IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 04, Issue 10 (October. 2014), ||V3|| PP 48-50

Algorithm for Radar cross section estimation

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Abstract: *- Radar cross-section (RCS) is a measure of how detectable an object is with a Radar. A larger RCS indicates that an object is more easily detected . An object reflects a limited amount of radar energy. A number of different factors determine how much electromagnetic energy returns to the source such as; the material of which the target is made , absolute size of the target , the relative size of the target in relation to the wavelength (λ) of the radar, the incident angle , the reflected angle and the polarization of transmitted and the received radiation in respect to the orientation of the target. A personnel computer (PC) will be programmed to estimate the RCS of targets.*

Keywords: *Radar, RCS ,Wave length ,Personnel computer .*

I. INTRODUCTION

Radar cross section is used to detect planes in a wide variation of ranges. For example, a stealth aircraft (which is designed to have low delectability) will have design features that give it a low RCS (such as absorbent paint, smooth surfaces, surfaces specifically angled to reflect signal somewhere other than towards the source), as opposed to a passenger airliner that will have a high RCS (bare metal, rounded surfaces effectively guaranteed to reflect some signal back to the source, lots of bumps like the engines, antennas, etc.). RCS is integral to the development of radar stealth technology, particularly in applications involving aircraft and ballistic missiles. RCS data for current military aircraft is most highly classified.

In some cases, it is of interest to look at an area on the ground that includes many objects. In those situations, it is useful to use a related quantity called the differential scattering coefficient (also called the normalized radar cross section or backscatter coefficient) σ^0 ("sigma naught"), which is the average radar cross section of a set of objects per unit area:

$$\sigma^0 = \left\langle \frac{RCS_i}{A_i} \right\rangle \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where:
RCS_i is the radar cross section of a particular object.
A_i is the area on the ground associated with that object.

II. APPROACH

The RCS of an object is the cross sectional area of a perfectly reflecting sphere that would produce the same strength reflection as would the object in question. (Bigger sizes of this imaginary sphere would produce stronger reflections.) Thus, RCS is an abstraction: The radar cross sectional area of an object does not necessarily bear a direct relationship with the physical cross sectional area of that object but depends upon other factors.

More precisely, the RCS of a radar target is the hypothetical area required to intercept the transmitted power density at the target such that if the total intercepted power were re-radiated isotropically, the power density actually observed at the receiver is produced. This is a complex statement that can be understood by examining the primary radar equation one term at a time:

$$P_r = \frac{P_t G_t}{4\pi r^2} \sigma \frac{1}{4\pi r^2} A_{eff} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

where
P_t = power transmitted by the radar (watts).
Gt = gain of the radar transmit antenna (dimensionless).
r = distance from the radar to the target (meters).

σ = radar cross-section of the target (meters squared).
A_{eff} = effective area of the radar receiving antenna (meters squared).
Pr = power received back from the target by the radar (watts).

RCS is an extremely valuable concept because it is a property of the target alone and may be measured or calculated. Thus, RCS allows the performance of a radar system with a given target to be analyzed independent of the radar and engagement parameters. In general, RCS is a strong function of the orientation of the radar and target, or, for the primary radar a function of the transmitter-target and receiver-target orientations. A target's RCS depends on its size, reflectivity of its surface, and the directivity of the radar reflection caused by the target's geometric shape.

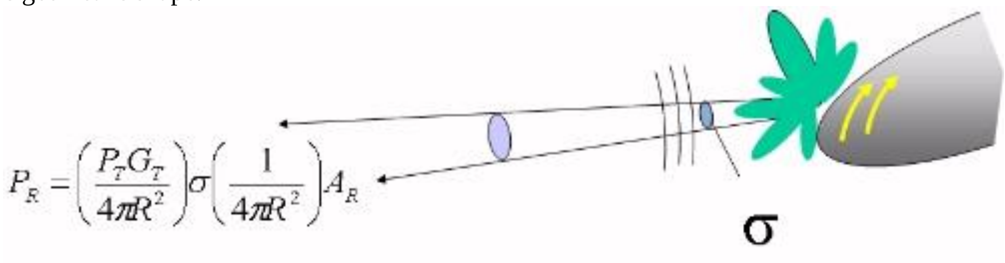
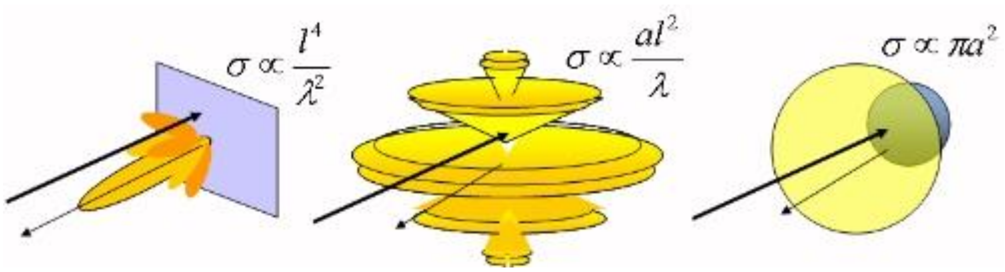


Figure (1) Sketch showing the RCS (σ)

Radar cross section is dominated by shape, because it's the shape that governs how much of the incident power is captured and sent back, as illustrated in the three examples in figure (2) below, where the objects are assumed to be large compared to the incident wavelength. The example in figure (2-a) illustrates mirror-like reflection or specular reflection, here the reflection is proportional to (1/λ^2). Example in figure (2-b) shows the amplitude of the reflections from a vertical cylinder. Looking straight onto the cylinder produces maximum backscatter. However, at certain angles other than 90 degrees there can be also considerable reflection as shown. For a cylinder, the reflected signal is proportional to (1/λ). Example in figure (2- c) is a sphere, which also reflects back a signal proportional to the radius of the sphere (and not a function of wavelength). Orientation of the shape is critical. The worst case when the wave is incident perpendicular to a flat part of the surface, which results in specular reflection. Canting the surfaces redirects this echo.



(a) (b) (C)

Figure (2) Three examples indicating the value of (σ)

III. ALGORITHM

The proposed computer algorithm is based on supplying the computer with the type of the target , size of the target, distance from the radar transmitter ,material of the target ,angle of the incident wave, …..etc. According to the fed data the program calculates the (RCS) of the target The algorithm is :

Start
Initialization :
--- Clear all the screen..

Screen design :
--- Design a data entry screen for filling the fields:
Field 1 Pt = power transmitted by the radar (watts).
Field 2 Gt = gain of the radar transmit antenna (dimensionless).

Field 3 r = distance from the radar to the target (meters).
Field 4 Aeff = effective area of the radar receiving antenna (meters squared).
Field 5 .Pr = power received back from the target by the radar (watts).
.Data entry :
--- Fill the five fields in the screen.
Data acquisition :
--- Get the data filled in the screen.
Data processing :
---- Apply the formula for the calculation of (RCS).
---- Display the calculated value of (RCS) on the screen of the computer.
Optional end of program :
----- If end of program ,then go to end.
----- Go to screen design.
END.

IV. RESULTS

Table (1) below shows the results obtained from six types of targets when applying the algorithm in paragraph (III) above. The table gives the values of (RCS) in (m 2) and in (dBm) ..We may notice the difference in values of (σ) for different types of targets . It is assumed that the size of the target is greater than (λ).

Table 1 RCS values for different types of targets

Objects (Targets)	(RCS) in (m 2)	(RCS) in (dBm)
Jumbo Jet	100	20
Fighter aircraft	6	7.78
Human being	1	0
Missile	0.5	- 3
Bird	0..001	- 20
Insect	0.00001	- 50

V. CONCLUSION

Radar cross section (RCS) is the measure of a target's ability to reflect radar signals in the direction of the radar receiver, i.e. it is a measure of the ratio of backscatter power per unit solid angle in the direction of the radar (from the target) to the power density that is intercepted by the target .

Electromagnetic waves, with any specified polarization, are normally diffracted or scattered in all directions when incident on a target. These scattered waves are broken down into two parts. The first part is made of waves that have the same polarization as the receiving antenna. The other portion of the scattered waves will have a different polarization to which the receiving antenna does not respond. The two polarizations are orthogonal and are referred to as the Principle Polarization (PP) and Orthogonal Polarization (OP), respectively. The intensity of the backscattered energy that has the same polarization as the radar's receiving antenna is used to define the target radar cross section (RCS).

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