Stalemate: How the Future of Air Power might look in the shadow of the emerging fifth-generation Air Threat

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PAK-FA: a weapons system that has the potential to strike fear in to the heart of Western air power for decades. This article will examine the background and proposed open source capabilities of the Russian stealth fighter program and argue that if the PAK-FA marketing brochure truly reflects the fielded capability of the platform, then the impact on Western air power at both the strategic and tactical level will be profound. The paper argues that simply procuring the Joint Strike Fighter and F-22 Raptor in the quantities proposed will not necessarily be enough to counter PAK-FA. Western air power must also look to the development of networked air, ground and sea-based technologies capable of detecting and engaging the airborne stealth threat, an F2T2EA chain optimized for speed and a rebalancing of front-line training towards within visual range combat. The penalties for not taking action in the immediate future to counter the emerging stealth threat could well be catastrophic to our national intent and global impact.

Introduction

On 29 January 2010, the eyes of the aviation world were fixed upon the maiden flight of an aircraft that has the potential to change the balance of military air power as we know it. The Sukhoi T-50 / PAK-FA (Prospective Airborne (K)Complex of Frontline Aviation) is designed to be stealthy, agile, aware, fast and lethal; in short, all of the attributes required to be designated a fifth-generation fighter platform. The Sukhoi T-50 constitutes the Russian answer to the US F-22 Raptor in the battle for supremacy over both the battlespace and the international market place. This milestone was closely followed by the Chinese fifth-generation fighter project with the maiden flight of the Chengdu J-20 on 11 January 2011.[1] If the hyperbole surrounding the Sukhoi and Chengdu platforms is to be believed, and our international competitors are successful in achieving a fifth-generation fighter capability, then the technological dominance enjoyed by Western-aligned air forces over recent decades will be at best challenged and at worst, lost.

A true indication of how the Sukhoi T-50 and Chengdu J-20 will fare against the F-22 Raptor or the F-35 Lightning II Joint Strike Fighter (JSF) will not reveal itself until the aircraft actually meet in combat. Aside from the F-22, all of the other projects are currently too immature for a direct and accurate comparison to be fair or worthwhile. However, if our competitors are successful in achieving the potential claimed by Sukhoi and Chengdu, then the stealth threat represents the greatest challenge to Western technological and air power dominance for decades.

Whilst Sukhoi have advertised the pedigree and potential of the T-50, many in the West have sought to play down the impact that the aircraft is expected to have. In February 2011, following the platform's maiden flight, US Air Force Secretary Michael Donley told reporters:

> *"I didn't see anything … that would cause me to rethink plans for the F-22 or F-35".*[2]

However, US political reaction may have been flavoured by the recent decision to cut the number of F-22s to be delivered to the USAF, along with a fear of tarnishing the chances of the largely American-manufactured F-35 JSF in the export marketplace. Furthermore, the West has seen wildly over-inflated claims of prototype Russian fighter aircraft capability before that have failed to come to fruition. For example, the Mig-25 Foxbat was touted as capable of flying over three times the speed of sound with unparalleled agility, worrying US politicians enough to commission the design of the F-15 Eagle. It wasn't until Victor Bolenko defected with his Mig-25 to Japan in 1976 that the true capabilities of the Foxbat were revealed as falling well short of Russian claims.[3] Certainly, the much publicised engine trouble suffered by one of the Sukhoi T-50 prototypes at the 2011 Moscow Airshow has provided some ammunition to the aircraft's detractors.[4]

Proliferation

Perhaps a more pragmatic view is that whilst the eventual capability of production standard Very Low Observable (VLO) supersonic air threats remains to be seen, they have the potential

to proliferate amongst our premier economic and ideological competitors within the UK military's Future Force 2020 planning timeframe. General He Weirong, Deputy Commander of the People's Liberation Army Air Force (PLAAF), expects the Chengdu J-20 to enter operational service in the 2017-2019 timeframe.[5] Additionally, Russian Air Force commander-in-chief, General Alexander Zelin, recently told reporters that he expects the first of the 200 production T-50s earmarked for the Russian Air Force to be delivered in 2014-2015.[6] Even allowing for the traditional delay associated with in-service dates for military aviation development projects, this timeline puts the T-50, and aircraft like it, squarely in the bracket of threats that need to be considered without delay. General Roger Brady, Commander US Air Forces in Europe, gave an indication of the US view in February 2011, when he remarked:

"I don't know if it's (Sukhoi T-50) *really a fifth-generation aircraft. What I do know is that it's very clear that they're working on a fifth-generation technology. The key is, we must continue to do fifth-generation and sixth-generation research and put money against it because other people clearly are,"*[7]

The development process and financial muscle of the Sukhoi project has been significantly bolstered by Russia's partnership with India. It has been reported in the Russian media that India has provided thirty-five per cent of the six billion dollar development costs and intends to procure between two hundred and two hundred and fifty airframes.[8] It is widely felt in the aviation industry that the involvement of Indian technological and economic power is key to the Sukhoi project as it severely reduces the likelihood of failure along the lines of previous Russian military aviation projects. Vietnam is expected to be the second export customer and the Republic of Korea has recently placed the Sukhoi T-50 on the initial contenders list for its F-X III fighter replacement tender.[9]

China has yet to commit publicly as to how many J-20s will be purchased for the PLAAF. However, it has been speculated that the J-20 is expected to replace the Chinese SU-27SK Flanker B and SU-30MKK Flanker G fleets. A direct platform swap would result in approximately four hundred J-20 airframes accepted in to PLAAF service.[10] Consequently, it can be seen that the proliferation of VLO threats may well be significant, with the potential for up to a thousand VLO platforms pencilled in to the combined Sukhoi and Chengdu order books.[11]

Global Relevance

It has been argued that a VLO air threat will make obsolete conventional third and fourth-generation fighter aircraft (such as Typhoon, Rafale and Gripen) that don't enjoy stealth technology.[12] Whilst it is too early to be confident of such stark conclusions, it seems certain that if opposition stealth platforms can achieve even half of the kill ratio that the F-22 Raptor currently enjoys against more conventional fighter aircraft during training exercises, then the balance of power in the air will have shifted significantly.

Western-aligned air forces have long enjoyed a technological dominance of the air above the battlespace with the ability to detect a threat and engage the enemy with long range, active

radar guided missiles. If enemy air platforms can deny detection to Western surface and air-based radars until extremely short range, then conventional third and fourth-generation platforms will have surrendered technological superiority, and control of the air will no longer be so easily attained. Even if an air force is able to deploy F-22 Raptors or F-35 JSF aircraft, the potential capability of opposition VLO platforms may well drag the kill ratio towards parity, with no guarantee that military or political objectives can be achieved within an acceptable cost.

When the number and identity of important European allies who are not F-35 JSF customers and have no true fifth-generation platform in their near future is taken in to account, then the prognosis for Western-aligned military coalitions faced with a VLO threat comes in to stark focus. Currently, only the European air arms of the UK, Italy, Holland, Denmark and Norway expect to procure F-35 JSF aircraft. Notably, France, as a key UK and NATO partner nation, has no plans to procure a fifth-generation platform at the time of writing; although Dassault Aviation, the French aircraft manufacturer, is currently playing a leading role in the Neuron project, a supersonic, VLO Unmanned Combat Aerial Vehicle (UCAV) capable of delivering nuclear weapons.[13]

As seen with both the F-22 and F-35 JSF projects, the price tag of developing stealth platforms is beyond the reach of many nations[14], meaning that VLO threats will not be present in every future theatre of operations. Therefore, the argument follows that a lack of global proliferation somewhat reduces the relevance of the VLO threat platforms. For example, the 2011 military intervention in Libya highlights the continued utility of third and fourth-generation fighter platforms in dominating the airspace over a 'poor' nation state that lacks the means to procure a fifth-generation fighter.[15]

The counter-argument to this school of thought must be that such a national viewpoint may well relegate the state in question from the global top table should a dispute involving a VLO-equipped adversary occur. Such a nation will be unable to operate in certain theatres without significant risk of loss to its combat forces. Thus, there would be some international events which that nation would be unable to shape decisively on an independent basis, although as part of a coalition it may be able to contribute to some low key military tasks.

The global impact of agile, stealth threats must also be balanced against the suggestion that both Russia and China intend to follow a more engaging and aggressive foreign policy in the immediate future. Russia's involvement in the 2008 South Ossetia war, as well as the recent re-introduction of long range patrol flights by the Russian Air Force strategic bomber fleet are evidence of a more outward-looking and militaristic stance than at any time since the end of the Cold War. Furthermore, Vladimir Putin has consistently argued during the 2012 Russian presidential campaign for a stronger military and Russian development of weapons superior to those of any potential enemy.[16] China has also shown evidence of a determination to project military power beyond its borders with the public confirmation of its first indigenous aircraft

carrier project by the People's Liberation Army Chief of Staff in June 2011.[17] Consequently, it cannot be discounted that in the coming decades the West might find itself at odds with Russia, China or a nation to which a VLO platform has been exported, making a fifth-generation air threat a distinct possibility.

Platform Capability

To examine what impact VLO threat aircraft might have on air power employment in the future, we must first consider what capability such a platform may possess. For the purposes of this article, the Chengdu J-20 platform is too immature and shrouded in secrecy to analyze projected capability to any meaningful level. However, due to slightly more longevity as a project, the Sukhoi T-50 has enjoyed a wider exposure and has therefore drawn considerable speculation concerning its projected capability. Consequently, a brief overview of the Sukhoi T-50's potential abilities will be examined, with the obvious caveat presented by the aircraft's relative immaturity and the secrecy that surrounds a military aviation project.

The open-source pictures of the Sukhoi T-50 prototype prove that the platform is VLO capable. Sukhoi have claimed that the T-50 will have approximately 1/40th of the radar signature of the SU-35S.[18] There is currently uncertainty as to whether the production T-50 will be an all-aspect VLO platform, such as the F-22. The aft and lower central portions of the prototype T-50 fuselage appears not to have been shaped appropriately for true VLO capability. This would result in an enlarged radar signature if the aircraft were to be viewed from the beam or stern, and therefore a longer range at which the aircraft could be detected from those aspects.[19]

The prototype T-50 is currently fitted with interim engines. Therefore, there is still much uncertainty as to how much VLO coverage the production T-50 will have as some aft fuselage re-shaping may occur before the production engines are fitted. It may also be that Sukhoi is minimising the exposure of the platform's potential capability whilst the prototype is in the public eye for exploitation and analysis. There is no doubt that the current aircraft design lends itself to a significant VLO capability when viewed head on.[20]

Agility

It seems possible that the T-50's lack of beam and stern VLO design is as a result of a compromised design philosophy in favour of extreme agility. For example, the inclusion of axi-symmetrical three dimension Thrust Vector Control (TVC) engine nozzles will give the aircraft a more significant beam and rear-aspect radar signature, but a superb manoeuvre capability. In comparison, the F-22A Raptor has only two dimension TVC nozzles because the design team favoured stealth over agility. The design of the T-50's fuselage and control surfaces has led to a consensus that the manoeuvrability of the platform will be second-to-none. This will provide two tactical strengths to the aircraft. Firstly, the T-50 will have the ability to out-manoeuvre almost all adversary platforms in a within visual range (WVR) fight. Secondly, the T-50 is expected by observers to be capable of out-manoeuvring any missiles launched against it.[21]

Engines

It is envisaged that the T-50 will be comfortably-capable of a tactical speed range well over the speed of sound, with enough internal fuel for significant combat persistence. Conventional, mechanically-scanned fighter aircraft radar may only detect the T-50 at very short range, consequently, the platform has the potential to successfully launch its missiles first, undetected by its adversary, or to get close enough for a WVR 'dogfight' with an unaware, less agile opponent. If the T-50 is detected at the sort of ranges expected, it is postulated that no current Western fighter type aircraft, except possibly the F-22 Raptor, will have the ability to out run or outmanoeuvre the T-50 without being engaged.[22]

Avionics

There is speculation that the platform's avionics design will be based upon an evolution of the SU-35S architecture. Initial claims made by the manufacturers are that the aircraft will enjoy five Active Electronically Scanned Array (AESA) radar apertures with a combination of X-band and L-band emitters. Current brochure information suggests that the T-50 will have L band AESA transmitters in the leading edge of the wings, with X-band radar receivers in the nose, cheek and tail of the aircraft, giving the T-50 a 360 degree radar detection capability.[23] Most third and fourth-generation fighter aircraft are only capable of using their radar approximately 60 degrees either side of the nose.

Traditionally, fighter aircraft radars transmit in the X band (8 – 12 GHz) of the electromagnetic spectrum as this is the best trade off between accuracy and signal attenuation in the airborne environment. Consequently, VLO technology is 'shaped' specifically to defeat X-band radar emissions. Although L-band (1-2 GHz) radar emissions lead to some inaccuracies in detection, they do enjoy an increased effectiveness over X-band radar waves in tracking current VLO fuselage shapes. The potential inclusion of L-band radar technology in the Sukhoi platform leads to the inescapable conclusion that the platform is intended to compete in the most demanding theatres of operations against the VLO threats of F-22, F-35 and J-20.

It is also suggested that T-50 will continue the Russian tradition of fielding top-of-the-range Infra Red Search and Track (IRST) technology.[24] It has been argued that IRST represents the future of long-range passive detection of VLO aircraft due to the difficulty both technologically and financially of masking the heat produced by fast-moving fixed wing aircraft. IRST has the obvious drawback of being unable to see through cloud. However, in clear airspace, IRST has proven to be a useful crutch in maintaining awareness on a target which is attempting to deny radar tracking through electronic defences, chaff and manoeuvre, effectively attempting to cover the weak spots in radar-based tracking. Therefore, it can be argued that, in an air-to-air war that is increasingly occurring above the tropopause against targets capable of minimising radar detection, IRST is a useful addition to any avionics suite.

Weapons

It is thought that the aircraft will be capable of carrying eight air-to-air missiles in two internal missile bays, compared to the Joint Strike Fighter load of four internally carried missiles and the F-22's six. It is widely believed that the first aircraft in to service will carry an extended-range version of the AA-12 Adder medium-range active air-to-air missile and an updated AA-11 infra-red missile for visual combat. For extremely close-in combat, the T-50 is expected to be armed with a derivative of the Gsh-30 series 30mm gun currently carried by the SU-35S Flanker. In the air-to-surface role, it has been suggested that the T-50 will be capable of internally carrying a clipped-wing version of the KH-38 anti-armour / ship missile, the KH-58 anti-radiation missile and a Russian version of the GBU-39 small diameter bomb.[25]

It has also been reported that the T-50 will be able to be fitted with eight external fuselage hard points for weapons carriage to allow for extra payload at the expense of RCS, should control of the air allow. It is expected that these hard points will be developed from the SU-35S Flanker design; therefore a similar cocktail of guided air-to-surface weapons is imagined for the T-50 to allow for compatibility in the logistical chain.[26]

On balance, it would appear that the design philosophy for T-50 is that of a highly potent combat aircraft able to operate at high altitude and extremely high speeds with the technology to camouflage itself against opponents until the last possible moment. This is not a platform designed to run away from a fight. Against third and fourth-generation threats the T-50 appears to have an avionics and weapons advantage that will allow it to detect and kill at range with its foe unaware of its presence. Against a VLO threat, such as the F-35 JSF, the tactical employment may well be to deny detection until the last possible moment, achieve first-detect, employ long-range weapons at the first opportunity and use high speed to cover the remaining distance to a WVR manoeuvring fight. The extreme agility of the T-50 is expected to help it to out-manoeuvre any missiles fired against it as well as opposing fighters in the ensuing visual fight.

Military Impact

The Problem

The strategic effect of agile, VLO threats capable of high speed will be immense and constitutes an original problem for the West. The mere presence of enemy VLO platforms in an operational theatre will change the risk level and thus the tactical modus operandi of Western air power.

For example, the defence of High Value Air Assets (HVAA), (force multipliers such as ISR platforms, strategic and tactical transport and air refuelling (AR) aircraft) will be a considerable challenge against a threat which cruises comfortably at well over the speed of sound and can't be detected by radar until much later than a conventional fighter. The head start that a multi-engine transport aircraft will need to out run a fast, VLO platform will be in the order

of hundreds of miles, and the fact that the detection of the threat may not occur until a small fraction of the defensive ranges required, adds considerably to the problem.

Consequently, traditional force multiplier platforms will be forced to operate hundreds of miles from the threat, thus limiting their effectiveness due to a lack of proximity to the battle space. For example, AR platforms will be forced to operate further away from contested airspace, thereby reducing the combat persistence and influence of friendly AR-capable fixed and rotary wing assets in the combat area. In relation to risk levels and task necessity, a VLO air threat might mean that transport aircraft may not fly at will, severely hampering the logistical effort and combat effectiveness of any ground campaign. A further conundrum will be posed in that the Western aircraft with the most advanced on-board detection technology, and therefore best suited to protecting HVAA platforms from a VLO threat, will be the F-22 and F-35. If these fighters are detailed to protect HVAA platforms then there will be fewer of our own VLO aircraft to undertake offensive strike missions on targets located in the dense integrated air defence system (IADS) networks found in many of the world's contested areas.

The Implication

The Sukhoi T-50 and Chengdu J-20 will likely reverse the trend of comfortable kill ratios expected by Western air planners towards parity. Modern fighter aircraft, and the personnel that fly them, are expensive commodities that cannot be produced or replaced overnight. Consequently, nations can ill-afford to absorb high-attrition rates to their pool of fighter aircraft, either financially or in the context of safeguarding a minimum number of platforms purely for the defence of national borders. This is especially so in an age where many countries are reducing the number of fighter jets in their inventories due to national economic problems or reconfiguring their force structures for a higher transport to fighter aircraft ratio for low air threat, counter-insurgency operations. A VLO capable adversary in the theatre of operations will have an enormous impact on the calculation of prospective losses for an airborne military action, not just for fighter aircraft, but for the extremely precious force-multiplier platforms as well. Consequently, lacking possession of a fifth-generation fighter capability will most likely confine a coalition partner nation to the lower-level support tasks of a campaign where an aircraft such as the T-50 is the primary air threat. The inability to field a credible counter to such a threat would therefore likely deny significant political and military influence on the direction of such a campaign and do significant damage to the nation's military reputation.

The Solution

The F-35 JSF promises to be an extremely capable counter to this potential stealth threat. However, Western society has become expectant of a kill ratio considerably more favourable than the parity that some foresee in a JSF versus T-50 fight. Furthermore, conventional Western fighters can expect to come off second best against the sort of capability touted for T-50 and J-20. At a strategic level, where media support, public opinion and simple economics count for so much, one has to question how much political appetite there might be for

involvement in an operational theatre in which an aircraft with the potential of the Sukhoi T-50 constitutes the primary air threat.

Tactical Impact

A high-speed, VLO threat will mean that the speed at which an air force is capable of conducting the F^2T^2EA Kill Chain (Find, Fix, Track, Target, Engage, Assess) will be even more crucial than it is today. Presently, Western air forces enjoy a long-range detection capability on an adversary that allows the luxury of time for the F^2T^2EA chain to occur on favourable terms. This means that friendly fighter aircraft are able to detect air threats, classify them as hostile, employ active weapons and successfully run away from any enemy missile fired in response. The emerging VLO threat will likely change this status quo.

If a high-speed target is not detected until comparatively short range, then the time available to process the Kill Chain is reduced. This will present significant tactical problems to tomorrow's fighter pilots in that detection of the VLO threat will be late and the time to positively identify the threat as hostile and engage will be minimal. There are several implications for this. Firstly, a compressed F^2T^2EA chain will almost certainly result in a higher attrition rate for Western aircraft. Secondly, there may well be an enhanced risk of fratricide as the pressure of survival on aircrew to engage such a capable threat at long range will be greater, leading to the increased likelihood of an itchy trigger finger.

Previously, target detection capability and active radar guided air-to-air missiles have conspired to achieve a high proportion of kills at a range greater than the capability of our opponents' long range missiles. This has largely negated the need for a Western fighter to get close enough to the threat to need to enter a visual manoeuvring fight, where the odds of survival are drastically reduced for the Western pilot. A VLO, high speed threat will achieve short-range detection as well as an ability to close the range from electronic detection to a visual range with an enemy extremely quickly.

Consequently, unless detection methods that overcome stealth technology can be developed, most VLO versus VLO platform engagements will take place at very short range, well within the distance at which it is possible to escape from modern air-to-air missiles. For example, open source documents state that the range at which the Chinese PL12 active air-to-air missile is inescapable is thirty-five kilometres (twenty-two nautical miles). Unclassified sources have also suggested that the AN/APG-81 radar fitted to the F-35 JSF would not detect the T-50 until approximately thirty nautical miles at best.[27, 28] This would allow very little time for the threat to be assessed before an ensuing missile attack on the Western fighter becomes inescapable. For this reason, a far higher number of VLO versus VLO engagements will culminate in a WVR dogfight, with the protagonists following short-range, high-energy missiles to a manoeuvring fight. Each participant will be unable to run away from the fight without surrendering inordinate tactical advantage by being 'shot in the back'. By extrapolation, the survival odds of an unaware third or fourth-generation fighter detected at long range by a stealth threat are slim.

In particular, the T-50's expected agility will likely redefine air-to-air and surface-to-air missile guidance requirements. If the threat platform is able to out-manoeuvre an incoming missile, then the probability of a kill becomes effectively negated as the missile cannot get close enough to physically damage the target. Consequently, missiles that are successful against aircraft like T-50 and J-20 will have to be capable of high speed and considerable close-in agility. The air arms of the United States learnt to their cost the dangers of a reliance upon long-range missile technology over WVR 'dogfighting' skills during the Vietnam war, where the ten to one kill ratio of the Korean War fell to almost one to one as the F4-C Phantom tangled with small, agile MIG aircraft.[29] To avoid re-learning the same lesson in the future, we must make sure that not only is missile technology continually developed, but that our aircrews are capable of dealing with an opponent adept at WVR manoeuvring.

Potential Solutions

The most obvious counter to a stealthy air threat is to procure a platform with superior VLO characteristics, the requisite technology for first detect capability and a weapons system advanced enough to achieve a high probability of kill. For the air arms of the UK, that solution is the F-35 JSF. However, no matter which mathematical formulae is used to calculate the final price tag of the JSF program to the UK taxpayer, there can be no doubt that it will be expensive in financial and political terms; thus the number of platforms procured for use by the RAF and RN may not be of the volume required to conduct simultaneous offensive and defensive operations. This will, most likely, force us to look to like-minded allies to provide additional VLO platforms for future operations against an agile, stealthy air threat. Given that many of our principle European allies, notably France, are not partners in the JSF project and have no tangible VLO platform procurement plans at present, the prospective members of such a coalition are small and geographically diverse.

Additionally, JSF has its critics; most notably in its apparent lack of manoeuvrability, payload and persistence.[30] This suggests that whilst JSF might achieve more than parity with the proposed capability of platforms such as the T-50 and J-20, we might not expect to see a marked superiority in quality. Therefore, it would be prudent to consider other facets of combat air power, such as tactics, additional technology and training, to maximise the chances of overcoming the potential VLO threat. This is especially so as the bulk of British offensive air combat capability for the coming decades will be provided by the fourth-generation, non-VLO Typhoon.

Tactical Solutions

One solution for overcoming the agile, VLO threat would be to overwhelm it through a substantial numerical advantage. On a very simple level, this could be achieved simply by throwing enough third and fourth-generation aircraft, such as Typhoon and Rafale, at the less-proliferated VLO threat to force it to run out of missiles, fuel or situational awareness. If executed correctly, this doesn't necessarily mean a suicide mission for the conventional fighters because they will have the advantage of numbers, although the tactic would still be

classified as high risk. With the limitation that stealth aircraft surrender much of their VLO capability by carrying external weapons, third and fourth-generation aircraft in sufficient numbers might exploit a potential lack of combat persistence. Simply put, if T-50 and J-20 are to operate as a true VLO platform then they are limited to an internally-carried weapons payload. Once the threat platform has run out of missiles, it can no longer employ offensive air power individually, effectively relegating itself to providing situational awareness to other platforms.

Additional Technology

This option might well be unpalatable for most nations due to the possibility of a high level of attrition. A more sensible use of numbers by the UK in detecting stealth threats might be through a tailored Integrated Air Defence System (IADS) with network enabled capability and datalink employment. The T-50's apparent lack of an all-aspect VLO capability may leave it susceptible to detection by any radar (airborne, sea or land-based) that has a view of the aircraft from the beam or tail aspect. Therefore, a positioning of radars around the battlespace to create a 'multi-axis radar pocket' that maximises the chances of at least one networked radar unit constantly able to see the side or rear of the T-50 will optimise the chances of detecting and tracking the aircraft.

The appearance of VLO technology as a threat will mean that research in to an IADS capable of detecting it will have to be financed. As mentioned previously, L band radars have been shown to have a potential in this area despite the inaccuracies inherent for airborne employment. Continued investment in research and development in this area will almost certainly yield increasingly positive results. IRST also represents an avenue of hope in VLO detection as it is difficult and costly to mask IR emissions in a fighter aircraft.

Fitting conventional fighters, such as Typhoon, with an upgraded VLO detection system, based on the data-fusion of off-board networked radars and on-board L-band, X-band, IRST and Electronic Protection Measures (EPM) technology, would negate a large chunk of a VLO threat platform's capability. The full suite may be expensive, but no doubt cheaper than procuring a new aircraft with a similar avionics suite in tandem with the VLO fuselage shaping required to realise a true fifth-generation capability. This option might give the UK an ability to combat the T-50 and J-20 threat without the need to opt for the prohibitively expensive option of fully replacing the Typhoon Force with JSF.

The agility of aircraft such as the T-50 must become the baseline design for future anti-aircraft missile manoeuvrability. Even if the T-50 and J-20 projects do not achieve the manoeuvrability capability expected of them, the possibility exists that highly agile, unmanned aerial vehicles free of the manoeuvring limitations of the human body will almost certainly become a threat within the lifetime of missiles in or about to enter the inventory. The detection problem that the stealth threat presents to Western air forces is considerable enough, but if the threat platform can manoeuvre itself out of the lethal ranges of missiles targeted at it then

the whole tactical concept of shot doctrine and missile kinematic performance will have to be re-defined.

Helmet-mounted missile cuing systems (HMS) will go some way towards overcoming an agility disadvantage in a visual, manoeuvring fight, and it is essential that JSF and Typhoon are fitted with such systems in light of emerging threat capabilities. From the author's personal experience of HMS on the F/A-18, these systems are a useful crutch and can give up to ninety degrees of angular advantage to aircrew in a turning fight. However, HMS does not replace the need for traditional ACM knowledge and proficiency, especially if the opponent is fitted with a similar system, which effectively neutralises the advantage.

In keeping with the potential that multi-axis, networked air and ground units could be used to detect a VLO threat, the use of capable, long-range strategic Surface Based Air Defence (SBAD) and maritime systems may well be essential. SBAD technology has already shown its capability against stealth aircraft, most notably in the Yugoslavian SA-3 shoot down of a USAF F-117 Nighthawk on 27 March 1999 during Operation Allied Force. The battery commander, Colonel Zoltán Dani, suggested subsequently that he detected the platform by modifying the SA-3 radar to operate on unusually long wavelengths that weren't anticipated by NATO forces or the F-117's designers.[31]

SBAD detection techniques have shown much potential against stealth technology. However, the bulk and weight of the equipment required to detect passively has, to date, kept the capability on the surface. Procurement of a long-range VLO detecting SBAD or maritime capability would, however, add an extra layer of defense against the VLO threat platforms of the future. The true advantage of having such a system would be the ability to operate HVAA platforms within the Missile Engagement Zone (MEZ) of a friendly long-range SBAD system with some element of protection against a VLO threat. The ability to detect VLO platforms from multiple directions from the ground or sea may also provide for earlier threat detection, allowing the HVAA to escape or the threat to be engaged. Surface-to-air systems such as the Russian S-400 / SA-21 Growler are said to have anti-stealth capability. If this is the case, then perhaps the UK should consider the procurement of a similar system to provide a protective umbrella for both our force multiplier aircraft and deployed forces, thereby releasing platforms like JSF for offensive operations.

Training

If VLO air combat is to be lethal, high altitude and at close range, then there is a pressing need to reverse the trends of recent years and re-emphasise the importance of training and currency in WVR air combat manoeuvring (ACM). If hostile aircraft become capable of getting very close to allied fighters before being detected, then it follows that we must ensure that the skills of our pilots to fight 'close in' are second to none. Anecdotal evidence suggests that the quantity and quality of ACM training in some Western air forces has decreased in recent years due to a reliance on the technological superiority in detection and corresponding increased kill range.

ACM has lost traction in some training regimes due to the fact that it uses fuel quicker than any other flying discipline and represents a low number of flying hours for a sortie generation rate. Despite a breathtaking improvement in the capability of flight simulators in recent decades, it is still impossible to truly recreate the sight, sound and feel of ACM in any environment other than the air. It may be that the only chance that a Typhoon pilot has to prosper against a T-50 is the use of manoeuvre, guile and electronic protection to survive to a visual merge before he or she can shoot back. Consequently, we must ensure that our pilots can take on and defeat a platform in a visual fight against which they have a considerable agility and detection disadvantage. The best method of achieving this is more emphasis upon ACM training and currency in both training units and front-line squadrons.

Summary

If the Chinese and Russian fifth-generation fighter projects achieve the proliferation and potency expected of them, then they have the potential to change the employment of air power by the West in the future operating environment envisaged within the UK military's Future Force 2020 planning timeline.

Both Russia and China have recently demonstrated a desire for a well-equipped military and an appetite for projecting a forceful foreign policy. If, as seems likely, the Sukhoi T-50 and Chengdu J-20 proliferate amongst our strongest competitors, then these platforms constitute a threat that the UK cannot ignore within its currently stated political policies.

An in-theatre stealth air threat will almost certainly force the UK to pursue any military campaign in tandem with like-minded allies that also possess a fifth-generation fighter capability. Currently, many of our closest European allies are a considerable distance away from possessing a true fifth-generation fighter platform, leaving the potential membership of a VLO fighter-capable coalition small and politically diverse. It may be that due to political and financial constraints, the lack of a fifth-generation capability will bar a nation from admission in to any future military airborne coalition involving a dispute with a T-50 or J-20 equipped state. At the very least, such a capability gap will reduce a nation to the periphery of international influence over contested airspace containing a fifth-generation air threat. Although the F-22 Raptor and F-35 JSF will most likely perform well against the Sukhoi T-50 and Chengdu J-20, for the first time in decades the West's future technological dominance of the air is open to question.

An in-theatre VLO threat will constitute a considerable challenge to any joint commander attempting to concurrently protect friendly strategic joint force concentrations and conduct an offensive joint action campaign. Additionally, the escalation in the potential for friendly losses may skew the balance of risk versus reward for our politicians, thereby limiting the influence that our nation is capable of bringing to bear.

Consequently, if we are to retain our current ability to dominate contested airspace in the shadow of an agile, VLO threat, fielding F-22 and F-35 in the quantities that are

currently expected in to service, whilst an encouraging first step, is the very least that needs to be achieved.

The key to combating the agile, high-speed stealth threat for a JSF-equipped UK will be an effective and efficient VLO aware targeting cycle and kill chain. Firstly, we must be able to detect, fix and track the threat by investing in networked technology such as L-band radar, IRST and SAM systems similar to the S-400 / SA-21 Growler. Additionally, we must reduce the threat of fratricide by optimising the speed in which a VLO aircraft can be classified as either friend or foe to give aircrew and SBAD operators the time to make a consistently correct engagement decision.

To successfully engage the threat, we must ensure that our air-to-air and surface-to-air missiles are agile enough to cope with the adversary's potential manoeuvrability. Equally, in a time of dwindling numbers of fighter aircraft, we have to work out how best to protect our HVAA platforms, whilst allowing them to operate close enough to the battlespace to carry out their tasking effectively within an acceptable level of risk. Specifically, we need to be able to provide a protective, networked IADS umbrella of airborne and surface systems with the ability to detect and engage VLO platforms. Of paramount importance, and much less expense, the combat air squadrons of the RAF and Fleet Air Arm must re-balance day-to-day training to focus more on the importance of WVR ACM expertise and tactics.

Countering the VLO threat has the potential to have a high price tag. Conversely, the opportunity cost of being ejected from, or barred entry to, a theatre of operations due to an inability to deal with an agile, VLO air threat might be catastrophically expensive in both financial and political capital. Therefore, if we are to retain a cutting edge air combat capability, not only must this emerging threat be matched, but we must also have the ability to achieve at least temporary, local air superiority over stealth threat platforms for a given time period of our choosing. However it is achieved, the agile, VLO threat will have to be countered; the ramifications of not doing so could well be disastrous.

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Sukhoi T-50