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Stealth in Naval Aviation: A Hard Look

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STEALTH: THE WORD ITSELF is spoken almost in a whisper, producing images of swarthy men in trench coats with turned-up collars ominously sneaking about in the dark of the night. According to Webster, that image is accurate; he defines stealth as the "act or action of going or passing furtively, secretly, or imperceptibly."[1] So it is fitting that the aircraft industry and the Department of Defense have widely applied the word stealth not only to the technology of reducing the radar cross-section (RCS) of an aircraft, but also to the entire genre of aircraft specifically designed to employ that technology. At present, the U.S. Air Force has operationally deployed its F-117A stealth aircraft in Iraq with reportedly impressive combat results, and has selected the Lockheed-Boeing YF-22 Advanced Tactical Fighter (ATF) for production. Not so successful was the U.S. Navy's stealth aircraft, the A-12 Avenger Advanced Tactical Aircraft (ATA), which was cancelled by Secretary of Defense Richard B. Cheney in January 1991.

Prior to the A-12's problems and the defense budget spending cuts, the navy had intended to produce the Naval Advanced Tactical Fighter (NATF), a carrier-capable version of the air force-led ATF; and from the navy-led ATA, in turn, the air force was to have created a new low-observable attack aircraft to replace the F-111. Not only do recent changes in this plan raise questions, but the low-observable technology itself raises questions that need to be asked from the navy's standpoint. Is stealth really needed in a mission and threat context? Is the technology supportable and maintainable on the flight deck of a carrier? Is stealth affordable for the navy in today's fiscal environment? (Former Secretary of the Navy John Lehman once said, "The rule of thumb is that you forgo two hundred of the existing generation of fighters to pay for the research to obtain a new one."[2]) Lastly, while waiting for the A-12 replacement, what do we do in the interim?

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Technology And The Navy's Mission

In 1970, then-CNO Admiral Elmo Zumwalt listed four U.S. Navy missions: Strategic Deterrence, Sea Control, Projection of Power, and Naval Presence.[3] These missions have been reaffirmed by subsequent naval leaders, most recently by Secretary of Defense Cheney in his comment on power projection, "the United States needs to maintain the capability to project power through the use of naval strike forces."[4] The only change arising over the years has been in the *instruments* used to carry out the missions. We have progressed through a series of increasingly capable and expensive aircraft, missiles, and weapons systems with which to achieve success. In general, technology has given us more reliable aircraft carrying larger payloads of more accurate weapons (including precision-guided munitions), and also the capability to deliver weapons in an all-weather environment. We also have support aircraft specialized for electronic jamming, air-air refueling, and airborne early warning—all designed to help us accomplish our mission more effectively. What then is to be gained by pursuing stealth?

Where Is Stealth Needed In Naval Aviation?

Within the navy's four overarching missions mentioned earlier lie individual warfare areas associated with specific types of aircraft; not all of these would benefit from the low-observable concept. Antisubmarine warfare and the S-3, airborne early warning and the E-2, and electronic jamming and the EA-6—all of these pairings, to give three examples, either involve radiation of electromagnetic energy (which negates stealth) or they do not act in a threat environment that justifies the cost of stealth.

Less obvious but certainly more contentious will be the assertion that current-design fighters performing as combat air patrol and strike escort would not gain enough from stealth to justify the cost of developing low-observable replacements. Any mission which includes detection and prosecution of enemy aircraft at range requires the fighter to use its radar to support its long-range missiles. The emissions of these high-power radar transmitters are detectable and identifiable at extremely long ranges and are thereby incompatible with the purpose of stealth. The passive infrared search and track system installed in the F-14D *is* consistent with stealth, and produces very impressive detection ranges, but it cannot alone direct the radar-guided AIM-54 Phoenix or AIM-7 Sparrow missiles. Further, as will be argued later, even if it were possible to make all tactical aircraft invisible, would it be the correct thing to do strategically?

Power Projection. The "power" in power projection is embodied in strike aircraft reaching the target and putting ordnance, whether Mk 80 bombs or precision-guided munitions, on target. It could be argued that even the *possibility* of becoming able to enter the enemy's airspace undetected, deliver this ordnance, and then return unscathed to home base is sufficient reason in itself to proceed with the stealth concept, regardless of cost or technological challenges.

However, today's tactical practice already calls for creation of a "sanctuary" in which strike aircraft can operate with a reasonable expectation, consistent with the accepted risk of the mission, of reaching the target and delivering weapons. Creating this sanctuary is a scenario-dependent and complex operation involving suppression of enemy air defenses (SEAD), which uses electronic jamming, deception, and anti-radiation missiles such as Shrike or the High-Speed Anti-Radiation Missile (HARM). Although this description of the SEAD effort is grossly oversimplified, it makes the point that *if* the SEAD campaign were perfect, rendering all enemy air defenses ineffective, the strike aircraft would then have its sanctuary and only putting "bombs on target" would remain for mission success.

If we can create this perfect sanctuary, stealth will not be needed for the strike aircraft. So should we not concentrate our resources on making perfect sanctuaries vice invisible aircraft? As a matter of cost-benefit analysis, then, should we invest money to improve our jammers, remotely piloted vehicles (RPVs, used for deception), the standoff ranges of weapons, and our cruise missiles so as to create near-perfect sanctuaries? Or should we pursue stealth with a view to reducing the number of fighters, jammers, and HARM launchers needed on a given strike and thereby increasing the ratio of bombers to support aircraft? Perhaps some of the many lessons yet to be learned from the war with Iraq will help answer these and other questions.

In keeping our focus on the aircraft carrier and its organic assets, however, it is probably unreasonable to postulate a perfect sanctuary—which brings up the final assertion regarding the mission or aircraft-related need for stealth. If we support a SEAD campaign with electronic jamming and deceptive RPVs intended to entice hostile radars to transmit and thus become vulnerable to HARM missiles, the HARMs would be most effectively employed by an undetected launch platform. A firing aircraft which is undetected can achieve optimum ranges and timing for missile launch, which increases the probability of success for the SEAD effort and the entire power projection mission.

But why use stealth just in a supporting role, as part of SEAD? On the surface, it would seem the real advantage of low-observable technology lies in its tactical use in the power projection mission. Because even though any high-value target is sure to be surrounded by a layered defense which includes fighter aircraft, surface-to-air missiles, and anti-aircraft guns, if we could produce an aircraft with a radar cross-section small enough to prevent missile or gun engagement our sanctuary would be with us wherever we go. With radar-dependent enemy air defenses no longer a factor, could we not then forgo the complex task of creating a sanctuary? Unfortunately, it is not so simple. For even if the strike is carried out in daylight, avoiding terrain obstacles and acquiring the target by visual means, our stealth aircraft is invisible only to radar and not to optically guided weapons or sightings by fighter aircraft. If the strike is conducted at night or in bad weather, then the use of any emitter in the attacking aircraft, whether it be radar altimeter, terrain-following radar, or target acquisition radar, transforms our aircraft into a detectable electromagnetic energy producer. Techniques exist to reduce such emissions, alleviating part of this problem, but the point remains that stealth technology is not a panacea for either daylight or night strike scenarios. An overstatement? Perhaps, but it is no more so than the idea of overflying hostile territory, attacking, and retiring, all without support and virtually undetected.

Deterrence and Presence. Let us assume for a moment that the technological challenges have been overcome and we have an aircraft that is all but invisible to current detection systems, one that operates in enemy airspace with impunity. But where now is strategic deterrence? Or naval presence? Or the psychological effect of scores of aircraft displayed on every long-range radar screen within hundreds of miles? To take the problem a step further, let us now assume tensions are increasing in some remote Third-World "brushfire;" could the very property of stealthiness be y*destabilizing*? For example, might not a nervou weapons system operator or fire control officer take preemptive action (such as launching a missile) against a tenuous or even spurious radar indication, thinking that *maybe* it was the barely detectable radar return of an attacking stealth aircraft, and thereby unnecessarily escalate tensions? Of course none of this can be stated with certainty, but quite possibly the quality of stealthiness which we have pursued with so much money and effort could in fact work in a destabilizing manner, increasing the chances of armed conflict rather than deterring it.

Having argued that low-observable properties could adversely affect, rather than enhance, the missions of deterrence and presence, it should be mentioned that one radar absorbing material (RAM), a paint known as "iron ball," could partly ameliorate this problem. It is reported that the radar-energy distortion capability, or mutability envelope, of iron ball can be manipulated through cockpit controls.[5] It would then be theoretically possible (still assuming all technological challenges can be overcome) to vary the radar signature of aircraft—displaying perhaps a twenty-five square meter radar return when it is important to reveal one's presence, then reducing the signature to perhaps one-tenth of a square meter or less to deliver the weapons. This concept does satisfy the naval presence problem, but nonetheless the mere *ability* to reduce RCS to the very edge of detectability remains destabilizing in periods of heightened tensions when attack is a possibility.

Detection by Other Means

The stealth concept has been discussed here only in the context of reduced radar cross-section and shorter detection ranges. However, radar is only one of several means of detecting aircraft. Electronic surveillance measures (ESM) and optical and infrared (IR) sensors are other examples. To be *really* stealthy, one must defeat these detection methods as well. As noted above, electromagnetic energy is detectable and identifiable by ESM, which presents problems in a night or bad-weather environment.

Tactical aircraft have long used various paint schemes for two purposes: to help reduce visual detection range and to confuse or delay enemy determination of an aircraft's aspect or direction of turn. Schemes to reduce visual detection ranges have extended from such basic measures as flat grey upper surfaces and white below to more exotic camouflage patterns using the colors of the specific battle arena. A recent navy experiment used water-based paint on F-14s in various flat blendable colors in an attempt to produce camouflage patterns nearly instantly adaptable to any over-land environment. Even this "fix" was not completely successful in that no one pattern or color has been found effective throughout the whole of even a single mission. For example, a green-brown camouflage may be effective when seen from above against a land background of similar color, but the same aircraft may show up as a distinct black silhouette against a light overcast sky. Other attempts at deception have included angular patterns designed to prevent resolution of aspect angle, and painting canopy silhouettes on the bottom of the fuselage to mask direction of turn. All these techniques have been effective to some degree, but none are perfect—we cannot make an aircraft invisible.

Composites technology, so critical to modern aircraft design and structure, has contributed to reduction of aircraft IR signature. Carbon composites such as carbon grain and ultradense carbon foam have excellent infrared radiation dissipation qualities, for example. The F-117A reportedly uses reinforced carbon fiber in outer skin panels near the engines to improve its IR signature reduction properties. Other techniques such as mixing cool bypass air with hot turbine exhaust gases in jet engines can also help reduce IR signatures. Afterburners, however, a requirement for a high-performance fighter, produce an infrared signature detectable for miles by even relatively unsophisticated sensors. Even if we assume non-afterburning performance is sufficient for a bomber, continuing improvements in IR search and track capabilities may eventually pose a detection threat to the stealth aircraft. On the other hand, it is also possible that IR signature-reducing technology will outstrip that of IR detection, in which case the IR spectrum would not provide detection ranges sufficient for early warning, maybe not even for effective weapons guidance, against a stealth platform. I cannot accurately predict the relative rate of development of these technologies, but infrared does represent a threat to stealth which cannot now be discounted.

For argument's sake, however, let us once again assume that stealth technology will triumph and that the signatures (radar and IR) of tactical aircraft can be reduced to the very edge of detectability. Even then problems still remain, particularly for carrier-based stealth aircraft.

Carrier Suitability

The stealth property of low RCS is produced in three primary ways: airframe shape, internal construction, and coatings. Airframe shape and internal construction are closely tied to low observability and can produce a small RCS even without a RAM coating. RAM paints, on the other hand, can provide some reduction of RCS even when applied to "non-stealth" airframes. So, although these three elements can be employed as independent techniques, they all can play a part in the stealth effort and all become special factors on an aircraft carrier flight deck, where salt spray and limited space for parking and maintenance take their toll.

The fundamentals of low-observable design include avoiding, first, boxy and angular airframes with parts joined at right angles; second, large, open, engine air intakes; and third, flat and nearly perpendicular surfaces such as planar radar antennas.[7] Externally carried weapons and fuel tanks, and cockpits not protected by specially treated canopies, are all well-known sources of radar reflectivity.

The fact that *anything* carried externally will destroy the low-observable properties of the airframe demands internal bomb bays in stealth designs. Internal bomb bays, in turn, result in much lower drag than in conventional aircraft with exposed bomb racks and weapons; they also result, however, in either a smaller payload, relatively speaking, or a larger airframe. In addition, creating a space within an airframe imposes its own weight penalty. The result is that stealth requires a larger, heavier, airframe to carry the same payload. Can technology, in the tradeoff between aircraft payload and size, produce a bomber with sufficient payload to be tactically effective which does not take up an inordinate amount of space on the flight deck? Some sort of compromise using "tactical contribution per area of flight deck occupied" as a criterion must be reached. There are also operational questions that arise regarding internal bomb bays. Exposed conventional bomb racks are easily accessible for quick loading for another combat mission. Can comparable re-arming times be achieved with internal bomb bays?

Airframe construction and RAM coatings, taken together, are another factor in low-observable aircraft design in the context of the aircraft carrier environment. Composite materials have been used extensively in combat aircraft in recent years; they include Kevlar, Spectra-100, and the Dow Chemical

Company's Fiballoy (speculated to have been used in the F-117A).[8] A great advantage of composites over metals is that the former can greatly reduce an aircraft's signature (RCS and IR) by absorbing and dissipating microwave and infrared radiation.[9]

But composites, if all their virtues are to be realized, must be manufactured under exacting standards to ensure uniformity of construction and strength. If a stealth airframe is damaged, the repair of the composite surface and underlying structure must maintain these exacting standards in order to preserve low-observable properties. Similarly, if the aircraft to be repaired has a RAM coating, that must be preserved without scrapes or large areas sanded bare. Although the difficulty of repairing composite and RAM-coated surfaces vis-a-vis aluminum would be greater aboard ship, that alone is certainly not a rationale for abandoning stealth in the navy. It is worth addressing, however, inasmuch as the navy has struggled to control the effects of the shipboard environment on aircraft since Eugene Ely first landed on the U.S.S. *Pennsylvania* in 1911. The inescapable fact remains that aircraft maintenance and movement in the close confines of an aircraft carrier still routinely result in dents and scrapes. Now with stealth, however, these imperfections would increase an airframe's radar reflectivity with respect to high frequency air intercept radars, undermining the very purpose of its low-observable design.

Stealth Technology Claims Viewed At The Extremes

So far in this article, the assumption has been that all problems associated with low observable technology can be overcome, producing a tactically effective aircraft at a reasonable cost. In view, however, of the recent cancellation of the Navy's A-12 Avenger program—woefully behind schedule with very little to show for the $3.1 billion invested—is this a valid assumption?[10] In fact, the nearly impenetrable veil of secrecy surrounding many aspects of stealth technology has hidden not only the problems but also whatever successes exist; there are no unclassified test results available to document actual stealth aircraft RCS values or detection ranges against state-of-the-art radar systems. Despite the one-millionth square meter RCS claimed by one source for the Northrop B-2 bomber (which, incidentally, has a 172-foot wingspan),[11] that aircraft underwent a major design change in 1983 to give it the additional structural strength in its wings needed for low vice medium-altitude penetration—to take advantage of terrain masking.[12] Was this significant change the result of an air force conclusion that medium altitude would expose the aircraft to too many threats? Could it be that low-observable technology is not as impressive as those who are spending billions of dollars on research and development would have us believe? Does the ability to defeat stealth already exist in some other highly classified program, or worse, in an existing radar capability?

At the other extreme is the possibility that our technology will have produced an aircraft that will remain nearly undetectable by any conventional method for years to come. It is also possible that the cost of developing a revolutionary stealth-detection capability may be so prohibitive that even the B-2, at nearly a billion dollars each, would be the correct and cost-effective answer.

What Is The Correct Course For The Long Term?

Do the technological risks, mission effectiveness considerations, questions of operational suitability, and exorbitant cost mean the navy should abandon stealth technology altogether? Probably not, since this option has an "inopportunity cost"—what if stealth *is* everything we ever imagined it would be, and more? Do we want to risk *not* having the stealth technology when the Soviets might? But if we do get our new stealth aircraft and replace all the KA-6 tankers on the flight deck (since the S-3 is not fast enough in many operational scenarios), are we now to use extraordinarily expensive stealth airframes as tankers? Some of these "devil's advocate" questions neither have nor need immediate answers, but they should remind us that the decision to pursue and integrate stealth will not be easy.

Although the navy has requested no money in the fiscal 1992 budget for an A-12 replacement, a follow-on stealth program called the A-X is being considered.[13] An accurate assessment of F-117 performance in Iraq will assist us in making the correct long term decision about stealth and its application to the special problems and needs of the navy. If stealth is pursued, the program management and technological lessons learned from the YF-22, YF-23, and A-12 programs should help the navy properly procure and integrate the low-observable technology.

And For The Near Term?

With the A-12 cancellation, a replacement is still needed for the A-6. The Intruder's 18,000-pound payload remains the biggest on the flight deck, but it is an old airframe and structural problems in its wings have become more and more serious. A partial solution is to "re-wing" A-6Es; this option is being pursued, with over $850 million included in the fiscal 1992 and 1993 spending plans.[14]

Another alternative is the existing F-14D, which has an air-ground capability that includes iron bombs and HARM along with its proven air-air arsenal of the AIM-54 Phoenix, AIM-7 Sparrow, and AIM-9 Sidewinder. With the 27 February 1991 announcement that the Department of Defense would not release $988 million authorized for fiscal 1991 to remanufacture twelve F-14As into F-14Ds,[15] there is now no funding in the budget for either production of new

F-14Ds or retrofit of older airframes to that configuration. While the Pentagon estimated that terminating the F-14D would save $14.8 billion through fiscal 1997, it also dropped budget provisions for NATF demonstration and validation while the air force develops its own ATF.[16] If then, as it seems, the NATF and F-14D (and its possible derivatives, Quickstrike and the ASF-14 Advanced Strike Fighter)[17] are no longer viable programs, the Navy has left itself only one possible alternative for A-6 and F-14 replacement: the F/A-18.

The proposal for the F/A-18 includes developing two new versions, the E and F models. As described in *Aviation Week and Space Technology*, the E version will be a modified single-seat version of the F/A-18 which includes larger wings, a fuselage plug, increased fuel and payload capability, and an increased thrust version of the General Electric F404 engine. The F version is a two-seat trainer aircraft, but the intent is to develop a true all-weather, attack aircraft that can bridge the gap until the A-X comes on line."[18]

Conclusion

Low-observable technology is intriguing and holds great promise for meeting the navy's power projection mission and possibly others as well. But we should not plunge headlong into this high-risk area without, first, taking a prospective look at what stealth can do *for* us, and second, taking a retrospective view of what stealth has done *to* us. In any investment the level of risk determines the level of rewards and losses. But can we afford to lose? As the A-12 program's demise confirms, failure is expensive, can occur for a variety of reasons, and has far-reaching effects. We must determine how low-observable technology will adapt to the carrier environment, how it will be employed tactically, and what implications it will have strategically. Considering the time and money required to develop and deploy a new tactical aircraft, we cannot afford another mistake.

Notes

1. Webster's Third New International Dictionary. (1981), p. 2232.
2. John F. Lehman, Jr., *Maritime Strategy in the Defense of NATO* (Washington: Georgetown University Center for Strategic and International Studies, 1986), p. 12.
3. Roger W. Barnett, "The Origin of the U.S. Maritime Strategy, Part II," *Naval Forces*, no. 5, 1989, p. 59.
4. John D. Morrocco, "Navy Weighs Alternatives After Cheney Kills Avenger 2," *Aviation Week and Space Technology*, 14 January 1991, p. 18.
5. Joseph Jones, *Stealth Technology: The Art of Black Magic* (Blue Ridge Summit, PA: Tab Books, 1989), p. 49.
6. *Ibid.*, p. 44.
7. *Ibid.*, p. 14. The F-117A does indeed have a "boxy, angular, airframe;" this design, however, dates from the 1970s when the calculations involved with smooth curves were beyond the grasp even of the famous Lockheed "Skunk Works," which produced the F-117. See Malcolm W. Brown, "2 Rival Designers Led the Way to Stealthy Warplanes," *The New York Times*, 14 May 1991, p. C12.
8. *Ibid.*, p. 77.
9. *Ibid.*, p. 44.

10. "Packard Was Right," *Aviation Week and Space Technology*, 14 January 1991, p. 7.

11. Jones, p. 85.

12. Robert R. Ropelewski, "Stealth Bomber Schedule and Cost Reflect Risks," *Armed Forces Journal International*, February 1989, p. 28.

13. John D. Morrocco, "Navy to Upgrade F/A-18s, Rewing Additional A-6s," *Aviation Week and Space Technology*, 11 February 1991, p. 83.

14. *Ibid.*

15. John H. Cushman, Jr., "Grumman F-14 Pact Is Canceled," *The New York Times*, 27 February 1991, p. D1.

16. David F. Bond, "Defense Dept. Seeks to End F-16 Production, F-14D Remanufacturing," *Aviation Week and Space Technology*, 11 February 1991, p. 80.

17. Quickstrike and ASF-14 (Advanced Strike Fighter-14) are enhanced derivatives of the F-14D. Quickstrike would include radar modes optimized for ground attack, FLIR navigation and targeting pods, and Standoff Land Attack Missile capability among other air-to-ground weapons, according to Grumman officials. The ASF-14, to be available about the turn of the century, would combine some ATF technology with the F-14 airframe. See Stanley W. Kandebo, "Grumman Makes 11th-Hour Offer To Get F-14 Into Fiscal '92 Budget," *Aviation Week and Space Technology*, 6 May 1991, p. 25.

18. Morrocco, p. 83.

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There seems to be no way to prevent the human mind from pushing forward the edges of knowledge and experience. Every area of the unknown, the untamed, or the incomprehensible presents a challenge.

Charles Scribner, Jr.
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