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Stealth Technology And Counter Stealth Radars: A Review

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ABSTRACT: *The purpose of this paper is to look into the developments in "counter stealth radars" contrary to stealth aircrafts which remained unanswered by conventional radars for decades. Stealth technology is based on the principle of reflection and absorption that makes the objects' observability lower. A 'stealth' vehicle will generally have been designed from the motive to reduce RCS (Radar Cross Section) of aircrafts i.e. radar signature of aircrafts. Stealth technology is based on the principle of reflection and absorption that makes the objects stealthy. It also gives the principle of operation of latest radars – quantum radar and LIDAR. It compares stealth & anti-stealth technology, consequently shows the future vulnerability of stealth aircrafts.*

KEYWORDS: *LIDAR, passive radar, quantum radar, RAM, RCS*

I. INTRODUCTION

If there is one dimension in the air attack–air defence succession that is riding high on the wings of enabling edge technologies, it is the use of stealth, both in the offensive and defensive spheres. The air defence combatants are engaged fielding high technology and high-definition sensors in active, passive, and electromagnetic (EM) based anti-stealth domains to challenge stealth attack. The cause-effect duel, thus, continues undyingly.

II. WHAT MAKES AN AIRCRAFT, STEALTH?

Radar Absorbing Material (RAM)

The concept behind the RAM is that of reflecting a light beam from a torch with a mirror. The angle at which the reflection takes place is also more important. When we consider a mirror being rotated from 0 degree to 90 degree, the amount of light that is reflected in the direction of the light beam is more. At 90 degree, maximum amount of light that is reflected back to same direction as the light beam's source. On the other hand when the mirror is tilted above 90 degree and as it proceeds to 180 degree, the amount of light reflected in the same direction decreases drastically. Today's highly developed technologies include dielectric composites and metal fibers containing ferrite isotopes. Paint comprises of depositing pyramid like colonies on the reflecting superficies with the gaps filled with ferrite-based RAM. The pyramidal structure deflects the incident radar energy in the maze of RAM. Ablative Paints As the name suggests, the paint does not absorb radiation, but conducts it over the skin tending to cool down any EM hot spots on the airframe. A commonly used material is known as 'Iron Ball Paint'. FSS are planar periodic structures that behave like filters to electromagnetic energy. The considered frequency selective surfaces are composed of conducting patch elements pasted on the ferrite layer. FSS are
used for filtration and microwave absorption.
The available results in Fig.1(a) and Fig.1(b) show that FSS can modify and improve the absorbing performances of RAM.

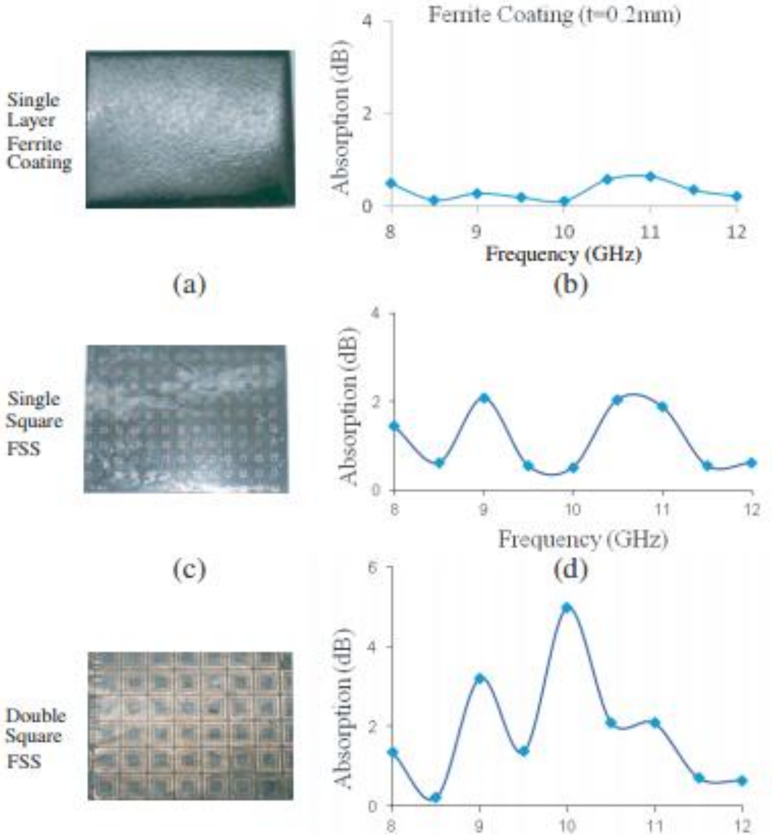

Fig. 1(a) Effect of different FSS on microwave absorption on normal incidence

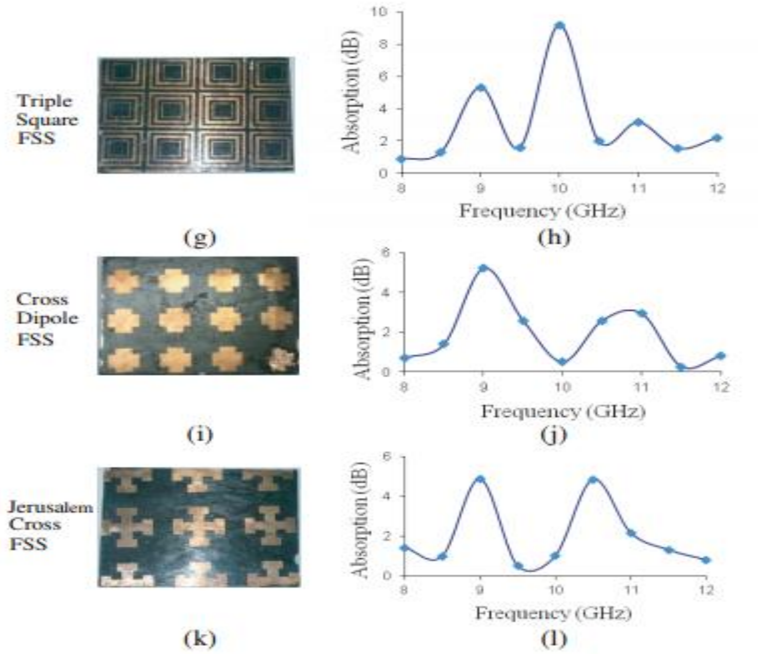

Fig. 1(b) Effect of different FSS on microwave absorption on normal incidence

2.1.1 PLASMA ACTIVE STEALTH

The principle of plasma stealth is to generate an ionized “layer” surrounding the aircraft to reduce RCS. It is a quasi-active system in which dangerous radar signatures are received and absorbed/scattered by plasma capable of absorbing/spreading a wide range of radar frequencies, angles, polarizations, and power densities. The use of plasmas to control the reflected electromagnetic radiation from an object (Plasma stealth) is feasible at higher frequency where the conductivity of the plasma allows it to interact strongly with the incoming radio wave, but the wave can be absorbed and converted into thermal energy rather than reflected. In 2002, the Russians examined a plasma-stealth device on board an SU27 and the radar cross-section (RCS) of the aircraft was decreased by a factor of 100.7

2.2 PROPULSION SUB-SYSTEM SHAPING

It refers to the fluidic spout for thrust vectoring in aircraft jet engines. Such spouts produce a much lower RCS (Radar Cross Section) due to the fact that these are less complicated, mechanically simpler, and less bulky with no moving parts/surfaces. Why we avoid moving parts? Because they increase the probability of getting detected by a Radar. An F-117 stealth fighter was shot down during a mission in Serbia against the Army of Yugoslavia on 27 March 1999, during Operation Allied Force. The army had detected the aircraft on radar when its bomb-bay doors opening, raising its radar signature. In B-2 stealth bomber there are very few leading edges for radar to reflect from, reducing its signature dramatically, despite having a 172-foot wingspan, the B-2's radar signature is an astounding 0.1 square metres. To further reduce the B-2′s signature, the engine intakes are sunk into the main body.

Above all ways were to reduce RCS. Why we reduce RCS? Because decreasing RCS reduces radar signature.

III. COUNTER STEALTH

All present stealth airplanes were designed to counter X-band radars, but those shapes are getting useless if radar works in s-band and even more useless when the radar works in L-band. The cause for the stealth airplane to be found is the wavelength of the radar, radar working in L-band produces wavelengths with size relative to the aircraft itself and should exhibit scattering in the resonance region rather than the optical region, so that most of the existing stealth aircraft will turn from sightless, to visible.

3.1 LIDAR - LIGHT DETECTION AND RANGING

LIDAR is a Multi-Band and Multi-Static anti-stealth technology. Laser radar can detect stealth targets efficiently because it has short wavelength, high beam quality, high directionality and high measuring accuracy, which helps functions of target identifying, posture displaying and orbit recording. Apart from these, LIDAR holds higher resolution and counter -jamming ability due to its coherence property and ultimately high frequency. The Fig.1 illustrates the difference in image generated using LIDAR and RADAR

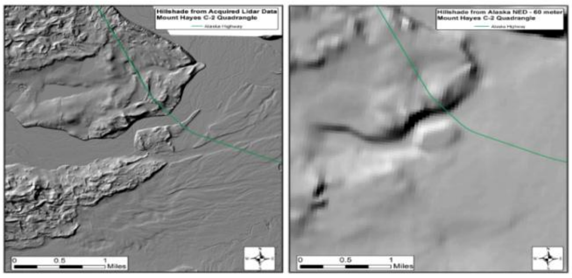

Fig.2: Difference in images generated by LIDAR & Radar .

Table 1. Specifications of LIDAR

1	Wavelength	1000-1500 nm
2	Pulse Rep. Rate	140 kHz
3	Pulse Width	10 nsec
4	Scan Angle	40° - 75°
5	Scan Rate	25 - 40 Hz
6	Footprint	0.25 - 2 m (from1000m)
7	Resolution	0.75 meters
8	GPS frequency	1 Hz
9	Operating Altitude	500 - 2000 m

3.2 Multi-Band 3D Radar: This is a modern technology, evolved by Russia in late 2008. This radar system is a pack of three to four discrete radars and a single Processing and Command unit. One of such existing radar system is the Nebo Radar. The VHF- Band element of the system provides sector search and track functions of low RCS targets, with the X-Band and L-Band elements providing a nice tracking capability. Trial s to jam the

Nebo-M will be tough, since a huge amount of power is required for jamming these types of radars. All of them have a passive angle tracking capability against jammers, as a result of which utilization of a jammer allows passive triangulation of the target using three-angle track outputs.Passive Anti-Stealth Measures ‘Passive Anti Stealth Radar’ concept. These systems do not use reflected energy and, hence, are more accurately denoted as Electronic Support Measure (ESM) systems. Well- known examples of passive radars comprise the Czech TAMARA/VERA system and the Ukrainian Kolchuga system.

Fig.3 Czech Tamara/VERA system

Fig.4 Ukrainian Kolchuga System

Cassidian, part of the vast Europe-wide European Aeronautic Defence and Space Company (EADS), has developed a type of "passive radar" which it claims can find stealth aircraft. Passive radar detects radiation signals emitted by different sources -- be they radio broadcasts or mobile phone networks -- and analyze distortions to calculate out where objects are located. The system Cassidian claims, however, wouldn't be spoofed by standard stealth covering methods because it takes benefit of a range of signals which encircle us constantly. There's no need to send out signals and search for their reflections -- instead, the detector system looks at a group of signals present in the atmosphere already (like aforementioned radio and mobile phone signals) and looks for how they're blocked or varied by having to pass through or around objects. Triangulating distinct sources can construct a picture of a landscape or airspace, with stealth planes and ships just as noticeable as all-anything else.

Passive radar stations don't radiate anything, there's no way to trace them down.

Fig.5 A cassidian passive radar developed by EADS.

It has high detection-update frequency (every 0.5 seconds); covers 360 degrees; has 3-D (meaning that it includes altitude) capability to about 40,000 feet.

3.3 QUANTUM RADAR

Quantum radar is a hypothetical remote-sensing method based on quantum entanglement. One possible implementation of such technology has been developed and patented by defence contractor Lockheed Martin.[2] It intends to create a radar system which provides a better resolution and higher detail than classical radar can provide. The technology is hoped to work by using photon entanglement to allow several entangled photons to function as if a shorter wavelength was used to allow detection of small details while having an overall longer group wavelength that allows long distance transmission. If a stealth airplane tries to intercept these photons and resend them in a way that camouflages its location, it would necessarily alter the photons' quantum properties –disclosing any interference. In order to jam our imaging system, the target must disturb the tender quantum state of the imaging photons, thus introducing statistical errors leading to suspicion. Modern era's best jamming technology sends back 'fake' signals that fool radar operators into believing their target is innocuous or elsewhere. New technology can point out these kinds of tricks by reading the quantum signature of photons transmitted to guarantee the signal is authentic. Any attempt to measure a photon always changes its quantum properties

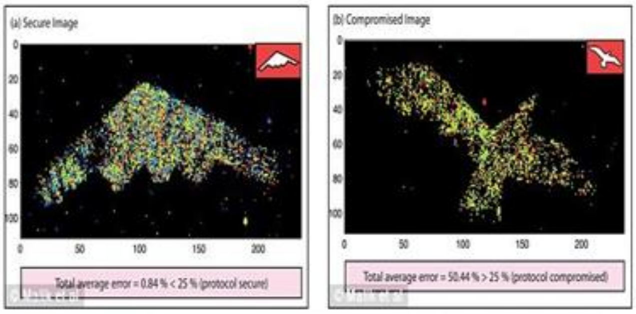

Fig. 6 Comparison of actual image and spoof image

No fooling us: when there is no jamming attack, the received image faithfully reproduces the actual object, shown left, if the target attempts to send a 'spoof' image like one on the right, the imaging system can detect the presence of the jamming attack, because of the large error rate in the received polarization .

3.4 CONCLUSION

Stealth and Anti-Stealth technology is an interesting and topic and as much of the research and technology development done in this area is secretive, it is impossible to know exactly what sort of new advances lie in the future. Till date, no advancement has been made against quantum radar because of its technology and LIDAR because of its higher accuracy and weather independence. As above all methods of reducing RCS have been cracked. The stealth technology has gone as far as it could go. The fact that a stealth technology aircraft like F-117 could be downed by a Third World country (Serbia) by upgrading its 1960 SAM system, proves the fact that all stealth aircraft are vulnerable to existing and futuristic counter-stealth technologies.

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