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RCS REDUCTION IN CONTEXT OF STEALTH TECHNOLOGY: Theoretical Aspects

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Abstract:

RCS is the proportion of the objective's capacity to reflect radar signal toward the radar recipient. Some techniques such as shaping, radar absorbing material (RAM), passive cancellation and active cancellation have been used for RCS reduction purposes. RCS reduction is the main reason behind the stealth technology for low observable (LO) platforms. In this paper, we have discussed RCS reduction along with their merits & demerits for stealth.

Keywords **—RCS, Low observable, RAM, Stealth, UAV.**

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I. INTRODUCTION

Stealth has been an interesting area of research in defence science [1]. After radar developed during World War II, radar cross-section (RCS) continued to be pursued as a passive technique to reduce detection. [2].

The radar emits electromagnetic waves and receives signals backscattered by the target. The RCS is a measure of the EM waves that scatter and return from the target when illuminated by an incident wave. Now, since the advancement of missile systems, the requirement of RCS reduction has been actively needed. RCS reduction has increased the possibility of low observable platform survivability on the battlefield. Here we have discussed few aspects for RCS reduction.

II. RADAR CROSS-SECTION AND FACTORS AFFECTING IT

Radar cross-section (RCS) of aircraft is used to identify the type of aircraft (B52, F16, Su 30 MKI etc.). The maximum detection range of UAV by radar is proportional to the one-fourth power of radar cross-section of aircraft. RCS (σ) is expressed in units of area (m^2). RCS is related to shape, size, the material of aircraft and ratio of incident and reflected power. On tracking UAV, the radar measures reduced radar cross-section (RRCS).

RRCS is given by $10\log_{10} \sigma$ (dB). The size and ability of a target to reflect radar energy can be concise into a particular term, σ, known as the radar cross-section that has units of m^2. This unit depicts, that the radar cross-section is an area. If totally all of the incident radar energy on the target were reflected equally in all directions, then the RCS would be equal to the target's cross-sectional area as seen by the transmitter. It is observed that some energy is absorbed and the reflected energy is not distributed equally in all directions.

Therefore, the RCS is quite difficult to estimate and is generally determined by measurement. The factors affecting the target radar cross-sectional area are as follows:

a) The radar transmitter's frequency,

b) The direction of the sending radar
c) The aircraft dimensions and shape
d) The material used in its design.
f) Polarization of EM wave with respect to target
g) Transmitter and receiver polarization.

The relative phase and amplitudes of the echo signal from various scattering surfaces of the flying airplane as measured at the receiver determine the total radar cross-section.

The Radar Range Equation is given below by
R**max**

$$R_{max} = \left(\frac{P_t G^2 \lambda^2}{(4\pi)^3 P_{r\,min}} \sigma \right)^{1/4} \quad \text{......... (1)}$$

Where, Rmax: Maximum detection range for the object (distance between radar and object)

Pt: Power Transmitted by the radar
G: Gain of a radar antenna
λ: Wavelength
Pr min: Minimum power that can be detected by the radar
σ: Radar Cross Section (RCS) of the object

Thus, the maximum detection range of airplanes by radar is proportional to the One-fourth power of the radar cross-section of the airplane.

III. DETERMINATION OF THE RADAR CROSS SECTION

Radar cross-segment (RCS) is the proportion of an objective's capacity to reflect radar signals toward the radar collector, for example, it is a proportion of the proportion of backscatter density toward the radar (from the objective) to the power density that is caught by the objective. Since the power is distributed on the shape of a sphere, a small part of this $((4\cdot\pi\cdot r^2))$ can be received by the radar [3].
Radar cross-section σ is as defined as:

$$\sigma = \frac{4\pi r^2 P_r}{P_t} \quad \text{.......... (2)}$$

Where the parameters are defined as given:-

σ: a proportion of the objective's capacity to reflect radar signals in course of the radar collector, in [m²]
Pt: power density that is intercepted by the target, in [W/m²]
Pr: scattered power density in the range r, in [W/m²]
The radar cross-section (RCS) of a target is equal to the projected area of a metal sphere that would scatter the same power in the same direction that the target does.

IV. MEASURES FOR RCS REDUCATION

A poster presentation is available in figure 1 that outlines various theatrical aspects of radar cross section.

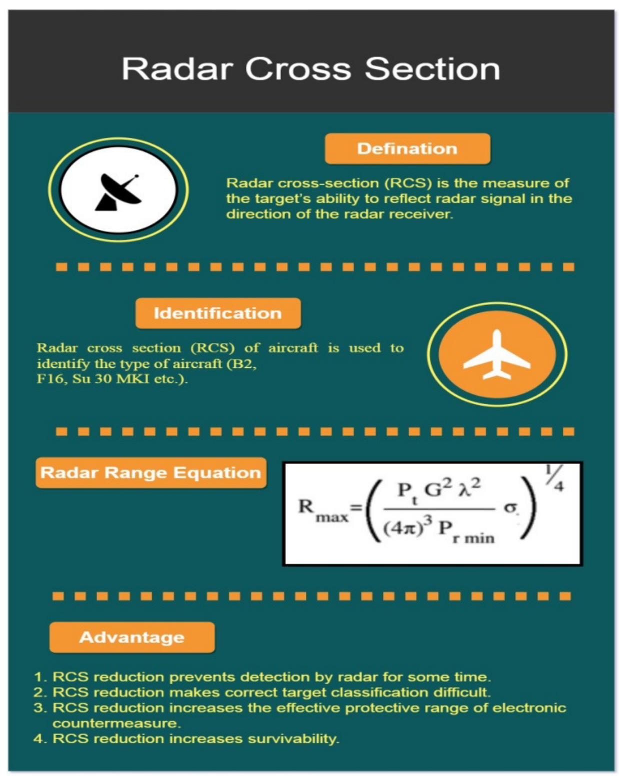

Figure1: Poster of radar cross section (RCS)

A few RCS techniques such as shaping [4], radar-absorbing material (RAM) [5], passive cancellation [5], active cancellation [6] and meta-material absorber [7, 8, 9] have been used for RCS reduction purpose. The uses of shaping and radar absorbing materials are most effective in the design stage of low observable platforms. We can utilize radar engrossing materials where forming is not powerful alone. Passive cancellations have been used from the discovery of the concept of reduced RCS reduction. Active cancellation is used for low frequency (limited range i.e. Narrowband) radar cross-section. A layer of meta-materials on the absorber is used for RCS reduction.

V. ADVANTAGE OF RCS REDUCTION

RCS reduction has a good advantage for Low observable platforms as given:-

RCS reduction prevents detection by radar for some time.RCS reduction makes correct target classification difficult.RCS reduction increases the effective protective range of electronic countermeasure. RCS reduction occurs to various filler added to radar absorbing materials [10-12]. RCS reduction increases survivability of UAV in a contested airspace.

VI. DISADVANTAGE OF RCS REDUCTION

RCS reduction has some disadvantage for low observable platforms as given

1. There is a reduced payload of the LO platform due to reduced RCS structural changes.
2. There is a reduced range of LO platforms due reduced internal fuel carrying capacity.
3. There is added weight due change in structure of object.
4. There is increased maintenance due to the radar absorbing material on outer coating.

VII. CONCLUSION

RCS is an important parameter for the stealth of Low observable platforms. RCS reduction increases the chances of survivability of Low observable platforms. RCS reduction is done by shaping, radar absorbing material, passive cancellation, active cancellation, meta-material absorbers. For RCS reduction, the designer must know about radar signature too. Thus, RCS reduction is necessary for stealth technology to survival in a contested war domain.

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