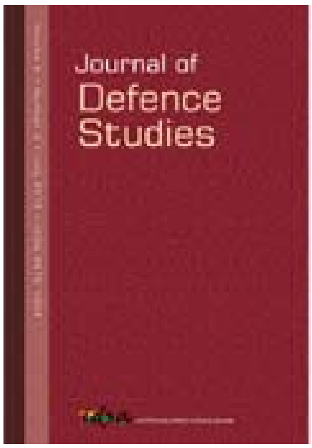

Stealth and Counter-stealth Some Emerging Thoughts and Continuing Debates

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To cite this article: V.K. Saxena (2012): Stealth and Counter-stealth Some Emerging Thoughts and Continuing Debates, Journal of Defence Studies, Vol-6, Issue-3.pp- 19-28

URL:
http://www.idsa.in/jds/6_3_2012_StealthandCounterstealthSomeEmergingThoughtsandContinuingDebates_VKSaxena

Stealth and Counter-stealth
Some Emerging Thoughts and Continuing Debates

V.K. Saxena*

> *What is a stealth bomber? It is a bomber that doesn't show up on radar and you can't see it. Then we don't need one.*
>
> —Robin Williams[1]

The Eternal Duel

If there is one dimension in the air attack–air defence continuum that is riding high on the wings of enabling edge technologies, it is the use of stealth, both in the offensive and defensive domains. While a multiplicity of modern day aerial threat vehicles like B-2, F-22, F-117A, SU 35, JXX/J-20, UH-60, Mig 35, etc., are relying on latest stealth techniques to increase their survivability (and, hence, kill capability) in active air defence environments dotted by a hierarchy of sensors in range and depth, the air defence warriors are busy fielding high technology and high-definition sensors in active, passive, and electromagnetic (EM) based anti-stealth domains to defy stealthy attack. The cause-effect duel, thus, continues eternally.

This paper presents certain emerging thoughts and continuing debates in the field of stealth and counter-stealth.

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ISSN 0976-1004 print

Journal of Defence Studies, Vol. 6, No. 3, July 2012, pp. 19–28

Offensive Stealth: Spreading its Wings

Besides a multitude of aircraft, it will be of interest to know whether stealth technology is also being applied to Unmanned Aerial Vehicles (UAVs). One such UAV is Boeing's Phantom Ray UAV (see Figure 1), which had its first flight in April 2011.[2]

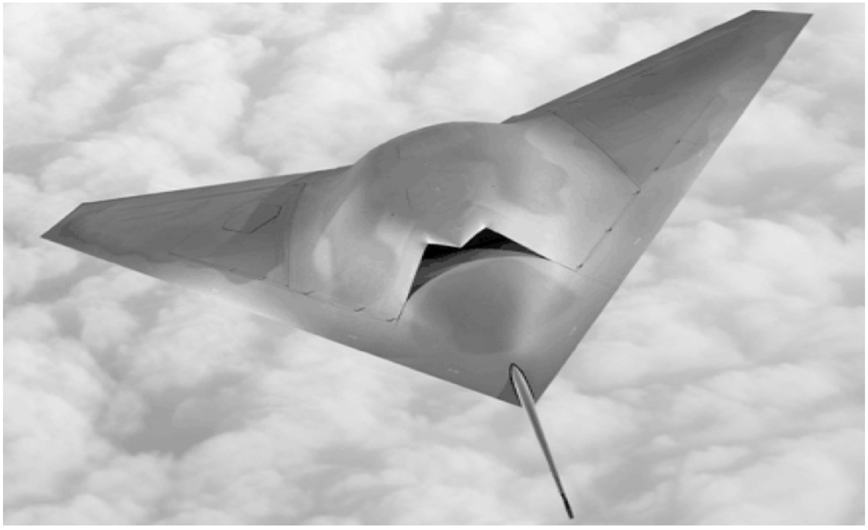

Figure 1 Phantom Ray UAV
Source: http://deepbluehorizon.blogspot.com

This unmanned combat aerial vehicle is being built using the technology from X-45 experimental programme and is a stealthy combat UAV capable of performing a host of combat functions ranging from reconnaissance, close air support to Electronic Warfare (EW), and autonomous mid-air refuelling. Costing a cheap $50 million, experts opine that the stealth features of this combat UAV are such that it is capable of ripping through the most advanced air defences supported by air superiority fighters such as F-22 or EWRQ-170, etc. Offensive stealth is indeed a growing field.

Disadvantages of Stealth Aircraft[3]

While much has been said of the virtues of stealthy aircraft and helicopters, and their fighting prowess, these air-machines have to pay the price of the stealthy technologies in terms of other combat features. Some of these are briefly enumerated below.

Speed and Maneuverability

Firstly, stealth aircraft can neither fly as fast as conventional aircraft nor are these as manoeuvrable. For example, the F-22 aircraft may be fast and manoeuvrable, but it cannot go beyond Mach 2 and cannot make turns like SU-37.

Payload

Another serious disadvantage with the stealth aircraft is the reduced payload that these can carry. This is primarily due to the fact that most of the payload is to be carried internally, in order to reduce radar signature.

Comparative Cost

Stealth machines are comparatively much costlier than their conventional brethren. Experts opine that stealth aircraft cost their weight in gold (Phantom Ray UAV—$50 million, F-117—$70 million, F-22—$100 million). The Russians are trying to break this cost barrier. Great designers like Mikhoyan Gurevich and Sukhoi are designing stealthy frames with price tags in the affordable range of Third World countries.

Some Contemporary Technologies at the Cutting Edge

Planform Alignment of Stealthy Machines[4]

In addition to various stealth features and technology on board various

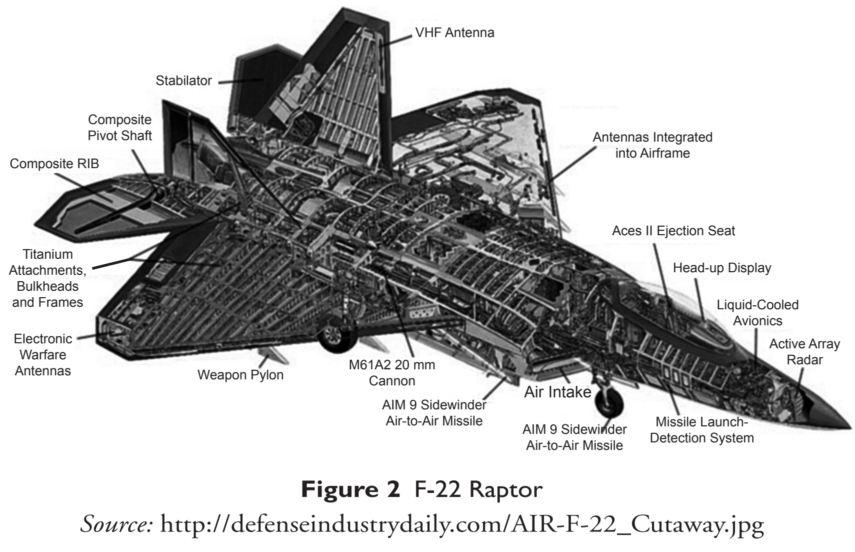

Figure 2 F-22 Raptor
Source: http://defenseindustrydaily.com/AIR-F-22_Cutaway.jpg

aircraft, a design feature called 'Planform Alignment' is worth knowing. It involves using a small number of surface orientations in the shape of the aircraft structure, for example, in F-22A Raptor (see Figure 2), the leading edges of the wing and tail surfaces are at the same angle. Careful inspection will show that many small structures—such as the air intake bypass doors and the air-refuelling aperture—also have the same angles.

The effect of the Planform Alignment is to return the radar signature in a very specific direction away from the radar emitter, rather than returning a diffused signature that is detectable at many angles (by Bi-Static, Multi-Static and MIMO radars).

Plasma Driven Stealth: A Quasi-active System[5,6]

Although considered an active stealth technology, 'Plasma Active Stealth' is actually a quasi-active system in which threat radar signatures are received and absorbed/scattered by a plasma capable of absorbing/scattering a wide range of radar frequencies, angles, polarizations, and power densities. Rather than actively sending threat radar signatures directly back to the transmitter, the plasma is more likely to scatter the radar energy, more akin to a faceted, passive surface approach. Nevertheless, Plasma Stealth (see Figure 3) is an active system with regard to the significant detectability provided over a broad range of threat radar frequencies, polarities, and transmission angles. In 2002, the Russians tested a plasma-stealth device on board an SU27 and the radar cross-section (RCS) of the aircraft was reduced by a factor of 100.[7]

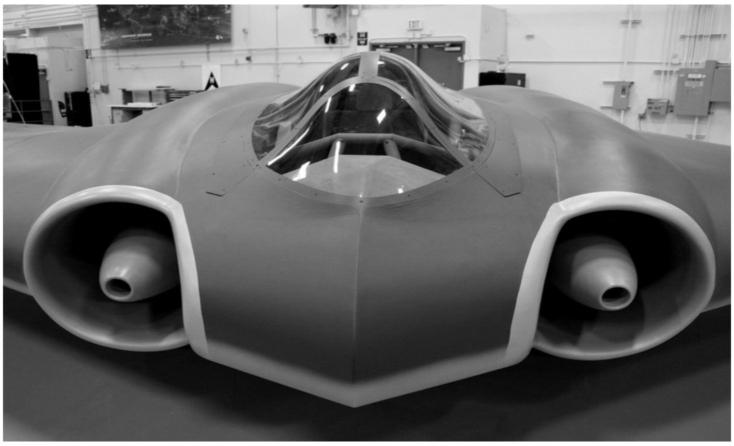

Figure 3 Plasma Stealth System

Propulsion Sub-system Shaping

In addition to the various stealth technologies, one new technology in research is called the 'Propulsion Sub-System Shaping'. It refers to the fluidic nozzles for thrust vectoring in aircraft jet engines. Such nozzles produce a much lower RCS due to the fact that these are less complex, mechanically simpler, and less massive with no moving parts/surfaces. These are likely to find usage in 6th generation fighter aircraft/UCAVs.

Radar Absorbing Material (RAM)

It will be of interest to know that the RAM technology has really come a long way. There was a time when the RAM coating material MX 410 was so heavy (due to its iron content) that it actually made the aircraft unwieldy or even too heavy to fly![8] Today's cutting-edge technologies include di-electric composites and metal fibres containing ferrite isotopes. One innovative paint consists of depositing pyramid like colonies on the reflecting surface with the gaps filled with ferrite-based RAM. The pyramidal structure deflect the incident radar energy in the maze of RAM, reducing resultant RCS by many degrees of magnitude.

Ablative Paints[9]

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. These paints, previously heavy, have been reduced in weight considerably, allowing more areas to be covered, which would reduce the radar signature even more. A commonly used material is known as 'Iron Ball Paint'.

Computers and Other Advance Electronics

Computers and advanced electronics make a great contribution to stealth. Fly-by-wire systems will make manageable flying machines out of the most exotic configurations. They will also allow control surfaces such as fins and rudders to be reduced in size, or even eliminated, as in the B-2 ATB.

Smart Skin Technologies

In the field of visual stealth, while various types of painting strategy are being used, the cutting edge of research is the Chameleon or Smart-Skin technology, which would enable an aircraft to change its appearance to mimic its background.

Latest Advances in Counter Stealth

Light Detection and Ranging (LIDAR) Technology[10]

In the field of counter-stealth, another very interesting radar is called the LIDAR. The key technology of LIDAR detecting stealth targets is based on two methods: Multi-Band and Multi-Static anti-stealth technology. Laser radar can detect stealth targets effectively because it has short wavelength, high beam quality, strong directionality and high measuring accuracy, which aids functions of target identifying, posture displaying and orbat recording.[11] In addition to the above, LIDAR possesses higher resolution and anti-jamming ability due to its coherence property and extremely high frequency.[12] This attribute indicates that LIDAR has a huge potential in target-detection, track and range. Research proves that LIDARs can be very useful in stealth aircraft detection with proper coverage region when the range reaches 20–30 km and the angle of precision exceeds 0.3 mrad.[13] The emerging technology calls for a combination of visible, infra-red (IR), and LIDAR to enhance detection probability of stealth targets.

Multi-Band 3D Radar[14]

This is a recent technology, developed by Russia in late 2008. This radar system is a package of three to four discrete radars and a single Processing and Command Post. Each of these radars operates on different frequency bands. One of such existing radar system is the Nebo Radar (see Figure 4).

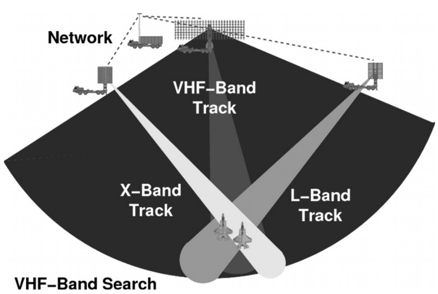

Figure 4 NEBO-M

Capability of Nebo-M

The Nebo-M system is clearly designed to hunt stealth aircraft. The VHF-Band component of the system provides sector search and track functions of low RCS targets, with the X-Band and L-Band components providing a fine track capability. By proper deployment of the radars relative to the threat axis, the L-Band and X-Band components illuminate the incoming target from angles where the target RCS is sub-optimal. Attempts to jam the Nebo-M will be problematic, since a large amount of power is required for jamming all these radars. All of them have a passive angle tracking capability against jammers, as a result of which usage of a jammer permits passive triangulation of the target using three-angle track outputs.

Multiple-Input Multiple-Output (MIMO)[15] Radar

MIMO technology is a variation of the Multi-Static concept. It is a radar technology of a new generation, which has received widespread attention in the last few years. Its core thought is using spatial diversity gain of the signal, partially or completely, to replace coherent gain used in traditional the Phased Array Radar.

MIMO Radar (see Figure 5) employs multiple transmit waveforms and has the ability to jointly process signals received at multiple antennas. The receiver enjoys the fact that the average (overall information streams) Signal to Noise Ratio (SNR) is more or less constant, whereas in conventional systems, which transmit all their energy over a single path, the received SNR varies considerably. The terms 'Input' and 'Output' refer to the radio channel carrying the signal, not to the devices having antennas.

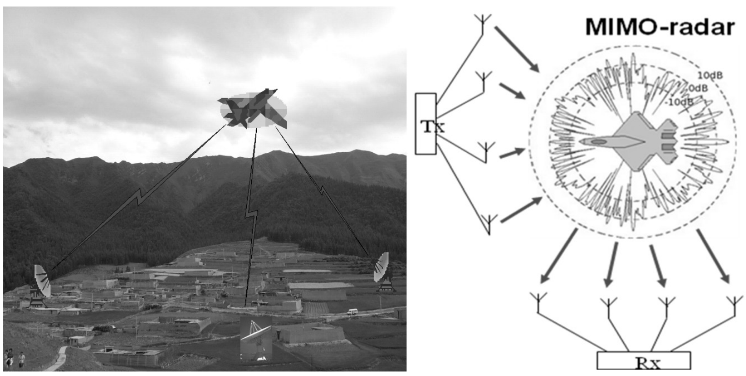

Figure 5 MIMO Radar

Passive Anti-Stealth Measures

Faced with the prospect of aerial stealth proliferation, states in the 21st century are looking for anti-stealth defence options using cost-economic means. One such alternative is the 'Passive Anti Stealth Radar' concept. These systems do not exploit reflected energy and, hence, are more accurately described as Electronic Support Measure (ESM) systems. Well-known examples of passive radars include the Czech TAMARA/VERA system and the Ukrainian Kolchuga system (see Figure 6).

Figure 6 Kolchuga and Vera Passive Radar System

Cellphone Radar (CELLDAR)[16]

This is the most recent and promising technology—still at the conceptual stage—in the detection of stealth aircraft. This was conceptualized by

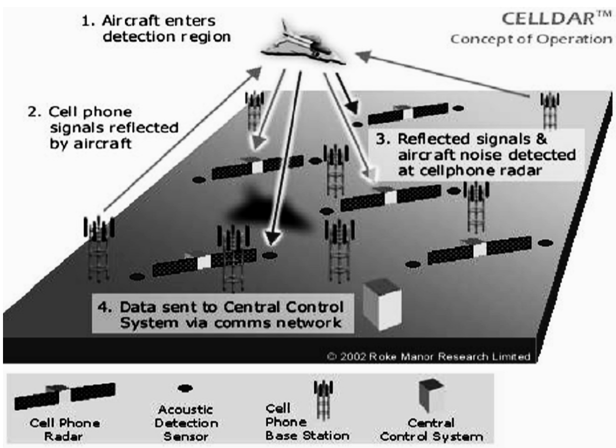

Figure 7 CELLDAR Concept

Roke Manor Research Group (UK). A prototype is under construction in collaboration with BAE Systems. The concept (see Figure 7) is described briefly below:

(a) When a target enters the detection region, cell phone reflected signals are detected by the cell phone radars.
(b) The collected data are then sent back in real time to a central control system via a communication network.

Fusion takes place, and this passive system is able to determine the position and the speed of the target objective.

Stealth-Counter Stealth—The Eternal Debate

Comparative Economics

In the eternal cause-effect context of stealth and counter-stealth, economics plays a major role. Judged against this parameter, counter-stealth beats stealth hollow; for example, a typical anti-stealth radar in Australia costs US $1.3 billion, whereas an F-22 Raptor costs US$ 28 billion). It is, thus, much cheaper to go for counter-stealth than to develop stealth.

Abiding Vulnerability

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, which are comparatively much cheaper than the corresponding stealth technologies.

Comparative Diplomatic Baggage[17]

On the diplomatic front, developing counter-stealth technology carries less diplomatic baggage than developing stealth technology. The reason is obvious. Counter-stealth technologies are purely for defensive purposes, whilst stealth technology is, without a shadow of doubt, for aggressive purposes since its raison d'être is to penetrate enemy defences. Thus, committing to counter-stealth technology development runs less risk of antagonizing neighbours than developing stealth technology.

Hypothetical Comparative Arms Race

According to expects, if out of two countries, A and B, one dedicated to stealth and other to counter-stealth, run a hypothetical course of development for a few years, the economic liability of A will far outstretch that of B.

Be that as it may, the eternal war of 'cause' and 'effect' continues to unroll in the stealth and counter-stealth domain.

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