# CHAPTER 2. USING RADAR FOR THE FIRST TIME

This chapter describes basic information on radars and explains technical terms used in radar operation for those who is using a radar for the first time.

## 2.1 What is a radar ?

A marine radar is one of the navigation equipment installed on a ship. It emits a radio wave in very high frequency called a microwave from its antenna and receives the reflected radio wave from objects on the sea (e.g., other ships, buoys, and lands). The received radio wave is converted into an electric signal which is displayed on a display screen to indicate the presence of such objects. Although it is very difficult to find other ships or the destination coast with human eyes at night or in thick fog, a radar helps you detect objects on the sea helping you avoid danger when sailing. The antenna turns 360 degrees as it radiates waves, allowing you to grasp ambient conditions around your ship at a glance.

The radio wave radiated from the antenna is called a pulse wave and the radar performs transmission and reception alternately. Several hundred to several thousand pulse waves generally are transmitted while the antenna rotates one turn.

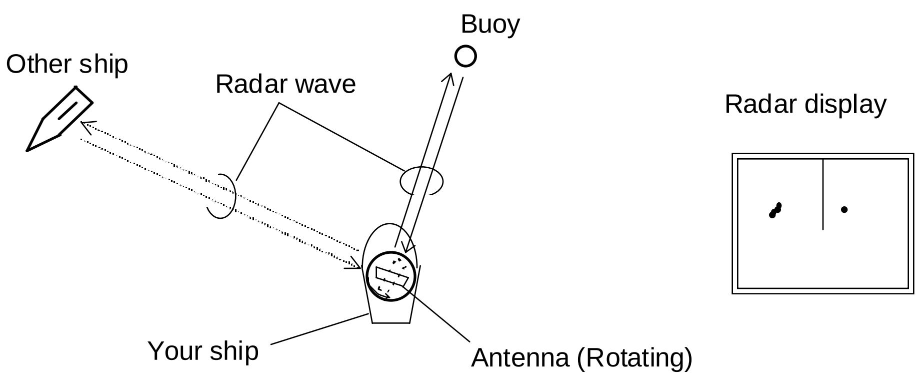



**Fig.2-1 What is a radar?**

**Antenna**

There are many types of antennas generally used for a radar. For example, these include a parabolic antenna and a slotted-array antenna. The performance of the antenna determines that of the radar. The dominant factors are the antenna's beam width and side lobe level. The narrower the beam width, the higher the resolution of the angle direction. The lower the side lobe level, the fewer the effect of a false echo.

**Side lobe**

A beam in one direction in which the strongest radio wave is radiated from the antenna is called the main lobe and beams in other directions are called "side lobes". The side lobe level refers to the difference in level between the largest side lobe and the main lobe.

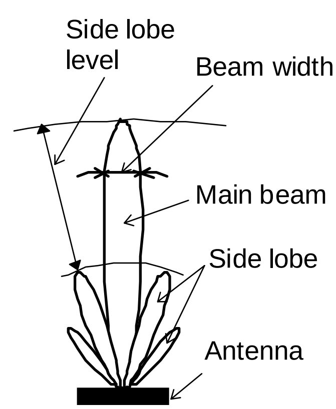



**Fig.2-2 Antenna pattern**

**Beam width**

A beam width is defined as the width of the main lobe at an angle where the radiated power is halved as measured from the position from which the strongest radio wave is radiated.

## 2.2 Characteristics of Radar Wave

Radio waves from the radar propagate while bending slightly along the terrestrial surface. This characteristic varies dependent on the density of the atmospheric air. The sight distance D of a radar generally is said to be approximately 6% longer than the optical sight distance and is calculated using the equation below :

$$D\,(NM) = 2.22(\sqrt{h1} + \sqrt{h2})$$

where, h1= antenna height in meters
h2= target height in meters

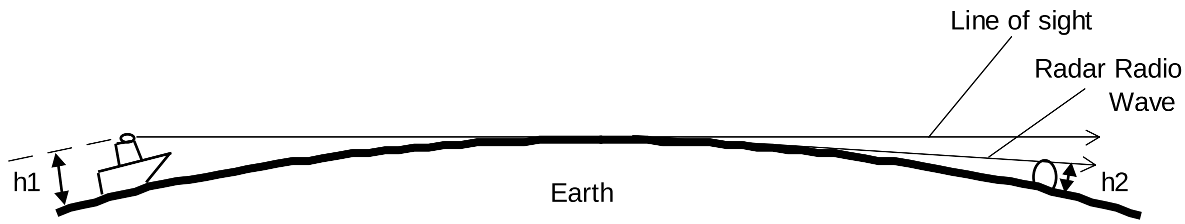



**Fig.2-3 Radar wave**

**Targets difficult to display on screen**

The intensity of the reflected wave from a target depends on the distance, height, and size of the target, as well as its material and shape. Targets constructed with FRP, wood, or other low-reflectance materials or those that have a small incident angle are difficult to display on a screen. Therefore, FRP and wooden ships, sandy beaches, and sandy or muddy shallows all are difficult to catch and require attention when monitoring on the screen. Especially, coast lines on the radar image appear to be present more apart from the ship than they are actually located. Therefore, it is important not to misinterpret the available data.

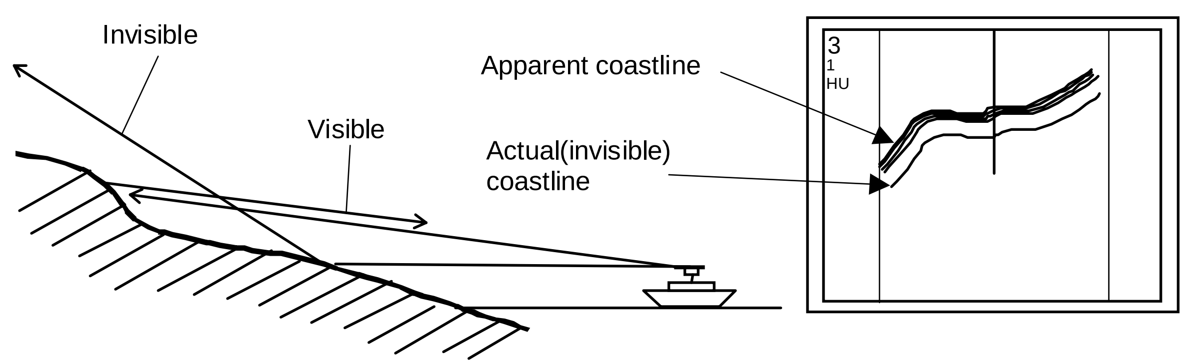



**Fig.2-4 Targets difficult to display on screen**

**Shadow zones of radar**

Radar waves are characteristic in that they propagate straight ahead. Therefore, if the ship's smokestack or mast is located near the antenna or there is a tall ship or mountain at the side of the ship, such an object generates a shadow behind it. In this case, some objects produce a complete shadow and some produce a partial shadow. In an extreme case, the shadow of an object may extend to a position far away and cannot be displayed on the screen at all. Since these shadows can be discovered when installing an antenna, the problem can be avoided by changing the place of antenna installation to minimize the shadow. Targets in shadow zones are difficult to display on the screen.

## False echoes

A false echo of an actually nonexistent object may sometimes appear on the screen when sailing. The following explains the cause of each of such phenomena.

### A. Ghost echoes

It sometimes happens that one large object near the ship appears at two different bearings. One is the actual echo and other is a ghost echo generated as the wave is re-reflected from the ship's own smokestack or mast. The former appears at the correct distance and bearing on the screen and the latter appears behind the smokestack or mast. This type of false echo is also generated by re-reflection of waves from bridges and quay walls other than the ship itself.

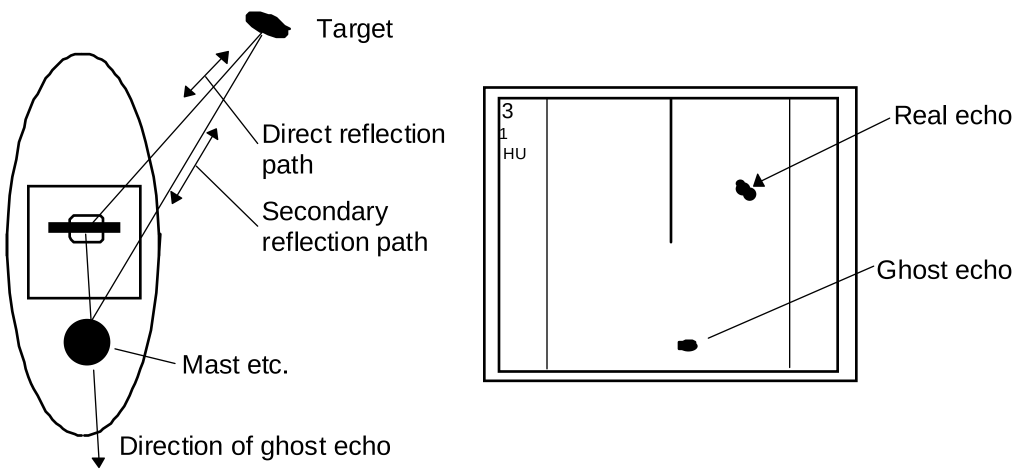



**Fig.2-5 False echoes of radar (Ghost echoes)**

### B. Multiple echoes

If there is a large vertical reflecting plane near the ship as in the case when your ship passes alongside a large ship, the wave is repeatedly reflected back and forth between your ship and the other object. For this reason, two to four images appear on the screen at equal intervals in the same bearing. A false echo that is generated by such multiple reflections is called multiple echoes. In this case, an image appearing at the nearest position is the real echo. Multiple echoes disappear as the ship moves away from the reflecting object or its bearing changes. Therefore, it is not difficult to determine the correct image.

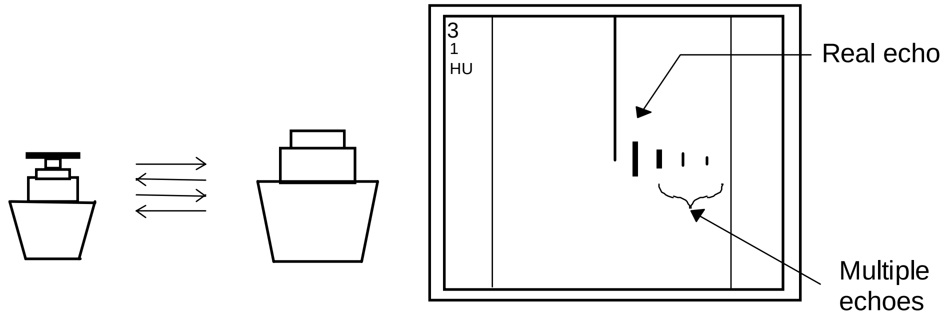



**Fig.2-6 False echoes of radar (Multiple echoes)**

**C. False echoes caused by side lobe**

The radiant beam emitted from an antenna contains side lobes in directions other than that of the main beam. Since the side lobe level is low, it in no way affects distant targets. However, if there is a strong reflecting target near the ship, it sometimes appear as a circular-arc false echo on the screen.

> ⚠ **CAUTION**
>
> **When located near large targets such as land, the ship's mast, etc. sometimes appears as a false echo of circular-arc shape.**

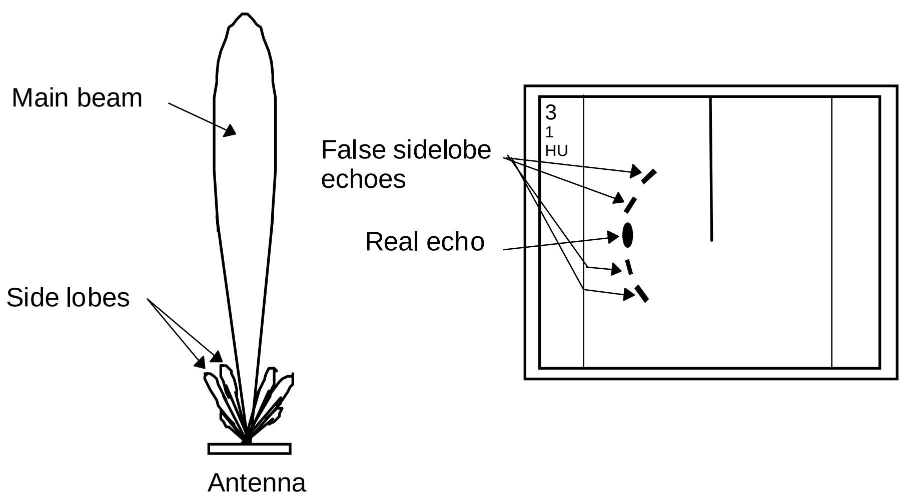



**Fig.2-7 False echoes of radar (Caused by side lobe)**

**D. Distant false echoes caused by duct phenomenon**

Depending on meteorological conditions, duct phenomenon sometimes occurs in temperature inverting layers of air. In such a case, the wave propagates erratically reaching a location surprisingly far away from the ship. In this case, a target present at a distant location more than the radar's maximum distance range appears on the screen presenting a false echo that can be misunderstood to be present nearer than the actual position. This phenomenon is attributed to the fact that since echo from the distant target arrives late, it gets out of the pulse repetition frequency and is displayed on the screen as an echo in the next frequency. If the target distance changes as you switch over the distance range, you can determine that it is a false echo.

**Radar interference**

If a radar operating in the same frequency exists near your ship, interference noise may appear on the screen that is caused by transmitted waves from that radar. This interference appears in various ways. In most cases, however, it appears as spiral or radial patterns.

The RA40C/41C/42C radar has a function to eliminate interference. Use of this function helps you minimize interference.

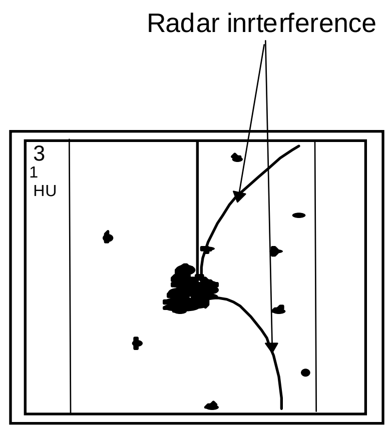



**Fig.2-8 Radar interference**

## 2.3 Terms Specific to Radar

**HM (Heading Marker)**

This is a line-shaped marker used to indicate the advancing direction of your ship.

**North Mark**

This marker indicates the north direction. It is a short line approximately 1/6 of the screen size.

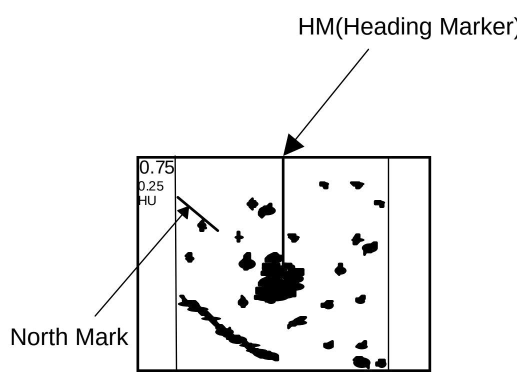



**Fig.2-9 Heading Marker and North Mark**

**Display modes**

This refers to a radar's display modes. There are four display modes depending on the direction in which the top of the screen faces with respect to the ship.

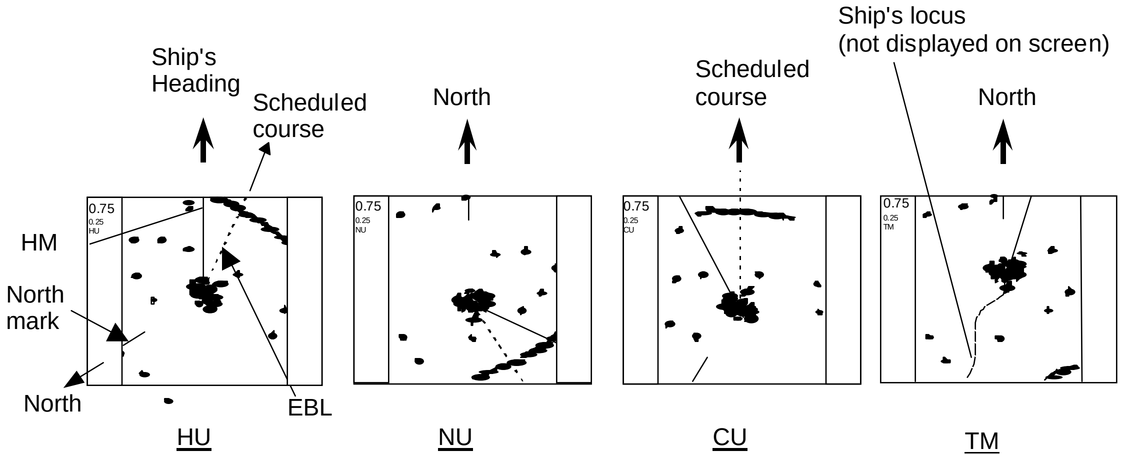



**Fig.2-10 Display modes**

**Head Up (HU)**

In this mode, the ship's heading always indicates the upward direction of the screen. This mode lets you know the relative positions of your ship and other ships or land.

**North Up (NU)**

In this mode, the north direction always indicates the upward direction of the screen, allowing you to compare your ship position with a marine chart as you navigate.

**Course Up (CU)**

The ship's heading in a course-up mode always indicates the upward direction of the screen as the bearing toward the destination. In this mode, the ship can be maneuvered to sail the shortest distance to the destination by steering it in such a way that its heading marker always directs to the upward direction of the screen. If the ship drifts due to tidal current, care must be taken because the fixed targets move to other positions.

**True Motion (TM)**

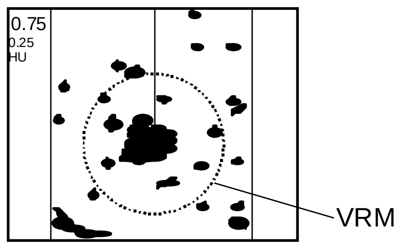
In this mode, the ship is displayed as if it is moving on a marine chart while the fixed targets such as islands and seashores are fixed in position. When the ship reaches a certain position on the screen (approx. 2/3 of screen size), the ship is placed back to the opposite side on the screen. (The top of the screen faces north.)

Note: Navigation equipment such as a gyrocompass or magnet compass must be connected to your radar system before it can be operated in NU, CU, and TM modes. (Refer to Section 3.9 for details on how to connect your radar to navigation equipment.)

**VRM (Variable Range Marker)**

This is a circular-shaped marker whose size can be changed as desired. You can use this marker when you want to examine the distance of an echo from your ship.

When measuring the distance of an echo from your ship, be sure to measure at a point close to the center of the echo image on the screen.



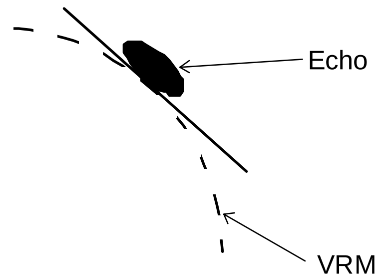
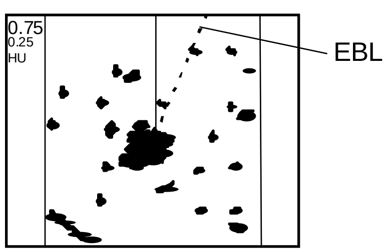




**Fig.2-11 VRM**

**EBL (Electronic Bearing Line)**

This is a marker shaped like a straight line segment that can be changed to any direction centering around the ship position. Use this marker to examine the advancing direction of your ship and its relative angle with an echo. When measuring the angle of an echo, position the marker at the center of the echo.



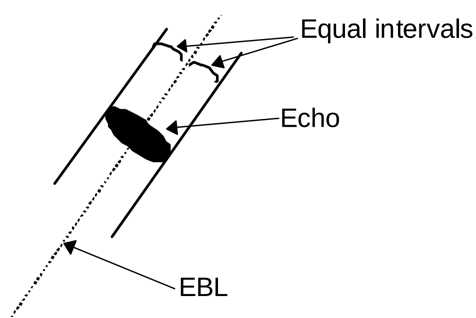




**Fig.2-12 EBL**

**STC (Sensitivity Time Control)**

Since echo signals received by the radar are strong when they are coming from a short distance, it is difficult to compare signal strength between each reflected signal. To overcome this difficulty, signal strength is adjusted in such a way that the received signal levels coming from a short distance are lowered and those from a long distance are raised. This function should prove useful when there are large reflected waves from sea surfaces during rough weather.

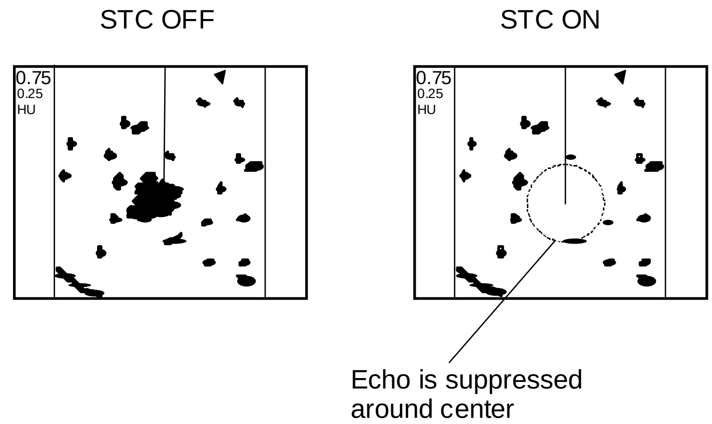



**Fig.2-13 STC**

**FTC (Fast Time Constant)**

When it rains or snows, fine noise may appear over the entire screen, making it difficult to identify echoes. In such a case, echo images on the screen can be made easily distinguishable by adjusting FTC.

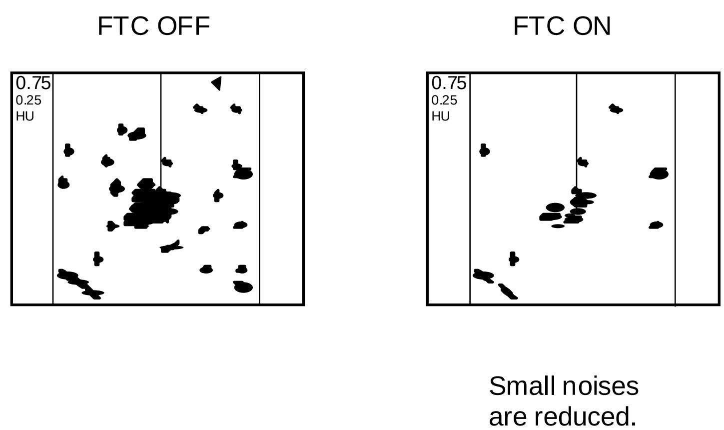



**Fig.2-14 FTC**