Operator's

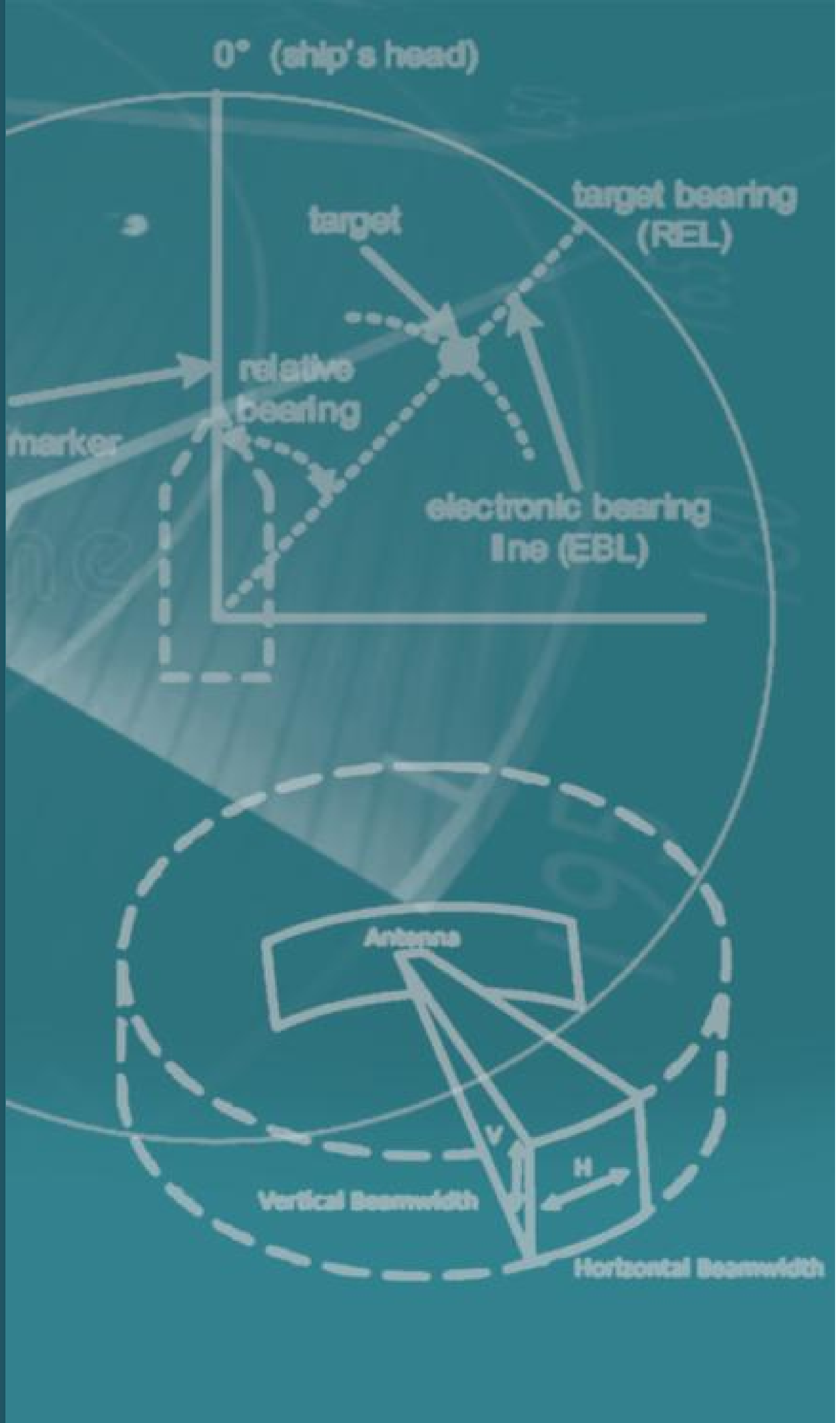
Marine **Radar Guide**

Version 1.0

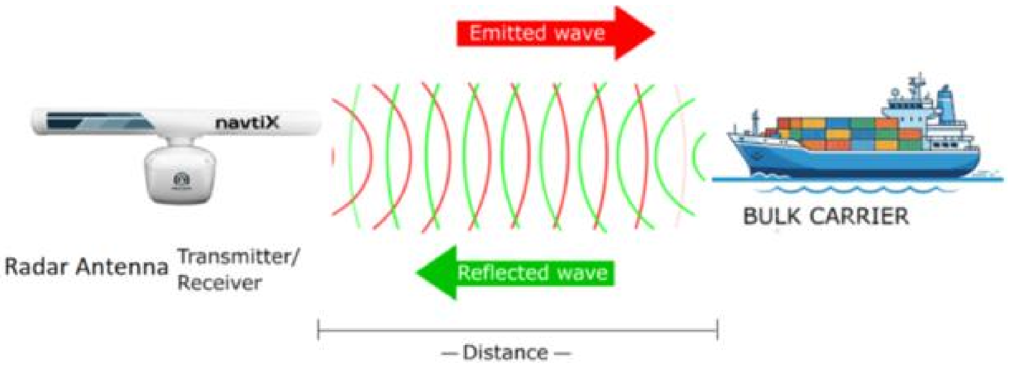
navtiX

Contents |

Principles



Marine radar works by transmitting short pulses of radio-frequency electromagnetic energy, measuring the time it takes for the signals to bounce off a target and return, and using the direction of the rotating antenna to calculate range and bearing. Key elements include radio wave transmission, echo reflection, and time-distance calculation



- **Transmission**: The scanner (antenna) rotates 360 degrees, emitting rapid, high-frequency pulses of electromagnetic energy that travel at the speed of light.
- **Reflection**: When these pulses strike targets like other vessels, land, or buoys, a portion of the wave energy bounces back as a reflected echo.
- **Calculation**: The system measures the exact time it takes for the echo to return to compute the target's distance, while the antenna's orientation determines the target's bearing.
- **Display**: Processed data is mapped onto a screen (Plan Position Indicator) as visual blips indicating position and relative movement.

Principles |

Types of Marine Radar

Marine radars are categorized into **two** primary classification systems based on their internal technology or their radio frequency band.

1. By Transmission Technology

- **Magnetron (Pulse) Radar**: Traditional systems that transmit high-power microwave bursts.
- **Solid-State (Continuous Wave/Compression) Radar**: Modern, low-power systems that offer sharper resolution, faster boot times, and safer radiation levels.

2. By Frequency Band

- **X-Band (9 GHz / 3 cm)**: High-resolution, sharp detail. Ideal for close-range piloting and docking.
- **S-Band (3 GHz / 10 cm)**: Long-range performance. Penetrates heavy rain, fog, and storms at sea.

What Radar Can Do

Marine radar provides critical situational awareness by tracking and identifying surrounding objects. It serves as a primary tool for navigation, safety, and collision avoidance at sea.

Core Capabilities

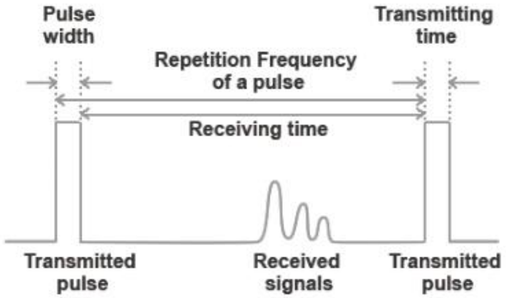
- **Target Detection**: Locates ships, shorelines, buoys, islands, and low-lying rocks.
- **Collision Avoidance**: Calculates the speed, course, and Closest Point of Approach (CPA) of nearby vessels.
- **Navigation**: Determines a vessel's position by measuring ranges and bearings to known landmarks.
- **Weather Tracking**: Detects and tracks moving storm fronts, heavy squalls, and rain cells.
- **Search and Rescue**: Locates emergency beacons, life rafts, or survival craft equipped with Radar Transponders (SARTs).

Principles |

How Radar determines range

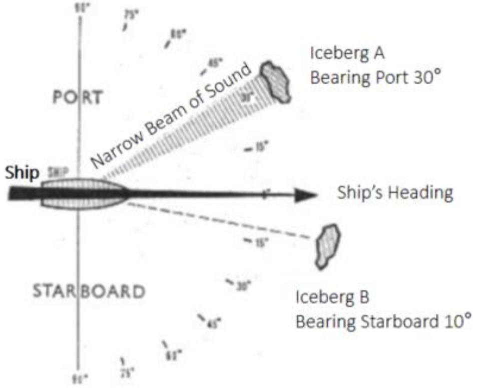
Radar determines range by measuring the time it takes for a radio pulse to travel to a target and return. Because these waves travel at the constant speed of light, the system converts this elapsed time into precise distance

$$\text{Range} = \frac{\text{Speed of Light} \times \text{Time Delay}}{2}$$



How Radar determines bearing

Radar determines bearing—the directional angle to a target relative to the ship's bow—by linking the exact physical direction the antenna is facing to the precise moment an echo is received

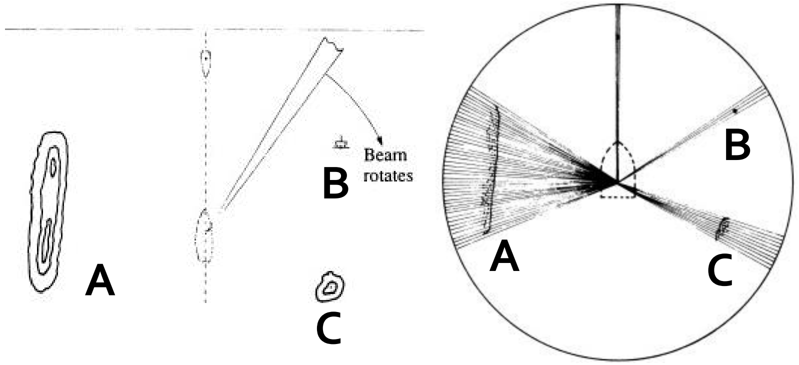


The Directional Method

- **Directional Beam**: The radar antenna does not broadcast in all directions at once; it focuses energy into a highly concentrated, narrow horizontal beam (usually 1° to 2° wide).
- **Synchronized Rotation**: As the antenna rotates 360°, an electronic sensor (called an encoder) continuously tracks its exact pointing angle relative to the ship's centerline or True North.
- **Echo Alignment**: When a reflection returns, the system notes the antenna's exact angle at that microsecond, mapping the target "blip" onto that specific heading line on the screen

How the Radar displays targets

Radar displays targets on a circular screen called a **Plan Position Indicator (PPI)**. The center of the screen represents your own vessel, and the display maps the surrounding area geographically



How the Display is Built

- **Sweep Synchronization**: A glowing trace line sweeps from the center to the edge of the screen, rotating in perfect synchronization with the physical scanner.
- **Target Painting**: When an echo returns, the screen illuminates a bright pixel ("blip") at the exact angle of the sweep line and at a distance proportional to the time delay.
- **Persistence**: The pixels remain illuminated briefly after the sweep passes, allowing the operator to see a continuous, real-time map of the surroundings.

Principles |

Marine Radar Range

Marine radar range typically spans from **less than 20 metres up to 96 nautical miles**, depending on the radar type and power output. Small recreational radars generally reach 24 to 48 nautical miles, while large commercial systems extend to 72 or 96 nautical miles.

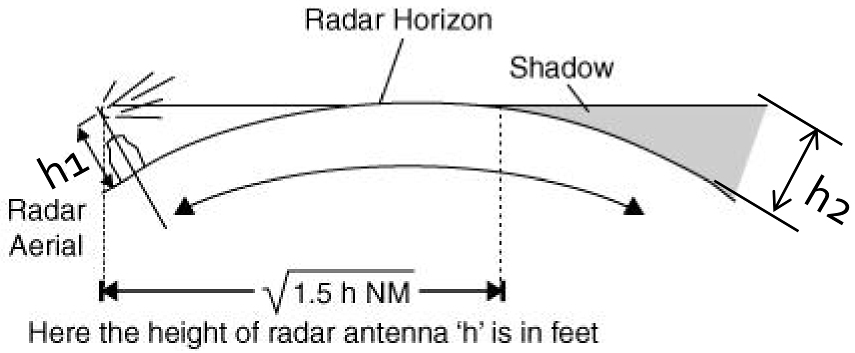
Key Factors Determining Effective Range

- **Target Height and Size**: Large objects like cliffs or cargo ships reflect signals from much farther away than low-lying buoys, small fiberglass boats, or jet skis.
- **Radar Horizon (Line of Sight)**: Radar waves travel in straight lines and cannot curve around the Earth. The physical limit of what a radar can see depends strictly on the height of the antenna and the height of the target.
- **Transmitter Power**: Higher power outputs (measured in kilowatts for traditional magnetrons) allow the pulse to travel farther, bounce back, and still be strong enough for the antenna to detect.

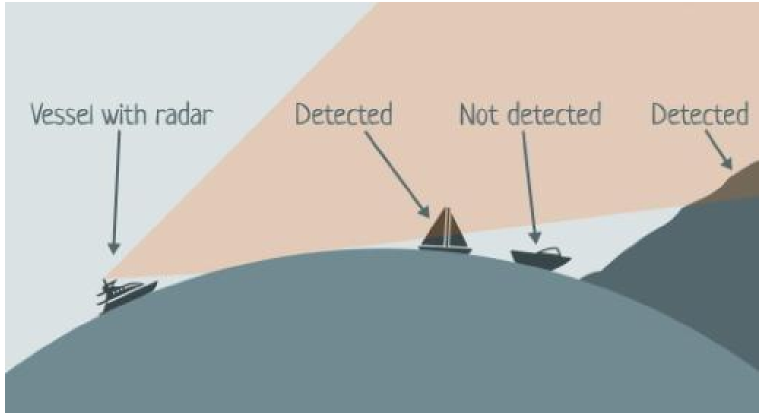
$$D = 1.22(\sqrt{h1} + \sqrt{h2})$$

D=Radar Distance (nm)

h1: Antenna Height (ft); h2: Target Height (ft)



Marine radars caan only detect ogjects above the horizon.
The curvature of the Earth limits their detection range.

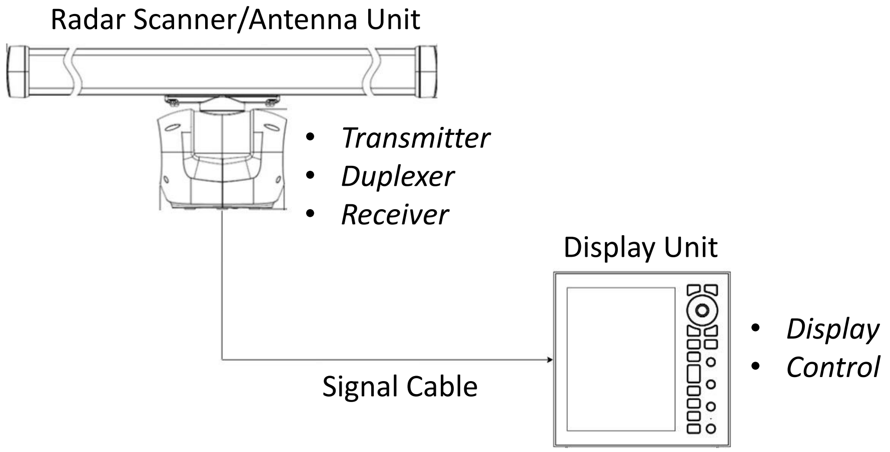


System Configurations

Basic system

A basic marine radar system consists of **five core components** that work together to transmit signals, receive echoes, and display information

1. Transmitter: Generates the high-frequency radio pulses (using either a magnetron or solid-state technology).
2. Duplexer: Acts as a fast electronic switch. It connects the antenna to the transmitter during transmission, then quickly switches it to the receiver to listen for the echo.
3. Antenna (Scanner): Focuses the radio energy into a narrow beam, transmits it, collects the returning echoes, and rotates 360 degrees to scan the horizon.
4. Receiver: Detects the tiny, weak returning echoes picked up by the antenna, amplifies them, and converts them into digital video signals.
5. Display (PPI): Microprocessors calculate the range and bearing of the signals and project them as visual "blips" on the screen for the operator.



System Configuration | *Scanner unit components*

- **TX/RX Switch**

TX/RX Switch is the high-speed electronic process that allows a marine radar to use a single rotating antenna for both sending out powerful pulses and listening for incredibly weak returning echoes.

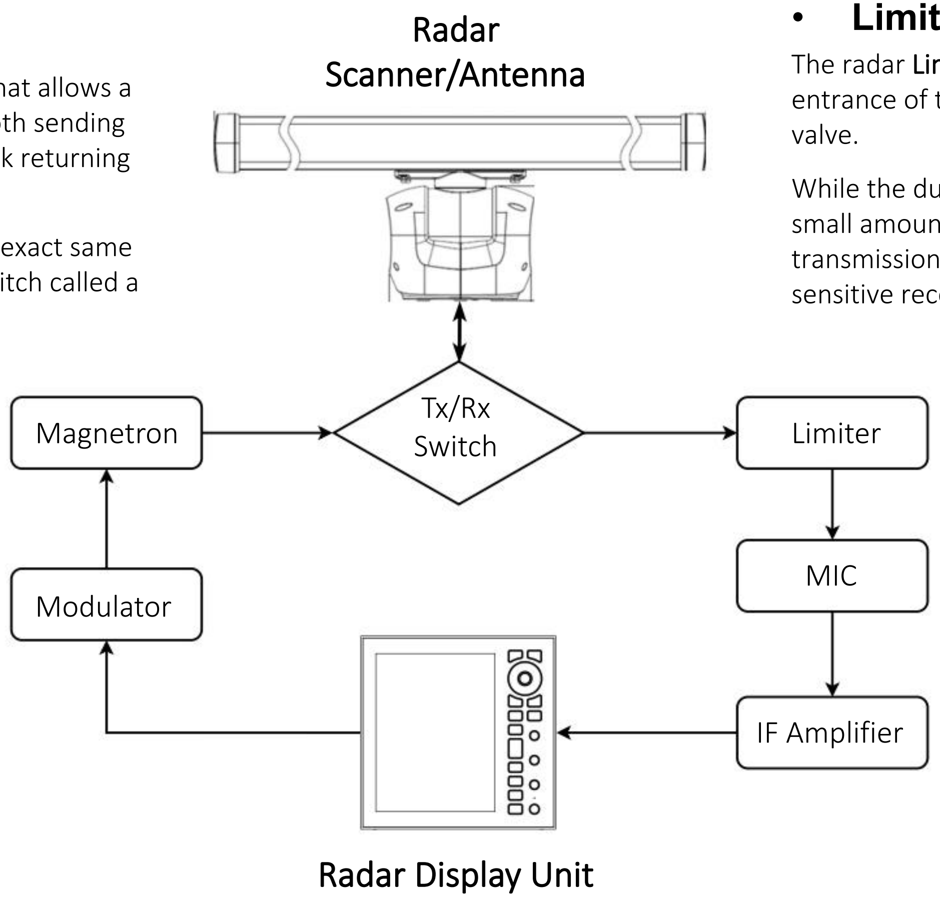
Because a radar cannot transmit and receive at the exact same microsecond, it relies on a specialized electronic switch called a duplexer to handle this routing

- **Magnetron**

A Magnetron is a specialized vacuum tube that acts as the high-power transmitter in traditional marine radar systems. It converts electrical energy into powerful bursts of microwave radio waves

- **Modulator**

The Modulator acts as the master electronic trigger of a magnetron-based marine radar system. Its primary job is to take steady electrical power from the ship's supply, store it, and release it as ultra-short, high-voltage square pulses to fire the magnetron



- **Limiter**

The radar Limiter is a critical protective component situated right at the entrance of the receiver circuit. It acts as a final electronic firewall or safety valve.

While the duplexer (TX/RX switch) handles the bulk routing of high power, a small amount of dangerous microwave energy can still leak past it during transmission. The limiter stops this residual energy from destroying the sensitive receiver.

- **MIC (Microwave Integrated Circuit)**

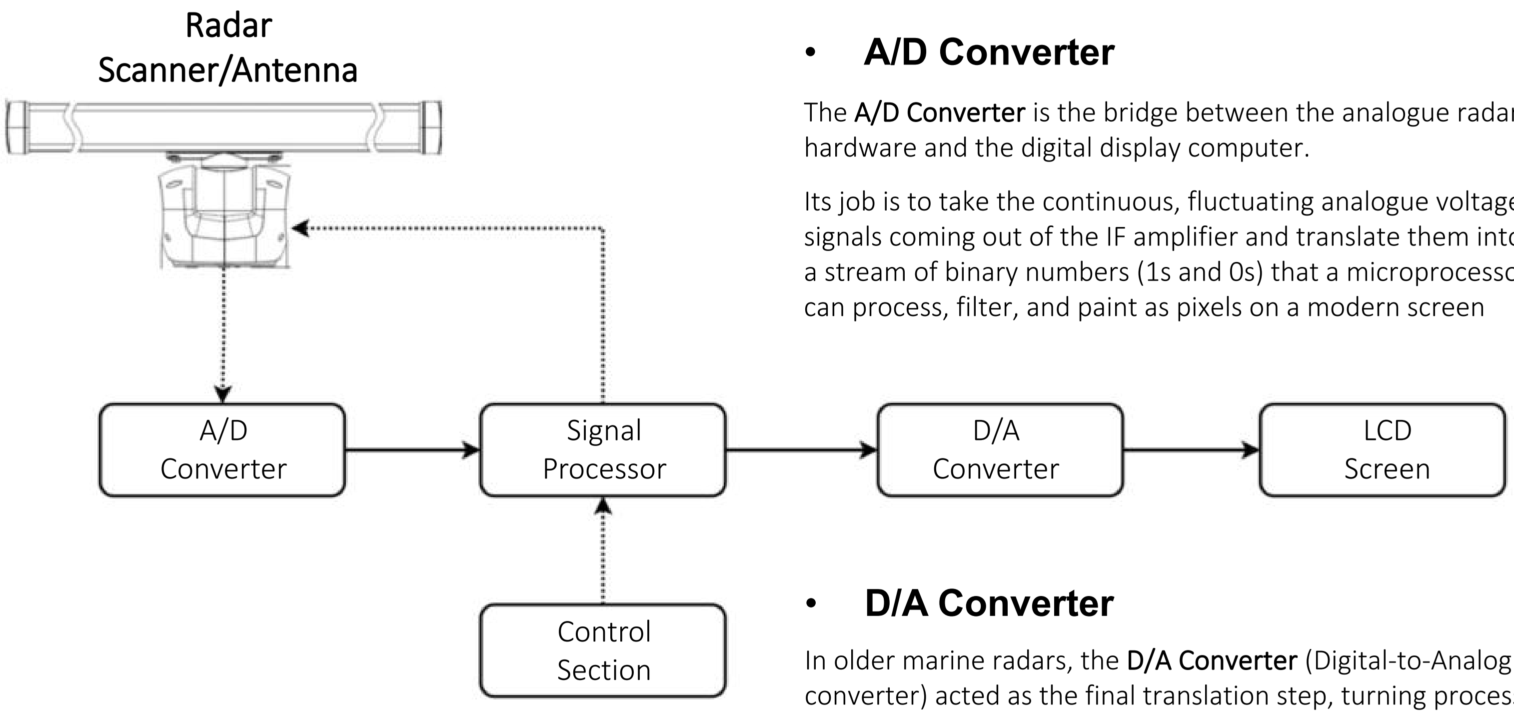
The Microwave Integrated Circuit (MIC)— is the tiny, high-tech semiconductor chip that acts as the frontline processing hub for a marine radar's receiver stage. It handles the incoming ultra-high frequency microwave signals (such as 9.4 GHz for X-band or 3 GHz for S-band) and prepares them for the radar's computer display.

- **IF Amplifier**

The Intermediate Frequency (IF) amplifier is the component in a marine radar receiver that processes the signal immediately after it leaves the Microwave Integrated Circuit (MIC).

Its main job is to take the down-converted 30 MHz or 60 MHz IF signal from the mixer, heavily amplify it, filter out background noise, and prepare it for conversion into visual pixels on the display screen

System Configuration | *Display unit components*



• A/D Converter

The **A/D Converter** is the bridge between the analogue radar hardware and the digital display computer.

Its job is to take the continuous, fluctuating analogue voltage signals coming out of the IF amplifier and translate them into a stream of binary numbers (1s and 0s) that a microprocessor can process, filter, and paint as pixels on a modern screen

• D/A Converter

In older marine radars, the **D/A Converter** (Digital-to-Analogue converter) acted as the final translation step, turning processed digital target data back into continuous voltage sweeps to physically drive the electron gun of an analogue CRT monitor. However, in modern marine radar systems, standalone D/A converters for the video signal have been completely eliminated. Modern screens (LCD and LED panels) are native digital displays that read data directly from the computer's graphics memory buffer

• Signal Processing

Marine radar **Signal Processing** is the "brain" of the radar system. It takes the messy, raw binary data stream from the A/D converter and applies advanced mathematical algorithms to clean up the image, eliminate environmental interference, and extract target tracking data before sending it to the screen

• Control Section

The **Control Section** of a marine radar serves as the user interface, allowing the captain or navigator to adjust the radar's internal hardware and digital signal processor (DSP). Modern marine radars house these controls within an on-screen menu system operated via touchscreen, trackball, or a physical keypad.
Adjusting these controls directly alters how components like the modulator, IF amplifier, and DSP manipulate incoming signal data

Terminology

- **Radar Range Resolution**
- **Radar Bearing Resolution**
- **Pulse Repetition Rate**
- **Horizontal Beamwidth**
- **Vertical Beamwidth**
- **Output Power**
- **Minimum Detectable Range**
- **Maximum Detectable Range**

Terminology | *Radar Resolution (Range & Bearing）*

Marine radar resolution refers to the system's ability to display two closely spaced targets as separate "blips" on the screen, rather than blurring them together into a single large object.Radar resolution is split into two distinct dimensions: Range Resolution (depth) and Bearing Resolution (width)

Range Resolution (Separation by Distance)

Range resolution is the radar's ability to distinguish two separate targets that are on the exact same heading line, but at slightly different distances from your ship.

- **The Determining Factor**: It is strictly determined by the **Pulse Width (PW)**—the physical length of the transmitted radio pulse.
- **The Rule**: To see them as separate objects, the physical distance between Target A and Target B must be greater than **half the pulse length**.
- **Operational Performance**:
    - **Short Range**: The radar automatically uses a very narrow pulse width (e.g., 0.05 microseconds). This creates an exceptional range resolution of around **7.5 metres**. Targets closer together than this will remain separate.
    - **Long Range**: The radar uses a long pulse width (e.g., 1.0 microsecond) to get maximum energy out to the horizon. This drops the range resolution to roughly **150 metres**, causing close targets to merge into one blob

Bearing Resolution (Separation by Angle)

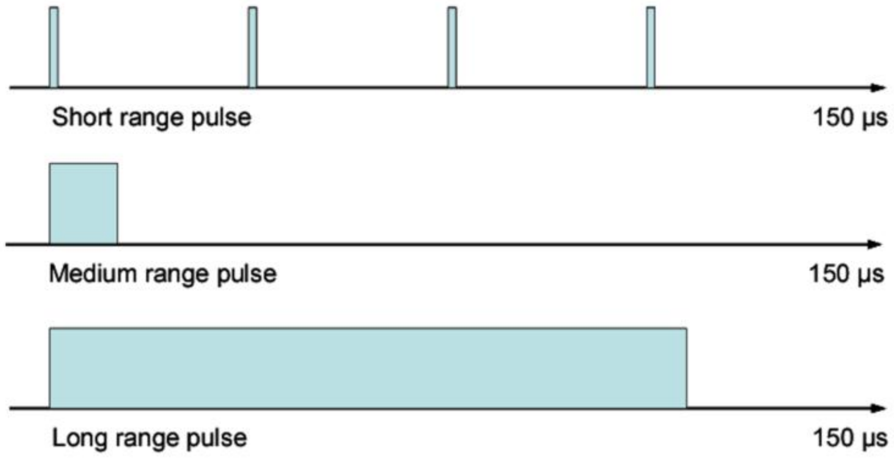
Bearing resolution (or azimuthal resolution) is the radar's ability to separate two distinct targets that are at the exact same distance from your ship, but positioned slightly side-by-side.

- **The Determining Factor**: It is strictly determined by the **Horizontal Beamwidth** of the radar antenna.
- **The Rule**: If two targets are closer together than the angular width of the radar beam, the energy will hit both targets simultaneously during the sweep, painting them as a single continuous line on the monitor.
- **Antenna Size Impact**: A narrower beamwidth provides sharper bearing resolution. Because physics dictates that longer antennas create narrower beams, a large 6-foot commercial "open array" antenna has a very narrow beam (approx. 1.2°), offering incredible target separation. A small 18-inch enclosed dome antenna has a wider beam (approx. 4° to 5°), meaning side-by-side targets blur together much more easily.

Terminology | *Pulse Width Adaptation/ Pulse Repetition Rate*

The Pulse Repetition Frequency (PRF)—also called the pulse repetition rate (PRR) —is the number of times the radar transmitter fires a microwave pulse into the atmosphere every second. It is measured in Hertz (Hz) or pulses per second. Marine radars automatically vary this rate from roughly 600 Hz up to 4,000+ Hz depending on the distance range selected by the operator. When an operator changes the range setting on the display, the radar automatically alters its pulse characteristics.

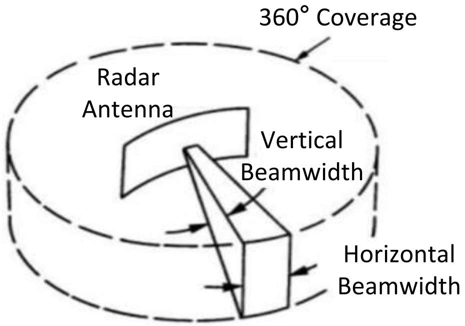
- Short Range (< 1.5 NM): The radar uses a Short Pulse. This provides exceptional target separation and clarity for docking, but lacks the energy to travel far.
- Mid-range (1.5 to 12 NM): The radar automatically switches to a Medium Pulse. This setting acts as a balanced compromise between the other two modes:
    - Energy vs. Resolution: It provides more energy than a short pulse to reach mid-distance targets, while maintaining better target clarity than a long pulse.
    - Primary Use: Operators use mid-range scanning for general coastal navigation, tracking moving vessel traffic, and monitoring local weather cells.
- Long Range (> 12 NM): The radar switches to a Long Pulse. This injects maximum energy into the environment to detect distant storms or coastlines, though it reduces close-range detail.

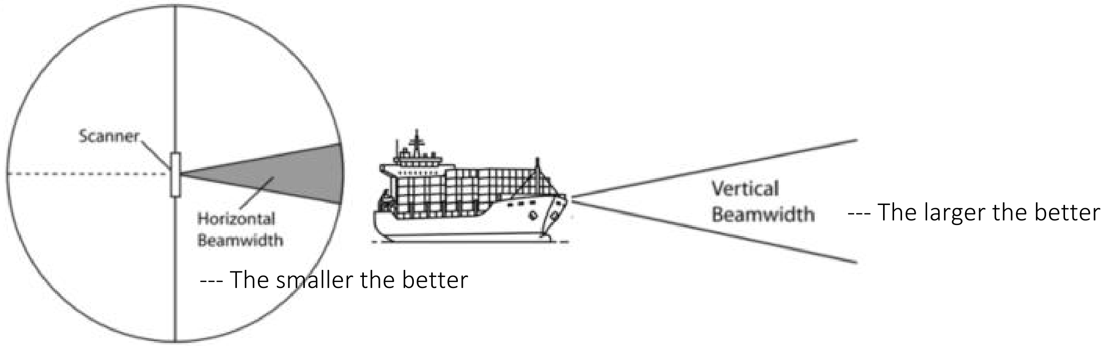


Terminology | *Beamwidth (Horizontal & Vertical)*

Marine radar beamwidth refers to the angular width or "spread" of the microwave energy emitted by the rotating antenna. It is measured in degrees and directly determines a radar's **bearing resolution** (the ability to separate side-by-side targets).

Radar beamwidth is divided into two dimensions: **horizontal** and **vertical**





Horizontal Beamwidth (The Sharpness Control)

Horizontal beamwidth controls the angular width of the radar beam as it sweeps across the water's surface.

- **The Goal**: It must be **as narrow as possible** (typically between **1° and 4°**). A narrow beam acts like a focused flashlight, painting razor-sharp targets on the screen.
- **Target Separation**: If two boats are sitting side-by-side close together, a 1° beam can pass between them and show them as two distinct objects. A wide 4° beam will hit both boats at the same time, merging them into one confusing blob on the display.
- **The Antenna Size Rule**: Horizontal beamwidth is governed by the physical length of the radar antenna. Due to the physics of microwave diffraction, **longer antennas create narrower beams**.
- Small enclosed domes (18 to 24 inches) have a wide horizontal beamwidth of **4° to 5°**.
- Large commercial open-arrays (4 to 6 feet) create a highly compressed horizontal beamwidth of **1° to 2°**

Vertical Beamwidth (The Pitch and Roll Safety Net)

Vertical beamwidth controls how wide the radar beam spreads up and down into the sky and water.

- **The Goal**: It must be **intentionally wide** (typically between **20° and 25°**).
- **Vessel Movement Protection**: Boats do not stay perfectly flat; they pitch up and down over waves and heel (lean) heavily to one side when turning or under sail.
- **The Benefit**: If the vertical beam were narrow (like the horizontal beam), the radar would shoot its energy into the sky or down into the water every time the boat rolled, losing sight of targets. A wide 25° vertical fan ensures the radar keeps a steady grip on the horizon, tracking targets continuously regardless of the vessel's movement

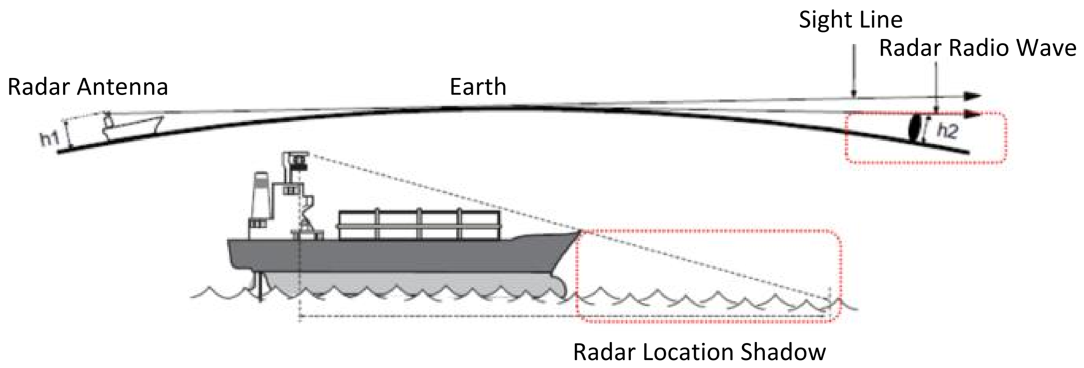
Terminology | *Output Power & Min/Max Detectable Range*

Output Power:

Traditional Magnetron Radar Power (High Peak Power)

Traditional radars rely on massive, short bursts of raw energy. This power is measured as **Peak Power**—the absolute maximum wattage achieved during the brief microsecond the pulse is firing.

- **Recreational / Small Commercial (4 kW to 6 kW)**: Standard for small fishing boats, yachts, and tugboats. This provides reliable scanning out to 36 or 48 nautical miles.
- **Mid-Sized Commercial (10 kW to 12 kW)**: Common on coastal cargo ships, ferries, and larger workboats. This offers cleaner target detection through heavy rain and out to 72 nautical miles.
- **Large Commercial / Deep Sea (25 kW to 50+ kW)**: Used on ocean-going container ships, tankers, and naval vessels. This immense power is required to punch through severe open-ocean storms and maximize long-range tracking up to 96 nautical miles.



Minimum detectable range:

The **minimum detectable range** is the shortest distance from your vessel at which a radar can successfully detect and display an object. If a target—such as a small boat, buoy, or concrete piling—is closer than this distance, it enters a "blind zone" around your ship and completely disappears from the screen.

In traditional marine radars, this minimum distance typically ranges between **15 to 30 metres**.

$$\text{Minimum Range} = \frac{\text{Speed of Light} \times \text{Pulse Width}}{2}$$

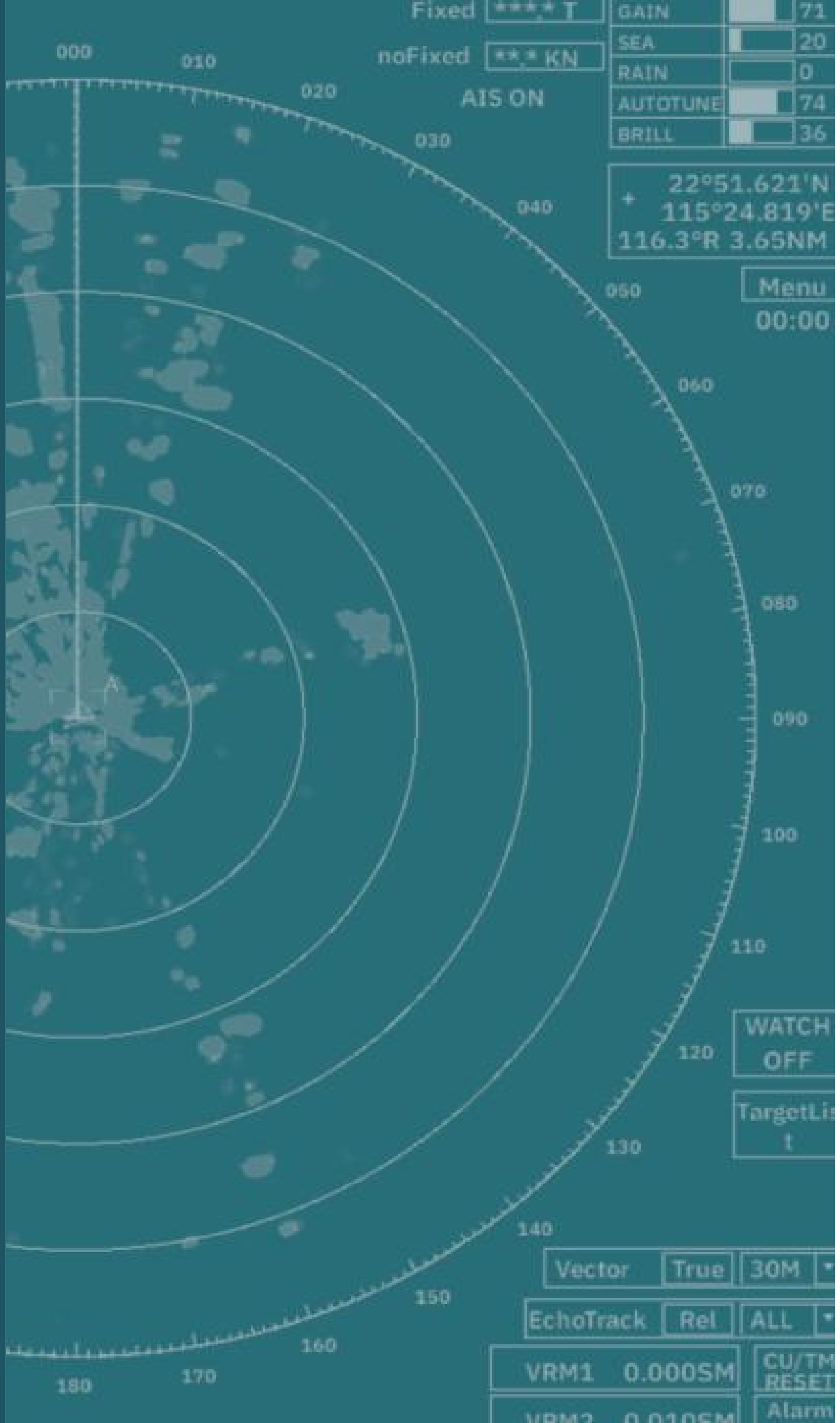
Maximum detectable range:

The **maximum detectable range** is the furthest distance at which a marine radar can identify an object before it disappears from the screen. For standard commercial and recreational vessels, this range typically spans from **24 to 96 nautical miles**.

Unlike minimum range, which is limited by internal electronics, maximum range is primarily dictated by geography and physics

$$\text{Maximum Distance (NM)} = 2.22 \times (\sqrt{h_{\text{antenna}}} + \sqrt{h_{\text{target}}})$$

Radar Controls



Operating and maintaining a marine radar requires strict safety and operational precautions. Because these systems handle both high-voltage electricity and high-frequency microwave radiation, operators must follow specific guidelines to protect both personnel and the equipment.

This section briefly describes the function, objective and usage of Radar controls.

Note that some controls described here may not be provided on your Radar.
For detailed control description, check your Operator's Manual.

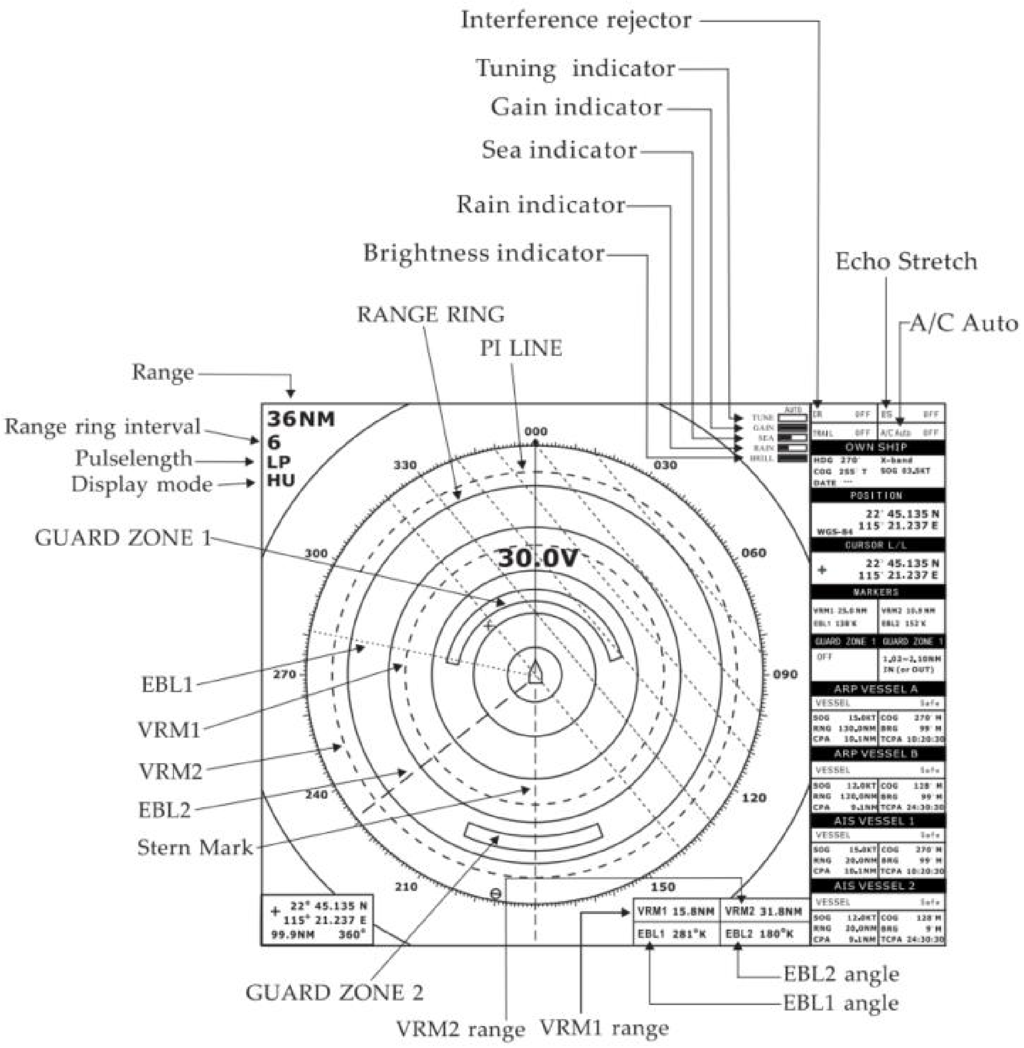
Radiation Hazards (Health Precautions)

High-power traditional magnetron radars (4kW to 25kW+) emit microwave radiation that can cause severe internal tissue damage, particularly to the eyes.

- Clear the Mast: Never work on the radar mast or approach the antenna scanner while the system is transmitting.
- Establish Safe Distances: Ensure no crew members are within the radar's physical line of sight close to the antenna (typically within 2 to 5 metres for commercial units) when turned on.
- Switch to Standby: Always switch the radar to Standby (STBY) mode or turn it completely off when entering a crowded marina or docking alongside other vessels to avoid radiating people on adjacent docks

Radar Control |

To control a marine radar effectively, you must follow a structured process to turn on the equipment, clear away environmental interference, and use electronic tools to measure hazards



- ST BY/TX: ---- Press this key to transmit radio pulses. To stop transmitting, press the key again.
- Gain: ---- This control adjusts receiver sensitivity. Adjust the gain to increase ensitivity and display echoes. For long range, adjust the control so background noise is just visible on the display. For short range, some Radar operators set this control relatively high and adjust sensitivity using the A/C SEA control.
- A/C Rain (FTC): ---- The Rain control, also called FTC (Fast Time Constant), suppresses the reflected echoes from rain and snow to clear the display. On the X band Radar, because of its short pulselength, the echoes from legitimate contacts can become lost in the echoes from precipitation, called rain clutter. When rain clutter masks the display, adjust this control to break up the clutter and distinguish echoes. Adjust the control so that the clutter just is appears; too much A/C Rain action may shrink or erase the echoes from legitimate targets.
- A/C Sea (STC): ---- Sea control, also called STC (Sensitivity Time Constant), suppresses reflections from waves near own ship. In rough seas the reflected echoes from wave crests are very strong, producing a mass of echoes which cover the central part of the display. This is called sea clutter. Any echoes within the clutter will be partially or totally obscured. Adjust this control to reduce the clutter and distinguish echoes. The proper setting should be such that the clutter is suppressed and echoes become distinguishable. If the control is set too high, both sea clutter and echoes will disappear from the display. When there is no sea clutter visible on the display, turn the control fully counterclockwise.

Radar Control |

- **Brill:** ---- This control adjusts the display brilliance.

- **Range:** ---- Press the [+] and [-] keys to raise and lower the range respectively. When you change ranges, the number of range rings and range ring interval as well as pulselength are automatically changed. For confirmation, the range and range ring interval appear on the display.

- **Rings:** ---- Press this key to show or hide the range rings. Range rings provide an estimate of the range to a target. The number of range rings and range ring interval automatically change with the range. Ring interval (distance between rings) appears on the display.

- **VRM:** ---- The VRM (Variable Range Marker) measures the range to targets. To measure range, press the key to display the VRM. It appears as a dashed circle. Adjust the VRM so that it touches the inner edge of the target. The range to the target appears in a data box on the display. Some Radars may display two VRM's; the length of the dash of the VRM-2 is longer than that of the VRM-1.

- **EBL: ----** The EBL (Electronic Bearing Line) measures bearing to targets in degrees. To measure bearing, press the key to display the EBL. It appears as a dashed line. Adjust the EBL so that it bisects the target. The bearing to target appears in a data box on the display. Some Radars can display two EBL's; the length of the dash of the EBL-2 is longer than that of the EBL-1.

- **Offset EBL: ----** This EBL can be shifted to any location on the display. This allows you to predict other ships' course (to avoid collision) and measure the range and bearing between two targets.

- **Plot:** ---- This function plots the movement of all ships relative to own position. Press the key to start plotting. The positions of all targets at the end of the preset time are marked on the display.

- **Echo Trails:** ---- This feature continuously shows the movements of other ships in afterglow. It is useful for assessing target movement and collision possibility.

- **Display Mode:** ---- The display mode determines target position and movement on the display. There are two types of display mode: Relative and True.
  - ✓ **Relative Bearing Display:** This mode is also known as Head-up, since own ships heading is always at the top of the display. The position of own ship is fixed and echoes of all other objects therefore move relative to own ship. This is the usual form in small Radar sets.
  - ✓ **True Bearing Display:** This mode is sometimes called North-up since the display is oriented North. This mode is suitable for long-range observation since it is somewhat like looking at a nautical chart.

Radar Control |

- Off Center: ---- This key shifts the display center to location desired. The off-center display allows the operator to view the situation around own ship without changing the range. Set the cursor where you want the center position to be, and then press the key. To cancel the off-center display, press the key again.

- Zoom: ---- The ZOOM feature allows you to take a closer look at a target of interest. Set the cursor near the object you want to zoom and press the key. To cancel zoom, press the key again.

- Parallel Index Lines: ---- Parallel Index lines are useful for maintaining a constant distance between own ship and the coastline or a partner ship. Press the key to toggle paraallel index lines on and off.

- Interference Rejection: ---- This control reduces or eliminates interference received from another ship's Radar. Turn it off when no Radar interference exists.

- Guard Alarm: ---- The guard alarm creates a zone about own ship, either complete 360 degree zone or a specific area forward of own ship. If targets enter or exit the zone an audible alarm sounds to alert the operator.

- Echo Averaging: ---- The Radar's internal circuitry processes echo data to obtain a desired effect. The result depends on the Radar model. For example, some Radars may suppress brilliance of unstable echoes (sea clutter, etc.) or emphasize an unstable small echo.

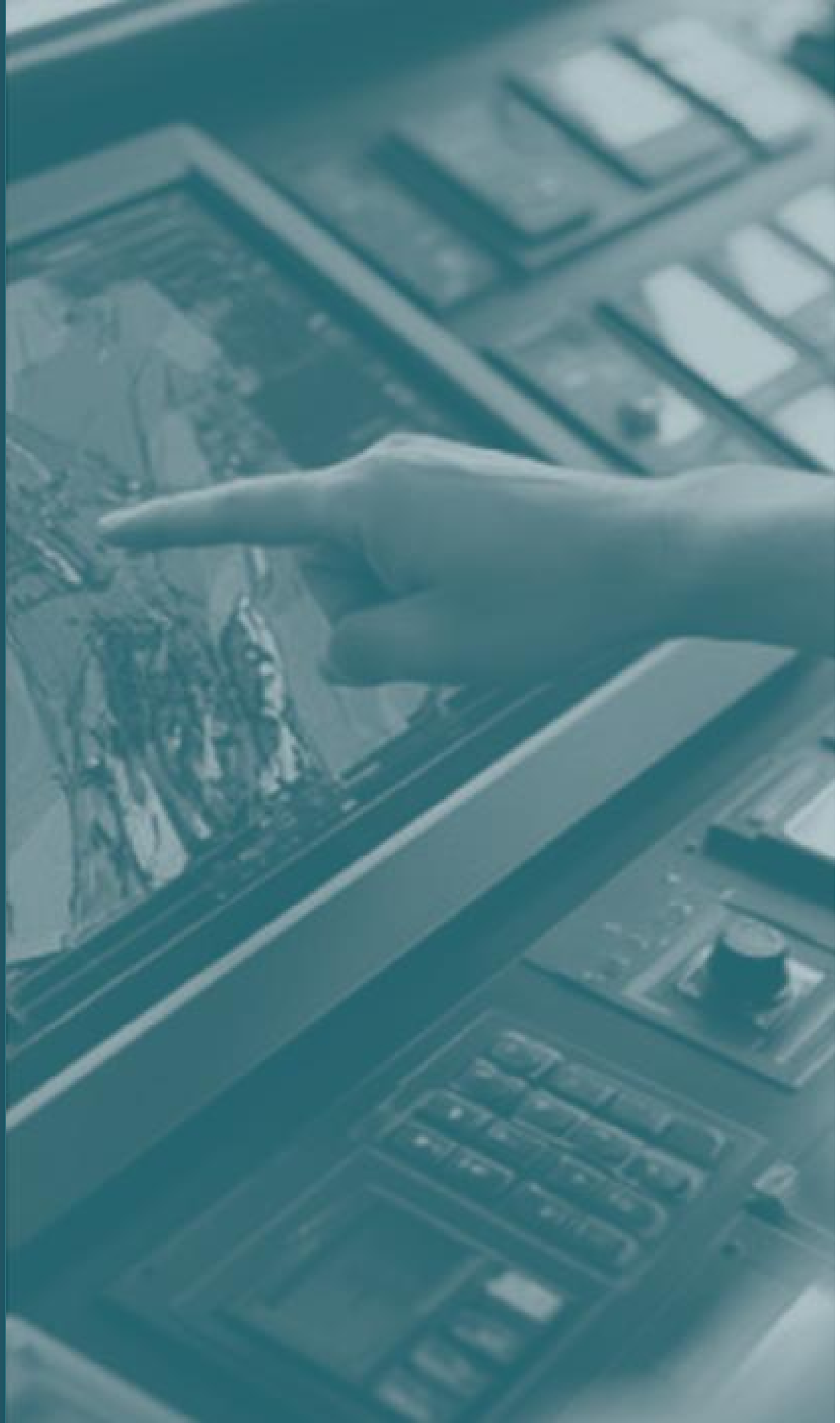
- Echo Color & Background Color: ---- These settings change display color and background color respectively to improve display visibility. Note that marks and characters also change color when the keys are pressed.

- Heading Marker Off: ---- The heading mark may sometimes hide a small echo. To show that echo, press and hold down the Heading Marker OFF key to temporarily erase the heading mark . Release the key to display the heading mark.

- Echo Stretch: ---- This function 'stretches' small echoes to make them easier to see. It stretches not only small echoes but also returns from sea and rain clutter and Radar interference. For this reason, make sure clutter and interference are sufficiently suppressed before using echo stretch.

- NAV: ---- This key shows/hides navigation data, including position, range and bearing to waypoint, ship's speed and more. This feature usually requires a navigation aid which can output data in NMEA0183 or NMEA2000 format. If a gyrocompass is connected to the Radar, a dashed line connects navaid-selected waypoint with own ship's position.

Radar Operation



Basic operations for a marine radar involve a standard sequence to safely start, tune, and utilize the system for navigation and collision avoidance on the water.

Usually adjust the controls in below order:

1. Brilliance
2. Gain
3. *Frequency tuning* (if present) ….. Range at 5~6 nm.*
4. Then reduce to half or quarter-mile range and adjust sea clutter. (Good weather turn off Rain/Snow Clutter)

Usually the Brilliance, Sea Clutter and Rain Clutter controls adjust from low to high, Gain control adjust from high to low.

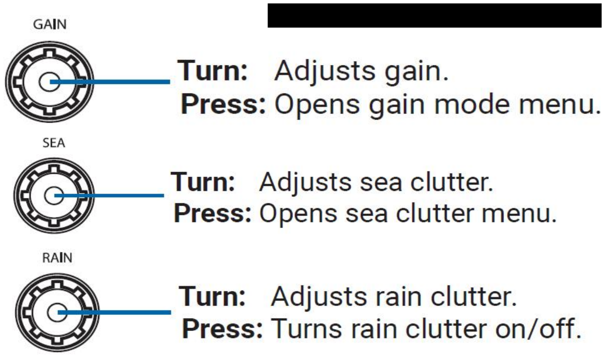
Radar Operation | *Operation Guideline*

AUTO MODE

If your radar has automatic control functions, auto-GAIN or auto-SEA/RAIN, allow the radar to set the auto-levels until you are familiar with the manual controls.
But you should also learn to manage these functions yourself (unless your radar is completely automatic and doesn't provide this manual option.)
Once you have learned to control these functions' manual adjust, you will find that in bad sea state/weather, you can do a better job to get a clear radar picture than the automatic modes possibly can.

【Recommend】
- New operator uses Auto-mode.
- Experience operator uses Manual-mode.

MANUAL MODE



Radar Operation | *Basic Operation*

The Startup Sequence

- **Power On**: Turn on the main circuit breaker and press the power button on the control console.

- **Warm-Up Phase**: If using a traditional magnetron radar, a countdown timer will appear (typically **2 to 3 minutes**) while the transmitter filament heats up.

- **Standby Mode (STBY)**: Once warmed up, the radar enters Standby. The system is active, but the antenna is not rotating and it is not transmitting radiation. **Transmit (TX)**: Press the "TX" or "STBR/TX" button to begin physical antenna rotation and live signal transmission

Setting Up the Screen (The "Step" Tuning Method)

To ensure you do not miss critical targets, adjust your controls in this exact sequence every time you start the system:

- **Select Range**: Choose a mid-range setting (like 6 or 12 nautical miles) for open water, or a short range (1.5 nautical miles) for tight channels.

- **Adjust Gain**: Turn the Gain control up until a light speckle of background static appears across the screen, then back it off slightly until the screen is clean.

- **Clear Sea Clutter (STC)**: If waves are creating a bright cluster around the center of your screen, gradually turn up the Sea control until the wave static dissolves, leaving solid targets visible.

- **Clear Rain Clutter (FTC)**: If passing through rain or fog, gently apply the Rain control to strip away the fuzzy blocks of weather data and reveal hard edges

Basic Navigation Tools

- **Range Rings**: Turn these electronic concentric circles on to instantly estimate the distance of an object from your center position.

- **VRM (Variable Range Marker)**: Roll this adjustable ring out until it touches a specific target to read its exact distance down to the decimal mile.

- **EBL (Electronic Bearing Line)**: Rotate this digital pointer line until it cuts through a target to measure its exact directional angle relative to your bow or True North

Radar Operation | *Advanced Operation - 1*

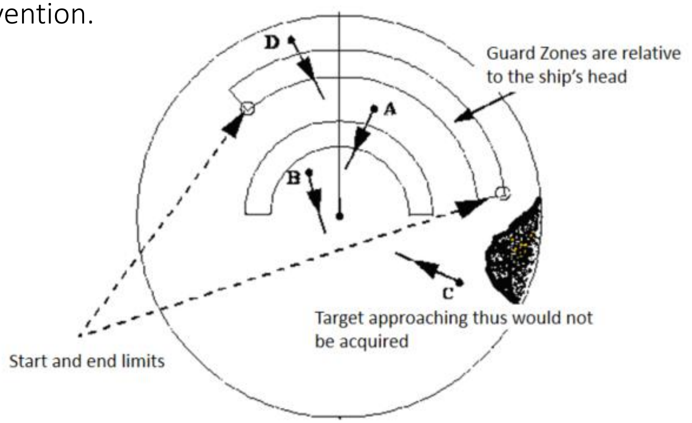
Advanced operations move beyond basic screen tuning to actively leverage the radar's computer processor for precision navigation, tactical route planning, and automated collision avoidance.
These functions require integration with the vessel's electronic compass (Gyro/GPS compass) and speed log.

Setting Up Guard Zones and Acquisition Zones

Operators use the control section to draw electronic boundaries on the radar map to automate watchkeeping during long ocean passages.

- **Guard Zones**: An operator sets a sector arc (e.g., between 045° and 135° at a distance of 3 to 5 nautical miles). If any untracked echo—like a sudden squall, a fishing vessel, or a jet ski—enters this zone, a loud alarm sounds on the bridge.

- **Acquisition Zones**: A specialized zone where the ARPA processor automatically intercepts any incoming target, locks onto it, and immediately begins calculating its speed, heading, and CPA without human intervention.



Automated Target Tracking (TT=ARPA / MARPA)

Automatic Radar Plotting Aids (ARPA) and Mini-ARPA (MARPA) allow the radar's processor to track moving vessels over time to calculate collision risks.

- **Acquisition**: The operator clicks on a target blip, or the system automatically locks onto targets entering designated sectors.

- **Vector Lines**: The radar displays a line (vector) extending out from the target ship. The length of the line shows where that ship will be in a set time (e.g., 6 or 12 minutes).

- **CPA & TCPA Calculation**: The processor calculates the **Closest Point of Approach (CPA)** in distance and the **Time to Closest Point of Approach (TCPA)**. If a ship's CPA falls below your safety threshold (e.g., 1.0 NM), the system triggers an audible bridge alarm.

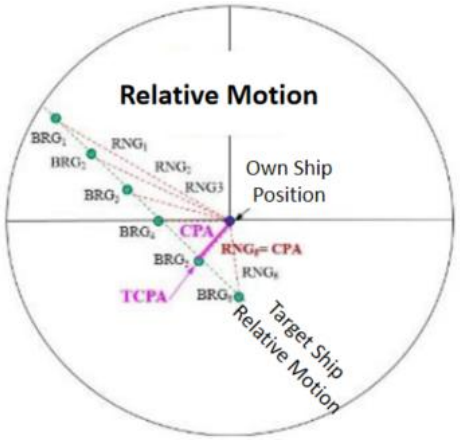
Radar Operation | *Advanced Operation - 2*

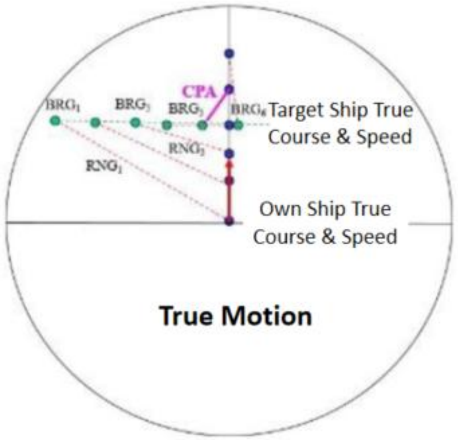
True Motion vs. Relative Motion Displays

Advanced operators switch between display stabilization modes depending on the navigational environment.

- **Relative Motion (RM)**: Your vessel remains locked at the center of the screen. All landmasses and buoys appear to move backward past your ship. This mode is highly preferred for **collision avoidance** because it immediately shows how close other vessels will pass relative to you.

- **True Motion (TM)**: Landmasses, islands, and buoys remain perfectly frozen on the screen. Your own vessel moves across the screen according to its actual speed and heading. This mode is preferred for **coastal pilotage and narrow channels** because it shows the true geographic movement of all vessels without the distortion of your own ship's turning circles.



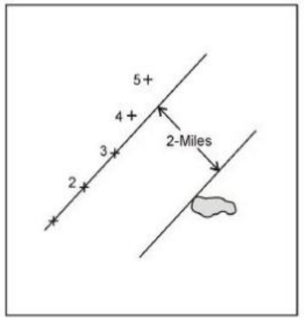


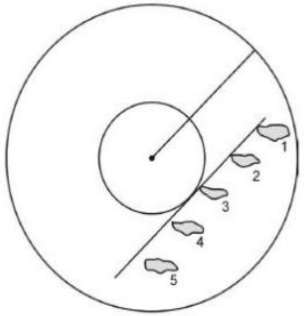
Advanced Navigation and Chart Overlay

Modern marine radar consoles can merge traditional radar imagery with electronic vector charts.

- **Radar Overlay**: The live radar picture is layered directly on top of the electronic chart display (ECDIS). This allows the captain to immediately verify if a radar target is a charted physical object (like a light tower or buoy) or an uncharted hazard (like a moving vessel or drifting debris).

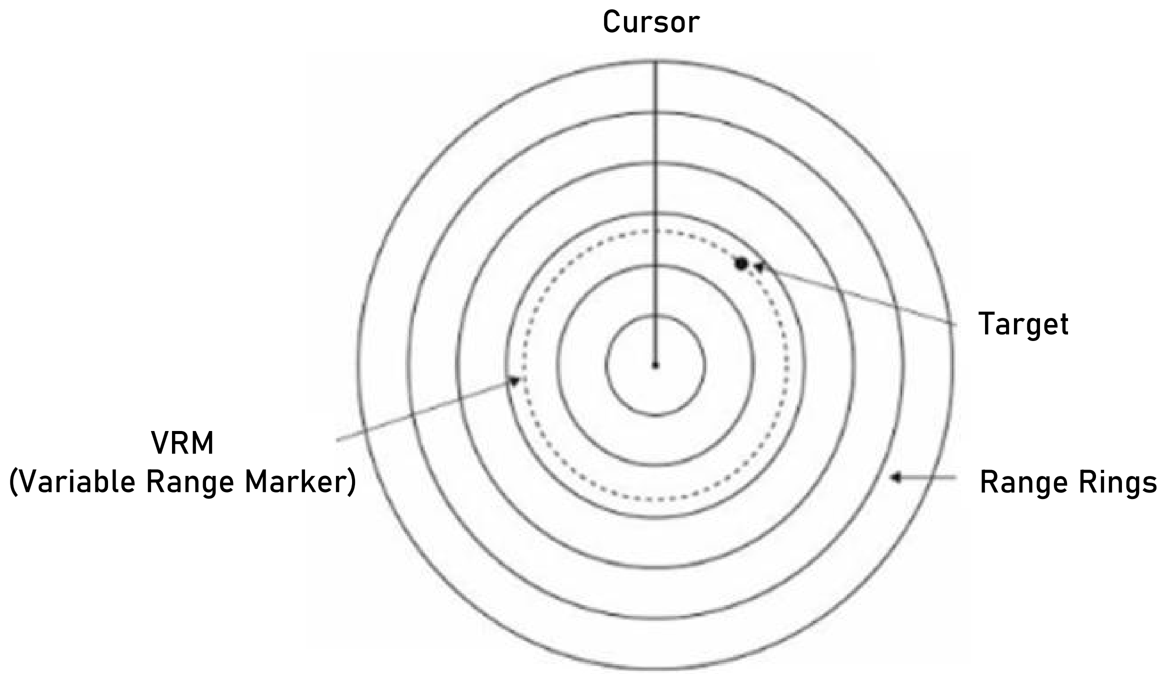
- **Parallel Index Lines (PI Lines)**: The operator draws fixed, electronic lines on the radar screen parallel to the ship's planned track line. By ensuring the radar echo of a known shoreline or island slides perfectly along the PI line, the navigator can instantly tell if wind or cross-currents are pushing the vessel off course, without needing to look at a GPS chart.





Radar Operation | *How to Measuring Range*

The range from own ship to target can be measured in three ways: by range rings, by cursor, and by VRM



By Range Rings:

The RINGS key shows/hides the range rings and adjusts their brilliance. To measure range by the range rings, count the number of rings between the center of the display and the echo. Check the range ring interval at the top of the display and judge the distance of the echo from the inner edge of the nearest ring.

By Cursor:

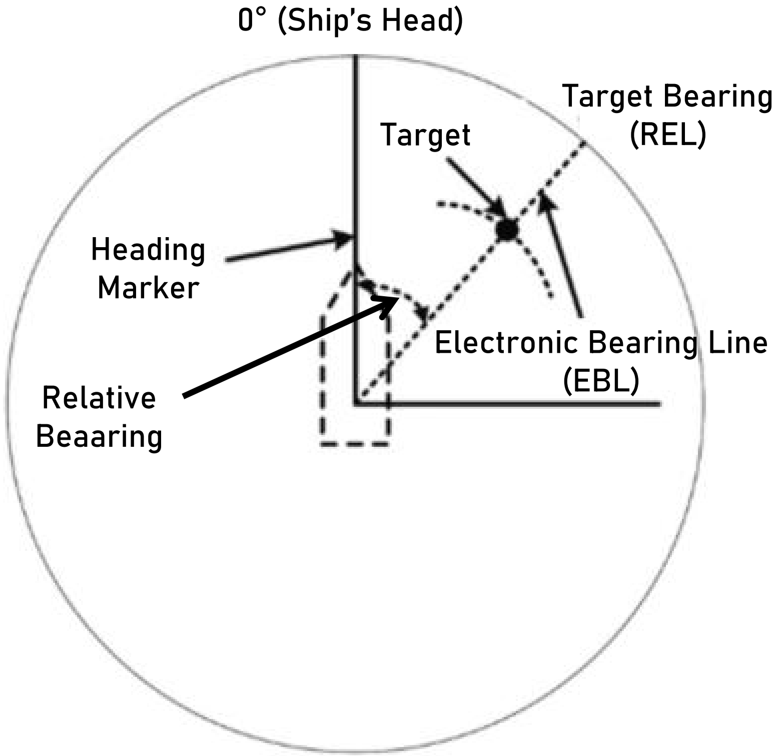
The cursor provides a more accurate measurement of range to targets. Set the cursor intersection on the inner edge of the target. The range from own ship to target appears on the display.

By VRM:

The VRM, like the cursor, provides a more accurate measurement of the range to targets. Display a VRM and adjust it so that it rests on the inner edge of the target. The range to target appears on the VRM readout.

Radar Operation | *How to Measuring Bearing*

The relative bearing of own ship to targets can be measured by cursor or EBL. When connect with gyrocompass, you can show the true bearing.



By Cursor:

Set the cursor intersection on the center of the echo. The bearing from own ship to target appears on the display

By EBL:

Display an EBL and adjust it so that it bisects the target. The bearing to the target appears on the EBL readout. Bearing relative to heading is relative bearing, while bearing relative to North is true bearing.

- No Gyrocompass Connection: ---- Relative Bearing

You can determine true bearing by adding relative bearing to your compass reading. If the sum is over 360 degrees, subtract 360 from the number.

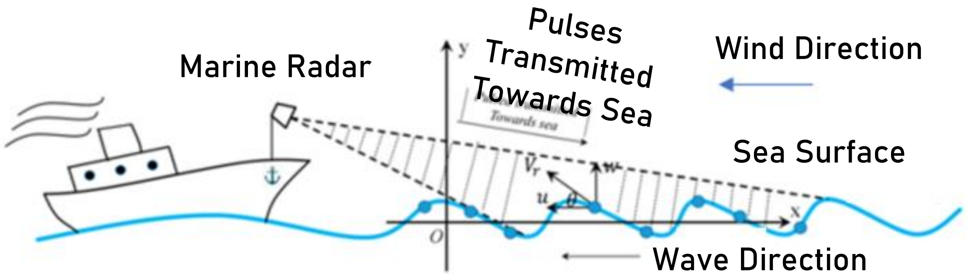
- Gyrocompass connection: ---- True Bearing

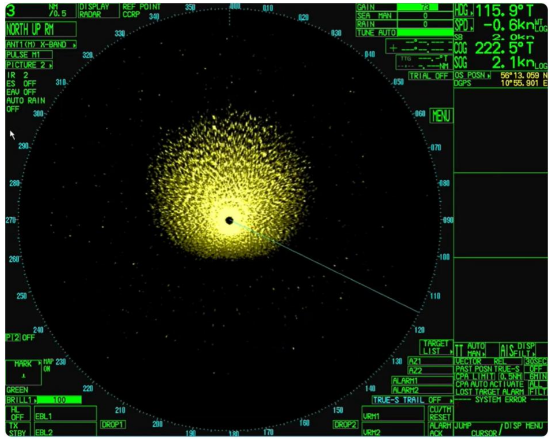
Select the true bearing display, north-up mode. Measure the bearing by the EBL and check the EBL readout.

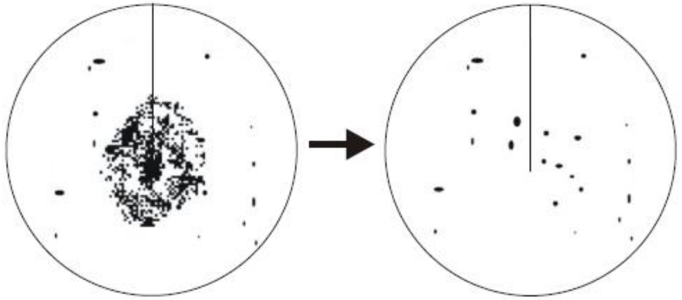
Radar Operation | *How to Suppress Sea Clutter*

To suppress sea clutter and clear the bright, chaotic wave reflections around the center of your screen, use the **Sea Clutter Control** (scientifically known as **STC** or Sensitivity Time Control). **The sea clutter typically from the ranges of 2 ~ 3 nm**

This control must be adjusted manually using a specific, step-by-step technique to avoid accidentally erasing real targets







Sea clutter at display center

A/C SEA control adjusted; sea clutter suppressed.

Step-by-Step Manual Suppression Process

1. Zero out the Sea Clutter Control ---- Turn the **Sea (STC)** knob completely down to 0% (or turn off Auto-Sea). This turns off all wave filtering and allows you to see the true extent of the clutter.

2. Set your Main Gain ---- Adjust your **Gain** control first. Turn it up until a light, even speckle of background electronic static appears on the outer edges of the screen, then back it off a fraction. The center of your screen will now look like a solid, bright blob of wave reflections—this is normal.

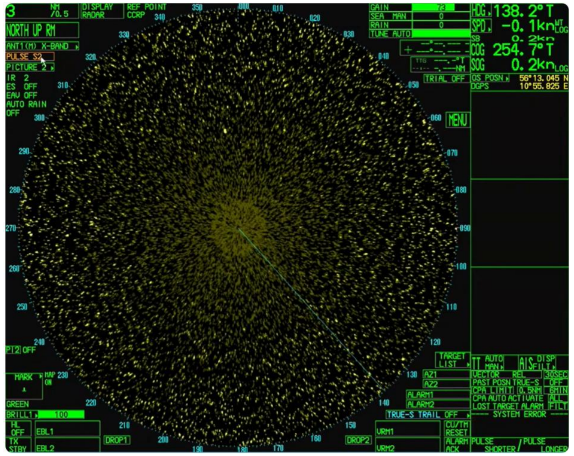
3. Gradually increase the Sea Clutter Control ---- Slowly turn the **Sea (STC)** knob clockwise. Watch the center of the display closely as you do this. You will see the wave static begin to dissolve, starting from the center your ship and cleaning outward.

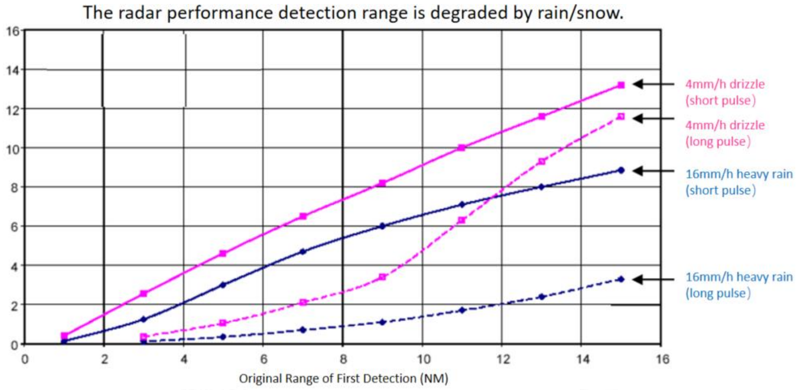
4. Stop at the "Optimal Break" Point ---- Stop turning the knob the exact moment the solid blob breaks apart into individual, tiny, flickering dots, allowing real targets (like a buoy or a boat hull) to stand out clearly.

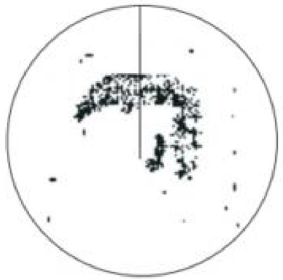
Radar Operation | *How to Suppress Rain Clutter*

To suppress rain clutter and clear the fuzzy blocks of light caused by precipitation, use the **Rain Clutter Control** (scientifically known as **FTC** or Fast Time Constant). Unlike sea clutter control, which targets a specific distance around your boat, rain clutter filtering acts on the **duration** of the returning echoes across the entire screen.

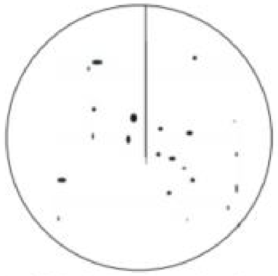
The rain clutter typical range to be within 6nm for drizzle and 3nm for heavy rain







Appearance of rain clutter



A/C RAIN control adjusted; raain clutter suppressed

Step-by-Step Manual Suppression Process

1. Identify the Weather Mass ---- Locate the rain cell on your display. It will appear as a large, fuzzy, semi-solid block of light with soft, indistinct edges that masks everything behind it.

2. Gradually Increase the Rain Control (FTC) ---- Slowly turn the **Rain (FTC)** knob clockwise. Watch the solid mass of weather closely. You will see the dense blocks of light begin to thin out and turn translucent.

3. Tune for Target Isolation ----Stop turning the knob the moment the fuzzy background cloud fades enough for solid, bright, hard-edged pixels (like ships or islands hidden inside or behind the rain) to break through.

Typical Interferences

Marine radar screens frequently display reflections that do not correspond to actual physical hazards. These are caused by environmental conditions, structural obstructions, or electronic conflicts.

Navigators must identify these interferences and false echoes to avoid making dangerous steering decisions.

Main Electronic Interferences ---- These are caused by external radio-frequency energy or system alignment issues rather than physical reflections.

- Radar-to-Radar Interference
- Side-Lobe Echoes
- Second-Trace Echoes

False Echoes Caused by Your Own Ship ---- The physical structure of your own vessel can intercept and distort the radar beam.

- Indirect Echoes (Reflection)
- Blind Sectors & Shadow Zones

Environmental False Echoes ---- These are real physical reflections from the environment, but they do not represent navigational hazards.

- Sea Clutter
- Rain Clutter
- Multiple Echoes

Typical Interferences | *Main Electronic Interferences*

Radar-to-Radar Interference:

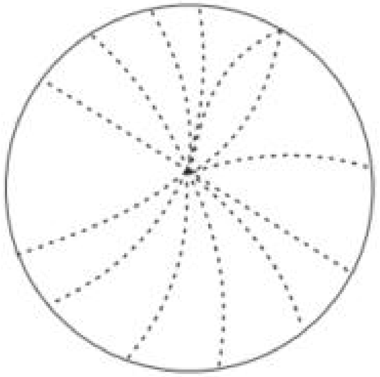
Caused when another vessel nearby is operating a radar on a similar frequency. It appears on the display as a chaotic, distinctive **spiral pattern of bright dots or dashed lines** radiating outward from the center of your screen. It is easily eliminated by turning on the **Interference Rejection (IR)** control.

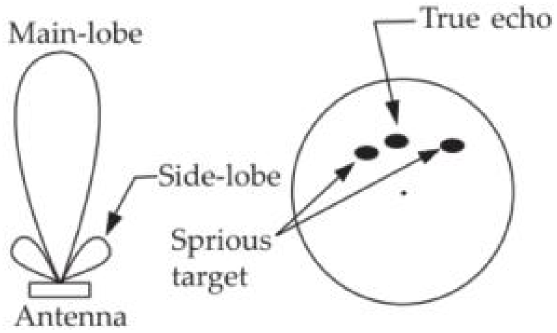
Side-Lobe Echoes:

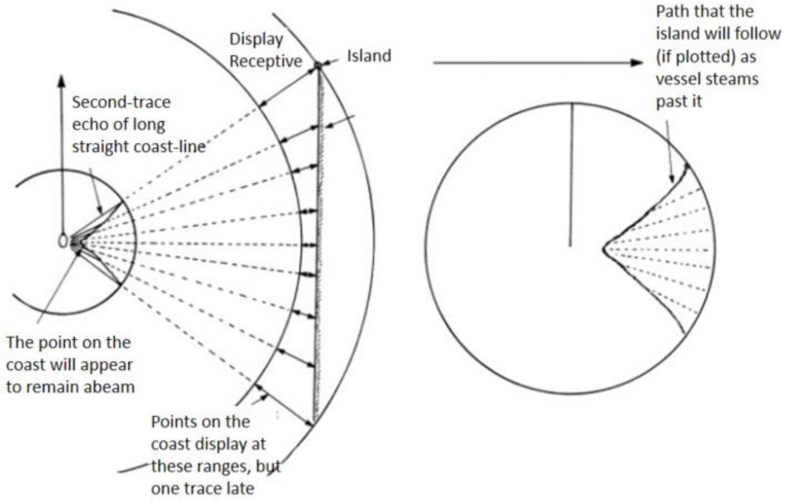
A radar antenna focuses 95% of its energy into a central main beam, but it also leaks small amounts of energy to the sides (side-lobes). If a massive steel target (like a container ship) is very close, these side-lobes will hit it and bounce back. This causes the target to appear not just at its real bearing, but as a series of **false duplicate blips forming an arc** on both sides of the real vessel.

Second-Trace Echoes:

Occur during atmospheric conditions that allow radar waves to travel super-long distances (ducting). A pulse travels way past the radar's selected range, hits a distant mountain, and returns after the next pulse has already fired. The radar computer mistakes this late echo for a close-range target, creating a false **"ghost target"** that moves erratically when you change your radar range scale.



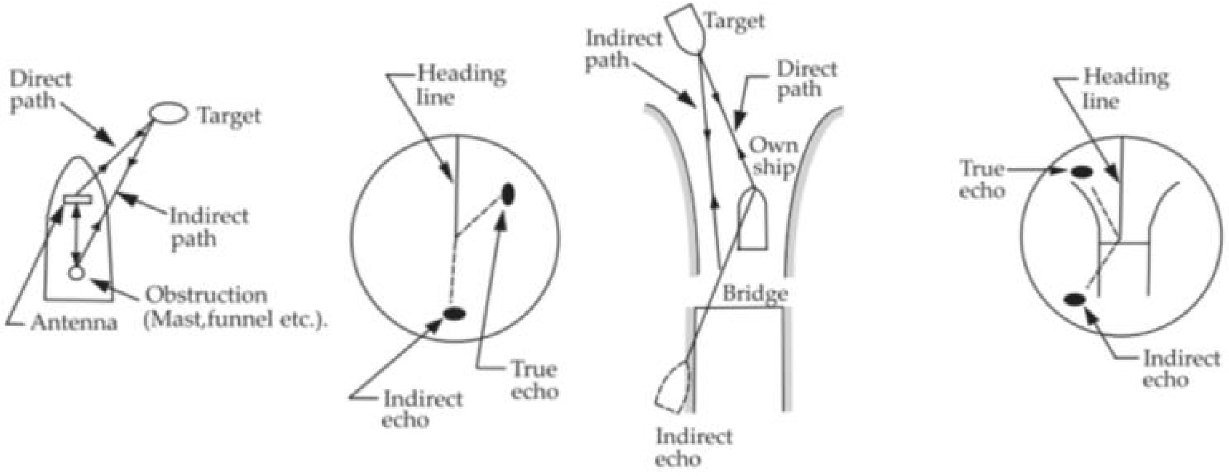




Typical Interferences | *False Echoes Caused by Your Own Ship*

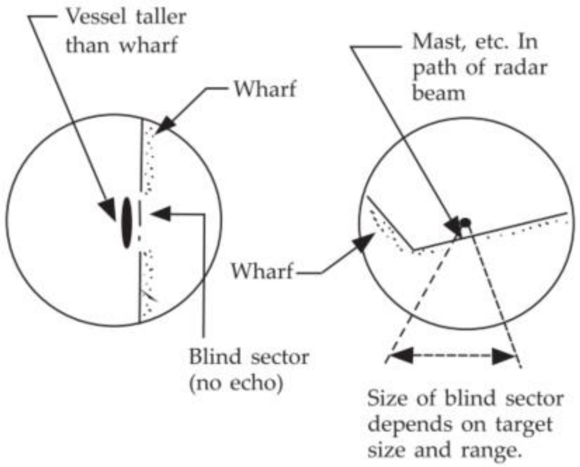
Indirect Echoes (Reflection):

Occur when the radar pulse hits a large metal part of your own ship—such as a crane boom, a large mast, or a stack funnel—and bounces sideways toward a real target. The echo returns along the exact same path. Because the radar thinks the beam went straight ahead, it displays the target on a **completely false bearing line** matching the position of your mast. You can spot these because they typically sit inside your known blind sectors



Blind Sectors & Shadow Zones:

Large masts or structures block the radar beam entirely. This creates permanent **shadow zones** on your screen where the radar is completely deaf. Real targets entering these sectors will vanish. Operators must map these blind spots (usually recorded on a placard near the radar display) so they know exactly where their visual blind spots are



Typical Interferences | *Environmental False Echoes*

Sea Clutter:

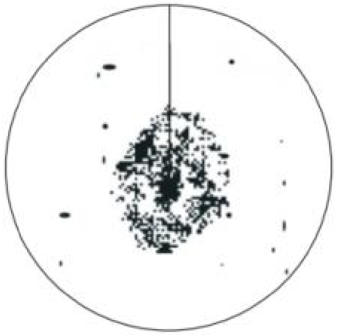
Caused by the radar beam bouncing off nearby wave crests. It appears as an unstable, bright, jagged cluster of light centered entirely around your vessel. It is managed using the **Sea Control (STC)**

Rain Clutter:

Caused by rain, snow, or dense fog scattering the radar pulses. It displays as large, fuzzy, semi-solid blocks of light that completely mask real ships or landmasses hidden inside the weather. It is managed using the **Rain Control (FTC)**

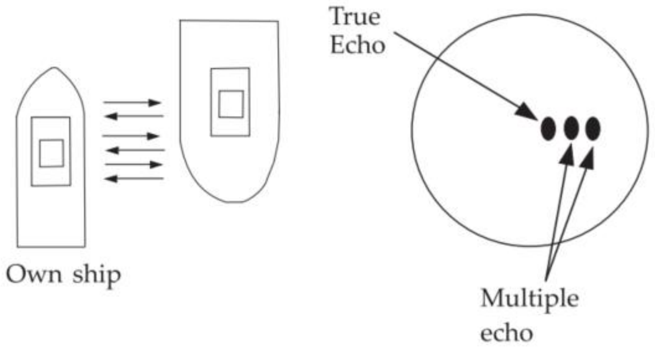
Multiple Echoes:

Occur when your vessel passes very close to another large, flat-sided metal ship or a solid concrete dock wall. The radar pulse bounces back and forth between your hull and the target multiple times. This paints a **row of false targets spaced at equal distances** stretching out behind the real object.



Sea clutter at display center

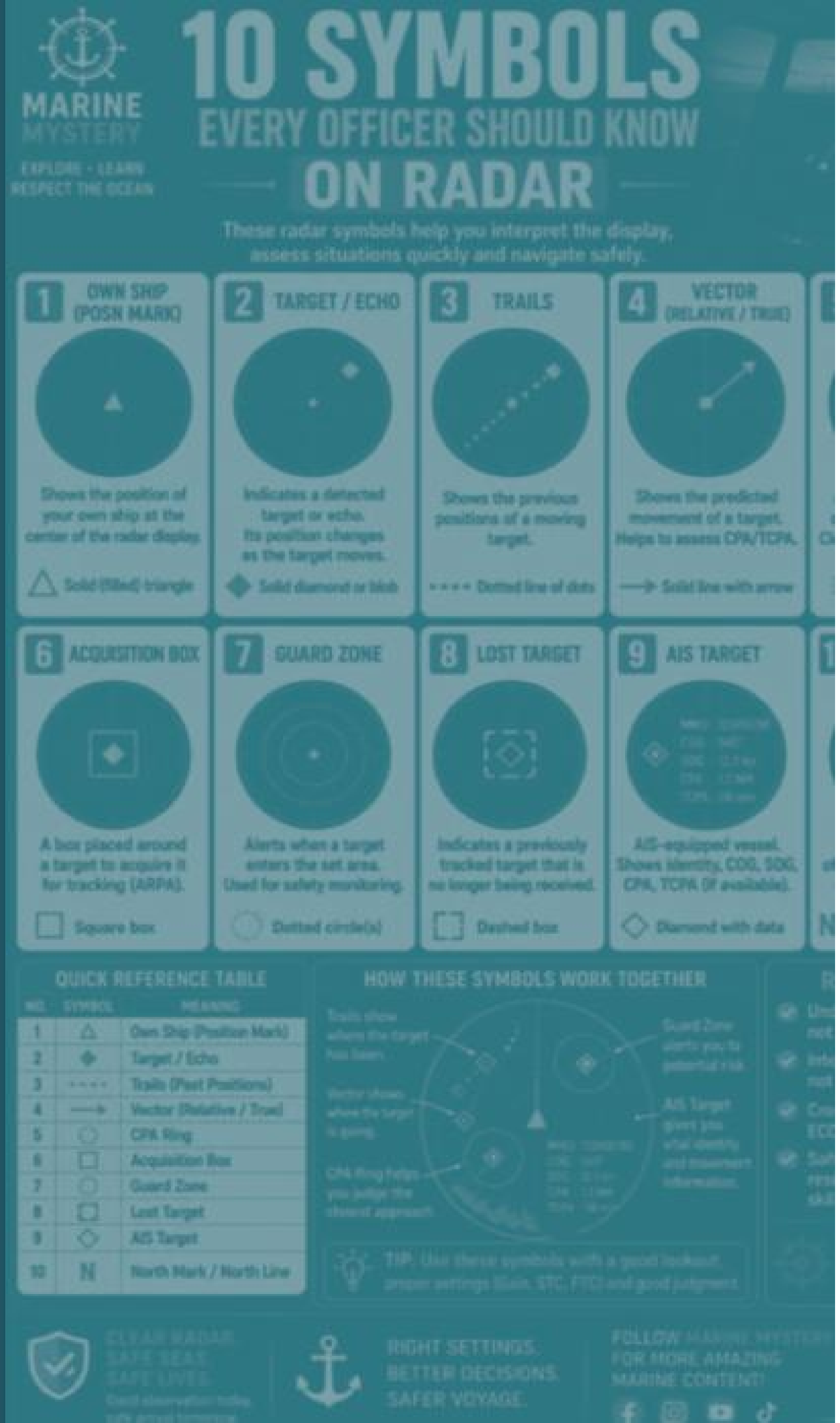
Appearance of rain clutter



Typical Interferences | *Summary Diagnostic Guide*

Visual Pattern on Screen	Probable Cause	Quick Fix/Action
Spiral or starburst lines from center	External Radar Interference	Turn on Interference Rejection (IR)
A target duplicated into a circular arc	Side-Lobe Echo	Lower the Gain control slightly
A target hidden behind a known mast line	Indirect Echo/Shadow Zone	Cross-check visually or adjust course
A string of identical ships lined up	Multiple Echoes	Ignore the trailing targets; focus on the closest

Radar Mark Definitions



navtiX

T/T (ARPA) Target Display

- Immediately after Acquisition
- Acquiring Target
- 1 min after Acquisition
- Acquiring Target (Vector unreliable)
- 3 min after Acquisition
- CPA Alarm (Flashing)
- Sleeping Target
- CPA Alarm Acknowledged
- Lost Target (Flashing)
- Target Selected

AIS Target Display

- Sleeping Target
- Real AIS AtoN
- Actived Target
- Virtual AIS AtoN
- ROT Higher Than Preset ROT
- Base Station
- Selected Target
- Airborne SAR aircraft
- Dangerous Target
- AIS SARTs
- Lost Target

Marine Radar FAQ's

navtiX

Question: How big does my boat have to be to have a Radar?
Answer: There is no size limitation for a boat to have a Radar. As long as you have a mounting platform for the antenna installation and enough dash space to mount a display, navtiX has a Radar for you.

Question: I am going to purchase a navtiX Radar system and was wondering if I would be better off with an open array unit or a radome type of antenna unit?
Answer: In generally speaking, the open array Radar antenna will have better performance than a radome antenna of comparable output power. The open array antenna focuses its output power beam better then the radome's, resulting in better bearing resolution and target separation. This is the best measured by the horizontal beam width of an antenna. The smaller the horizontal beamwidth provide the better target resolution. If you have the space, the open array is the best choice for the better performance.

Question: What are the benefits of upgrading from a dome radar antenna to a larger, more powerful open array radar antenna?
Answer: The larger Radar antenna has a narrower horizontal beam width. Therefore, the Radar display has better target resolution (a sharper picture). Larger power combined with higher resolution give the operator a better chance of detecting and separating small, weak targets at a longer distance as well as the ability to better penetrate through fog or bad weather.

Question: Can I mount a masthead light on top of my Radome radar antenna?
Answer: Making any kind of penetration in the upper dome assembly is not recommended as it will void your warranty. This almost always leads to water intrusion due to improper sealing, or physical damage to the radome radar antenna.

FAQ's |

Question: Can I cut my Radar cable to length or should I coil it and store it?
Answer: It is not recommended to cut your Radar cable. Find a place to hide and coil the excess. If there is no other way to hide the cable, it can be reduced in length but this should be done by an authorized navtiX dealer. If not performed correctly, cutting the cable could lead to corrosion and may result in voiding the warranty.

Question: How can I adjust my new navtiX Radar for the best performances?
Answer: Usually using the auto modes will be good for most situations. If you want to adjust the Radar manually to get better performance then please try the following:

1. Transmit the Radar in maximum range
2. Set STC (sea clutter) to minimum
3. Set FTC (rain clutter) to minimum
4. Set the GAIN control to maximum (the screen should show mostly noise)
5. Now adjust the GAIN control to show a very small amount of noise (only a few noise spots on the screen)
6. Select the appropriate working range without disturbing the GAIN control
7. Adjust STC(sea clutter) as desired
8. Adjust FTC(rain clutter) if needed

Question: Should I manually tune my navtiX Radar or use the automatic tuning feature?
Answer: Unless a problem is suspected with the automatic tuning circuit, automatic tuning is superior to manual tuning. The automatic tuning circuits adjust the receiver sensitivity to each transmitted pulse. It would be impossible to duplicate this procedure using manual tuning. Most navtiX Radars have an automatic tune compensation adjustment that must be done as part of the initial installation alignments.

Question: I have accessed the installation menu for my navtiX Radar but cannot select heading or sweep timing adjustments. When selected with the [ENTER] button the Radar display just beeps twice and nothing happens. Why?
Answer: Heading alignment and sweep timing adjustment cannot be selected unless the Radar is in transmit mode. Place Radar in transmit mode before accessing the Installation Menu.

FAQ's |

Question: Why does my navtiX Radar transmit for about 30 seconds, beep, and then go into stand-by mode for 5 minutes?
Answer: It sounds like you have the Watchman mode turned on. The Watchman mode sets the Radar to stand by and then transmits the Radar at a user selected interval to check for target changes in the Guard Zone. If any changes occur, the Radar will sound an audible alarm, cancel the atchman mode and continue to transmit. Please refer to your operator's manual for instructions on turning this mode off. Most navtiX Radars will have a notation of [Watchman] on the display when the function is active and the display will beep when going into or out of this mode.

Question: My Radar doesn't pick up targets as far as it previously did. What could be the cause?
Answer: The most likely cause is the magnetron. Please contact your local navtiX dealer for repair information.

Question: What are the "streaks" or "spiral lines" that sometimes show up on my Radar display?
Answer: If they appear intermittently and then go away, it is most likely Radar interference from other vessels or perhaps even a second Radar aboard your own boat. navtiX Radars offer several levels of interference rejection, or "IR". IR is usually selectable from a menu setting. Start by applying the first level of IR and see if the interference stops. Even if higher levels of IR are necessary, you will note very little degradation of your Radar picture.
CAUTION: Interference Rejection may suppress certain very weak targets and/or Radar signals from RACON buoys.

Question: My ARPA auto Radar plotter is erratic or drops targets. What could be causing this to happen?
Answer: All navtiX ARPA plotters require an heading input with a 25ms refresh rate. It will not work properly with a GPS NMEA heading input. Please check to make sure you are using the proper type of heading input.

Question: Will I be able to detect weather with my navtiX Radar?
Answer: Yes, most marine Radars will detect weather fronts. With navtiX true color Radars you will be able to see individual weather cells at a great distance.

FAQ's |

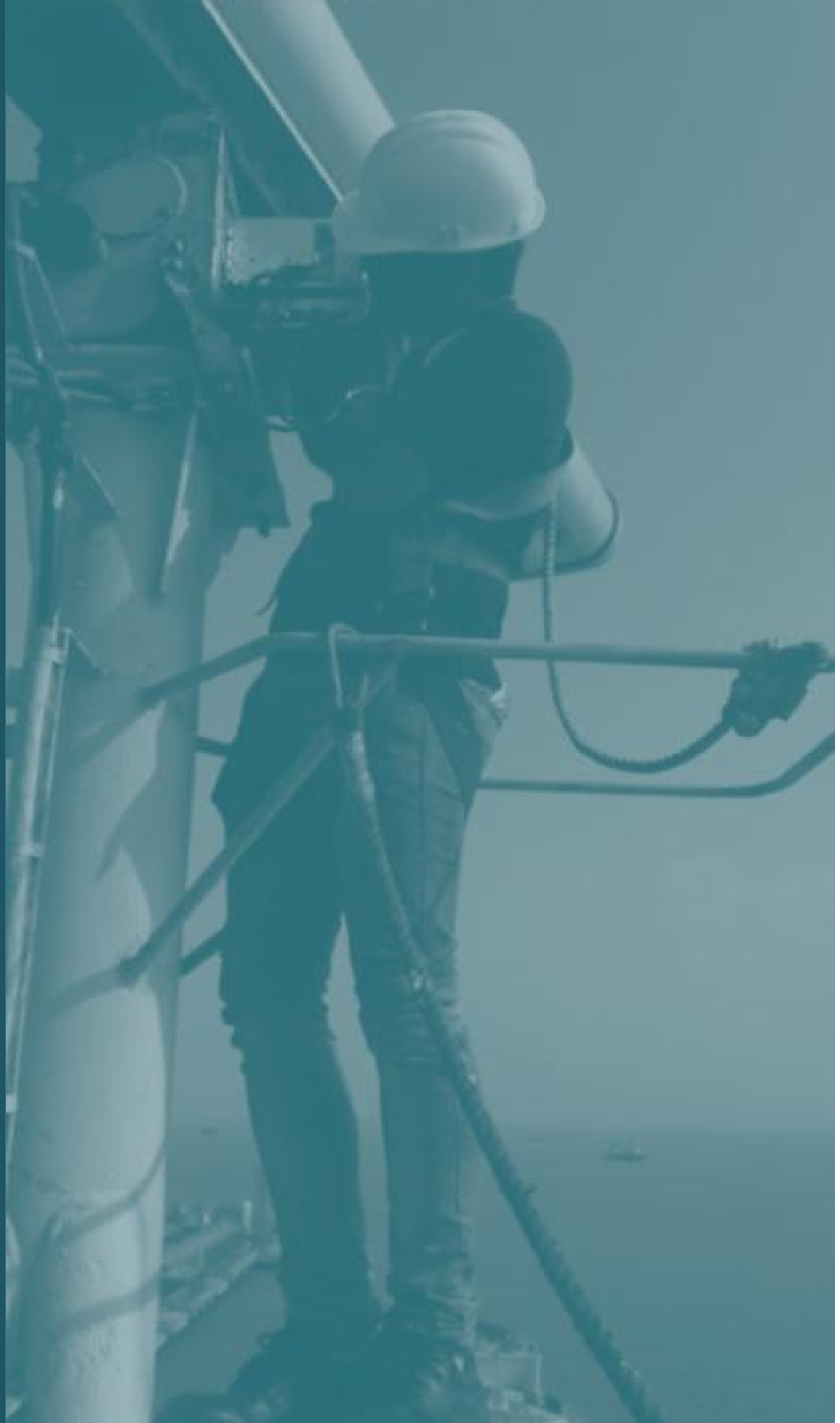
Question: What is the difference between a true color Radar and a "color" Radar?
Answer: With a true color Radar the return signal strength from the target(s) determines the color represented on the display for the target(s). Strong targets are depicted in warm colors, such as red. Weak targets are represented in cool colors such as yellows and greens. A good example would be observing a thunder storm with your true color Radar. With the Radar properly set up and adjusted you can see strong cells within the storm depicted in reds. Areas of the storm with light rain are depicted in yellows and greens. A "color" Radar represents all targets in one color, no matter what the signal strength is.
Note: All navtiX color Radars are true color Radars.

Question: What are Radar side lobes and what do they do?
Answer: Side lobes are naturally occurring areas of transmitted energy that are part of virtually any transmitter used in marine electronics. Radar, echo sounders (fishfinders) and sonars all generate a "main beam", which is also known as the "main lobe". "Side lobes" are transmitted energy that is outside of the "main beam" or "main lobe". Reflections from side lobes can sometimes cause false targets and/or "noise" on your display. All navtiX products have gain and clutter controls to help minimize the affects of side lobe returns. Many installation menus and settings exist for fine-tuning navtiX products.

Question: Why does my Radar have to wait 2 minutes after I turn it on before I get a radar picture?
Answer: The component that transmits Radar energy is called a magnetron and is similar to that which is in your microwave oven, but much more powerful. This is a tube, which will be damaged if the filament isn't heated to a proper temperature. Therefore, Radars have a timing circuit – typically 2 or 3 minutes – which disables the magnetron from transmitting until the filament is sufficiently heated. This protects the magnetron from being damaged.

Question: Is it okay to paint my Radar antenna?
Answer: Yes, it is okay to paint your Radar antenna. However, the paint MUST be epoxy-based with NO metallic ingredients. Paint with metallic ingredients will cause poor performance and may cause damage to your Radar.

Marine Radar Maintenance



DANGER

Turn off the power before performing any maintenance or troubleshooting procedure.

Hazardous voltages can shock, burn or cause death. Only qualified personnel totally famillier with electrical circuits should work inside the units.

RF RADIATION HAZARD

The radar antenna emits high frequency radio radiation which can be harmful, particularly to your eyes. Never look directly into the antenna from a distance of less than two feet when the radar is in operation as you could injure the cornea of your eyes. Always make sure the radar is set to stand-by or is turned off before starting work on the antenna unit.

Recommended Maintenance Program

Period	Item	Check point	Remarks
3 to 6 months	Exposed nuts and bolts on antenna unit	Check for corroded or loosened nuts and bolts. If necessary, clean and repaint them thickly. Replace them if heavily corroded.	Sealing compound may be used instead of paint. Apply a small amount of grease between nuts and bolts for easy removal in future.
	Housing	Check for wear and sealing. Permanent damage to the antenna`s internal circuitry will result if water leaks into the radome.	If a crack is found it should be temporarily repaired or seal ring is damaged by using a samll amount of sealing compound or adhesive. You should then contact your dealer for service.
6 months to 1 year	Display unit connectors	Check for tight connection and corrosion.	If corroded, contact your dealer for replacement.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