

RADAR DISPLAYS

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Abstract- Radar is an object-detection system that uses radio waves to determine the range, altitude, direction, or speed of objects. Modern radar systems typically use some sort of raster scan display to produce a map-like image. Early in radar development, however, numerous circumstances made such displays difficult to produce. People ultimately developed several different display types. Early radar displays used adapted oscilloscopes with various inputs. Radar systems require an indicator system to display the video information generated. The paper briefly describes various types of displays.

Index Terms- CRT (Cathode Ray Tube), A-Scope, Range Height Indicator (RHI), Plan Position Indicator (PPI), B-Scope, C-Scope

I. INTRODUCTION TO RADAR

The word RADAR is a contraction of Radio Detecting and Ranging. As implied by this contraction, radars are used to detect the presence of an aim and to determine its location. The radar antenna transmits pulses of radio waves or microwaves that bounce off any object in their path. The object returns a tiny part of the wave's energy to antenna that is usually located at the same site as the transmitter. The electronic principle on which radar operates is very similar to the principle of sound-wave reflection. If you know the speed of sound in air, you can then estimate the distance and general direction of the object. The time required for an echo to return can be roughly converted to distance if the speed of sound is known. Radar uses electromagnetic energy pulses in much the same way. The radio-frequency (RF) energy is transmitted to and reflected from the reflecting object. A small portion of the reflected energy returns to the radar set, called echo. Radar sets use the echo to determine the direction and distance of the reflecting object.

A radar system has a transmitter that emits radio waves called *radar signals* in predetermined directions. When these come into contact with an object they are usually reflected or scattered in many directions. Radar signals are reflected especially well by materials of considerable electrical conductivity. The radar

signals that are reflected back towards the transmitter are the desirable ones that make radar work. If the object is *moving* either toward or away from the transmitter, there is a slight equivalent change in the frequency of the radio waves, caused by the Doppler Effect. Radar receivers are usually, but not always, in the same location as the transmitter. Although the reflected radar signals captured by the receiving antenna are usually very weak, they can be strengthened by electronic amplifiers. The weak absorption of radio waves by the medium through which it passes is what enables radar sets to detect objects at relatively long ranges—ranges at which other electromagnetic wavelengths, such as visible light, infrared light, and ultraviolet light, are too strongly attenuated. Such weather phenomena as fog, clouds, rain, falling snow, and sleet that block visible light are usually transparent to radio waves. Certain radio frequencies that are absorbed or scattered by water vapor, raindrops, or atmospheric gases (especially oxygen) are avoided in designing radars, except when their detection is intended. Radar relies on its own transmissions rather than light from the Sun or the Moon, or from electromagnetic waves emitted by the objects themselves, such as infrared wavelengths (heat). This process of directing artificial radio waves towards objects is called *illumination*, although radio waves are invisible to the human eye or optical cameras.

II. RADAR DISPLAYS

The information available from a radar receiver may contain as many as several million separate data bits per second. From these and other data, such as the orientation of the antenna, the indicator should present to the observer a continuous, easily understandable, graphic picture of the relative position of radar targets. It should provide size, shape, and insofar as possible, indications of the type of targets. A cathode-ray tube (CRT) fulfils these requirements to an astonishing degree. The cathode-ray tube's principal shortcoming is that it cannot present a true three-dimensional picture. The fundamental geometrical quantities involved in

radar displays are the RANGE, AZIMUTH ANGLE (or BEARING), and ELEVATION ANGLE. These displays relate the position of a radar target to the origin at the antenna. Most radar displays include one or two of these quantities as coordinate of the crt face. The actual range of a target from the radar, whether on the ground, in the water, or in the air is known as SLANT RANGE. The majority of displays use as one coordinate the value of slant range, its horizontal projection (GROUND RANGE), or its vertical projection (ALTITUDE). Range is displayed by means of a linear time-base sweep, starting from a given point or line at a definite time in each pulse cycle. Thus, distances along this range sweep actually measure slant range. The sweep speed determines the scale factor, which relates the distance on the tube to actual range. The sweep length is the total distance represented. Distances are expressed in miles (statute or nautical) or yards. The origin of the range sweep may be on or off the tube face.

The most common types of displays, called scopes, are the A-scope, the RANGE-HEIGHT INDICATOR (RHI) SCOPE, PLAN POSITION INDICATOR (PPI) SCOPE, B-Scope and C-Scope discussed in the next section.

2.1 A-SCOPE

The A-scope display, shown in figure 2.1, presents only the range to the target and the relative strength of the echo. Such a display is normally used in weapons control radar systems. The bearing and elevation angles are presented as dial or digital readouts that correspond to the actual physical position of the antenna. The A-scope normally uses an electrostatic-deflection crt. The sweep is produced by applying a sawtooth voltage to the horizontal deflection plates. The electrical length (time duration) of the sawtooth voltage determines the total amount of range displayed on the crt face. The A-scope is a deflection-modulated CRT display in which the vertical deflection is proportional to target echo amplitude and the horizontal coordinate is proportional to range. The azimuth and elevation angles are presented as dial or digital readouts that correspond to the actual physical position of the antenna. The ranges of individual targets on an A-scope are usually determined by using a movable range gate or step that is superimposed on the sweep. The A scope was used for the earliest types of radar.

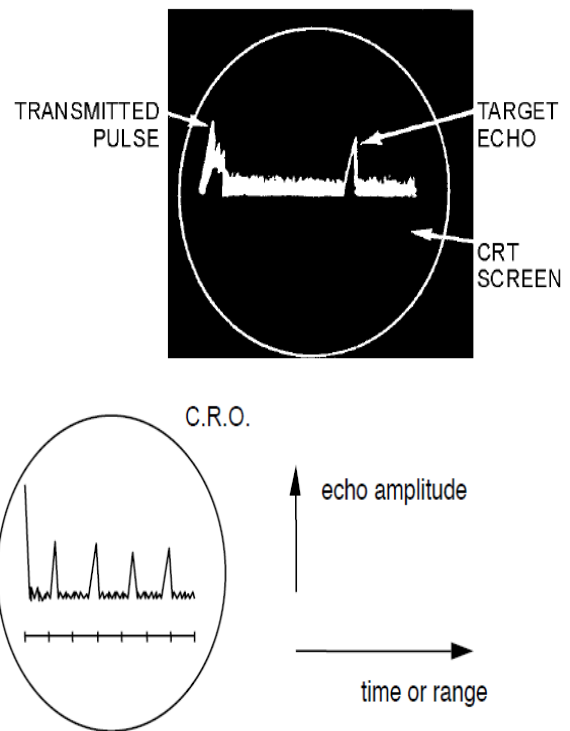


Fig 2.1 A- Scope Radar Display Key Features:

- A sawtooth voltage generator is attached to the X-axis to move the oscilloscope spot across the screen at a fixed speed.
- The start of the "sweep" is triggered to coincide with the start of a radar pulse being sent out of the antenna.
- The speed of the sweep is set to make it reach the far end (typically right side) of the display at the end of the pulse's maximum return time.
- Any reflected signal is amplified and sent directly to the display's Y-axis input, displacing the beam upward.
- A target will appear along the X-axis as a function of time, and corresponds to the distance to the target.
- The magnitude of the deflection along the Y-axis is indicative of the echoing area.

2.2 RANGE HEIGHT INDICATOR (RHI)

The RHI is an intensity-modulated display with height (altitude) as the vertical axis and range as the horizontal axis. This display is often used with height finding search radars to obtain altitude information. The sweep originates in the lower left side of the scope. It moves across the scope, to the right, at an angle that is the same as the angle of transmission of the height-finding radar. The bottom horizontal line indicates the line-of-sight to

the horizon. The area directly overhead is straight up the left side of the scope. Target echoes are displayed on the RHI as blips. The operator determines altitude by adjusting a movable height line to the point where it bisects the centre of the blip. Target height is then read directly from an altitude dial or digital readout. Vertical range markers are also provided to estimate target range. The range-height indicator (rhi) scope, shown in figure 2.2,

is a two-dimensional presentation indicating target range and altitude. The sweep originates in the lower left side of the scope. It moves across the scope, to the right, at an angle that is the same as the angle of transmission of the height-finding radar. The line of sight to the horizon is indicated by the bottom horizontal line. The area directly overhead is straight up the left side of the scope. Target echoes are displayed on the scope as vertical PIPS or BLIPS (spots of increased intensity that indicate a target location). The operator determines altitude by adjusting a movable height line to the point where it bisects the center of the blip. Target height is then read directly from an altitude dial or digital readout. Vertical range markers are also provided to estimate target range.

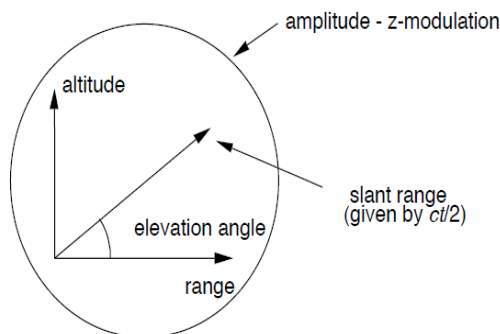
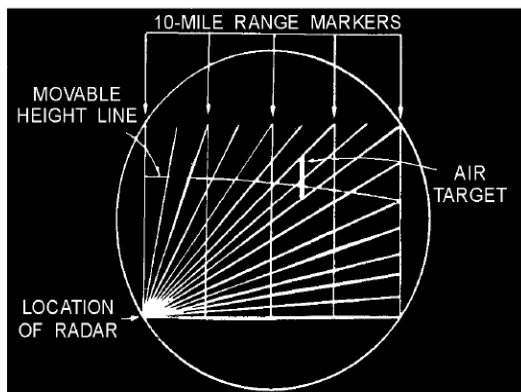


Fig 2.2 RHI Scope Radar Display

2.3 PLAN POSITION INDICATOR (PPI)

The PPI, also called the P-Scope, is by far the most commonly used radar display. It is an intensity-modulated circular display on which echo signals are shown in plan position with range and azimuth angle displayed in polar coordinates. It is a polar coordinate display of the area surrounding the radar platform. Own ship is represented as the origin of the sweep, which is normally located in the center of the scope, but may be offset from the center on some sets. The PPI uses a radial sweep pivoting about the center of the presentation. This results in a map-like picture of the area covered by the radar beam. A long-persistence screen is used so that the display remains visible until the sweep passes again. The origin of the polar coordinates is at the location of the radar, and is normally located at the center of the display. The PPI uses a radial sweep pivoting around the center. The result is a map-like display of the area covered by the radar beam. Azimuth angle to the target is indicated by the target's angular position in relation to a line extending vertically from the sweep origin to the top of the scope. The top of the scope is usually true north. Figure 2.3 shows the PPI display.

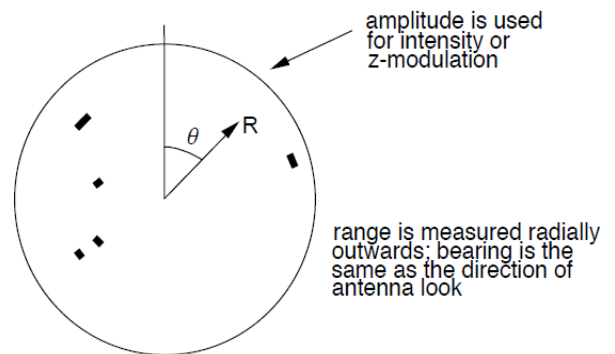
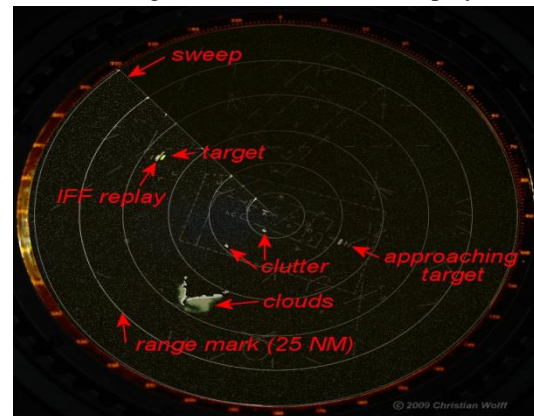


Fig 2.3 PPI Scope Radar Display Key Features:

- The PPI display provides a 2-D "all round" display of the airspace around a radar site.
- The distance out from the center of the display indicates range, and the angle around the display is the azimuth to the target.
- The current position of the radar antenna is typically indicated by a line extending from the center to the outside of the display, which rotates along with the antenna in real-time.
- It is essentially a B-scope extended to 360 degrees. The PPI display is typically what people think of as a radar display.

2.4 B- SCOPE

A B-scope provides a 2-D "top down" representation of space, with the vertical axis typically representing range and the horizontal axis azimuth (angle). B-scope displays were common in airborne radars in the 1950s and 60s, which were mechanically scanned from side to side, and sometimes up and down as well. The B-scope's display represented a horizontal "slice" of the airspace on both sides of the aircraft out to the tracking angles of the radar. The spot was swept up the Y-axis in a fashion similar to the A-scope's X-axis, with distances "up" the display indicating greater range. This signal was mixed with a varying voltage being generated by a mechanical device that depended on the current horizontal angle of the antenna. The result was essentially an A-scope whose range line was rotated to point up, and then rotated back and forth about a zero point at the bottom of the display. The radio signal was sent into the intensity channel, producing a bright spot on the display indicating returns.

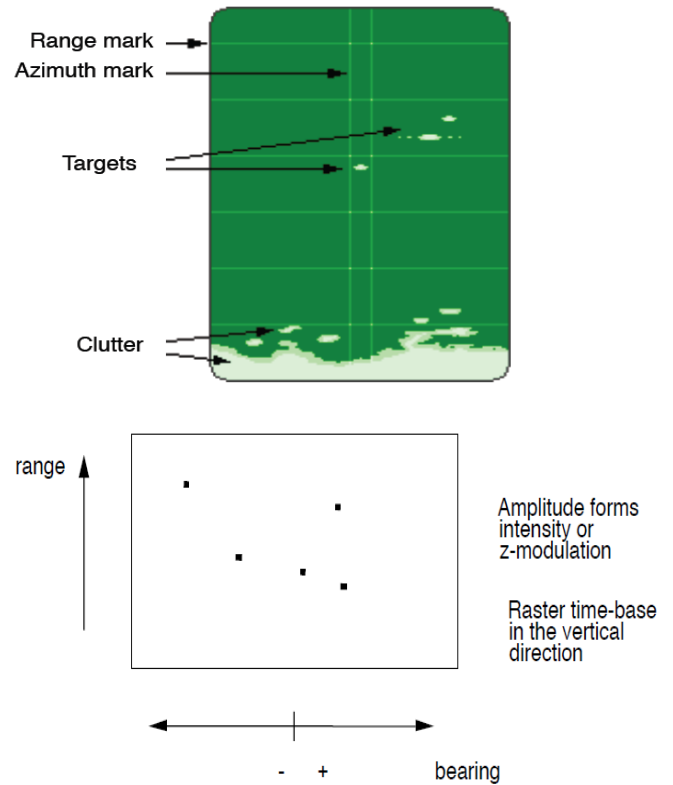


Fig 2.4 B-Scope Radar Display Key Features:

- A B-scope provides a 2-D "top down" representation of space, with the vertical axis typically representing range and the horizontal axis azimuth (angle).
- B-scope displays were common in airborne radars in the 1950s and 60s, which were mechanically scanned from side to side, and sometimes up and down as well.
- The spot is swept up the Y-axis similar to the A-scope's X-axis, with distances further "up" the display indicating greater range.
- This signal is mixed with a varying voltage being generated by a mechanical device that depends on the current (horizontal) angle of the antenna.
- The result is essentially an A-scope whose range line is rotated to point upwards, and then rotated back and forth about a zero point at the bottom of the display.
- The radio signal is sent into the intensity channel, producing a bright spot on the display indicating returns.

2.5 C – SCOPE

A C-scope displays a "bull's eye" view of azimuth vs. elevation. The "blip" was displayed indicating

the direction of the target off the centreline axis of the radar, or more commonly, the aircraft or gun it was attached to. They were also known as "moving spot indicators", the moving spot being the target blip. Range is typically displayed separately in these cases, often as a number at the side of the display. Almost identical to the C-scope is the G-scope, which overlays a graphical representation of the range to the target. The C-scope gives the target azimuth angle against the target elevation (vertical) angle, essentially giving the direction to the target but not its actual range. The vertical dimension on a C-scope presents the targets relative elevation and the horizontal dimension presents the targets relative azimuth. This is basically a "gun sight" configuration that might be used, for example, in an early interceptor aircraft.

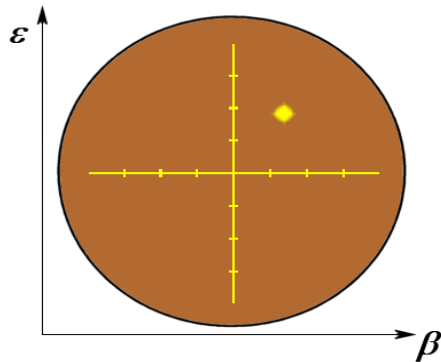


Fig 2.5 C-Scope Radar Display3.

III. ADVANCED RADAR DISPLAY SYSTEMS

As computer workstations continue to increase in capability of displaying more information, the necessity for simple intuitive Graphical User Interfaces (GUI) for computer monitors becomes paramount. Touch screens can reduce HMI complexity and minimize response time for human interaction. Although touch screens have these advantages, humans tire when required to touch a screen for hours, so a combination of touch screen and mouse is considered optimal. The use of color coding to alert operators of events has been shown to reduce response time. An example of this for radar systems would be to change background color when the system becomes not ready, so that it becomes readily apparent. Artificially Intelligent decision aids have also proved useful. These aids would help the user decide a course of action for specific events. Software-based displays have also facilitated the incorporation of various other useful information elements. An example is geographical information in the form of map overlays and cursor

location. Symbolic representation, based on target classification is often used to present targets.

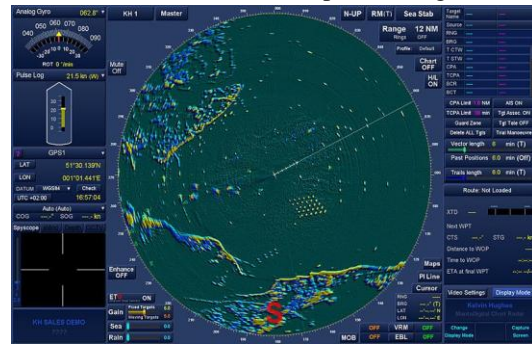


Fig 3 An example of advanced radar display: Marine Radar

IV. CONCLUSION

The purposes of radar systems are to detect and locate targets. The information that is gathered by the radar system must be communicated to the human user of the system for analysis, interpretation, and decision-making. This fact clearly demonstrates the importance of display systems for radar systems, since the advantage was provided by a better display system, not better detection capability. The paper included all different types of radar displays and brief description about how each display was different from other displays. The most common Analog Radar Displays were A-Scope, PPI and RHI. Modern displays have started to incorporate new designs, and will possibly be the advantage in future military conflicts.

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