NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

AIRPORT SURVEIlLANCE RADAR

GRADUATION PROJECT
EE400

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ABSTRACT

Radar is an electromagnetic system for the detection and location of objects it operates by transmitting a particular type of waveform. A pulse-modulated sine wave for example.

An elementary form of radar consists a transmitting antenna emit in electromagnetic radiation generated by an oscillator of some sort, a receiving antenna, and an energy detecting device, or receiver. A portion of the transmitted signal is intercepted by reflecting object (target) and is retaliated in all direction. It is the energy reradiated in the back direction that is the prime interest to the radar. The receiving antenna collects the returned energy and delivers jt to a receiver, Where it is processed to detect the presence of the target is determined by measuring the time taken for the radar .signal to travel to the target and back. The direction, or angular position, of the target may be determined from the direction of arrival is with narrow antenna beams. If relative motion exist between target and radar, .the shift in the carrier frequency of the reflected wave (Doppler effect) is a measure of the target's relative (radial) velocity and may be used to distinguish moving targets from stationary objects. In radars, which continuously track the movement ofa target, a continuous indication of the rate of change of the target position is also available.

INTRODUCTION

We had thought to do our work on the radar system, and then we searched for the important part on this subject which is the airport surveillance radar(ASR), ASR is considered as one of the most common and important parts in the communication system. In modem times, .radar is used in wide variety of application including air traffic control, defense, met~prology, and even mapping, radar is "radio detecting and ranging". An electrorrıagneticjsensor used for detecting , locating, tracking, and identifying objects of variousi.kinds at considerable distances, it operates by transmitting electromagnetic eııergy toward objects, commonly referred to as targets, and then observing the echoes returııed from them. The target may be aircraft, ships, spacecraft, automotive vehicles, Çııdiastronomicalbodies, or even birds, insects, and raindrops.

Radar can not only determine the presence, löcation, and velocity of such objects but can sometimes obtain their size and sliape\a.s;well. What distinguishes radar from optical and infrared sensing devices is .its .ability<todetect faraway objects under all weather conditions and to determine their range fyithprecision.

Radar is an "active" sensing device in that it has its 9vın source of illumination (a transmitter) for locating targets. In certain respect s, it l'ySyınblesactive sonar, .which is used chiefly for detecting submarines and other objects undeny~tyr; h<l\Vever, the acoustic waves of sonar propagate differently from electromagnetic waves and have different properties. Radar typically operates in the microwave region of the electromagnetic spectrum namely, at frequencies extending from about 400 MHz to 40 GHz. It has been used at lower frequencies for long-range applications.

Surveillance radar a device which, by measuring the time interval between transmission and reception of radio pulses and correlating the angular orientation of the radiated antenna beam or beams in azimuth and/or elevation, provides information on range, azimuth, and/or elevation of objects in the patlı of transmitted pulses.

Surveillance radars are divided into two general categories. Airport surveillance radar (ASR) and air route surveillance radar (ARSR). Surveillance radars scan though 360 degrees of azimuth and present target information on a radar display located in a tower.

The project is divided into four chapters and conclusion:
Chapter one presents of some Basic Radar Principles, Radio wave frequency and wavelength, Radio Wave Polarization, phase interference, and Propagation, Radio System Basics, Antenna Basics, A simple Pulse. Radar System, Band Radar and types of Band Radar.

Chapter two, presents the various types of radar systems such as (ASR), Weather Radar(WR), Pulsed Radar System PRS),CW Radar, Pulse Doppler Radar, Pulse-Compression Radar, Synthetic Aperture Radar (SAR), 3-D Radar.

Chapter three present the (ASR), primary surveillance radar, secondary surveillance radar for afterwards, we explain the radar's role in the air traffic control showing the advantages and the disadvantages ofthe airport radar.

Chapter four covers the radar systems in Ercan Airport, we also explain the operation and the basic elements of the radar systems used in Ercan Airport further, we present some important systems related with Ercan's radar to make the operation ofthe ATC easier.

Finally, in the conclusion we part present the important comments related to this project.

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CHAPTERONE

RADIODETECTION AND RANGING

1.1 Overview

Radar is a system that uses electromagnetic waves to identify the range, altitude, direction, or speed of both moving and fixed objects such as aircraft, ships, motor vehicles, weather formations, and terrain. A transmitter emits radio waves, which are reflected by the target and detected by a receiver, typically in the same location as the transmitter. Although the radio signal retumed is usually very weak, radio signals can easily be amplified. This enables a radar to detect objects at ranges where other emissions, such as sound or visible light, would be too weak to detect. Radar is used in many contexts, including meteorological detection of precipitation, air traffic control, police detection, and by the military. The term RADAR was coined in 1941 as an acronym for Radio Detection and Ranging. This acronym of American origin replaced the previously used British abbreviation RDF.The term has since entered the English language asa standard word, radar, losing the capitalization in the process.

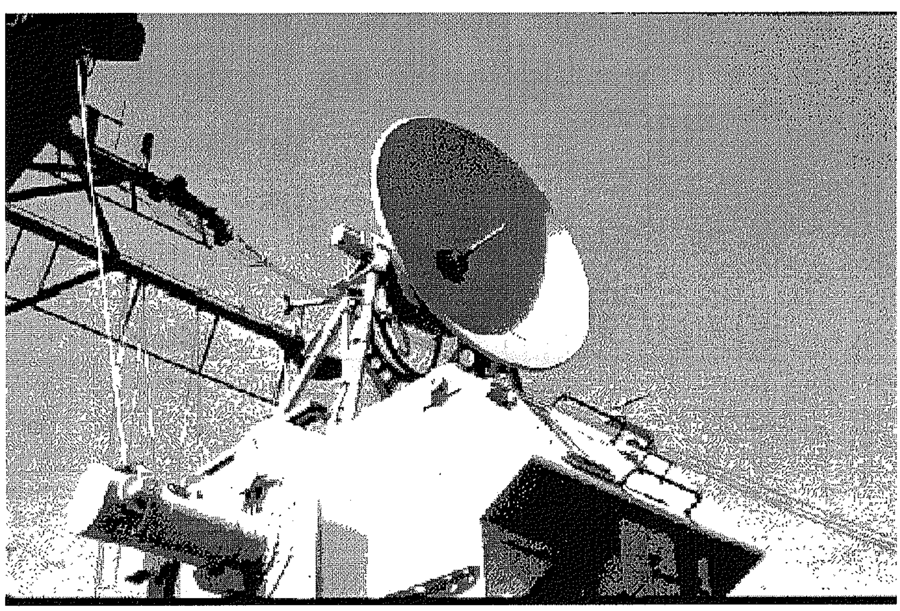


Figure 1.1: Basic Radar system

1.2 Some Basic Radar Principles

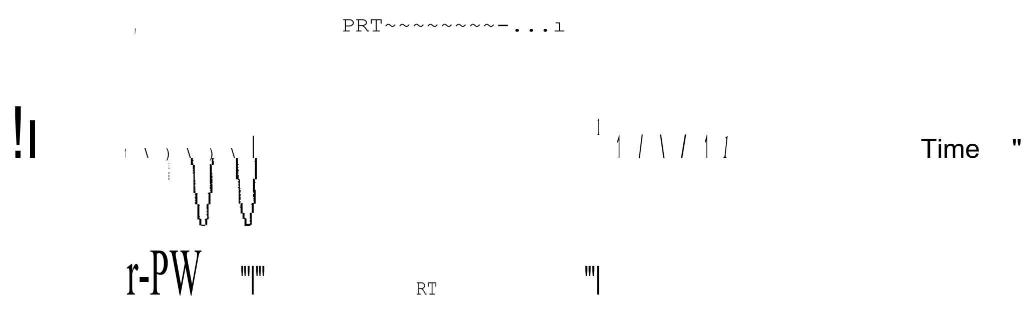
Radar is an acronyın for Radio Detection and Ranging. The term "radio" refers to the use of electromagnetic waves with wavelengths in the so-called radio wave portion of the spectrum, which covers a wide range from 10^4 km to 1 cm.Radar systems typically use wavelengths on the order of 10 cm, corresponding to frequenciesof about 3 GHz. The detection and ranging part of the acronyın is accomplished by timing the delay between transmission ofa pulse of radio energy and its subsequent retum. If the time delay is ~t, then the range may be determined by the simple form.ula:

$$R = \frac{Ch.\ t}{2} \qquad (1.1)$$

Where $c = 3 \times 10^8$ m/s, the speed of light at which all electromagnetic waves propagate.

The factor of two in the form.ula comes from the observation that the radar pulse must travel to the target and back before detection, or twice the range.

A radar pulse train is a type of amplitude modulation of the radar frequency carrier wave, similar to how carrier waves are modulated in communication systems. In this case, the information signal is quite simple: a single pulse repeated at regular intervals. The common radar carrier modulation is known as the pulse train.



Figurel.2: Pulse train

PW = pulse width. PW has units of time and is commonly expressed in ~s. PW is the duration of the pulse.

RT = rest time. RT is the interval between pulses. It is measured in ~s.

PR'F = pulse repetition time. PRT has units of time and is commonly expressed in ms. PRT is the interval between the start of one pulse and the start of another. PRT is also equal to the sum, PRT = PW+RT. PRF = pulse repetition frequency. PRF has units of time^{-1} and is commonly expressed in Hz (1 Hz = 1/s) or as pulses per second (pps). PRF is the number of pulses transmitted per second and is equal to the inverse of PRT. RF = radio frequency. RF has units of time^{-1} or Hz and is commonly expressed in GHz or MHz. RF is the frequency of the carrier wave which is being modulated to form the pulse train.

1.3 Radar.Components

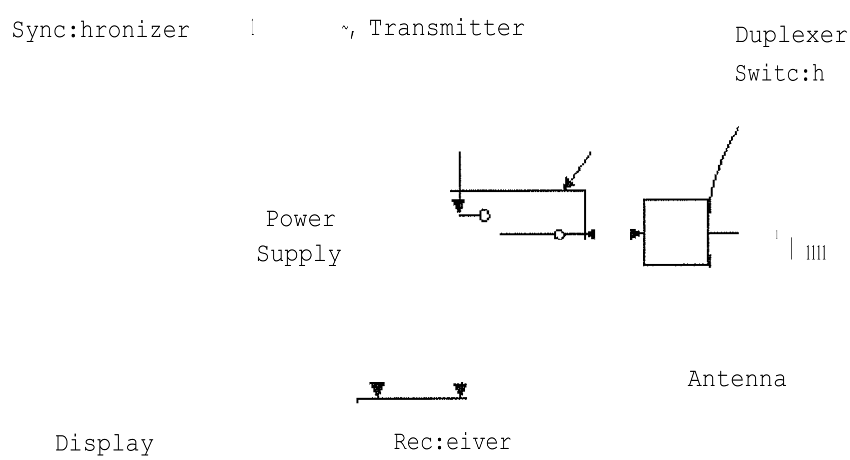


Figure 1.3: A practical radar system requires seven basic components.

The radar has transmitter and receiver, The transmitter send high frequency radio wave and when it hits an object it will send back to the receiver. By measuring the time it needs for the wave to retum and the amount of the radio wave which retum to the receiver it will identify the position and the size of the object on the screen.

If a lot of the signal is received then it means that the object is close. And if a little bit of the signal is received then it means that the object is far. If a little bit .returns then it mean that the object is small. If a lot of the wave retums then it means that the object is large.

1.3.lTransmitter

The transmitter creates the radio wave to be sent and modulates it to form the pulse train. The transmitter must also amplify the signal to a high power level to provide adequate range. The source of the carrier wave could be a Klystron, Traveling Wave Tube (TWT) or Magnetron. Each has its own characteristics and limitations.

1.3.2 Receiver

The receiver is sensitive to the range of frequencies being transmitted and provides amplification of the retumed signal. In order to provide the greatest range, the receiver must be very sensitive without introducing excessive noise. The ability to discem a received signal from background noise depends on the signal-to-noise ratio (SIN).

The background noise is specified by an average value, called the noise-equivalent-power (NEP). This directly equates the noise to a detected power level so that it may be compared to the retum

$$P_r > (S/N)\ NEP \tag{1.2}$$

Where P_r is the power of the retum signal. Since this is a significant quantity in determining radar system performance, it is given a unique designation, S_{min}, and is called the Minimum Signal for Detection.

$$S_{min} = (SIN)\ NEP \tag{1.3}$$

S_{min}, expressed in Watts, is usually a small number, it has proven useful to m,.uın;:; the decibel equivalent, MDS, which stands for Minimum Discemible Signal.

$$MDS = 10\ Log\ (S_{min}/1\ mW) \tag{1.4}$$

3.) Fast Time Constant (FTC). This feature is designed to reduce the effect of long duration returns that come from rain. This processing requires that strength of the return signal must change quickly over it duration. Since rain occurs over and extended area, it will produce a long, steady return. The FTC processing will filter these returns out of the display. Only pulses that rise and fall quickly will be displayed. **in** technical terms, FTC is a differentiator, meaning it determines the rate of change in the signal, which it then uses to discriminate pulses which are not changing rapidly.

1.3.3 **Power** Supply

The power supply provides the electrical power for all the components. The largest consumer of power is the transmitter which may require several kW of average power. The actually power transmitted in the pulse may be much greater than 1 kW. The power supply only needs to be able to provide the average amount ofpower consumed, not the high power level during the actual pulse transmission. Energy can be stored, in a capacitor bank for instance, during the rest time. The stored energy then can be put into the pulse when transmitted, increasing the peak power. The peak power and the average power are related by the quantity called duty eyde, DC. Duty eyde is the :fractionof each transmission eyde that the radar is actually transmitting. Referring to the pulse train, the duty eyde can be seen to be:

$$DC = \frac{P\backslash\backslash V}{PRF} \qquad (1.5)$$

1.3.4 Synchronizer

The synchronizer coordinates the timing for range determination. It regulates that rate at which pulses are sent (i.e. sets PRF) and resets the timing clock for range determination for each pulse. Signals from the synchronizer are sent simultaneously to the transmitter, which sends a new pulse, and to the display, which resets the return sweep.

1.3.5 Duplexer

This is a switch which alternately connects the transmitter or receiver to the antenna. Its purpose is to protect the receiver :from the high power output of the transmitter. During the transmission of an outgoing pulse, the duplexer will be aligned to the transmitter for the duration of the pulse, PW. After the pulse has been sent, the duplexer will align the antenna to the receiver. When the next pulse is sent, the duplexer will shift back to the transmitter. A duplexer is not required if the transmitted power is low.

1.3.6 Antenna

The antenna takes the radar pulse' from the transmitter and puts it into the air. Furthermore, the antenna must fobı.ıs the energy into a well-defined beam which increases the power and permits a detemıin.ation of the direction of the target. The antenna must keep track of its own orientation which can be accomplished by a synchronic-transmitter. There are also antertn.asystems which do not physically move but are steered electronically (in these cases, the orientation of the radar beam is already known apriori).

The beam-width of an antenna is a measure of the angular extent of the most powerful portion ofthe radiated energy. For our purposes the main portion, called the main lobe, will be all angles :from the perpendicular wherethe power is not less than ½ of the peak power, or, in decibels, -3 dB. The beam;.\vidthisthe)rarige of angles in the main lobe, so defined. Usually this is resolved into a plarteofinte:rest, such as the horizontal or vertical plane. The antenna will have a separate horizôı:italand vertical beam-width. For a radar antenna, the beam-width can be predicted :from the dimension of the antenna in the plane of interest by

$$\theta = \frac{\lambda}{L} \qquad (1.6)$$

Where:

θ is the beam-width in radians.λ is the wavelength of the radar, and L is the dimension of the antenna, in the direction of interest.

In the discussion of communications antennas, it was stated that the beam-width for an antenna could be found using 8 = 21ı,/L. So it appears that radar antennas have one-half of the beam-width as communications antennas. The difference is that radar antennas are used both to transmit and receive the signal. The interference effects from each direction combine, which has the effect of reducing the beam-width. Therefore when describing two-way systems (like radar) it is appropriate to reduce the beam-width by a factor of *Yı* in the beam-width approximation formula.

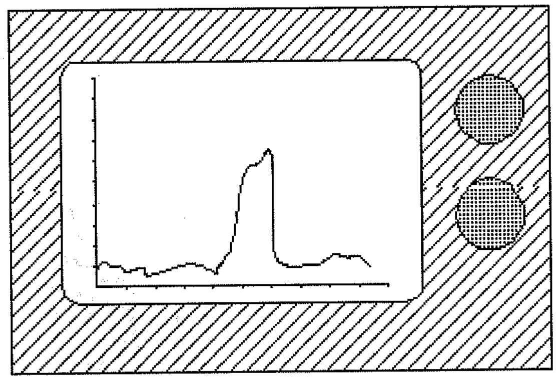
The directional gain of an antenna is a measure of how well the beam is focused in all angles. If we were restricted to a single plane, the directional gain would merely be the ratio 2rc/8 .. Since the same power is distributed over a smaller range of angles; directional gain represents the amount by which the power in the beam is increased. In both angles, then directional gain would be given by:

$$G_{dir} = \frac{4\pi}{\$8} \tag{1.7}$$

Since there are 4rc steadies corresponding to all directions solid angle, measured in steadies, is defined to be the area of the beam front divided by the range squared, therefore a non-directional beam would cover an area of $4\pi R^2$ at distance R, therefore 4rc steadies).Here we used:~=horizontal beam-width (radians) ⟠ = vertical beam-width (radians)Sometimes directional gain is measured in decibels, namely 10 log(Gdir).As an example, an antenna with a horizontal beam-width of 1.5° (0.025 radians) and vertical beam-width of 20° (0.33 radians) will have: directional gain (dB) = 10 log (4 rc/0.025 0.333) = 30.9 dB

Display

The display unit may take a variety of forms but .in general is designed to present the received information to an operator. The most basic display type is called an A-scan (amplitude vs. Time delay). The vertical axis is the strength of the return and the horizontal axis is the time delay, or range. The A-scan provides no information about the direction of the target.

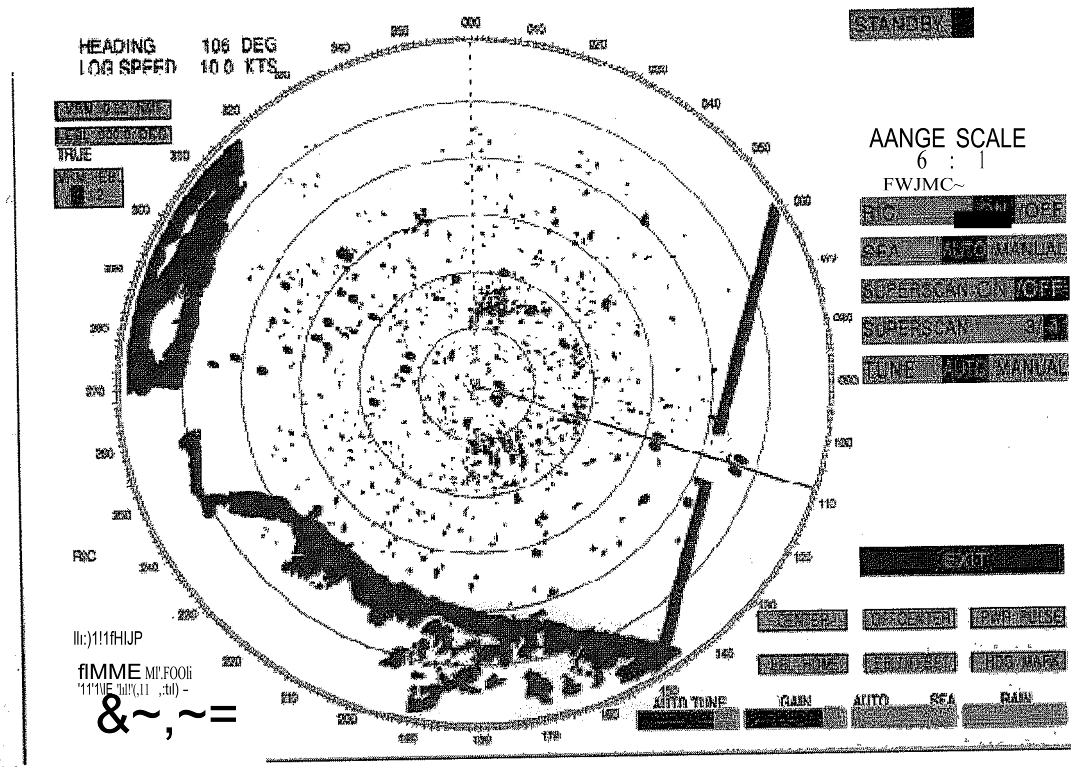


Figurel.4: A-scan (amplitude vs. Time delay)

The most common display >is the PPI (plan position indicator). The A-scan information is converted into brightness and then displayed in the same relative direction as the antenna orientation. The result is a top-down view of the situation where range is the distance from the origin. The PPI is perhaps the most natural display for the operator and thetefore the most widely used. In both cases, the synchronizer resets the trace for each 'pulse so that the range information will begin at the origin.

1.4 Simple Pulse **Radar** System

Pulse-Doppler is a radar system capable of not only detecting target location (bearing, range, and altitude), but also measuring its radial velocity (range-rate). It uses the Doppler effect to determine the relative .velocity of objects; pulses of RF energy retuming from the target are processed to measure the frequency shift between carrier cycles in each pulse and the original transmitted frequency. To achieve this, the transmitter frequency source must have very good phase stability and the system is said to be coherent.



Figurel.5: STC

The use of increased STC to suppress the sea clutter. All of the parameters of the basic pulsed radar system will affect the performance in some way. Here we find specific,examples and quantify this dependence where possible.

Pulse Width The duration of the pulse and the length of the target along the radial direction determine the duration of the returned pulse. In most cases the length of the return is usually very similar to the transmitted pulse. In the display unit, the pulse (in time) will be converted into a pulse in distance. The range of values from the leading edge to the trailing edge will create some uncertainty in the range to the target. Taken at face value, the ability to accurately measure range is determined by the pulse width. If we designate the uncertainty in measured range as the rangc resolution, RREs, then it must be equal to the range equivalent of the pulse width, namely:

$$R_{RES} = \frac{cPW}{2} \tag{1.8}$$

The reason that it cant take the leading edge of the pulse as the range which can be determined with much finer accuracy, that it is virtually impossible to create the perfect leading edge.

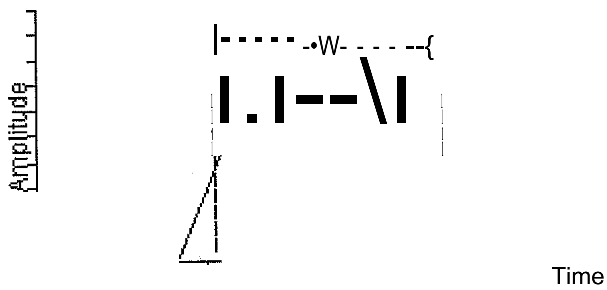


Figure 1.6: The ideal pulse

To create a perfectly formed pulse witha vertical leading edge would require an infinite bandwidth. In fact you may equate the bandwidth, B, of the transmitter to the minimum pulse width, PW by:

$$PW = \frac{1}{2B} \qquad \textbf{(1.9)}$$

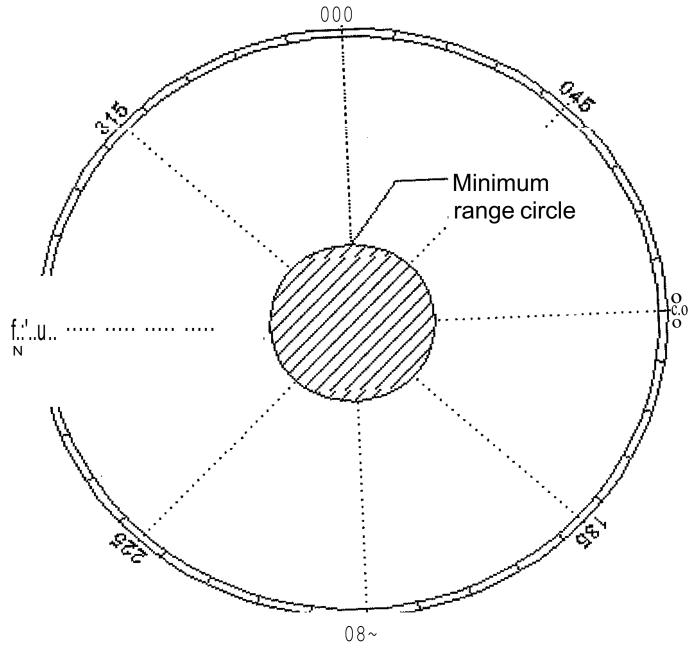
Given this insight, it is quite reasonable to say that the range can be determined no more accurately than cPW/2 or equivalently

$$R_{RES} = \frac{c}{4B} \qquad \textbf{(1.10)}$$

The high resolution radar is often referred to as wide-band radar which you now see as equivalent statements. One term is referring to the time domain and the other the frequency domain. The duration of the pulse also affects the minimum range at which the radar system can detect. The outgoing pulse must physically clear the antenna before the return can be processed. Since this lasts for a time interval equal to the pulse width, PW, the minimum displayed range is then:

$$R_{MIN} = \frac{c\,PW}{2} \qquad \textbf{(1.11)}$$

The minimum range effect can be seen on a PPI display as a saturated or blank area aroundtheorigin.

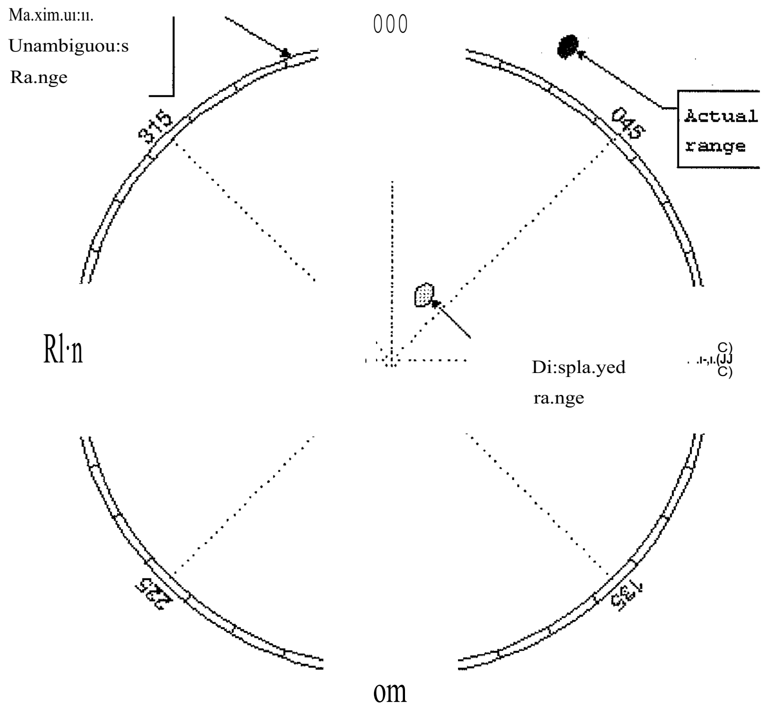


Figurel.7: PPI (plan position indicator) shows the minimum range circuit.

Increasing the pulse width while maintaining the other parameters the same will also affect the duty cycle and therefore the average power. For many systems, it is desirable to keep the average power fi.xed. Then the PRF must be simultaneously changed with PW in order to keep the product PW x PRF the same. For example, if the pulse width is reduced by a factor of *Yι* in order to improve the resolution, then the PRF is usually doubled.

1.4.1 Pulse Repetition Frequency (PRF):

frequency of pulse transmission affects the maximum range that can be displayed. Recall that the synchronizer resets the timing clock as each new pulse is transmitted Returns from distant targets that do no reach the receiver until after the next pulse has been sent will not be displayed correctly. Since the timing clock has been reset. They will be displayed as if the range where less than actual. If this were possible, then the range information would be considered ambiguous.



Figurel.8: PPI (Plan Position lndicator) shows the maximum range.

The maximum actual range that can be detected and displayed without ambiguity, or the maximum unambiguous range, is just the range corresponding to a time interval equal to the pulse repetition time (PRT). The maximum unambiguous range.

When radar is scanning, it is necessary to control the scan rate so that a sufficient number of pulses will be transmitted in any particular direction in order to guarantee reliable detection. If too few pulses are used, then it will more difficult to distinguish false targets from actual ones.

False targets may be present in one or two pulses but certainly not in ten or twenty in row. Therefore to maintain a low false detection rate, the number of pulses transmitted in each direction should be kept high, usually above ten.

For systems with high pulse repetition rates (frequencies), the radar beam can be repositioned more rapidly and therefore scan more quickly. Conversely, if the PRF is lowered the scan rate needs to be reduced. For simple seans it is easy to quantify the number of pulses that will be returned from any particular target. Let D represent the dwell time, which is the duration that the target remains in the radar's beam during each scan. The number of pulses N that target will be exposed during the dwell time. So it is easy to see that high pulse repetition rates require small~ dwell times. For a continuous circular scan, for example, the dwell time is related to the rotation rate and the beam-width.

Radar Frequency Finally, the frequency of the radio carrier wave will also have some affect on how the radar beam propagates. At the low frequency extremes, radar beams will refract in the atmosphere and can be caught in "ducts" which result in ranges. At the high extreme, the radar beam will behave much like visible light and travel in very straight lines. Very high frequency radar beams will suffer high losses and are not suitable for long range systems.

The frequency will also affect the beam-width. For the same antenna size, a low frequency radar will have a larger beam-width than a high frequency one. In order to keep the beam-width constant, a low frequency radar will need a large antenna.

1 Theoretical Maximum Range

A radar receiver can detect a target if the retum is of sufficient strength. I us designate the minimum retum signal that can be detected as S_{min}, which should h units of Watts, W. The size and ability ofa target to reflect radar energy can be summarized into a single term, D, known as the radar cross-section, which has units of m^2.If absolutely all of the incident radar energy on the target were reflected equally in **all** directions, then the radar cross section would be equal to the Target's cross-sectional area as seen by the transmitter.

practice, some energyl is absorbed and the reflected energy is not distributed equally in all directions. Therefore, the radar cross-section is quite difficult to estimate a is normally determined by measurement.

The transmitter puts out peak power into the antenna, which focuses it into a beam w gain G. The power gain is similar to the directional gain except that it must also include losses from the transmitter to the antenna. These losses are summarized by the single term for efficiency.

The radar energy spreads out uniforınly in all directions. The power per unit area must therefore decrease as the area increases. Since the energy is spread out over the surface ofa sphere the factor of 1/4DR2 accounts for the reduction.

The radar energy is collected by the surface of the target and reflected. The radar cross section accounts for both of these processes. The reflected energy spreads out just like the transmitted energy.

The receiving antenna collects the energy proportional to its effective area, known as the antenna's aperture, Ae. This also includes losses in the reception process until the signal reaches the receiver. The effective aperture is related to the physical aperture, by the same efficiency terın used in power gain, given the symbol.

Our criterion for detection is simply that the received power, P, must exceed the minimum, Smin· Since the received power decreases with range, the maximum detection range will occur when the received power is equal to the minimum If you solve for the range, you get an equation for the maximum theoretical radar range:

$$R_{max} = \sqrt[4]{\frac{P_t G \sigma A_e}{(4\pi)^2 S_{min}}} \quad (1.12)$$

Perhaps the most important feature ofthis equation is the fourth-root dependence. The practical implication of this is that one must greatly increase the output power to get a modest increase in perforınance. For example, in order to double the range, the transmitted power would have to be increased 16-fold. You should also note that the minimum power level for detection, Sımın, depends on the noise level. In practice, this quantity constantly is varied in order to achieve the perfect balance between high sensitivity which is susceptible to noise and low sensitivity which may limit the radar's ability to detect targets.

1.5 Band Radar

1.5.1 L band radars

Operate ona wavelength of 15-30 cm anda :frequencyof 1-2 GHz. L band radars are mostly used for clear air turbulence studies.

1.5.2. S band radars

Operate on a wavelength of 8-15 cm and a :frequencyof 2-4 GHz. Because of the wavelength and :frequency,S band radars are not easily attenuated. This makes them useful for near and far range weather observation. The National Weather Service (NWS) uses S band radars on a wavelength of just over 10 cm. The drawback to this band of radar is that it requires a large antenna dish and a large motor to power it. It is not uncommon for a S band dish to exceed 25 feet in size.

1.5.3 C band radars

Operate on a wavelength of 4-8 cm and a frequency of 4-8 GHz. Because of the wavelength and :frequency,the dish size does not need to be very large. This makes C band radars affordable for TV stations. The signal is more easily attenuated, so this type of radar is best used for short range weather observation. The frequency allows C band radars to create a smaller beam width using a smaller dish.C band radars also do not require as much power as an S band radar. The NWS transmits at 750,000 watts of power for their S band, where as a private TV station such in Des Moines only broadcasts at 270,000 watts ofpower with their C band radar.

1.5.4 X band radars

Operate ona wavelength of 2.5-4 cm anda :frequencyof 8-12 GHz. Because ofthe smaller wavelength, the X band radar is more sensitive and can detect smaller particles. These radars are used for studies on cloud development because they can detect the tiny water particles and also used to detect light precipitation such as snow. X band radars also attenuate very easily, so they are used for only very short range weather observation. Also, due to the small size of the radar, it can therefore be portable like the Doppler on Wheels. (DOW) Most major airplanes are equipped with an X band radar to pick up turbulence and other weather phenomenon. This band is also shared with some police speed radars and some space radars.

1.5.5 K band radars

Operate ona wavelength of .75-1.2 cm or 1.7-2.5 cm anda corresponding frequency of 27-40 GHz and 12-18 GHz. This band is split down the middle due to a strong absorption line in water vapor. This band is similar to the X band but is just more sensitive. This band also shares space with police radars.

CHAPTERTWO

TYPES OF RADAR

2.1 Introduction

Radar systems can be classified by their operational characteristics or by their functions. We will describe the types of radar based on the individual techniques they employ.

2.2 Airport Surveillance Radar

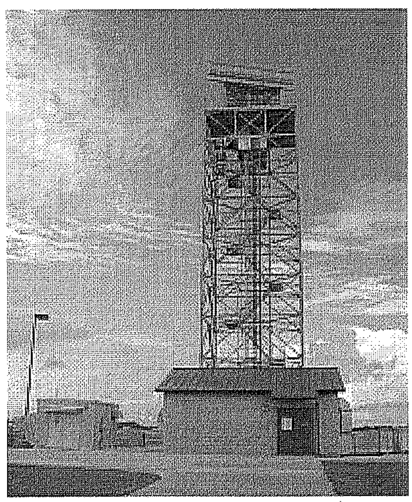


Figure 2.1: Airport Surveillance Radar

This is a medium-range radar system capable of reliably detecting and tracking aircraft at altitudes below 25,000 feet and within 40 to 60 nautical.miles of the airport where it is located. Systems of this type have been installed at more than 100 major airports though out the United States.

TheASR-9 is designed to be operated at least 99.9 percent of the time, which means that the system is down less than 10 hours per year. This high availability is attributable to reliable electronic components, a built-in test to search for failures, remote monitoring, and redundancy (i.e., the system has two complete channels except for the antenna, where one channel rnust be shut down for repair, the other continues to operate). The ASR-9 is designed the operate unattended with no rnaintenance personnel at the radar site. A nurnber of radar units can be rnonitored and controlled frorn a signal location. When trouble occurs, the fault is identified and a rnaintenance person dispatched for repair.

Echoes :frorn rain that mask the detection of aircraft are reduced by the use of Doppler filtering and other techniques devised to separate rnoving aircraft frorn undesired clutter it is irnportant for air-traffic controllers to recognize areas of severe weather so that they can direct aircraft safely around, rather than through, rough or hazardous conditions. The ASR-9 has a separate receiving channel that recognizes weather echoes and provides their location to air-traffic controllers. Six different levels of precipitation intensity can be displayed, either with or without the aircraft target superirnposed.

The ASR-9 systern operates within S band from.,2.7 to 2.9 GHz. Its klystron transrnitter has a peak power of 1.3 rnegawatts, a pulse width of 1 rnicrosecond, and an antenna with a horizontal bearn width of 1.4 degrees that rotates at 12.5 revolutions rep rninute (4.8 second rotation period).

The reflector antenna shows in the photograph is a section ofa parabolic. It is 16.5 feet wide and 9 feet high. Atop the radar (riding piggyback) is a lightweight planar array antenna for the Air Traffic Control Radar Beacon systern. Its dirnensions are 26 feet by 5.2 feet. ATCRBS is the prirnary rneans for detecting and identifying aircraft equipped with a transponder that can reply to the ATCRBS interrogation. The ATCRBS transrnitter, which is independent of the radar systern and operates at a different frequency, radiates a coded interrogation signal. Aircraft equipped with a suitable transponder can recognize the interrogation and send a coded reply at :frequencydifferent :from the interrogation :frequency.The interrogator rnight then ask aircraft, by rneans of other coded signals, to autornatically identify it self and to report its altitude. ATCRBS only works with cooperative target (i.e., those with an operationaltransponder).

2.3 Doppler Radar

A radar system used to measure the relative velocity of the system and the radar target. The operation of these systems is based on the fact that the Doppler frequency shift in the target echo is proportional to the radial component of target velocity.

Airborne systems are used to determine the velocity of the vehicle relative to the Earth for such purposes as navigation, bombing, and aerial mapping, or relative to another vehicle for fire control or other purposes. Ground or ship equipment is used to determine the velocity of vehicular targets for fire control, remote guidance, intercept control, traf:fic control, and other uses.

Doppler navigation radar is a type of airborne Doppler radar system for determining aircraft velocity relative to the Earth's surface. It is generally used with a navigation computer. The signal from a single beam can provide only the velocity component in the direction of that beam. Complete velocity determination requires, therefore, the use of at least three beams. Most systems use four beams for symmetry.

A preferred technique for obtaining coherent detection is to employ sinusoidal frequency modulation. A sideband of the detected beat between echo and transmitter signal is used. Modulation index and rate and the sideband order are chosen such that echoes from nearby objects are rejected, while those from distant objects are accepted. Leakage noise is reduced at the expense oflowered efficiency.

Pulse Doppler radars are useful tools for the observation of the movements of precipitation particles. The Doppler frequency shift associated with the velocity of atmospheric targets, such as precipitation particles or artificial chaff, is always a very small fraction (10^{-6} to 10^{-8}) of the radar operating frequency. The observation and measurement of such small frequency shifts require excellent radar system frequency-stability characteristics that are not usually found in conventional radars but can be added without a drastic increase in equipment cost.

2.4 lmaging Radar

Iınaging radar attempts to form a picture of the object as well. Several techniques have evolved to do this. Generally they take advantage of the Doppler shift caused by the rotation or other motion of the object and by the changing view of the object brought about by the relative motion between the object and the back-scatter that is perceived by radar of the object (a plane) flying over the earth. Through recent improvements of the techniques, this can be precisely calculated. Imaging radar has been used to map the Earth, other planets, asteroids, other celestial objects and to categorize targets for military systems.

2.5 Bistatic Radar

Bistatic radar is the name given to a radar system which comprises a transmitter and receiver which are separated by a distance thafis comparable to the expected target distance. And it uses a separate antennas for transmissiôn and reception as opposed to monostatic radar where a signle antenna is used for transmitting and receiving. Bistatic scattering characteristics of dense, strongly scattering media are importaiit in many practical applications, including millimeter-wave scattering :from snow, ice, and trees.

2.6 FrequencyModulated Continuous-wave radar (FM-CW)

(FM-CW) radar is a system where a known stable :frequencycontinuous wave radio energy is modulated by a triangular modulation signal so that it varies gradually and llien mixes with the signal reflected from a target object with this transmit signal to produce a beat signal.

Variations of modulation are possible but the tria11ğlem.6du.lationis used in FM-CW radars where both range and velocity ate desired/ With the advent of modern electronics, the use of Digital Signal Processing is used for most detection processing. The beat signals are passed through an Analog to Digital converter, and digital processing is performed on the result.

FM-CW radars can be built with one antenna using either a circulator, or circular polarization. Most modem systems use one transmitter antenna and multiple receiver antennas. The most common form of FM-CW radar is the radar altimeter which used in the Aircraft to determine the height above the ground

2.7 3DRadar

3D radar provides for radar coverage on three dimensions unlike the more common 2D radar. While the normal 2D radar provides range the conventional manner but uses an antenna that is rotated about a vertical axis to determine the azimuth, the 3D radar provides elevation information with range and azimuth. Applications include weather forecasting, defense and surveillance.

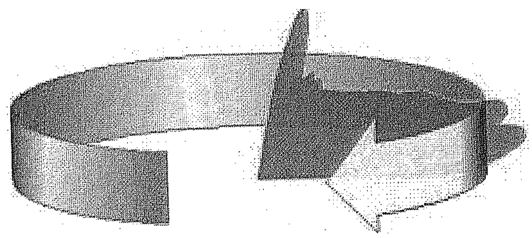


Figure 2.2: Diagram ofa typical 2D-Radar the rotating cosecant squared antenna pattem

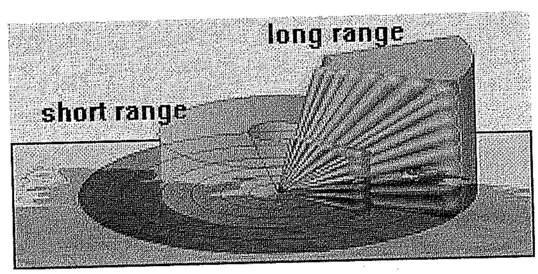


Figure 2.3: Diagram ofa typical 3D-Radar, ajudicial mix ofvertical electronic beam steering and mechanically horizontal movement ofa pencil-beam

2.8 Automotive Radar

The idea to mount a radar on a car isn't a new one. Since the 1960s, various ideas have been developed and tested, but the devices were either too bulky or too expensive for mass production. At the time of writing, several manufacturers around the world have developed small and lightweight devices, and efforts at making them affordable for the average driver are underway.

The main advantage of radar over competing devices, such as laser or infrared vision equipment, is the radar's ability to look through rain, fog and snow. Current devices are concentrating on Adaptive Cruise Control (ACC) and collision waming, with features such as 'collision avoidance' or 'autonomous driving' still on the list of things to come.

2.9 A Radar Gun

Is a small Doppler radar used to detect the speed of objects. A radar gun does not retum information regarding the object's position. It relies on the Doppler Effect applied to a radar beam to measure the speed of objects it is pointed at.

Radar guns may be hand-held or vehicle-mounted. They can be used as a tool in the regulation of traffic speed by law enforcement and also to measure speeds in sports.

Most of today's radar guns operate at X, K, Ka, and (in Europe) Ku bands. An altemative technology, LIDAR, uses pulsed laser light.

2.10 Monopulse **Radar**

Monopulse radars use antennas that provide a local cluster of simultaneous beams (instead of scanning just one beam) to make the same precise angle estimate with each pulse transmitted. Since angle information is contained in each retum, fluctuations in echo strength do not significantly degrade the measurement. Monopulse radars with mechanically positioned antennas address only a single target, and average the measurements over many pulses for improved accuracy. Radars using electronic beam steering in stationary phased-array antennas may make such a measurement in a single-pulse "dwell," doing so on dozens of targets, returning to each several times a second if necessary.

2.11 Millimeter Cloud Radar

Millimeter-wave cloud radar is a radar system designed to monitor cloud structure with wavelengths about ten times shorter than those used in conventional storm surveillance radars such as NEXRAD.

The National Oceanic and Atmospheric Administration designed MMCR to monitor clouds overhead at various testing sites of the U.S. Department of Energy's atmospheric radiation measurement program. The radars operate continuously at these sites in Oklahoma, Alaska and the tropical western Pacific Ocean, and are designed to function for at least ten years with rtıinimal manned attention. The MMCR is a vertically pointing doppler radar that operates at a frequency of 35 GHz. The main purpose of this radar is to determine cloud boundaries.

The shorter wavelength of the radar helps detect tiny water and ice droplets that conventional radars are unable to "see". The radar also helps to estimate microphysical properties of clouds, such as partide size and mass content, which aids in understanding how clouds reflect, absorb and transform radiant energy passing though the atmosphere. MMCR also reports radar reflectivity (dBZ) of the atmosphere up to 20 km. and possesses the capability to measure vertical velocities of cloud consitutents.

2.12 Passive Radar

A receive-only radar used for search, tracking, surveillance, identification, guidance, and mapping. The operation of passive radars depends upon the detection of microwave or infrared radiation from warm bodies.

Many potential military targets radiate .high noise power, such as ships at sea, exhaust from trucks, tanks, missiles, and airplanes, and factory chimneys. Unlike an active radar, a passive radar cannot determine the range to a target. However, using high antenna directivity obtainable at microwave and infrared wavelengths, a passive radar can locate a source of radiation accurately in direction and discriminate between nearby targets.

A passive radar can track a target closely and be used to direct weapon fire toward it. A passive radar, mounted on a missile, can be used to home the missile in on a target by using.just the pointing information provided by the radar. The power required to operate such a radar is quite small because there is no transmitter. Ground surveillance-and mapping can be accomplished with an airbome ground scanner. This type of radar provides an infrared picture of the terrain and any targets which may be present.

The absence of transmitted power makes the location, and even the existence, of a passive radar difficult to determine. Even if the position of a passive radar is known, its frequency cannot be determined; for this reason and because of the high angular resolution, it is difficult to jam.

2.13 Planar Array Radar

A fixed delay is established between horizontal arrays in the elevation plane. As the frequency is changed, the phase front across the aperture tends to tilt, with the result that the beam is moved in elevation. The differing :frequenciescause each successive beam to be elevated slightly more than previous beams. A 27.5 degree elevation is scanned by the radar.

2.14 Precision Approach Radar

A radar system located on an airfield for observation of the position of an aircraft with respect to an approach patlı, and specifically intended to provide guidance to the aircraft during its approach to the field; the system consists of a ground radar equipment which is altemately connected to two antenna systems; one antenna system sweeps a narrow beam over a 20° sector in the horizontal plane; the second sweeps a narrow beam over a 7° sector in the vertical plane; course correction is transmitted to the aircraft from the ground. Abbreviated PAR.

2.15 The Signal Corps Radio, model 270 (SCR-270)

It was one of the first operational early waming radars. It was the U.S. Army's primary long-distance radar throughout World War II and was deployed around the world. It is also known as the Pearl Harbor Radar, as it was a SCR-270 set that saw the incoming raid about halfan hour before the attack commenced.

2.16 Pulsed Radar System

2.16.1 Operation ofa Pulsed Radar System

The :frequency generation and timing system, discussed in parts of a radar system, periodiclly cause the transmitter to generate a pulse or burst of illumination electromagnatic energy. The power levels of this burst vary depending on the enviroment and the required performance of the system. The width of the pulse can vary between nanoseconds and milliseconds. The transmitted pulse is not a true pulse. A carrier waveform is in fact transmitted for the pulse duration. The transmitter unit, which transmitted the RF pulse, then waits for the ech. If the echo is received D t seconds later then the range can be easily worked out as:

$$R = C.\frac{Dt}{2} \tag{2.1}$$

The transmitter does not wait idefinitely for the echo as there is a maximum range :from which a targets echo is so weak it can not be detected.

Therefore the transmitter waits for inter pulse period (IPP) which disctates the maximum range, R_{max}, which the pulsed radar system can detect a target. The inverse of the IPP is the pulse repetition :frequency(PRF).

Another factor, apart :from R_{max}, that influences the PRF is the antenna rotational frequency. The antenna rotates so as to try to detect targets all around it.

To measure the time delay it takes for the echo to reach the receiver we need a :referancepoint in the transmitted signal. The echo that will be picked up by receiver from the target will be an attenuated version of the transmitted signal and so its shape will be vary similar to that of the transmitted pulse. The pulse shape to be transmitted therefore needs to have, one sharp referrence point.

2.16.2 Range Ambiguity

Range ambiguity results from the fact that we only wait a limited period of time for an ech from a target before the next pulse is transmitted.

Range ambiguity occurs when if for some reson we get an echo from a distance greater than Rmax, i.e, after a second pulse has been transmitted. The receiver then can not tell from what range the echo came from.

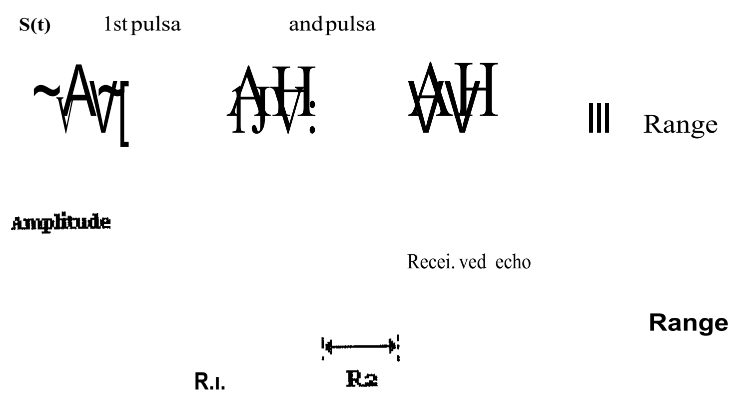


Figure 2.4: Range Ambiguity

If for instance the target echo was detected 0.000005 seconds after a pulse, and the IPP is 0.0006. Rmax for this system is therefore 90 Km. The echo could thefefore have come from a range of 750 mor 90.75 Km.It is therefore the IPP or the PRF that determines the amount of range ambiguity.

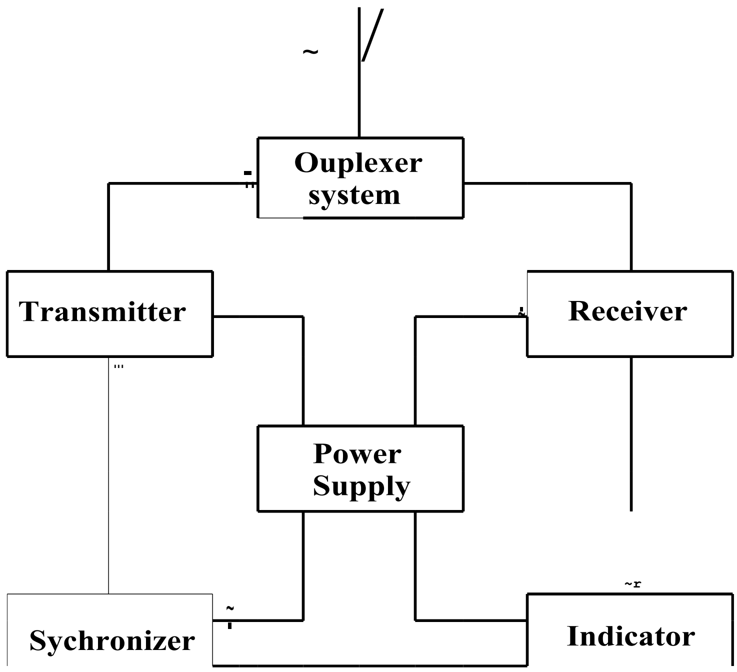


Figure **2.5:** Pulse Radar

lf we set the PRF to a larger enough value we can be certain we will not get any echoes from greater than Rmax. But there are other factors like antenna rotational speed that limit the PRF value. Therefore we can not remove the problem entirely.

2.16.3 Range Resolution

Range resolution is the system to distinguish between two target that are closely positioned. The eches of the two targets must therefore not overlap to such atı extent that they can not be still recognized as two separated echoes. Therefore the shrter the pulse duration period the higher the range resolution.

.2.17 Simple Pulse **Radar**

Pulse radar is the most widely used technique and represents what might be called conventional radar. Even in more complecated radar system, the pulse-modulated waveform is generally used. These more advanced radars are distinguished from simple pulse radar by the fact that they have additional features that provide enchanced performance

2.18 Moving Target lndication (MTI) radar

MTI is a form of pulse radar that measures the doppler frequency shift of the reflected signal to detect moving target, such as airplans and tanks, and to distinguish them from stationary objects that do not have a frequency shift. Almost all ground-based airplans surveillance radar systems use some type ofMTI.

2.19 Pulse Doppler Radar (with high pulse repetition frequency)

Pulse Doppler radar is another form of pulse radar that uses the Doppler frequency shift of the reflected signal to eliminate clutter and detect moving objects. The difference between pulse Doppler radar and MTI lies in thier respective pulse repetition frequencies (prf). For example, a high prf pulse Doppler system might have a prf of 100 KHz, while a typical MTI system has a prf of about 300 Hz. The MTI uses a lower PRF so as to obtain an unambiguous measurement of range. The tadeoff is that such a system yields highly ambiguous readings of radial velocity and can even miss some detections. Conversely, pulse Doppler, with its high PRF, yields unambiguous radial velocity measurements but the transmission of multiple waveforms with different prfs.

2.20 Pulse Doppler Radar (with medium pulse repetition frequency)

This type of pulse Doppler radar operates at a lower PRF than the high-prf system, and it yields ambiguities in both range and Doppler shift measurement. It is better for detecting aircraft with low closing speeds than in high-prf pulse Doppler. An aircraft-mounted medium-prf pulse doppler radar might have to use as many as seven or eight different prfs to obtain accurate target information.

2.21 High Range Resolution Radar

This is a type of radar that uses a very short pulse width to provide extemely accurate range measurement. Such radars provide range resolution from several meters to a fraction ofa meter, and they can profile a target and measure its lenght in the range dimension.

2.22 Pulse Compression Radar

For accurate range measurements at long distances it would be desirable to transmit very ahort pulses with high peak power and high energy waves. Unfortunately, this ability is limited in practice by voltage breakdown, or arcing in the transmitter or antenna. Thus, high range resolution radars with short pulses are limited in peak power and, therefore, also in operating range. Pulse compression sloves this problem by transmitting a long, high energy pulse to be compressed in either frequency or phase. The modulation allows the pulse to be compressed in the receiver, thus achieving the range resolution of short pulse transmission with longer pulses.

2.23 Over The Horizon Radar·(OTH)

Radio waves, a form of electromagnetic radiation, tend to travel in straight lines. This generally limits the detection range of radar systems to objects on their horizon due to the curvature of the Earth. For example, a radar mounted on top of a 10 metre mast has a range to the horizon of about 13,000 m, taking into account atmospheric refraction effects. If the target is above the surface this range will be increased accordingly, so a target 10 metres high can be detected by the same radar at 26 km. In general it is impractical to build radar systems with line-of-sight ranges beyond a few hundred kilometers. OTH radars use various techniques to see beyond the horizon, making them particularly useful in the early warning radar role.

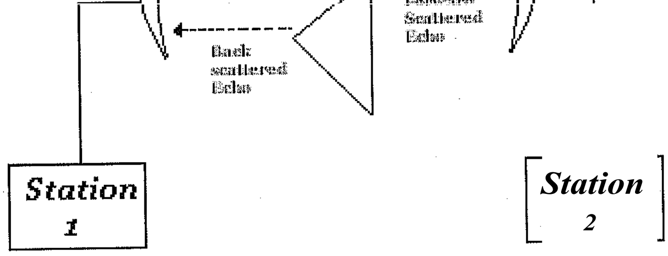


Figure 2.6: OTH Radar

The most common method of constructing an 0TH radar is the use of ionospheric reflection. Only one range of frequencies regularly exhibits this behaviour: the high frequency (HF) or shortwave part of the spectrum from 3 - 30 MHz. Given certain conditions in the atmosphere, radio signals in this frequency range will be reflected back towards the ground. The "correct" frequency to use depends on the current conditions of the atmosphere, sö systems using ionospheric reflection typically employ real-time monitoring of the reception ofbackscattered signals to continuously adjust the frequency of the transmitted signal.

After reflection off the atmosphere, a small amount of the signal will reflect off the ground back towards the sky, and a small proportion of that back towards the broadcaster. Given the losses at each reflection, this "backscatter" signal is extremely small, which is one reason why OTH radars were not practical until the 1960s, when extremely low-noise amplifiers were first being designed.

2.24 X-band Radar

Itself has a variety of types. Some of these types are continuous-wave, pulsed, single-pole, dual-pole, SAR, or phased array. X-band radar has various uses in civil, military and government institutions. X-band radar is used in some systems for: weather monitoring, air traffic control, maritime vessel traffic control, defense tracking, and vehicle speed detection for law enforcement.

X-band radar systems have been of great interest in the Iast few decades. The relative short wavelength at X-band frequencies makes possible high-resolution imaging radars for target identification and target discrimination

2.25 Tracking Radar

This type of radar employs a large dish type antenna that emits a narrow, symmetrical "pencil" beam. The purpose of tracking radars is to track a single target in both range and angle to determine its patlı, or trajectory, and to predict it future position.There are two main types of tracking radar, single target tracking radar and multiple target tracking radar.

2.25.1 Single-Target Tracking Radar (continuous tracking radar)

Single-target tracking radar observes only one target at a time. Initial search and acquisition of the target is normally done by a separate radar and the target is handed over to the tracking radar. Single-target tracking radars maintain continuous contact with the target,therefore,continually illuminating the target with electromagnetic energy. An example of a single-target tracking radar is a tracking and illuminating radar fora semi-active homing missile.

2.25.2 Multiple-Target Tracking Radar (track while scan).

Multiple-target tracking radar maintains tracking information on a number of targets. This radar normally operates in a numberofdifferent modes (track-while-scan (TWS) being one of them) and therefore normally performs its own search and acquisition tasks. TWS radars do not maintain continual contact with any one target as the radar continues to scan other sectors while maintaining the track on its established targets. Airborne early-waming radars and air superiority multimode radars are examples of radar systems that can benefit from TWS techniques.

2.26 Track-While-Scan Radar

Also known as automatic detection and tracking,or ADT, this is a type of surveillance radar that provides tracking of all targets within its field of coverage by measuring thier locations on each rotation of the antenna. Rather than showing individual detections(blips) on the screen, an ADT radar usually displays tracks or vectors of the targets thatreveal both thier direction and speed.

2.27 Synthetic Aperture Radar

Synthetic Aperture Radar (SAR) is a radar system proven to be very useful in oil spill detection. There are various stations around the globe, including Alaska and Norway that recieve SAR information from satellites for the use of oil spill detection.

SAR relies on the surface geometry ofthe object it is scanning; rough objects appear light, smooth objects appear dark. Oil slicks cause the ocean surface to become calm, thus oil slicks appear very dark surrounded by unaffected rough waters.

Frequently, after a possible oil slick is identified, an aircraft is sent out to scan the area using other detection techniques. This helps positively identify the oil slick and offers a more localized and detailed image ofthe spill.

SAR is very useful for early detection of an oil spill because it can be run 24 hours a day, regardless of cloudcover, After an oil spill is located, a picture detailing the spill can be produced within two hours.

SAR uses the geometry ofthe ocean surface for its detection. False alarms can occur when wind speeds are very low. When wind speeds are very high detection can also be a problem because the slicks will have minimal affects on the ocean surface

2.28 Inverse Synthetic Aperture Radar

üne can generate a high resolution image of some fixed object, by flying a synthetic aperture radar around the object.

üne generates exactly the same image with a fixed radar by rotating the object. Ifthe target rotates by a small amount, it has the same effect as if the transmitter / receiver were to travel a distance equal to the arc length at the range R.

Inverse Synthetic Aperture Radar (ISAR) is a well-establishedtechnique to identify the reflectivity centers of the target with high spatial resolution. A fine two-dimensional reflectivity map of the target is generated by using a large bandwidth transmitted signal in order to achieve high range resolution; and by coherently processing the echoes received :from different aspect angles of the target, to achieve fine cross-range resolution. The availability of a two-dimensional high resolution image permits the radar operator/researcher to better identify of the target and it can also be useful for the purpose of target classification.

2.29 Side-Looking Airborne Radar (SLAR)

Side-Looking Airbome Radar (SLAR) is an oil detection technique requiring the use of an aircraft to travel over the location to be mapped.

SLAR uses a radar beam transmission in the form of microwaves that is sent to the ground perpendicular to the aircraft's patlı of flight. Areas with a smooth surface emit dark image spots and areas with a rough surface emit lighter image spots.

The radars use of microwaves allows images to be retrieved night or day. The microwaves can also penetrate clouds, thus allowing for detection through adverse weather conditions.

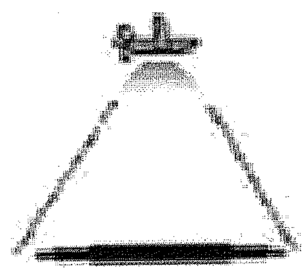


Figure 2.7 SLS (Side Looking Sonar)

SLAR is installed on aircrafts, so a qualified pilot is necessary for any successful mapping of an area. The course set by the pilot needs to be consistent and thoroughly mapped. This method can be an inefficient way to locate an oil spill without prior knowledge of the existing spill. However, with the combination of other techniques such as SAR, it is a very cost efficient way to receive quality images of an area.

2.30 Ship's Radar (SHIRA)

SHIRA is digital X-band radar, which uses an antenna commonly, installed on boats or elevated platforms as a means of oil detection. SHIRA produces a time-series of images which makes it possible to conduct continuous surveillance. The versatility of SHIRA allows it to be a useful tracking mechanism, but sometimes timely depending on the location of the spill. Image sequences contain information on temporal statistical properties of the sea surface making it possible to detect small targets in a contaminated sea surface where navigation radar is normally suppressed.

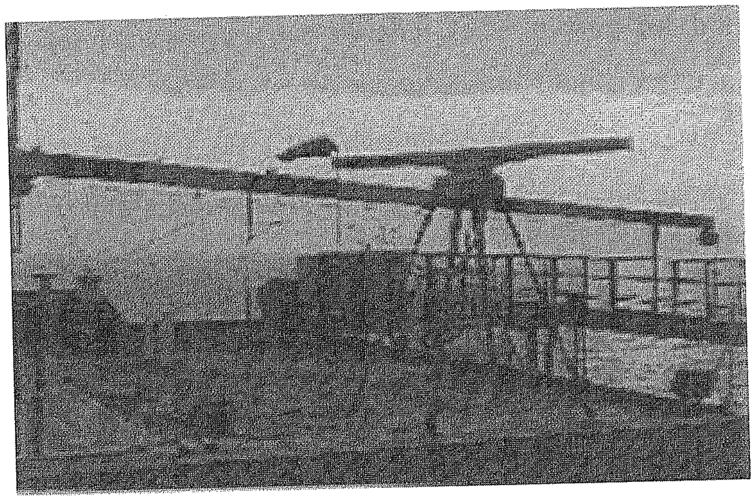


Figure 2.8 Ship Radar (SHIRA)

Oil slicks produce a low radar echo causing them to show up as dark patches. This process is typically done by SAR and SLAR, however radar has a lower sensitivity in shallow water. Due to SHIRA's higher integrated cababilities it is useful in shallower areas where oil spills occur.

, The expansion of this technology will help to detect .oil slicks in larger, more contaminated areas. Research is also being done on the automation of oil slicks to minimize the workload on human operators. SHIRA is a very new process that is undergoing further research and in the future may become essential in tracking oil spills.

2.31 Weather Radar

2.31.1 Introduction

Weather radars inauguration held on 20th ofthe september in 2000. The radar is 515 m above sea level and it is 24 m high. Compared to other weather radars in Finland Luosto radar has a digital receiver and larger antenna giving better resolution of observations, which is especilly important in the winter conditions of Lapland. The radar is also used in development of radar technology and signal processing algorithıns. Doppler radar covers almost the whole Lapland without the most northest part.

The Meterological Institue provdes weather radar picture for both intemal and extemal use. Radar and satellite picture are an essential tool for the meteorologist on duty and are use in research also. For the public these radar pictures have become familiar :from for example the weather forecasts presented in the evening news.

2.31.2 Weather Radar Working

Meteorologists use weather radar to detect, locate, and measure the amount of precipitation within or falling :from clouds.

RAdio Detection: Weather radars are both transmitters and receivers. Weather radars transmit a microwave beam and then "listen" for echoes that bounce back from precipitation-sized particles (or "targets") within or falling from clouds. (Doppler weather radars can also operate in a "clear air mode" in which cloud droplets can be detected.)

And Ranging: Since we know both the direction in which the radar transmitter is pointing and the speed at which microwaves travel (close to the speed of light), the direction and distance :from the transmitter to the precipitation can be determined. (Distance to the precipitation echoes is calculated by dividing the travel time (outbound and inbound) in half and multiplying by the speed of light.) This permits mapping ofprecipitation over the region surrounding.the radar site.

Precipitation inteıısity: can be determined by measuring the strength of the echoes received by the radar antenna. The amount of energy reflected back to the radar is proportional to the precipitation intensity--the greater the energy reflected back to the radar, the greater the precipitation intensity. Echo strength is measured in units of DBZ (decibels). In general, DBZ values greater than 15 indicate areas where the precipitation is reaching the ground; DBZ values less than 15 indicates very light precipitation which may be evaporating before it reaches the ground (virga). In addition, Doppler weather radar is capable of measuring whether precipitation echoes are moving toward or away from the radar antenna, and can therefore measure rotation within storms which may precede severe storms.

2.31.3 Doppler Weather Surveillance Radar (WSR-88D)

Next Generation Weather Radar (NEXRAD), also known as Doppler weather surveillance radar (WSR-88D), excels in detecting the severe weather events that threaten life and property, from early detection of damaging winds to estimating rainfall amounts for use in river and flood forecasting. Most important, WSR-88D can increase advance waming--and the specificity of such wamings--for short-lived, often catastrophic events such as tomadoes, downbursts, and flash floods.
Using Doppler technology, the WSR-88D calculates both the direction and speed of motion of severe storms. By providing <lata on the wind pattems within developing storms, the new WSR-88D identifies the conditions leading to severe weather such as tomadoes. This means earlier detection of the precursors to tomadoes, as well as <lata on the direction and speed of tomadoes once they form.

The following WSR-88D products are available (most of these products are not widely accessible via the Intemet):

- Reflectivity
- Composite Reflectivity
- Layer Composite Reflectivity
- Mean Radial Velocity
- Echo Tops
- One-Hour Rainfall Accumulation
- Three-Hour Rainfall Accumulation
- Storm Total Rainfall Accumulation
- Hourly Digital Rainfall Array
- Vertically Integrated Liquid Water
- Velocity Azimuth Display Wind Profile

2.31.4 Technical Aspects

The main units in weater radar are the antenna with its pedestal, the transmitter, the receiver and the associated computer system The main computer controls all aspects of the radar' s operations and passes on the measurement results to the FMI main office in Helsinki.

Technical Data	**Measurement**
.A.ntennadiameter	Lousto 6.1 m, other radars 4.2 m
Randome diameter	Luosto 9.1 m, other radars 6.2 m
Beamwidth	Luosto 0.7 degrees, other radars 1 degrees
Transmitter	Radial magnetron
Frequency	5600-5650 MHz
Wavelenght	Approx. 5.3 cm
Transmtted pulse power	250KW
Average transmitter power	300W

CHAPTER THREE

AIRPORT SURVELLANCE RADAR

3.1 Introduction

Surveillance radar a device which, by measuring the time interval between transmission and reception of radio pulses and correlating the angular orientation of the radiated antenna beam or beams in azimuth and/or elevation, provides information on range, azimuth, and/or elevation of objects in the patlı of the transmitted pulses.

Surveillance radars are divided into two general categories: Airport Surveillance Radar (ASR) and Air Route Surveillance Radar (ARSR).

1. ASR is designed to provide relatively short-range coverage in the general vicinity of an airport and to serve as an expeditious means of handling terminal area traffic through observation of precise aircraft locations on a radarscope. The ASR can also be used as an instrument approach aid. The DFW terminal radar approach control (TRACON) facility provides radar coverage with four ASR-9 installations.

2. ARSR is a long-range radar system designed primarily to provide a display of aircraft locations over large areas. The Fort Worth air route traffic control center (ZFW ARTCC) provides radar coverage with a total of 9 long range radar installations, 2 radar beacon only sites and one ASR-9 installation.
Center Radar Automated Radar Terminal Systems (ARTS) Processing (CENRAP) was developed to provide an alternative to a no radar environment at terminal facilities should an ASR fail or malfunction. CENRAP sends aircraft radar beacon target information to the ASR terminal facility equipped with ARTS. Procedures used for the separation of aircraft may increase under certain conditions when a facility is utilizing CENRAP because radar target information updates at a slower rate than the normal ASR radar. Radar services for VFR aircraft are also limited during CENRAP operations because of the additional workload required to provide services to IFR aircraft.

Surveillance radars scan through 360 degrees of azimuth and present target information on a radar display located in a tower or center. This information is used independently or in conjunction with other navigational aids in the control of air traffic.

3.2 Airport Surveillance Radar (ASR)

Approach control radar uses to detect and display an aircraft' s position in the terminal area. ASR provides range and azimuth information but doesn't provide elevation data. Coverage of the ASR can extend up to 60 miles. The DFW terminal area is blanketed with four ASR-9 facilities.

Reliable maintenance and improved equipment have reduced radar system failures to a negligible factor. All of the DFW Radar facilities have components duplicated-one operating and another, which immediately takes over when a malfunction occurs to the primary component.

The characteristics of radio wave are such that they normally travel in a continuous straight line unless they are:

1. Bent abnormal atmospheric phenomena such as temperature inversions; the bending of the radar pulses, often called anomalous propagation or ducting, may cause many extraneous blips to appear on the radar operator's display if the beam has been bent toward the ground or may decrease the detection range if the wave is bent upward. it is difficult to solve the effects of anomalous propagation, but usirı.ğ beacon radar and electronically eliminating stationary and slow moving targets by a method called moving target indicator (MTI) usually negate the problem.

2. Reflected or attenuated by dense objects such as heavy clouds, precipitation, ground obstacles, mountains, ete.; radar energy that strikes dense objects will be reflected and displayed on the operators scope thereby blocking out aircraft at the same rage and greatly weakening or completely eliminating the display of targets at a greater range. Again, radar beacon and MTI are very effectively used to combat ground clutter and weather phenomena, and a method of circularly polarizing the radar beam will eliminate some weather retums. A negative characteristic of MTI is

that an aircraft flying a speed that coincides with the canceling signal of the MTI (tangential or blind speed) may not be displayed to the radar controller.

3. Screened by high terrain features. Relatively low altitude aircraft will not be seen if they are screened by mountains or are below the radar beam due to earth curvature. The only solution to screening is the installation of strategically placed multiple radars which has been done in some areas.

4. There are several other factors, which affect radar control. The amount of reflective surface of an aircraft will determine the size of the radar return. Therefore, a small light airplane ora sleek jet fighter will be more difficult to see on radar that a larger commercial jet or military bomber. Here a gain, the use of radar beacon in invaluable if the aircraft is equipped with an airbome transponder. All radars in the lone star SMO have the capability to interrogate MODE C and display altitude information to the controller from appropriately equipped aircraft. The controllers ability to advise a pilot flying on instruments or in visual conditions of his proximity to another aircraft will be limited if the unknown aircraft is not observed on the radar, if no flight plan information is available, or the volume of traffic and workload prevent his issuing traffic information. The controller's first priority is given to establishing vertical, lateral, or longitudinal separation between aircraft flying IFR under the control of Air Traffic Control (ATC).

3.3 Air Traffic Control Radar Beacon System (ATCRBS)

The air traffic control radar beacon system is a system used in air traffic control (ATC) to enhance radar monitoring and separation of air traffic. ATCRBS assists ATC radars by acquiring information about the aircraft being monitored, and providing this information to the radar controllers. The controllers can use the information to identify returns from aircraft (known as targets) and to distinguish those returns from ground clutter.

The ATCRBS, sometimes referred to as secondary surveillance radar, consists of three main components:

1. Interrogator. Primary radar relies on a signal being transmitted from the radar antenna site and for this signal to be reflected or "bounced back" from an object (such as an aircraft). This reflected signal is then displayed as a "target" on the controller's

radarscope. in the ATCRBS, the Interrogator, a ground based radar beacon transmitter-receiver, seans in synchronism with the primary radar and transmits discrete radio signals which repetitiously request all transponders, on the mode being used, to reply. The replies received are then mixed with the primary retums and both are displayed on the same radarscope.

2. Transponder. This airbome radar beacon transmitter-receiver automatically receives the signals from the interrogator and selectively replies with a specific pulse group (code) only to those interrogations being received on the mode to which it is set. These replies are independent of, and much stronger than a primary radar retum.

3. Radarscope. The radarscope used by the controller displays retums from both the primary radar system and the ATCRBS. These retums, called targets, are what the controller refers to in the control and separation of traffic.

The job of identifying and maintaining identification of primary radar targets is a long and tedious task for the controller. Some of the advantages of ATCRBS over primary radar are:

1. Reinforcement of radar targets.

2. Rapid target identification.

3. Unique display of selected codes

Apart of the ATCRBS ground equipment is the decoder. This equipment enables a controller to assign discrete transponder codes to each aircraft under his/her control. Normally only one code will be assigned for the entire flight. Assignments are made by the ARTCC computer on the hasis of the National Beacon Code Allocation Plan. The equipment is also designed to receive Mode C altitude information from the aircraft.

Center Radar Automated Radar Terminal Systems (ARTS) Processing (CENRAP) was developed to provide an altemative to a nonradar environment at terminal facilities should an ASR fail or malfunction. CENRAP sends aircraft radar beacon target information to the ASR terminal facility equipped with ARTS. Procedures used for the separation of aircraftmay increase under certain conditions when a facility is utilizing CENRAP because radar target information updates at a slower rate than the normal ASR radar. Radar services for VFR aircraft are also limited during CENRAP operations because of the additional workload required to provide services to aircraft.

3.4 Primary Surveillance Radar (PSR)

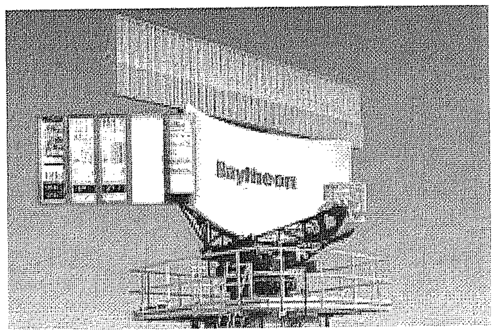


Figure 3.1: ASR-lOSS Solid-State Primary Surveillance Radar

Primary radar is a pulsed beam ofultrahigh frequency radio waves 'shone' in a circle from a rotating aerial. lf the radar beam 'illuminates' an object, some of the energy is reflected back. How much an object reflects depends on its size, shape and material. Metal aeroplanes and ships reflect well, while non-metallic ships and small boats often have metal radar reflectors mounted high up to improve their chances of been seen. But, at best, only a small amount ofthe out-going energy is reflected back. Thus the out-going pulse has to be strong, typically several megawatts. Of course, some military aircraft are designed and constructed to be non-reflective - the so-called stealth aircraft.

Thus the direction of the 'target' can be determined from the direction the aerial was facing when the target was illuminated. To find out how far in that direction the target lays, it is necessary to measure the time between the out-going pulse and the return. This is done almost instantaneously and a blob or 'trace' appears on the radar screen at a position representing the direction and range of the target. lf the target is a boat or ship, this is probably all the information you need. Indeed many ships and small boats are equipped with just such radar. The coverage is within 80 nautical miles approach control and within 200 nautical miles for en-route control purpose.

3.5 Secondary Surveillance Radar (SSR)

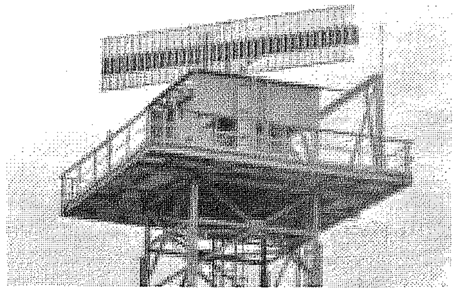


Figure 3.2: Secondary Surveillance Radar (SSR)

Scondary surveillance radar provides, after processing of <lata transmitted by the aircraft, the range, bearing, altitude and identify (Callsign) of an aircraft. The coverage can reach 250 nautical miles. A SSR can provid more useful information than Primary Surveillance Radar (PSR) but is subject to the proper functioning of the aircraft's transponder. To provide the best radar picture with a continuouss display of aircraft targets, the SSR is usually paired with a PSR for air traffic control operation.

3.6 Problems with Primary Radar

1. Rain makes target difficult to see.

2. Birds can show a retum that looks like an aircraft .

3. Some aireraft do not show up at ali.

4. Clutter from other inormation makes aircraft difficult to see.

3.7 Secondary Surveillance Radar helps to solve the problem

All the transponder equipped aircraft have numbers. Even the ones without primary retums. Birds and alien spacecraft dont have numbers.

1. 1200 means that the aircraft is navigating on its own under visual flight rules,and not talking to a controller.

2. Other numbers are assigned by controllers, and mean different things in different airspace.

For example,

- odd numbers mean arrivals
- even numbers mean departures.

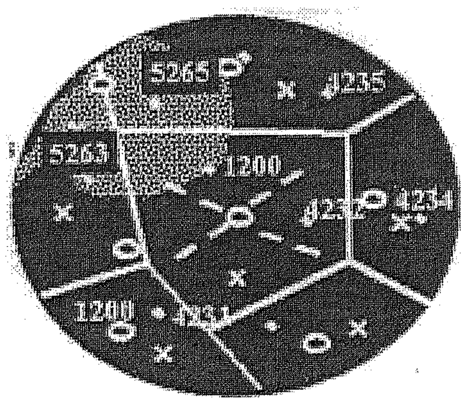


Figure 3.3: Monitor of SSR shows the targets.

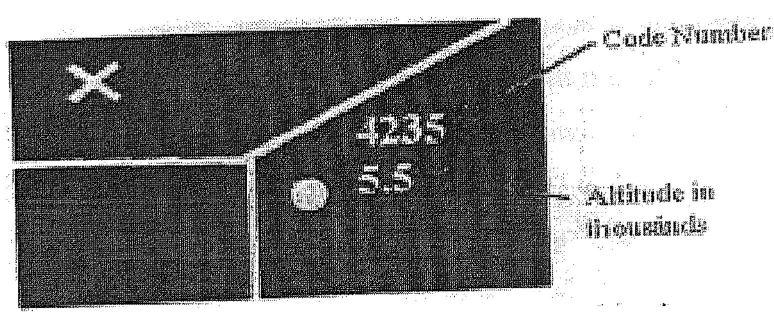


Figure 3.4: Monitor of SSR shows the altitude ofthe plane

3.8 Why it is difficult to provide Low-Level Radar Coverage?

Radio waves usually travel in straight line, they cannot detour round obstacles which curtail their line of travel, radar like al other radio based systems, therefore a line of sight instrument and vulnerable to screening by mountains or even, if the aircraft is flying low enough by the earth's curvature.

An aircraft flying behind a mountain, for example would not be visible to the radar, but as soon as it climbed above the mountain or emerged from behind it, the aircraft would once again appear as a target on radar screen. The higher the aircraft, the greater the radar ranges. In mountainous regions it is, therefore, difficult to provide low level radar overage which is why airports like Katmandu in Nepal, which are difficult to fly into even under the best conditions, cannot be made safer with the introduction of radar or indeed other line of sight navigational aids.

3.9 The Radar's Role in the ATC

The biggest drawback with primary radar is that it can only highlight targets within its range; it cannot positively identify those targets or their altitude. The controller must paint a three-dimensional picture in his mind so that knows the identification of each target, its altitude (as reported by the pilot), where it is going, how fast it is going and whether it is likely to conflict with any of the other targets on the screen.

If in doubt about a particular target's identity, the controller can request that aircraft to undertake a specific man oeuvre, such as a tum off course followed by a retum to course. By watching which target on his screen makes a momentary detour from course, the controller can pinpoint exactly which aircraft it is. It is a system that works well in areas of low traffic density. In busy skins, how ever, the controller is faced with a screen crowded with one-dimensional target for which he is trying to provide a three-dimensional air traffic control service. Under those conditions, indenting man oeuvres becomes more hazardous and some from of positive target identification is essential.

The answer is secondary surveillance radar. Unlike primary radar, which does not require the aircraft to carry any response equipment, secondary radar is an interrogative system: it transmits a signal to the aircraft to which.the aircraft replies with coded transmission. The aircraft must therefore be equipped with response equipment, known as a transponder.

In order to identify a target, the ground controller will ask that aircraft to 1:ransponder or squawk an assigned code number which immediately highlights a target on the controller's screen, identifying it as that particular aircraft. If the aircraft isiquipped with what is known asa Mode C transponder, the altitude of that aircraftfyillappear as an unidentified target.

These days, most radar <lata is collected in a computer processing systetrr which extracts the relevant aircraft information and discards the clutter of echoes/ğenerated by terrain or weather to create a much cleaner radar display showing all tarğefs<and, where relevant, identifying labels.

In busy airspace, or in the vicinity of terminal areas, primary and secoıid~iradar sensors are generally mounted together to ensure that controllers are a ware :rı_()y.}()ııely of all transponder equipped aircraft in their sector, but also any traffic ôperating without transponders, for upper level en route surveillance, longer range .secôıı.dary surveillance radar is generally used alone because there is less traffic .cö11.trôlde11.sity and-few, if any aircraft operate in those sectors without transponders. .Likeitsprimary counterpart, secondary radar is a line of sight tool and range restricted.<Whefe full secondary radar coverage is available, it is possible to reduce the separatiôrisbetween aircraft and therefore make more efficient use of the available airspace, thereby increasing the capacity of that controlled airspace. Howeverfradar'is limited to a range of about 200 nm on land, it is usually possible to install a sufficient number of radar sites to provide full radar coverage, practically as aircraft climb away from the earth's surface and obstacle interference. But it is impossible to provide radar cover over the full expanse of the world's oceans and it is rarely viable to provide full cover in the depth inaccessible terrain such as vast deserts.

3.10 Multi **Radar Tracking**

In many busy areas, radar coverage is so comprehensive that. several radar retums are generated for each aircraft. In reality, radar bias (the ra.dar.sigrıaLmaybe weekend by distance, weather conditions or other interference) or systematic error between radars means that each radar <lata will give a slightly different position reading The radar <lata processor will select the reading from the radar providing the strong signal and translate that into a target on the air traffic control display.

Multi radar tracking today collates the signal <lata from all the relevant radars, calculate the strength of each retum, and using all this information, define the aircraft's precise position.

3.11 Precision Approach Radar

At airport where it is not possible to install an (instrument landing system) or ILS, but it may be necessary to offer a precision approach capability, ICAO recommends the use of (Precision Approach Radar). In these circumstances, a local controller literally talks the aircraft down on to the runway. Because it is expensive and rarely used, PAR is not widely applied.

It involves the use of two radar picture, giving the controller both azimuth and elevation views of the aircraft on approach. The controller will then talk to the pilot giving minute navigation instructions to the aircraft established on the centerline and glide slope and keep there for the entire descent. In order for the controller to give accurate instructions, he must have elevation/height information include in the display. A straightforward azimuth or plan display. A straightforward azimuth or plan display would provide insufficient data.

3.12 Mode S

It is a system, which enhances existing radar-based surveillance and provides an additional <lata link function. It has been developed in order to over come sensitivity of existing systems to synchronous grabble and a critical shortage of transponder codes. Existing system are unable to assign unique identity codes to more than 4,096 aircraft in any one region at any given time. Although all aircraft operating in a specified region have individual codes, those same codes have to be used by other aircraft operating in different region across the globe. An aircraft passing through several regions may therefore have to be assigned a new identity code as it passes from one region into another to avoid an identity conflict with an aircraft already operating in that region with the same code.

Mode S is capable of recognizing up to 16 million unique codes, which means that every aircraft currently in existence could be assigned its own unique code when the Mode S transponder is installed. This code cannot be changed from the cockpit. Mode S codes are derived from the aircraft's registration number or other numbering scheme.

Another key feature of Mode S is tat it can selectively interrogate individual aircraft even if several transponder-equipped aircraft are simultaneously within view of the ground sensor. A Mode S transponder. In order to pick up unknown aircraft, a sensor periodically broadcasts a Mode S 'all-call' interrogation. Any Mode S transponder, which has not been specifically commanded to ignore all-call integration, will reply. Once a transponder has responder to all-call interrogation will reply. ünce a transponder has responded to all-call interrogation and been identified, the sensor will then instruct it to ignore all further all-call interrogations. Mode S is claimed to improve overall surveillance accuracy by a factor ofup to four.

As it is <lata link toll, mode S used the basic surveillance interrogation and replies to pass <lata link message, taking advantage of the selective address to exchange comprehensive <lata. As a result, air traffic controllers can receive on screen more

inforınation about the status of each aircraft interrogation than is currently possible with Mode A (identity) and Mode C (altitude).

In addition, using the Mode S data link function, a pilot may access weather and flight inforınation services, flight safety services,<automated terminal inforınation services (ATIS), initial connection service, and autonıated ~ıroute air traffic control connection mode services. ICAO as the secondary surveillanceiradar (SSR) standard ofthe future has adopted Mode S.

3.13 Displays

Display technology has made great strides over the last few years, giving 5786controllers a clearer picture of the airspace they are controlling. From the early days of round horizontal monochrome displays, air traffic control authorities are increasingly switching to vertical square color screens.

Until the advent of SSR, all radar surveillance involved the use of primary sensors. The data generated by these sensors was displayed on round PPI (Plan Pôsitiôıı Indicator) screens with a beam making a circular scan of the screen represeıııfeach revolution of the radar antenna, updating the echoes with every revolution. But, as well as picking up aircraft, the screen also displayed all other echoes generated by the radar and, as a result, the picture received by the controller was often cluttered.

The advent of SSR and the use of transponders meant that it was at least possible positively to identify and label targets and, as display technology improved, to select the amount of additional inforınation that was displayed on the screen. it was possible, for example, to screen out terrain and weather echoes, leaving just the active targets and giving controllers a much clearer picture.

3.14 AN/SPS-49 Very Long-Range Air Surveillance Radar

The Radar Set AN/SPS-49 is an L-band, long-range, two-dimensional, air-search radar system that provides automatic detection and repörtill.g)of targets within its surveillance volume. The AN/SPS-49 performs accurate Ceritrö\dinğôftarget range, azimuth, amplitude, ECM level background, and radial velocity .'\Vitlları.r.associated confidence factor to produce contact data for command and côı:ıtrôt)systems. In addition, contact range and bearing information is provided for displaY pli standard plan position indicator consoles. The AN/SPS-49 uses a line..of-siğlıtJ;i".lıôtizon-stabilized antenna to provide acquisition of low-altitude targets in all.s~@j!sfat~~riand also utilizes an up spot feature to provide coverage for high divingthreatsci1 1.Ytb.el:ıigh diver mode. Extemal control of AN/SPS-49 modes and operation bYitb.e:Cç§ınına1 1d and control system, and processing to identify and flag contacts as speciaE\al~fts.ate provided for self-defense support. The AN/SPS-49 has several operatiorialfe~tu:r.esfô allow optimum radar performance: an automatic target detection capabilitywith;;ıJfüse Doppler processing and clutter maps, ensuring reliable detection in normal .an.d severe types of clutter; an electronic counter-countermeasures capability for jamining environments; a moving target indicator capability to distinguish moving targets.from stationary targets and to improve target detection during the presence of clutter and chaff; the Medium PRF Upgrade (MPU) to increase detection capabilities and reduce false contacts; and a Coherent Side lobe Cancellation (CSLC) feature.

The AN/SPS-49 long range 2-dimensional air surveillance radar used for early target detection. The long-range AN/SPS-49 radar operates in the presence of clutter, chaff, and electronic counter-measures to detect, identify, and control low-radar-cross-section threats traveling at supersonic speeds. AN/SPS-49 provides the front-end element for successful target identification, designation, and engagement with either long range (SM-1 or SM-2) missiles and/or short range local defense missiles. A feature of the most recent version ofthe radar, the SPS-49A (V) 1 is single-scan radial velocity estimation of all targets allowing faster promotion to fırın track and improved maneuver detection. This is done using unique signal processing techniques originated and tested by the Radar Division ofNRL using 6.1 and 6.2 Office ofNaval Research (ONR) funds.

The AN/SPS-49(V) radar is a narrow beam, very long range, 2D air search radar that primarily supports the AAW mission in surface ships. The radar is used to provide long range air surveillance regardless of severe clutter and jamming environments Collateral functions include air traffic control, air intercept control, and antisubmarine aircraft control. It also provides a reliable backup to the three-dimensional (3D) weapon system designation radar.

The AN/SPS-49(V) radar operates in the frequency range of 850 - 942 MHZ. In the long range mode, the AN/SPS-49 can detect small fighter aircraft at ranges in excess of 225 nautical miles. Its narrow beam width substantially improves resistance to jamming. The addition of coherent side lobe canceller (CSLC) capability in some AN/SPS-49(V) radars also provides additional resistance to jamming/interference by canceling the jamming/interference signals. The moving target indicator (MTI) capability incorporated in the AN/SPS-49(V) radar enhances target detection of low-flying high speed targets through the cancellation of ground/sea return (clutter), weather and similar stationary targets. in 12 RPM mode operation, this effective for the detection of hostile low flying and "pop-up" targets. Features of this set include:

- Solid state technology with modular construction used throughout the radar, with the exception of the klystron power amplifier and high power modulator tubes
- Digital processing techniques used extensively in the automatic target detection modification
- Performance monitors, automatic fault detectors, and built-in-test equipment, and automatic on line self test features

Band	L
Frequency Band:	850 to 942 MHz three selectable 30MHz bands 48 Discrete frequencies
Transmitting Power:	360 kW peak 280 kW specified peak power 12-13 kW average power
Antenna Parameters:	Parabolic Reflector stabilized for roll and pitch 7.3m/24 ft wide, 4.3m/14.2 ft high
Rotating Clearance:	8.7m/28.4 ft diameter
Beam widths:	3.3°-3.3° azimuth 11 ° elevation
Gain:	28.5 dB
Scan rate:	6 or 12 rpm
Range:	250nm
Minimum Range:	0.5NMI
Frequency Selection:	Fixed or frequency agile
Range Accuracy:	0.03 NMI
Azimuth Accuracy:	0.5 deg
PRF:	280, 800, 1000 pps
Pulse width:	125 microseconds

3.15 Upgrading the Nation's Largest Space Surveillance Radar

Some of the custom electronics assemblies designed at SwRI for the AN/FPS-85 radar transmitter unit upgrade are shown at left. Large-quantity production factors were considered during the design phase. For example, a microcontroller (upper left) with highly integrated features were selected to minimize assembly complexity and parts count.The world's first large phased-array radar, the AN/FPS-85 was constructed in the 1960s at Eglin Air Force Base, Florida. Other large radars have been introduced since then, but the Grand Old Lady of the South, as the radar installation is known at Eglin, remains the nation's primary space surveillance radar because of its unsurpassed power and coverage.

The AN/FPS-85 is a valued asset to the U.S. Air Force, but one with an aging technology base that must be supported into the future. For example, the on-site maintenance crew repairs an average of 17 radar transmitter units per day at an expense of $2 million annually, a figure that will rise as the vacuum tube market diminishes. Recognizing that maintenance costs could be reduced by reliability improvements, the Air Force contracted with SwRI in 1992 to study ways of improving the installation's transmitter array system.

The AN/FPS-85 Phased Array Radar Facility is located in the Florida panhandle, near the city of Freeport, which is approximately 25 miles east of Eglin Air Force Base. A several mile no-fly zone surrounds the radar installation as a safety concern for the electro explosive devices, such as ejection seats and munitions, carried on most military aircraft.

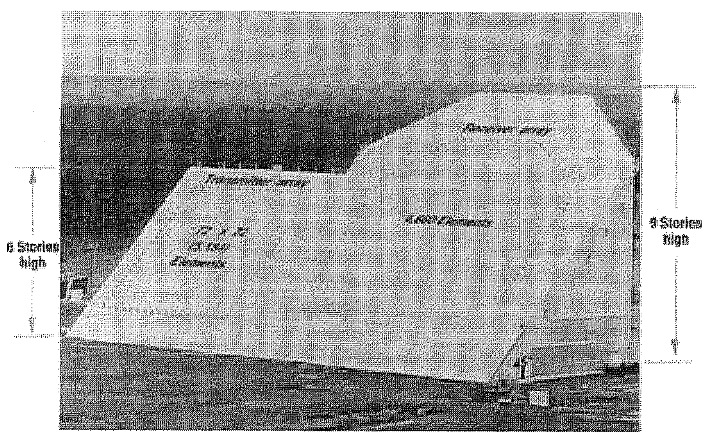


Figure 3.5: The AN/FPS-85 Phase Array Radar Facility in Florida, USA

CONCLUTION

Most of the airports are using the secondary surveillance radar (SSR) to detect the plans and for the air traffic control (ATC), secondary surveillance radar provides, after processing of data transmitted by the aircraft, bearing, altitude and identity (call sign) of an aircraft. The coverage can reach 250 nautical miles. A SSR can provide more useful information than Primary Surveillance Radar (PSR) but is subject to the proper function of the aircraft's transponder. To provide the best radar picture with a continuous display of aircraft target, the SSR is usually paired with a PSR for air traffic control operation.

The future of radar does not lie in large and more powerful system, put rather in slightly smaller systems that are more agile, intelligent and difficult to detect because of the large band width tat will be used. The resolution of radar, and the number of targets that can be tracked, can be expected to increase as large amount of low-cost computer power become available.

We hope that this project conveyed the main ideas and helped to understand the underlying principles of the airport surveillance radar. We hope also to have gained and appreciation of the importance of radar in many diverse areas, and sensed some of the excitement of working in this field.

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CHAPTER FOUR

SURVEILLANCE RADAR iN ERCAN AIRPORT

4.1 Civil Aviation Department in Ercan Airport

Name of the Government Organization is Civil Aviation Department, Ministry of communication and works, Turkish Republic of Northem Cyprus (TRNC).

Number of the engineers employed in company is four; three are Electrical & Electronic engineers and one Mechanical engineer they are responsible to maintain the available systems for the continuity of airport facilities, they are responsible to manage the technicians, also to make the work plan and they are responsible to prepare new project in order to improve Ercan Airport's facilities. There are 21 Technicians; 11 of who are Electric & Electronic Technicians and the rest are Mechanical Technicians.

The civil aviation in Northern Cyprus is responsible for Gecitkale Airport, which is the second Airport in Northem Cyprus. Cyprus Turkish Civil Aviation was established in 20/07/1974 it's head quarters is in Capital City Lefcosa (Nicosia), 23 Kın west of Ercan Airport. The Director ofthe Department is Mr. Orbay killicc.

4.2 Radar System in Ercan Airport

Radar system in Ercan Airport (The Main Airport in Northern Cyprus) is consisting of primary surveillance Radar (PSR), Secondary Surveillance Radar (SSR), Multi Radar Tracking (MRT), Multi Channel Tracking (MCT), Associated modem, Common Display System (CDS) and Digital System (DDS) the last two for monitoring.

4.2.1 Primary Surveillance Radar

Primary Surveillance Radar (PSR) it has 60 NMI. The transmitter of PSR, since a pass of about one Mw for Duration about one micro second through the magnetron this pass travels in the air with speed of light 162 000 nmi/s, when it hits the targets i.e. the plan it reflects back and the receiver of the system detect the echo and true the formula of

$$R=\frac{Ct}{T} \qquad (4.1)$$

Where R is the range, C is the speed of light and t is the time between the transmissions of signal and receiving of the echo, it calculates the range of the plane the purpose of PSR is detection and ranging only.

4.2.2 Secondary Surveillance Radar

The principle of Secondary Surveillance Radar is different than the Primary Surveillance Radar because it needs the assistant of the plan to detect the target.

The transmitter of SSR sends two passes in two different modes 3A, and mode C that ask the plane who are you? And what high are you?, the transponder in the plane detects these signals and answers in per determent model, the receiver of SSR detects and processing this reply. Lock at the figure.

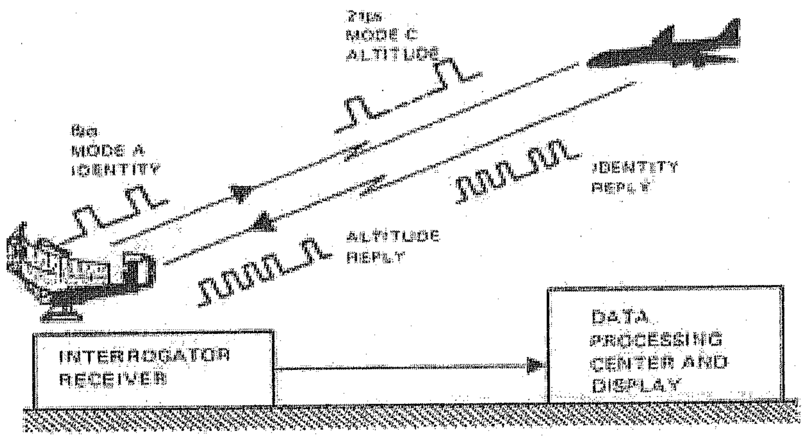

Figure 4.1: The basic principles for the operation ofthe SSR system in Ercan Airport.

4.2.2.1 SSR Performance and Limitations

The attached document contains part of annex 10 of the convention of (1 N C A) and it gives specifications and recommendations of for SSR to which the SSR must add here

- Detection the aircraft position without to use necessarily the decoding equipment;
- Identification of the aircraft height code; I
- To identify, when it is requested, a signal aircraft from the reply of special SPI (Special Pulse Identification);

To indicate, immediatlyian aircraft in an emergency condition or with the radio communication system in trouble such performance must be available, typical with in following limits for all the conditions

Up to 200 nautical miles ranges

Up to an altitude of 30.480 meter (100.00) for elevation angles between .5/45

Foran azimuth angle of 360

The advantages gamed from an SSR system are set by the following problems

Interrogation by antenna side lobes

Interrogation by means multiple patlı figure 4.2

Interrogation by coming from other SSR system figure 4.2

Replies coming from aircrafts closely spaced in heaving traffic areas

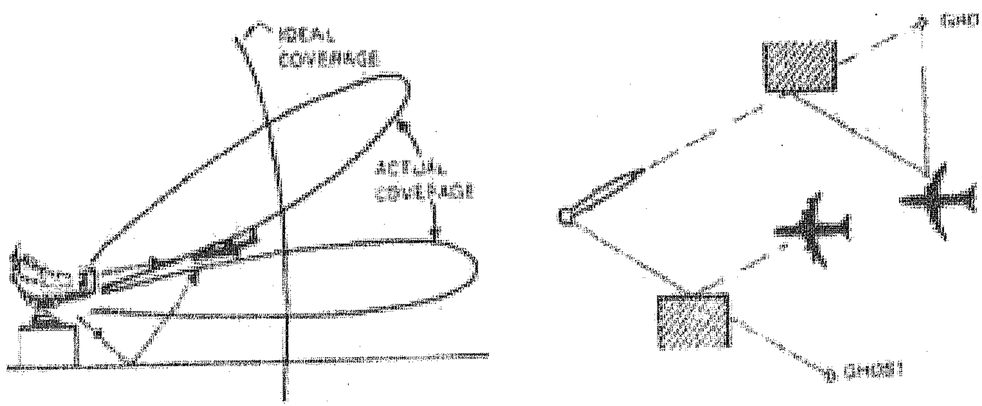

Figure 4.2: Reflection influence on SSR coverage in Ercan Airport

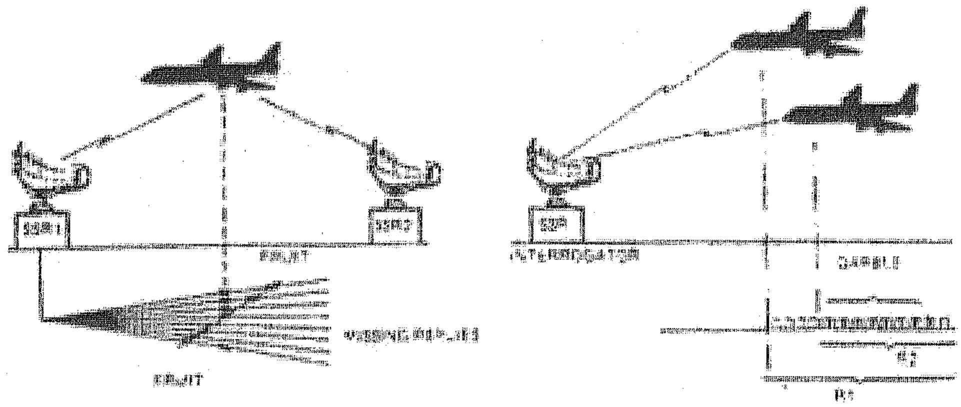

Figure 4.3: SSR Interferences Ercan Airport

4.3.3 MRT and MCT

MRT means Multiple Radar Tracking, MCT means Multiple Cannel Tracking, most ofthese are for processing and converting the <lata from PSR and SSR in form to send to DDS/CDs for the use of air traffic control. Also MCT combines the <lata of SSR coming from Ermenek City (central of turkey) to Ercan. Modems: these are used for transmission of <lata between Ercan Radar site, Ermenek SSR and the ATC (Air Traffic Control) center.

4.3.4 CDS and DDS

CDS means Common Display System, DDS means Digital Display system. These are monitoring system for the air traffic controls rule it has many different access to able an easier control when a controller looks at his displays he sees where the plane is, how high the plane is, what the speed of the plane is, very easily, and in a very clearway.

4.4 Basic Elements of Pulse Radar Systems in Ercan Airport

The basic elements in a typical pulse radar system are: The timer, modulator, antenna, receiver, indicator, transmitter, duplexer and rotary joint, as is shown.

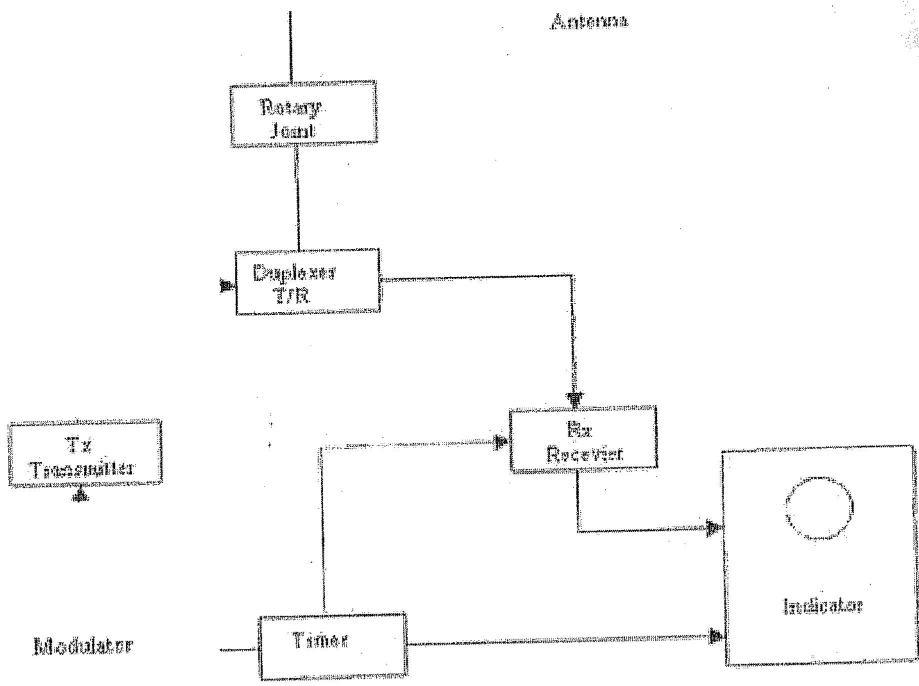

Figure 4.4: Basic elements of pulse systems radar in Ercan Airport

4.4.1 Timer

The timer or synchronizer is the heart of all pulse radar systems, it's function is insure that all circuits connected with radar system operate in a definite Time relationship with each other, and that the interval between pulse is of the [illegible] length. The timer may be a separate unit by it self or it maybe included is the transmitter or receiver.

4.4.2 Modulator

The modulator is usually a source of power for the transmitter it is controlled by the pulse from the timer, it sometimes is called keyer.

4.4.3 Transmitter

The transmitter provides RF energy at an extremely high power for a very short time. The frequency must to get cycles in to the short pulse.

4.4.4 Antenna

The antenna is very directional in nature because it must obtain the angles of elevation and bearing of the target to obtain tlıis directivity at centimeter wave lengths ordinary dipole antennas are used in conjunction with parabolic reflectors usually, in order to same space and weight the same antenna is used for both transmitting and receiving when tlıis system is used, some kind of switching device is required for connecting it to the transmitter when a pulse is being radiated, and to the receiver during the interval between pulse. Since the antenna only (sees) in one direction, it is usually rotated or moved a bout to cover the area around the radar set tlıis is called searching. The presence of targets in the area is established by this searching.

4.4.5 Duplexer

Such a device realized the antenna switching from transmitting phase to receiving phase enabling the patlı Transmitter-antenna and inhibiting the patlı Antenna-receiver during radiation; vice versa during reception.

4.4.6 Rotary joint

This device allows the transforming of the RF energy between the fixed part and the turntable one of the RF system.

4.4.7 Receiver

The receiver in radar equipment is primarily a super-hetero dyne receiver. It is usually quite sensitive. When pulsed operation is employed it must be capable accepting signals in a bandwidth of one to ten mega cycles.

4.4.8 Indicator

The indicator presents visually all the necessary information to locate the target on the indicator screen. The method of presenting the <lata depends on the purpose of the radar set. Since the spot (seans) the indicator screen to present the <lata, the method of presentation is often reflexes to as the type of scan, in the following sub paragraphs a brief description on the most common types of scan will be supplied.

4.5 Important Aviation System has related with Airport Surveillance Radar in Ercan Airport

There is also important aviation systems have related with radar, to make the air traffic control easier, in this section we are going to present these systems which used in Ercan Airport.

4.5.1 The Navigational Aids Systems in Ercan Airport

The purpose of navigation system is to ensure the safe, efficient transit of aircraft following established procedures. The elements which support the basic function en route and approach navigation, and landing at airports. The surveillance function, needed to provide Air Transit Services, is based on primary and secondary surveillance radar sensors to perform en route and approach air traffic control. Navigational aids system in Ercan Airport consists ofVOR, NDB and DME.

4.5.1.1 VOR

VOR is (Very High Frequency (VHF) Omni-directional Radio Range), each VOR equipment has a name of three characters and identi:fication in mores code the VOR station have different frequencies, if two VOR station will use the same frequency they should have 500 miles difference. What is the job of VOR equipment?

It has a global radio lines transmission; there are 360 radials 0 degree is adjusted to magnetic north. The frequency of VOR equipment is between 108 MHz- 117.95 MHz VOR equipment consists of solid state plug in modules, 220 VAC is converted to 40 VDC, 12 VDC and 24 VDC by transformer. There are mainly six parts in VOR equipment.

1. Power supply
2. Transmitter
3. Modulator
4. Electronic goniometric
5. Antenna
6. Monitor

The VOR frequency in Ercan Airport (ECN) is 117.00 MHz, and in Gectikale Airport (GKE) is 114.3 MHz.

4.5.1.2 NDB

NDB is Non Directional Beacon; it is a radio transmitter NDB frequency range is between (200-800 KHz), the frequency of Ercan Airport is 290 KHz. It can be identi:fied by a Morse code signal that it emits at frequent intervals, it offers no tracking guidance and most aircrafts are :fitted with an Automatic Direction Finder (ADF) to identi 1' the direction of the beacon from the aircraft. NDB's are usually used in the vicinity of airports as an aid to locating the airport itself.

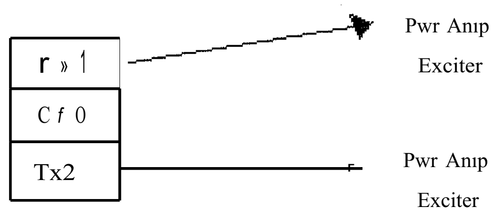

Figure 4.5: The NDB system.

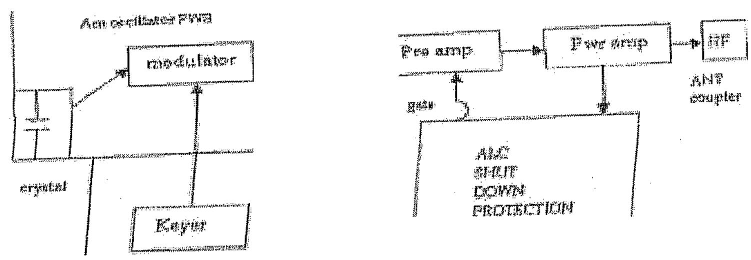

Figure 4.6: Block diagram ofNDB in Ercan Airport.

4.5.1.3 DME

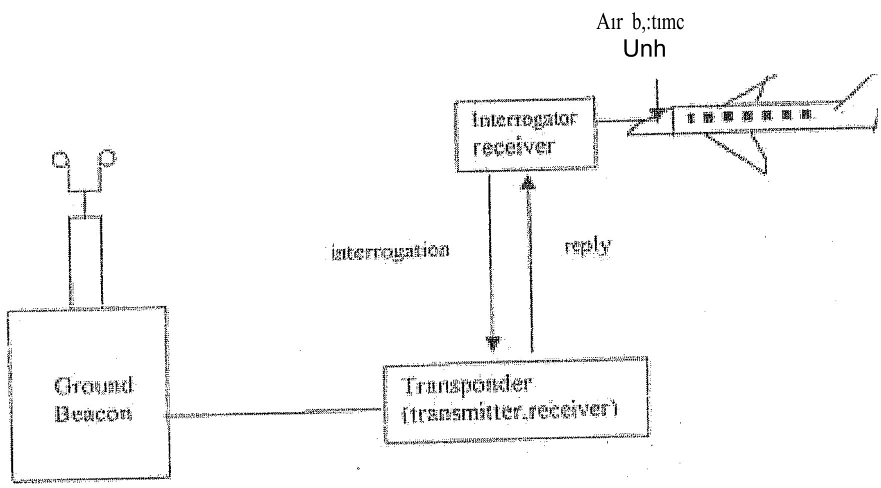

Figure 4.7: The DME system in Ercan Airport.

DME is Distance Measuring Equipment, DME is a frill-duplex VHF system, full duplex means transmission and reception can be realized at the salne time, in DME the frequency is different for every airport, for usage purpose there are two types of DME.

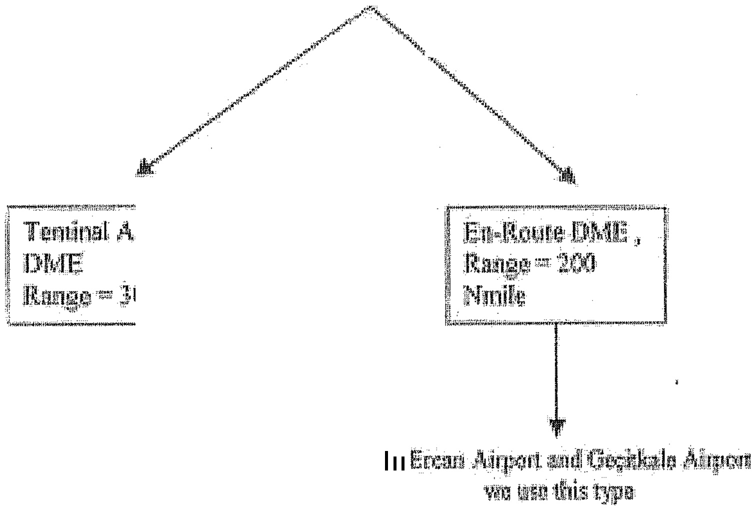

Figure 4.8: Types ofDME.

Face standard FSD-15 is used in Ercan Airport and the Airsys Navigation FSD-45 is used in Getcitkale Airport. The working principle of DME:

The interrogator / receiver in airborne unit sends the interrogation signal to the DME ground beacon, then the ground bacon sends a reply signal to the air borne unit, then calculates the distance using the time difference between the interrogation and reply signals by using the formula,

:rvı=t. e (4.2)

M is the distance, t is the time and c is the velocity of the light parts of DME ground beacon.

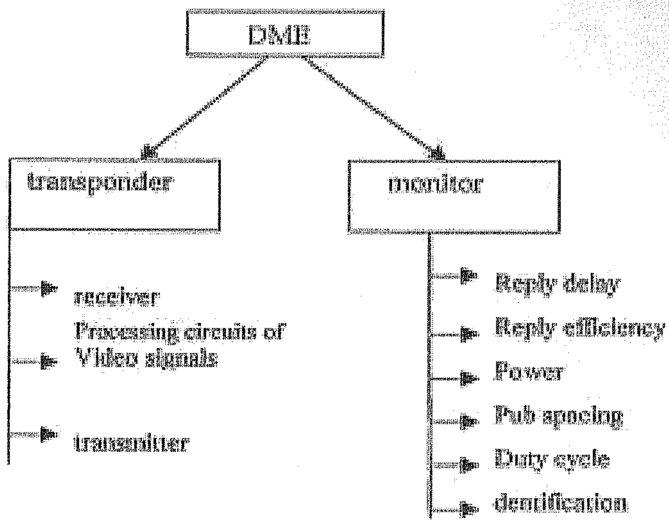

Figure 4.9: Parts ofDME ground beacon.

The monitor system continuously checks if the pulses and all the transmission properties are correct. The frequency of Ercan DME is as below,

Airport	Channel	Interrogation frequency	Reply frequency	Pulse frequency	VHF Channel
GKE	90x	1114 MHz	1177 MHz	12 us	114.3 MHz
GKE	90y	1114 MHz	1051 MHz	30 us	114.3 MHz
ECN	117x	1141 MHz	1024 MHz	12 us	117.0 MHz
ECN	117y	1141 MHz	1078 MHz	30 us	117.0 MHz

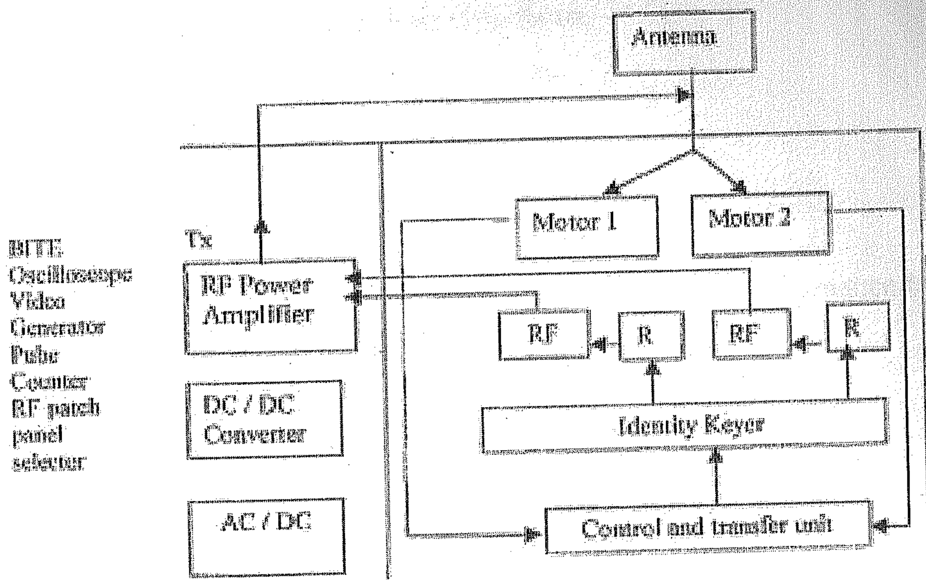

Figure 4.10: General Diagram ofDME in Ercan Airport.

4.5.2 VHF Voice Communication System in Ercan Airport

VHF frequency in general 30 - 300 MHz in air navigation. 118 MHz - 136 MHz separated for air navigation.

In Ercan Airport, frequencies used (assigned for Ercan), I C A 0 assigns these frequencies.

Frequency	Function
120.2 MHz	Tower frequency
126.7 MHz	Air traffic control frequency
126.9MHz	Approach frequency
121.5 MHz	Emergency frequency, it is same in all the airports
118.1 MHz	Spare tower frequency (Gecitkale tower frequency)

Local system situated in Ercan Airport for local frequency as,

120.2 MHz	2 transmitters, 2 receivers
126.7 MHz	1 transmitter, 1 receiver
126.9 MHz	I transmitter, I receiver
121.5 MHz	1 transmitter, I receiver
118.1 MHz	1 transmitter, 1 receiver

Yaula station system situated in yayla over mountains,

126.7 MHz	2 transmitter, 2 receivers
126.9 MHz	1 transmitter, 1 receiver
121.5 MHz	1 transmitter, 1 receiver

The system used in Yayla in order to have a greater coverage performance because they are situated over the mountains.

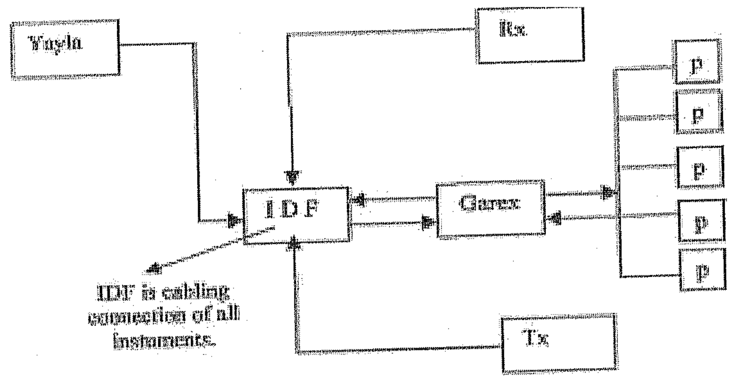

Figure 4.11: Voice communication in Ercan Airport.

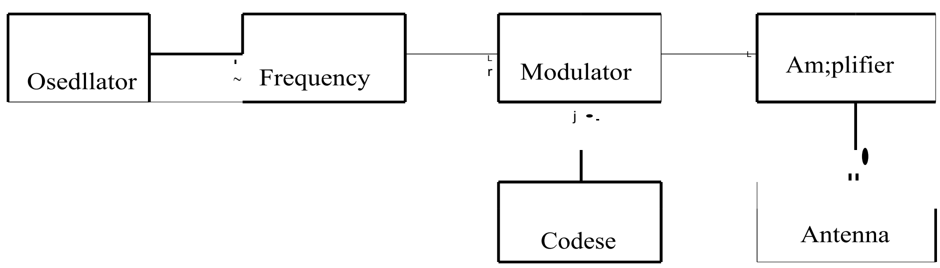

Figure 4.12: Simple block diagram oftransmitter in voice communication.

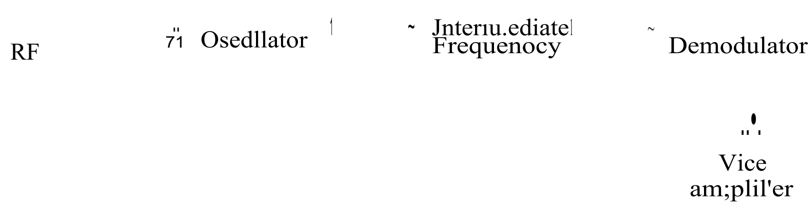

Figure 4.13: Simple block diagram ofreceiver in voice communication.

4.6 Summary

We can now understand the important of radar systems which include the SSR which inform the ATC room in Ercan about all the civil plans around Cyprus, as the mention that there are transponder in the plan resend the signal and inform Ercan the altitude and the identity of the plan, look to the figure below then we will know the navigation systems which consist of three main parts DIVIE, VOR and NDB these systems make insurance for the plan, so the pilot can know the altitude of the plan and its location. Here come the VHF voice communication systems, which is important also, the pilot can contact with the ATC room by this system by frequencies assigned for Ercan by ICAO so ere the employee in Ercan can tell pilot what is his altitude as what is written in the radar monitor in the ATC room, the pilot of course will look at the transponder of DME to make insurance, the plan can know what is going on the space by contact Ercan and what is the speed of other plans so the employee of ATC room here has big responsibility for what happens in the air,

Figure 4.14: The ATC room in Ercan Airport.