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ELECTRONIC STEALTH

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Abstract

This paper presents the fundamentals of the study of Electronic Warfare, precisely Electronic Countermeasures. It is a significant topic as it familiarizes as to how modern day wars are fought. It is believed by the defense community that the future of battle lies with the advancement of electronic warfare. Radar and Infrared(IR) weapons platform pose one of the greatest threats to air operations in the battlefield in the modern era. This paper focuses on Radar and Infrared technology weapon platform and countermeasures which are employed by aircrew to survive and successfully complete their mission. It is based on the principle of "SEE FIRST KILL FIRST".

Keywords: Radar; stealth; Electronic countermeasure(ECM);

1. Introduction

THIS document familiarizes about the fundamentals of electronic warfare and recent trends in the defense sector. In the late 1930's and 1940's Radar technology was commonly used for detecting aircraft. Since radar technology was developed during the Second World War, it should not be surprising to learn that the first attempts at stealth technology occurred during this period also. In simple terms, stealth technology allows an aircraft to be partially invisible to Radar or any other means of detection. This doesn't allow the aircraft to be fully invisible on radar. Stealth technology cannot make the aircraft invisible to the enemy or friendly radar. All it can do is to reduce the detection range or an aircraft. This is similar to the camouflage tactics used by soldiers in jungle warfare. Stealth technology is expanded into each of those areas which seek to detect the aircraft, ships & missiles. Thus, it is essential to develop visual, infrared acoustic and radar stealth. While no aircraft is totally invisible to radar, stealth aircraft limit current conventional radar's abilities to detect or track them effectively enough to prevent an attack. Stealth technology (or LO for "Low Observability") is not a single technology. It is a combination of technologies that attempt to greatly reduce the distances at which a vehicle can be detected; in particular, radar cross section reductions, but also acoustic, thermal, and other aspects. The most recent development of fighter aircraft like the F-22 employ some of the most advanced technologies. It is made as an aerodynamically efficient machine. It utilizes Radar absorbing material which makes it completely unseen by the enemy. The aircraft is a true representation of a 5^{th} generation fighter aircraft. The aircraft which are non-stealthy depend on their electronic countermeasures to act as an invisible cloak and help them buy time to complete their mission and survive in critical times.

2. Electronic Warfare

Radar technology has boomed significantly over the decades and now pose a great threat to air operations behind enemy lines. A fighter aircraft has to be sufficiently skilled to be able to outpower the enemy. Apart from flying at low altitudes to avoid getting detected by Ground control intercept radars, the modern-day fighters inculcate numerous other techniques like jamming pods and other electronic sets which are capable enough to saturate the enemies radar receivers. There are two classifications of EC namely

i) active ECM
   a) noise jamming
   b) deceptive jamming
ii) mechanical passive ECM
   a) chaff
   b) decoys

2.1 Noise Jamming

Noise jamming is one of the principal methods of radar jamming. The equipment onboard transmits high energy RF signal with noise or random amplitude changes towards the victim's radar frequency. This is dependent on the high power signals to saturate the victim's radar receiver and oppose range and intermittently, azimuth and elevation information to the enemies radar. the effectiveness of noise jamming is dependent on numerous factors like jamming-to-signal ratio(J/S), power density, the quality of noise signal and the polarization of the transmitted jamming signal There are three categories of noise jamming

a) Spot Jamming: In this approach, the jammer focuses all its energy on one particular frequency. This would severely degrade the receiver and make it difficult to track the aircraft on the particular frequency. On the other side, most modern day radars are frequency-agile like the MPR radar with India employs over 40 frequencies and thus it is very difficult to jam by this method. For the jammer to be able to jam a wide range of frequencies it would take a lot of resources.
b) Sweep Jamming: when the jammer continuously changes its power from one frequency to the other. Its advantage is that it can jam multiple frequencies in short duration. Although it does not jam all of them at the same time, and therefore its effectiveness goes down.
c) Barrage Jamming: in this case, the jammer blocks multiples frequencies at once. However, multiples frequencies are being tackled at once, the power of the jammer is being distributed among the following frequencies and hence the effectiveness of which each signal is jammed goes down.

2.2 Deception Jamming

Also, called DECM (defensive electronic countermeasures). It behaves like an invisible cloak that you carry with your sword. DECM provides electronic countermeasures that confuse, frustrate and deceive the enemy, rendering crucial time in a critical situation like war. It is a repeater set that maneuvers between the received signals and retransmits it to change the return what radar sees, an advantage is that it makes use of the same waveform as that of the operating radar. Memory management is the key feature in a deception jammer, and it has to be instantaneous. It requires less power as compared to noise jamming. It affects the plan and position

an indicator of the radar.During the early approach of the aircraft, a narrow beam of the PPI scope is painted with false returns, and as the aircraft moves closer to the radar the entire PPI scope is painted with false returns. As the radar makes use of the same waveform the radar receiver treats the return as a true reply and the receiver amplifies and processes it as a real target. The set utilizes a series of complex set of transmitting and receiving circuits to process and retransmit jamming pulses that appear as false targets. The radar operator will know that he is getting deceived but he cannot identify your true location.

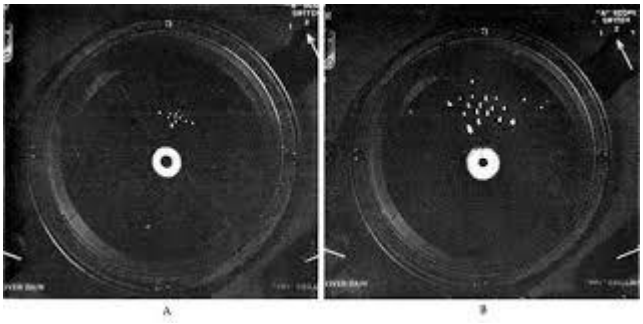

Fig 1: The PPI scope painted with false returns from aircraft

For effective jamming, the jammer must not only match the radars operating frequency but also other operating characteristics including pulse repetition frequency, pulse repetition interval, pulse width and scan rate.

2.3 Chaff and Decoys

These are defensive mechanisms used by military aircraft to avoid detection by adversary air defense systems. Chaff are made up of small fibers that reflect radar signals, and when deployed in a large number forms a cloud that hides the aircraft temporarily. Mostly aluminum foil and aluminum-coated glass fibers are used. When ejected out of an aircraft the chaffs form an electromagnetic equivalent of a visual smoke screen that temporarily hides the aircraft.

3. Radar Cross Section

Radar cross section is the measure of a target's ability to reflect radar signals back in the direction of the radar receiver. It is the measure of the ratio of backscatter power per steradian in the direction of the radar to the power density that is intercepted by the target. It is expressed in terms of area. A lesser RCS is better for stealth purposes. A greater RCS indicates that an object is easily detectable. Some methods to reduce RCS include:

i) Shape morphing
ii) Use of Radar absorbent materials (RAM)

3.1 Shape of an aircraft

The shape of an aircraft plays an important role in deciding its RCS. Also, the design of the shape of the aircraft is dependent on the type of materials feasible for use. A lot of research has been conducted in deciding the best shape for a stealth aircraft. In the late 1960's, Denys Overholser created a program called ECHO1. The program used equations to simulate the reflection and scatter of electromagnetic waves off 3-dimensional objects. These simulations were limited to flat panels and hence concluded that a diamond shape would be

better suited for stealth aircraft. Reflection of an electromagnetic wave from a surface can be either specular or scattered. Specular reflection occurs when the surface is flat and smooth (relative to the wavelength of the incident wave). Scattered/diffuse reflection occurs when the surface is rough or has small discontinuities or inconsistencies. For aeronautical applications, the surface needs to be smooth to have good aerodynamic properties. Let's take a comparison between a civil and a stealth military aircraft. The front of a Boeing 747 is a curved surface. On a curved surface, there are infinite tangent lines and an infinite number of lines normal to the surface. With infinite tangent lines, the possibility of the radar signal to be directed back to the receiver is greater. This makes the aircraft easy to detect on a radar. Whereas, the first stealth fighter plane had a diamond shape which consisted of flat surfaces. This has a limited number of tangent and normal lines on which the signal can be directed back.

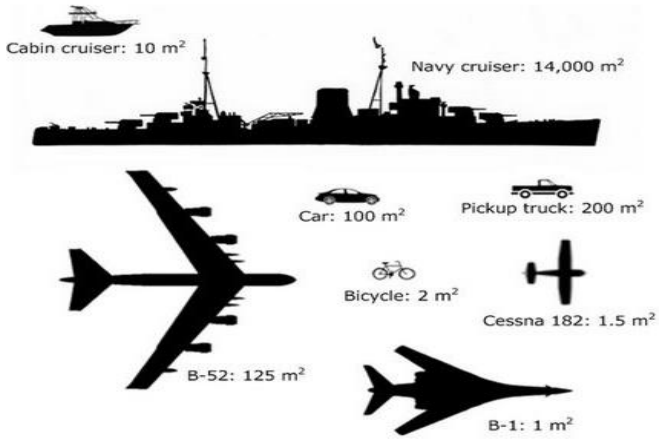

Fig2: Comparison of RCS of different objects

3.2 Radar absorbing materials (RAM)

Radar absorbing material is a common technology used to reduce the RCS of an aircraft. It usually involves coating the material with a radar absorbing paint. One example would be black paint. Black paint is the closest to a perfect emitter or a perfect absorber. It absorbs all the light that hits it. The main idea behind this technology is to absorb all the energy of the radio waves incident on it.

a) Iron Ball paint: It consists of iron particles with a coating of carbonyl iron or ferrite. A magnetic field is produced when electromagnetic waves hit the surface.

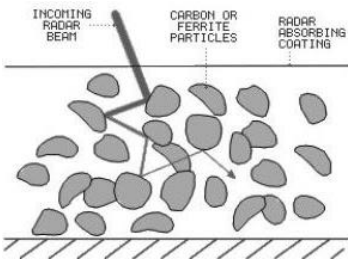

Fig3: Iron Ball paint

This magnetic field has an alternating polarity and dissipated the energy of the signal. This energy is dissipated in the form of heat which is a drawback as it will increase the IR signature of the aircraft.

b) Foam absorbers: foam absorbers use carbon black in urethane foam. It scatters and absorbs the incident electromagnetic waves as shown in the figure
c) Split ring resonator absorber:

4. Conclusion

The Detection and Stealth Technology has improved significantly more advanced in the last fifty years or so. This trend is likely to continue as these two oppose each other.
The current scenario appears something similar to the cold war. Both sides are accumulating weapons to counter each other and each side can be termed as "Stealth Technology" and the other as "Anti-Stealth Technology". It's an arms race except it isn't between specific countries. "It's a fight between Technologies".

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A Brief Author Biography

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