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## RESEARCH ARTICLE

# RESEARCH ON STEALTH AIRCRAFT AND ITS EFFECT ON RADAR SYSTEM IN MODERN WARFARE

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**ABSTRACT**

In this paper, my main emphasis on Stealth aircrafts that use stealth technology to avoid detection by employing a combination of features to interfere with radar as well as reduce visibility in the infrared visual, audio, and radio frequency (RF) spectrum. It involves technological methods of enabling military aircraft to evade radar and other sensors in the Electromagnetic (EM) spectrum deployed to detect and engage aircraft. Stealth technology is actually a mix of several different technologies, this technology is able to make a revolutionary change in the field of modern warfare.

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## INTRODUCTION

In modern world, stealth technology has emerged with an utmost importance in the field of defence. Stealth technology's prime factor is to reduce/avoid the aircraft detection in enemy radar system. A normal combat aircraft can easily be detected on every radar system which poses an advantage to the enemies. In order to gain combat advantage, now a day's aircrafts are integrated with some of most prominent/sophisticated stealth technology to reduce visibility of the aircraft on enemy radar. In recent years, advancement in engineering and signal processing field made it possible for stealth technology realization in aircraft to deceive the enemy radar system effectively. However we are able to reduce visibility to certain limit due to some constraints either from environment or lack or even more sophisticated advanced radar system. Some important researches were carried out and succeeded enough to name it as stealth technology; one such is echo cancellation in aircraft. This paper presents and describes the stealth technologies, which are more prominent. These protocols can be realised practically with extensive research in these fields. Some of the technologies explained are so promising, it gives us almost zero visibility in other words it is almost impossible to detect aircraft even by some advanced radar system. the concept behind the stealth technology is based on principle of reflection and absorption that makes aircraft "stealthy". Deflecting the incoming radar waves into another direction and thus reducing the number of waves, which returns to the radar. Another concept that is followed is to absorb the incoming radar waves totally and to redirect the absorbed electromagnetic energy in another direction. Whatever may be the method used, the level of stealth an aircraft can achieve depends totally on the design and the substance with which it is made of. The idea is for the radar antenna to send out a burst of radio energy, which is then reflected back by any object it happens to encounter. The radar antenna measures the time it takes for the reflection to arrive, and with that information can tell how far away the object is.

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### Why stealth techniques

- The goal of stealth technology is to make an airplane invisible to radar. There are two different ways to create invisibility:
- The airplane can be shaped so that any radar signals it reflects are reflected away from the radar equipment.
- The airplane can be covered in materials that absorb radar signals
- Most conventional aircraft have a rounded shape. This shape makes them aerodynamic, but it also creates a Very efficient radar reflector. The round shape means that no matter where the radar signal hits the plane, s ome of the signal gets reflected back:
- A stealth aircraft, on the other hand, is made up of completely flat surfaces and very sharp edges. When a radar signal hits a stealth plane, the signal reflects away at an angle, like this:

- In addition, surfaces on a stealth aircraft can be treated so they absorb radar energy as well. The overall result is that a stealth aircraft can have the radar signature of a small bird rather than an airplane. The only exception is when the plane banks -- there will often be a moment when one of the panels of the plane will perfectly reflect a burst of radar energy back to the antenna.

**Stealth Parameters of RADAR (Radio Detection and Ranging)**

RADAR (Radio Detection and Ranging) is a technology which finds most versatile usage in military applications due to its ability in detection of objects using Electromagnetic waves that are invisible for the human eyes. The principle behind its operation is quiet simple, an antenna (transmitter) capable of converting electrical energy into radio waves is used to shoot the Electromagnetic waves in a particular direction, if, an object is struck by this wave, certain amount of this wave is reflected back to the source point where another antenna (receiver) is used to capture the echoed wave. Thus depending on the intensity of this echo the approximate distance & height of the object is calculated. To be on a winning side in a war, the basic aspect is being sneaky enough to enter an enemy ground without giving a clue to them. For a team, to do the said, they should have a technology which could make them invisible to the eyes of the enemy RADAR. Stealth mode of operation not only benefits towards gaining an upper hand in the war but also helps the ground troops to foresee the challenges they may face once entered into the enemies' territory. One of the main challenges to be considered in adapting the stealth features to the vehicle is its performance, the implementing of defensive stealth layers to the aircraft should be done with minimum or with no compromise on the aircraft's performance in the battlefield. This paper gives a detailed picture on the technologies that are available on the 'Stealth mode of operation' for a vehicle especially briefing on different ways to make an aircraft invisible to the eyes of the enemy RADAR system. There are several parametric techniques in which one has to gain knowledge to make an aircraft stealthy enough to sneak without any trace. Some of widely recognised parameters one should get a sight on include:

- Shape of the aircraft
- Stealth materials to be used
- Radar cross section element
- Infrared radiation reduction
- Visual detection reduction
- Active stealth monitoring

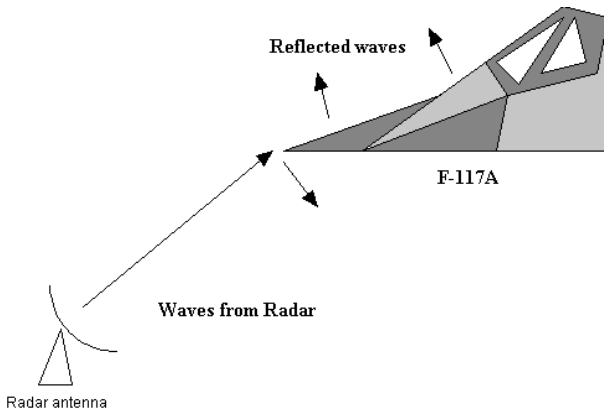
Although there is several stealth techniques based on different parameters, this paper gives a sight on stealth technologies that are in contrast to the Radar technologies. 'Radar Cross section technique' is one of the categories which are most widely debated & researched segment as it comes under target shaping, material selection & coating, passive cancellation and active cancellation. A paper on Radar cross section reduction was referred in which the visibility of the aircraft was reduced to a margin of 20% compared with the aircraft without this system. The system uses pre calculated approach with the values of Omni directional RCS, clutter & noise databases were calculated in advance. This system utilised active cancellation technique where in a cancellation signal is transmitted alongside the incoming signal in real time. Which indeed provides the phase and amplitude required to cancel the coherent echo signal. System showed an approach to generate an anti phased electromagnetic signal to a target's scattered signal with the required expressions to achieve the real time characteristics of electromagnetic waves. The surface of the aircraft also plays a major role in its ability to being invisible, the use of materials which absorb the electromagnetic waves rather than reflecting back should be considered for the body building of the aircraft. Some of the most promising protocols those can be referred/termed as stealth technology are listed below,

- Automatic Jammer's: In this, signal generator are employed/incorporated in aircraft which generates and transmits the exact replica of source wave.
- Low Reflecting materials: The more commonly/widely used technology is, using low reflective materials to manufacture aircraft.
- Controlled Intrinsic Impedance: This technology will majorly involve controlling the surrounding environment around aircraft, to achieve low reflection co-efficient.
- Advanced Aircraft Design: In this protocol either surface or the design of an aircraft is changed to suits low reflection of microwaves

**Methods for Create Invisibility of the Aircraft**

The metal body of an airplane is very good at reflecting radar signals, and this makes it easy to find and track airplanes with radar equipment. The goal of stealth technology is to make an airplane invisible to radar. There are two different ways to create invisibility:

a) The airplane can be shaped so that any radar signals it reflects are reflected away from the radar equipment.
b) The airplane can be covered in materials that absorb radar signal.




In addition, surfaces on a stealth aircraft can be treated so they absorb radar energy as well. The overall result is that a stealth aircraft like an F-117A can have the radar signature of a small bird rather than an airplane. The only exception is when the plane banks -- there will often be a moment when one of the panels of the plane will perfectly reflect a burst of radar energy back to the antenna.

***RAS (RADAR Absorbent surfaces)***

RAS (Radar Absorbent Surfaces) are the surfaces on the aircraft, which can deflect the incoming radar waves and

reduce the detection range. RAS works due to the angles at which the structures on the aircraft's fuselage or the fuselage itself are placed. These structures can be anything from wings to a refueling boom on the aircraft. The concept behind the RAS 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 0o to 90o, the amount of light that is reflected in the direction of the light beam is more. At 90o, 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 90o and as it proceeds to 180o, the amount of light reflected in the same direction decreases drastically. This makes the aircraft like F-117 stealthy.

**Radar Absorbent Materials (RAM)**

We all know that the radar works on the principle where micro waves are used to detect aircraft by analysing the reflected signal from the aircraft. All metal or objects will have their own reflecting properties, Hence sometimes the aircraft, particularly the stealth aircraft's are designed with such low reflecting material or coated with the material which will absorb the signal rather than reflecting the incident signal back to the source. These kinds of aircrafts possess a very poor result in radar's detecting performance. Radar absorbent surfaces absorb the incoming radar waves rather than deflecting it in another direction. RAS totally depends on the material with which the surface of the aircraft is made. Though the composition of this material is a top secret. When radar sends a beam in the direction of the B-2, the radar waves are absorbed by the plane's surface and are redirected to another direction after it is absorbed. This reduces the radar signature of the aircraft.

**Material Selection for stealth Aircaft**

For an fighter aircraft generally Nano-materials are formed by

Gas Phase synthesis process as follows:

- In homogeneous Chemical Vapor Deposition (CVD), particles form in the gas phase and diffuse towards a cold surface due to Thermo-Phoretic forces, and can either be scrapped of from the cold surface to give Nano-powders, or deposited onto a substrate to yield what is called *'particulate films'*.
- In heterogeneous CVD, the solid is formed on the substrate surface, which catalyzes the reaction and a dense film is formed.
- In order to form Nano-materials several modified CVD methods have been developed. Gas phase processes have
- inherent advantages, some of which are noted here:
- An excellent control of size, shape, crystallinity and chemical composition
- Highly pure materials can be obtained
- Multi-component systems are relatively easy to form and Easy control of the reaction mechanisms.

**Properties of nano-materials**

Nano-materials have the structural features in between of those of atoms and the bulk materials. While most micro-structured materials have similar properties to the corresponding bulk materials, the properties of materials with nanometer dimensions are significantly different from those of atoms and bulks materials. This is mainly due to the nanometer size of the materials which render them:

- Large fraction of surface atoms;
- High surface energy;
- Spatial confinement;
- Reduced imperfections, which do not exist in the corresponding bulk materials.

Due to their small dimensions, Nano-materials have extremely large surface area to volume ratio, which makes a large to be the surface or interfacial atoms, resulting in more "surface" dependent material properties. Especially when the sizes of Nanomaterials are comparable to length, the entire material will be affected by the surface properties of Nano-materials.

**Novel property**

**Small size effect (Quantum size effect)**

- Contain very small number of atoms (molecules)
- Electromagnetic forces are dominant.
- Wave particle duality. The electrons exhibit wave behavior.
- Quantum confinement.
- Discrete energy levels.

**Nano-materials for different Sectors of Aviation Industry**

Nano-materials can be primarily used in three areas of Aviation Industry. These are

**Airframe Material**

**Propulsion Material**

**Nano-coatings for aero-engine parts for stealth feature of aircraft**

The coatings are generally used for protecting the structures and surfaces of the aircraft from harsh environments. The stringent requirements like resistance to extreme temperatures, extreme climates, corrosion, abrasion and wear of engine part shave sparked an increased demand for more reliable high performance coatings. Some Nano-materials Coatings with improved high temperature properties may allow higher engine-operating temperatures and therefore improved performance in the future. In particular, magnesium alloys, which are far lighter than steel or aluminium, are prone to corrosion, due to the high chemical. Reactivity of magnesium. Coatings can help prevent corrosion, but the type, typically used contain chromium complexes which are a highly toxic pollutant. Materials used for these novel anti-corrosion Nano-coatings include silicon and boron oxides, and cobalt-phosphorous Nano-crystals. Nano-coatings are also now being used on turbine blades and other mechanical components which have to withstand high temperatures and friction wear. Tribological coatings can drastically lower the friction coefficient and improve resistance to wear - this greatly improves the efficiency of the engines.

**Radar detection techniques**

Following are techniques of detection for aircraft

- RADAR
- Heat detection
- Turbulence detection
- Visual detection

Radar is a system that allows the location, speed, and/or direction of a vehicle to be tracked. The word "radar" is actually an acronym standing for Radio Detection and Ranging since the device uses radio waves to detect targets. Radar works by sending out pulses of these electromagnetic waves and then "listening" for echoes bounced back by targets of interest. Even though a radar may transmit megawatts of power in a single pulse, only a tiny fraction of that energy is typically bounced back to be received by the radar antenna. The amount of power returned from a target to the transmitting radar depends on four major factors:

- The power transmitted in the direction of the target
- The amount of power that impacts the target and is reflected back in the direction of the radar
- The amount of reflected power that is intercepted by the radar antenna.
- The length of time in which the radar is pointed at the target.

**Future of stealth technology**

Stealth technology is clearly the future of air combat. In the future, as air defense systems grow more accurate and deadly, stealth technology can be a factor for a decisive by a country over the other. In the future, stealth technology will not only be incorporated in fighters and bombers but also in ships, helicopters, tanks and transport planes. Ever since the Wright brothers flew the first powered flight, the advancements in this particular field of technology have seen staggering heights. Stealth technology is just one of the advancements that we have seen. In due course of time we can see many improvements in the field of military aviation which would one-day even make stealth technology obsolete

**Conclusion**

The stealth aircraft is need of modern warfare technology. Every aviation related agencies have same agenda as they design and manufacture sixth generation fighter aircraft. Stealth has become the magic word in contemporary weapon systems. Contemporary work on stealth has its roots in long-standing efforts to reduce the visibility of military aircraft through camouflage paint schemes. However, as electronic sensors have replaced the eyes of pilots as the primary means of tracking other aircraft, more intricate means of defense were needed. This paper also concluded that potential of Nano-materials with Stealth Technology in Aviation (Defense) Sector. Using Nano-technology with Stealth Technology in aviation gives the Low Observability with Light Weight, High Strength, High Toughness, Corrosion Resistance, Less Maintenance & Durability with increase in carrying Pay load hence it becomes cheaper, safer and used for protecting to be the target than the conventional.

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