# Detection Of Airborne Objects using RADAR Technology

**[G18]** Nithin Uppalapati, Srinivas Mareddi, K Sai Rithvik

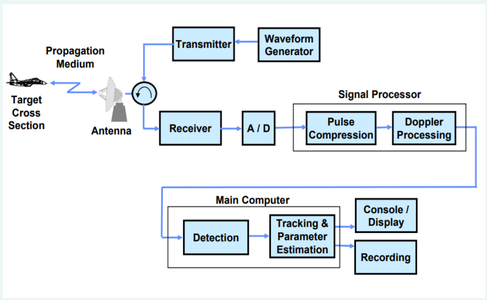
## What is a RADAR ?

**RADAR** [RAdio Detection and Ranging], is an object detecting technique, by using **Radio waves**, which determines the range of the object, direction, elevation and the velocity of the object.

*Radar in RAF Cold War base*

*INDRA Mobile Surveillance Radar*

## How does it work ?




*Flowchart describing the working of a Radar*

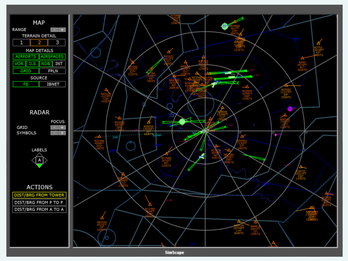
The Radio waves used by radar are produced by a device called **magnetron**. The signal is sent out in pulses, through a waveguide and radiated using an antenna which produces a narrow beam.

**Duplexer** makes the antenna switch back and forth between being a transmitter and a receiver. Duplexers can be based on frequency (often a waveguide filter), polarization (such as an orthomode transducer), or timing (as is typical in radar).

*References and Citations*

1. *Robert M. O'Donnell, MIT Lincoln Laboratory*
2. *Introduction to Camouflage and Deception, JV Ramana Rao.*
3. *Stealth Aircraft, Bill Sweetman.*
4. *http://understandingairplanes.com/ Stealth-Airplane-Design.pdf By Bermado Malfitano*
5. *International Journal of Engineering and*
6. *Technical Research (IJETR)*

## Analysing the Echo

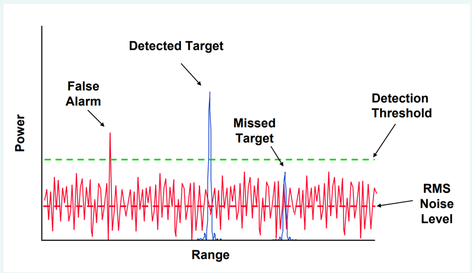


*Typical Radar Display (Plan Position Indicator)*

The properties of reflected waves such as **power, polarisation** and **shift in frequency** are analysed and the resulting information is processed and displayed.

By analysing the state of polarisation of reflected wave using certain algorithms we can predict the shape of the target. To eliminate the noise generated in case of **rainfall** circularly polarised waves are transmitted. This is because the reflected waves due to rain is also **circularly polarised** and is eliminated during processing. Based on **Doppler shift** the radial velocity of the target is calculated.

## Radar Range Equation




*Common Sources of noise are Galactic noise, Solar noise, Ground noise, Atmospheric noise and man-made interference(Radiostations, Radars, etc.)*

**Signal Power Reflected by target and received by radar**:

$$P_r = \frac{P_t G_t}{4\pi r^2} \sigma \frac{1}{4\pi r^2} A_{\text{eff}}$$

$P$ : *Power Transmitted(t) or Recieved(r)*

$Gt$ : *Antenna Transmission Gain*

$r$ : *Distance from Radar to Target*

$Aeff$ : *Effective Area of Recieving Antenna*

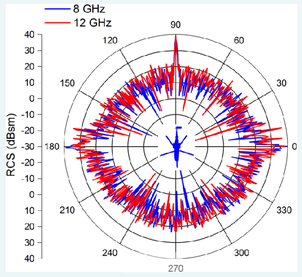
$\sigma$ : *Radar Cross-section of Target*

*All quantities are in SI Units*

## Radar Cross-section

**Radar Cross-section**(RCS) is a measure of the energy that a Radar target intercepts and scatters back towards the radar. A larger RCS indicates that an object is more easily detectable. RCS is a measure of the reflectivity of the target.

$$\sigma = \lim_{r\to\infty} 4\pi r^2 \frac{|E_s|^2}{|E_i|^2}$$




*RCS of an all metal surface helicopter on varying the incident angle*

## Measuring Radar Cross-section

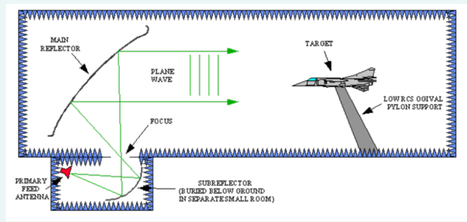
Radar cross-section can be found out by

- Scaled Down Measurement
- Full Scale Measurememt
- RCS Prediction

For **Full scale measurement**, the target is mounted on a Styrofoam tower(dielectric properties of it are close to free space) or a metal pylon(To reduce radar reflections).

In **Scaled Down Measurement** the target is scaled down by a factor of S and different parameters are scaled accordingly.

**RCS Prediction** can be approached either by High Frequency approximations or computationally intensive approach of using exact numerals.




*Scaled Down Measurement*

## Stealth Technology

(Reduction of RCS)

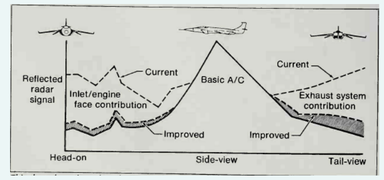
To reduce the visibility on Radars, aircrafts and missiles are designed to reduce RCS. RCS broadly depends on the following factors :

- **Primer Materials**
- **Dimension of the target**
- **Angle of reflection governed by design and orientation of target**
- **Polarisation**
- **Active radar cancellation**

| | Square meters |
|---|---|
| Small, single engine aircraft | 1 |
| Four passenger jet | 2 |
| Large fighter | 6 |
| Medium jet airliner | 40 |
| Jumbo jet | 100 |
| Helicopter | 3 |
| Small open boat | 0.02 |
| Small pleasure boat (20-30 ft) | 2 |
| Cabin cruiser (40-50 ft) | 10 |
| Ship(5,000 tons displacement, L Band) | 10,000 |
| Automobile / Small truck | 100 - 200 |
| Bicycle | 2 |
| Man | 1 |
| Birds | $10^{-2}$ - $10^{-3}$ |
| Insects | $10^{-4}$ - $10^{-5}$ |

*RCS of Various Objects*

## Design of Stealth Aircrafts




*Contribution of Various parts of an aircraft to RCS*

*Use of flares to avoid missile detection(Based on IR)*

Design techniques such as **Flattened Fuselages, Flattened Nozzle, Faceted Design, Aligning Edges, Avoiding Right angles, Serpentine Intakes, Non constant Radii of Curvature, Toothpick Leading Edges** and **ReEntrant Triangles** are used to reduce the amount of energy that is reflected back to the radar and hence reducing the visibility.

*US Airforce B2 Stealth Bomber RCS: 0.1 square meter*

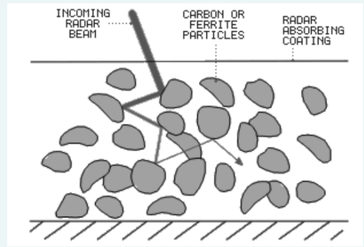
*Dassault Rafale RB002 RCS: Classified*

## Use of Primer Materials

The **Radar Absorbing Material**(RAM) is designed to impedance match with the surrounding, and also to incorporate lossy property to the extent required.

Some of the materials used are

- **Iron ball paint absorber.**
- **Foam absorber.**
- **Jaumann absorber.**
- **Split-ring resonator absorber.**
- **Carbon nanotube.**
- **Silicon carbide**.




*Radar beam dissipation due to RAM coating*