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A Naïve Introduction to Stealth Technology

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Abstract

Stealth technology has been a revolution for the aircrafts that are stealthy and disaster for the ground based radars. Since, they are blinded by the stealthiness of the target they are supposed to detect. An aerial object that has a smaller Radar Cross Section (RCS), is generally smaller and less visible to the radar. Moreover, it is capable of achieving greater penetration and striking the target. Most important of all, it has lower probability of being tracked and shot down by enemy. Stealth aircrafts provide a great level of deterrence as an aggressor because a surveillance radar would have limited means of knowing when and where an attack could take place.[1] Simulations show that a stealthy aircraft is not visible specially for monostatic radars (that have a single antenna that acts as both transmitter and as receiver). However, bistatic radars (that have a separate transmitting and receiving antenna) can be useful as stealth aircraft though low observable, cannot be called as invisible.[2] At certain angles there can be significant scattering which can be received.

[1] Robert M. O'Donnell, *Free Video Course in Radar Systems Engineering*, Lecture 8 Part-2, IEEE Aerospace and Electronic Systems Society, 2009.

[2]Butt, Faran Awais, Ijaz Haider Naqvi, and Ali Imram Najam. "A novel approach to counter the low observable characteristic of stealthy targets by analyzing the radar cross section." Progress in Electromagnetics Research Symposium Proceedings, 2015.

Introduction

Ever since the invention of the radar in the 1930's, the research and development on the reduction of the RCS of targets was started[3]. Over the last one decade, weapon systems have achieved significant advancements while attaining the experience gained from previous combat situations. The capability to detect the location of enemy equipments and deploy effective countermeasures has shown to be very effective in minimizing hostile threats and maximizing one's own weapons.[4] Surprise has always been an important element of military tactics, and electronics must make its contribution to the element of surprise.[5] Stealth air vehicles and antiradar missiles have become serious growing threats to military radars,and the ground based radars must extend their capabilities to cover anti stealth and anti ARM.[6]

RCS and Stealth

RCS is a measure of how big a target looks like to a radar system. Integrated air defence system has three prime tasks which are to detect , track and engage the aircraft, but stealth aircrafts penetrate this defence system owing to the reduced radar returns.The

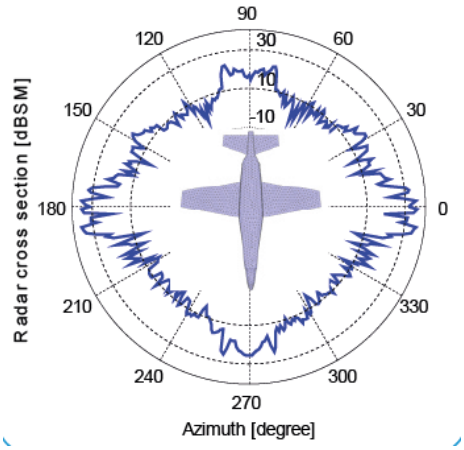
[3]R.Buderi, "*The invention that changed the world: the story of radar from war to peace*," New York: Simon & Schuster, 1996.

[4]Grant, P.M and Collins, J.H, "*Introduction to electronic warfare*,"IEEE Proceedings, Vol, 129, Pt.F, No.3, June 1982.

[5] Fuller, K.L, "To *see and not be seen [radar]*," Radar and Signal Processing, IEE Proceedings, Vol.137, Pt.F, No.1, February 1990.

[6] Li Neng-Jing, "*Radar ECCMS new area: anti-stealth and anti-arm*," Aerospace and Electronic Systems, IEEE Transactions Vol 31, 1995.

RCS of an aircraft can be reduced in different ways. i.e., with radar jamming equipment, by maneuvering tactics, by shaping the surface of an aircraft in such a way so that radar waves are scattered away from radar receiver and by the use of radar absorbing materials.[7]



Minimization of RCS

The current generation of stealth technoligies relies on five elements used in combination to minimize the RCS of a target.[8]

1. Radar Absorbent Material
2. Internal Radar Absorbent Construction
3. External Low Observable Geometry
4. Infrared Emissions Control
5. Specialized Mission Profile

Radar Absorbent Material

The radar absorbent material is used for coating the surface of the aircraft .The coatings usually contain iron ferrite material which dissipate the incoming radar wave.

[7] A.S.Clark and J.F.Lilley, *Defense Technology*, Westport: Praeger Publishers, 1989.

[8] http://www.globalsecurity.org/military/world/stealth-aircraft.htm

Internal Radar Absorbent Construction

IRAC approach creates surfaces with in the outer structure known as re entrant traingles which allows the incoming radar to scatter at different directions and radar returns becomes too weak.

External Low Observable Geometry

ELOG geometry gives the stealth aircraft angular geometry, this allows to reflect the incoming waves in all directions.

Infrared Emissions Control

IR emission control deals with the mechanics and heat production in the engine and controlling parts.

Specialized Mission Profile

Specialized mission profile deals with the current mission on which the aircraft is to operate and uses the information collected prior to the mission.

Generations Of Stealth Aircrafts

a) The first generation of stealth aircrafts aimed at using RAMs on aerodynamic design and this scheme was effective in certain range of frequencies and at times completely ineffective.

b) The second generation of stealth is F117 where the airplane was built from bottom up to be stealthy but it has never been completely invisible to the radar. It was shot down in serbia as well. Also, it was aerodynamically instable.

c) The third generation used the modelling and design tools and computing power to make an aerodynamic design that was more optimum. B2 stealth bomber is

the third generation stealth aircraft. The aircraft has a low RCS with engines buried within the wings, featuring a smooth blending of external structures.[9]

d) In fourth generation designers are able to add supersonic speed to the stealthy aircrafts. F-22 is the fourth generation stealth aircraft.[10]

e) According to a fifth generation of stealth aircraft, it must have high maneuverability and advanced avionics in addition to have better stealthy features. [11]Apart from that, it is expected to have multirole capabilities and should have features related to networked data fusion from various sensors and avionics. The exact characteristics of fifth-generation jet fighters are vague, with Lockheed Martin defining them as "having all-aspect stealth even when armed, low-probability-of-intercept radar (LPIR), high-performance airframes, advanced avionics features, and highly integrated computer systems capable of networking with other elements within the battlespace for situation awareness". [12]

[9] J.A.Adam, "*How to design an invisible aircraft*," Spectrum IEEE, Vol.25, no.4, pp.26-31, April 1988.

[10] Ibid

[11]De Briganti, Giovanni (9 May 2012). "F-35 Reality Check Ten Years On – Part 1: 'Fifth-Generation' and Other Myths". *Defense-aerospace.com*. Archived from the original on 14 October 2012. Retrieved 8 November 2012.

[12] F-35 Lightning II: Defining the Future" (PDF). Lockheed Martin. 2012. Archived (PDF) from the original on 7 September 2012.

Stealth Materials

Stealth aircraft requires materials that typically include adhesive bonding. It includes caulks, paints, adhesives that inherently require more time for preparation and are usually hazardous.The labor expenses are also in turn quite high. Radar absorbing materials can be used in the form of surface coverings, molded edges, or gap fillers. It consists of very fine grained ferromagnetic or ferrite particles suspended in a variety of rubber, resin binders, paints etc. Resistive cards consists of a sheet of fiber paper or very thin plastic covered with a continuous coat of ink, paint or extremely thin metallic film.Composite materials have a wide applications commercially and in industry. Composite materials can resist the conductivity, and can lessen the heat transfer hence they can limit the reflectivity. They are also durable and can be transformed into various shapes during manufacturing.They can be used to reduce the radar cross section through the use of radar absorbing composite materials.[13]

Stealth geometry

When ever an enemy aircraft enters into a territory of any other country, it is often illuminated by EM radiations from the radar and it is the objective of these radars to detect, localize and hence destroy the enemy aircraft before it destroy anything on

[13] http://www.globalsecurity.org/military/world/stealth-aircraft-material.htm

their territory. Stealth aircrafts are coated with anti-reflective materials to reduce their vulnerability to detection.The primary target of stealth is to reduce the radar cross section of the vehicle which is to be stealthed. F-117 was the first aircraft which had the desired stealth capabilities of lower radar cross section and it first came to the scene. It has faceted design with high angles of incidence, and hence causing the reflected power to scatter in direction away from the source. A computer program echo1 allowed designers to predict the radar return.[14]Significant reduction of RCS has tradionally dependent on external shaping and to a lesser degree material composition. There is a trade off with aerodynamics. Whenever, we enhance stealth capabilites of an aircraft. With the success of F-117, US airforce invested in other stealth systems like B2 and F-22 which have more refined aerodynamics while maintaining mimimum radar signature.[15]The majority of stealth aircrafts have to be equipped with the missiles, rockets, bombs, nuclear weapons, chafs, jamming pods and other suspension equipment. In the current state of stealth technology, these are hidden internally to the aircraft to optimize radar cross sections. It is highly probable that in the near future these equipment will be stealth configured.

Stealth Aircraft Vulnerabilities

Stealthy materials are usually highly toxic in nature and require high level of maintainance. The stealth aircraft is a permanent fixture and cannot be altered much without disturbing the already designed aerodynamics which is also not a flawless. The

[14] http://www.globalsecurity.org/military/world/stealth-aircraft-geometry.htm

[15] Ibid

technology also cannot be altered much i.e. RCS cannot be changed in response to new frequencies which the adversary might be using.

Low frequency radars although not good at determining the exact location of the target are good at spoting the stealthy aircraft. They can tell the general area that the airplane may be in, but there is a great lack of accuracy associated with them.The RCS of any target also depends upon radars transmitted frequency. Below 900 MHz, the target RCS increases significantly. However, there is increased return from undesirable clutters (i.e. non-target objects). Bistatic radar can exploit these vulnerabilties better than a monostatic radar. Since, the bistatic RCS can be quite different depending upon target scattering characteristics. Shaping requirements have negative effect on aerodynamics of the aircraft and these aircrafts are usually flown by having other trade-offs.

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