RACON)

Many navigation buoys, moored in key locations, are equipped with a device known as a *transponder* or RACON, in addition to a radar *reflector* which will be discussed next.

These devices are similar to the ones used on all commercial aircraft. The ***trans***mitting res***ponders*** (transponders) are designed to sense all 3 cm radar transmitted pulses that reach their antenna. They then amplify these pulses and retransmit the boosted signal back to the originating radar antenna.

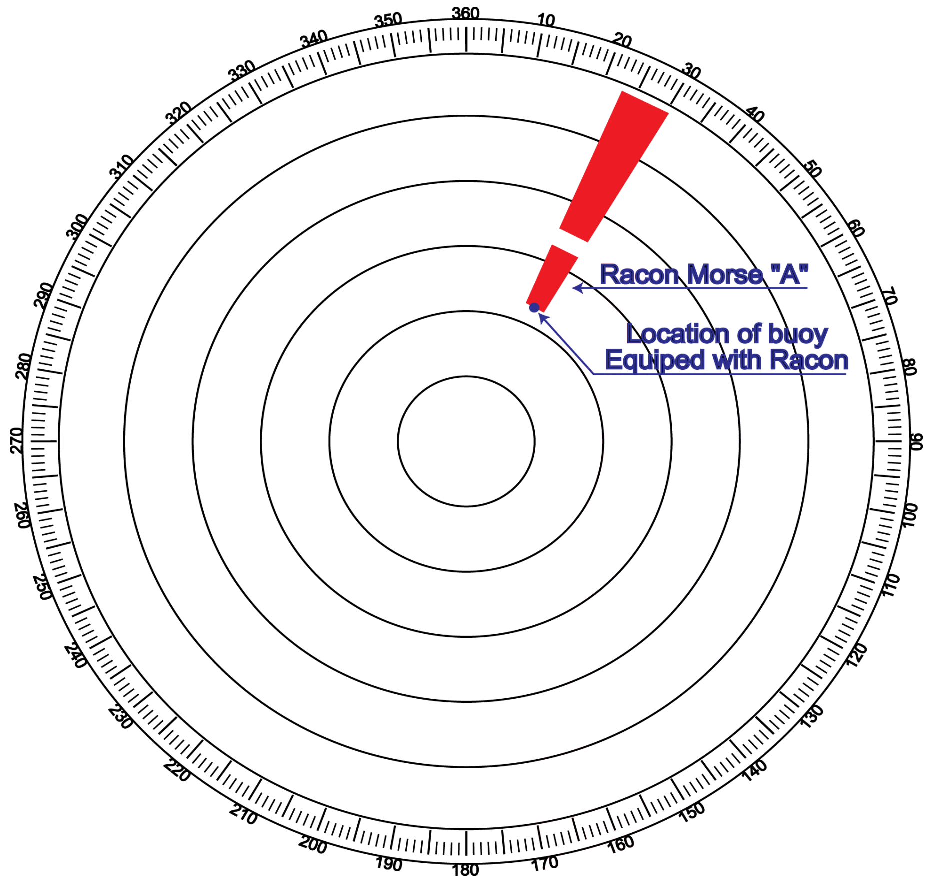


Figure 9.4 RACON displays

In addition to its ability to boost the reply, the RACON is designed to repeat the boosted signal in a sequence corresponding to its allocated Morse code letter as listed in the light list. (See Figure 9.4) Therefore, it is possible to pickup and **positively identify** a RACON-equipped aid, **at or even a little beyond** its nominal radar horizon distance due to its very much stronger signal strength. This is an **active** signal booster.

9.5.2 Passive signal boosters

Radar will only work when there is a reply (echo or return) strong enough that the receiver can amplify it sufficiently for the display to create a paint or "blip". Radar echoes are generated by the surface material of the target absorbing the energy and then re-radiating it back outward. If that surface is a good conductor, like steel or aluminum, the echo will be strong. However, when the surface is a good insulator, like fiberglass or wood, the echo will be very much weaker.

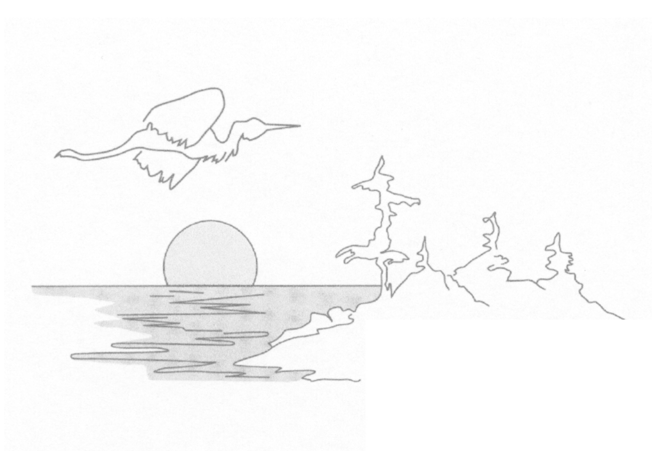
Size is also important. A steel supertanker will return a solid “bang”, a small steel buoy will not, and a fiberglass boat will be weaker yet. That is why the radar set on a freighter bearing down upon you may not actually be able to paint the radar echo from your composite hull, until you are already well *inside* **his** guard zone. There are a number of ways to improve the radar visibility of poor signal radiators using tuned radar reflectors which we look into next.

9.5.3 Radar reflectors

Radar reflectors are passive devices which rely solely upon the strength of the **incoming** radar pulses to work. While metals make the best radiators, some compositions of plastics molded into prismatic shapes are also efficient reflectors when tuned for specific frequency bands. Passive radar reflectors are specifically designed to use the reflecting, or “bouncing” property of 3 cm and 10 cm radio waves to significantly increase the portion of the transmitted pulse of energy reaching it **directly back** in the direction from which it came.

These reflectors come in various forms and materials. The most common and least expensive one is made from aluminum alloy in the familiar shape shown in Figure 9.5 on the next page. More expensive ones are assembled from different formulations and densities of plastic foams. These are then sculpted into particular tubular and dome shapes. They capture the pulse and efficiently concentrate the reflected energy back directly towards the transmitted source.

The three views in the bottom left of the diagram show the signals reflection off of three surfaces from the three perspectives of each individual surface. This is not the easiest diagram to follow, but careful examination will show you the process clearly.



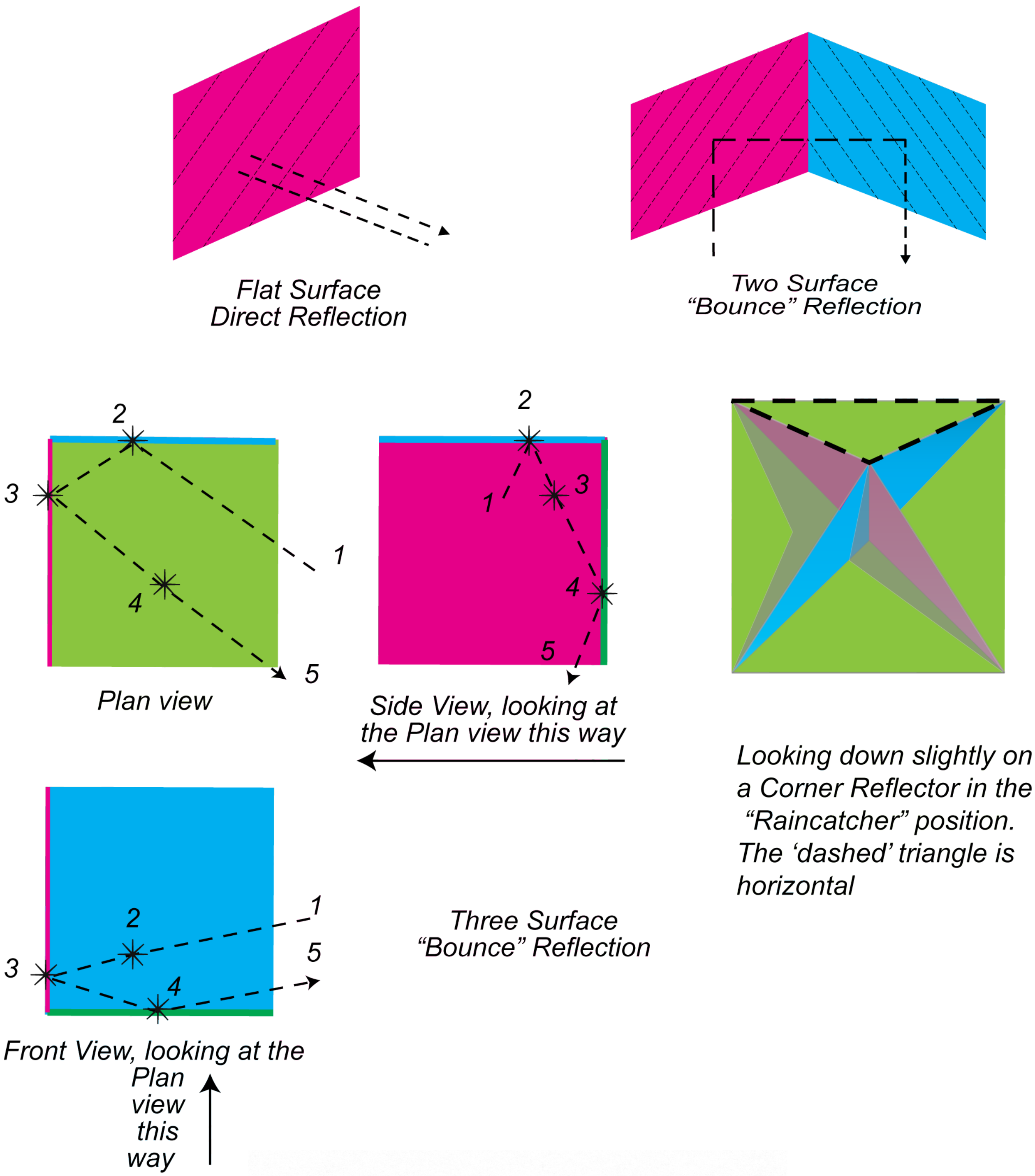


Figure 9.5 Radar Reflector in the “Raincatcher” Position

Radar reflectors can be seen on top of buoys, on poles atop fishing net markers and at the entrances to harbours. Above all, they follow the smart rule of “see and be seen” being commonly found on most non-metal boats. Reflectors can and do, greatly increase the radar visibility of the object to which they are attached. They should be used by all adventurous boaters and should be mounted as high as possible above the waterline.

9.6 Radar specific safety devices

There are two more classes of boosting devices that operate in the 3 cm and 10 cm radar frequency bands and which are often installed by “blue water” sailors. The first is a *radar signal detector* and the second is a ***S**earch **a**nd **R**escue **T**ransponder* (SART).

9.6.1 Radar signal detector

The radar signal detector is also a passive device (i.e. it can only sense received pulses). It is able to warn the watchkeepers of the presence of another transmitting radar. It also gives a rough indication of the direction in which the source vessel (or land-based radar installation) lies.

This device has a small fixed quadrantal antenna feeding a broadband receiver sensitive to 3 cm and 10 cm radar signals. The light-weight antenna is ideally mounted on the top of the mast or vessel superstructure. When an active radar sweep passes over the antenna an audible alarm sounds and a light on the unit indicates in which quadrant of the antenna the signal was detected.

A slow scan, say 5 rpm, is a likely indication that the other radar is mounted on a large commercial or naval vessel. These ships usually have their radar antennas mounted high above the waterline so an alarm could be indicating its presence from **well below your own radar horizon**. This can occur some time before the vessel is close enough to paint on your own radar display.

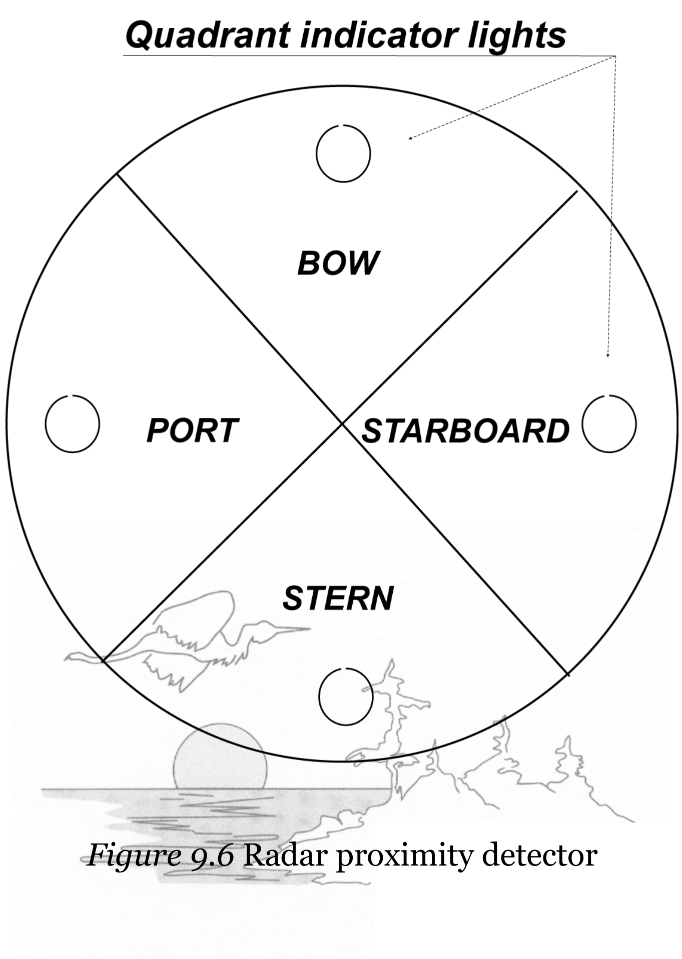


Figure 9.6 Radar proximity detector

Figure 9.6 illustrates how the detector displays the four segments of the antenna corresponding to the four primary directions around the vessel. If the “bow” indicator is the only one to light up, the transmitting source is between 315° and 045° relative, and so on. However, if both the bow and port indicators light simultaneously, then the transmitting source tripping the alarm is between 270° and 360° relative. In this way the visual signals can be interpolated to give at least the eight semi-quadrantal azimuths, plus or minus 45°.

9.6.2 Search And Rescue Transponder (SART)

The SART is comparatively new and is now a required safety device on commercial vessels under the GMDSS rules. It is a compact battery driven transponder contained inside a buoyant watertight container about 300 mm (1 ft) long and 40 mm (1.6 in) in diameter. It has an external antenna and weighs about 950 gm (2 lb). The transponder will be activated when the unit is immersed or switched on and can operate continuously for about 4 days. A maximum range of about 8 NM is claimed. Manufacturers suggest that automatic Clutter and Interference Reduction circuits should be turned off immediately if a SART signal is suspected.

The SART responds to a radar sweep by transmitting a series of 12 in-line dots along the SART’s azimuth of a receiving radar display. These dots are spaced about 0.64 NM apart. It is recommended that observers use a radar display range of 6 NM to 12 NM for the best pickup and definition of the emergency signal. Because this sequence of signals is unique to the SART, any mariners receiving the 12-dot signal **must** consider it a Mayday call and respond accordingly.

Like EPIRB or GPIRB units, the SART may be installed in a “float away” mount, kept in a clearly marked location, or placed in the Abandon Ship bag.

9.7 Summary

- Perhaps the most valuable feature of using radar is the ability it provides to quickly and accurately determine potential collision course conflicts, calculate the best possible evasion action, and determine the CPA.

- Radar can be used to great advantage in conditions of very poor visibility to navigate in close quarters through channels or harbour traffic.

- Skilled radar operators always consider that the curvature of the earth is distorting the radar picture as they approach land.

- Skilled navigators always calculate the range, bearing and approximate time of appearance of features or objects before they intend to use them to confirm a landfall.

- Radar can be very useful in heavy traffic areas when it is used to evaluate the best actions to take in avoiding random manoeuvring traffic.

- Signal boosters provide safety for the radar-equipped boat and aid in SAR security when required.

***Next* - Some final considerations**