Submission No 11

Review of the Defence Annual Report 2010 - 2011

Name: Mr Chris Mills

Organisation: REPSIM Pty Ltd

Joint Standing Committee on Foreign Affairs, Defence and Trade

A SUBMISSION TO THE DEFENCE SUB-COMMITTEE OF THE JOINT STANDING COMMITTEE ON FOREIGN AFFAIRS, DEFENCE AND TRADE

ASSESSING THE EVIDENCE PROVIDED BY AVM KYM OSLEY, NEW AIR COMBAT CAPABILITY PROJECT MANAGER

In the following statements, extracted from the Hansard Proof Transcript, AVM Osley has made statements that are inaccurate and/or misleading. REPSIM's response follows.

AVM Osley: *When the classified capabilities are taken into account, we have had Australian pilots flying high-fidelity simulators and they have been very impressed with the combat capabilities of the aircraft.*

Response: have these simulators been accredited and scenarios verified and validated in accordance with the Department's Simulation Policy? Are they academically qualified to assess the veracity and validity of simulations?

AVM Osley: *The stealth is meeting planned requirements.*

Response: Are these 'requirements' sufficient to avoid detection at tactically useful ranges by powerful air-to-air radars like the X-Band IRBIS-E and the L-Band leading edge radar, on the Su-35S or across the spectrum of modern Russian and Chinese Integrated Air Defence Systems which include HF Skywave, VHF AESA radars for which the JSF is not 'stealthed', and high power L-Band acquisition and fire control SAM radars?

AVM Osley: *Air Power Australia and RepSim principals offer a summary of the Pacific Vision exercise conducted in 2008 where they assert that it proves the vulnerability of the F35. The war game in question was not focused on air combat capability analysis at the required classification and level of detail necessary to draw valid conclusions on the relative merits of the F35 in force-on-force applications. The Pacific Vision 2008 exercise was not intended to test air-to-air capabilities and the analysis done by Air Power Australia and RepSim at the time was not accepted as valid by either Rand, the USAF or the RAAF.*

Response: AVM Osley has confused the activities at Pacific Vision 2008 – RESPIM was referring to its support of a RAND presentation that was made to Senior Officers attending the event. Mr Michael Price, Managing Director of REPSIM Pty Ltd will correct the record in a separate submission. RAND did accept the result of the simulations and used them in their presentation 'Air Combat, Past Present and Future'. The Analyst, Dr John Stillion, a former USAF Officer, subsequently presented the material in several locations in the USA to senior officers of the USAF, and personally reported to me that the veracity of the work was not challenged during these presentations, but caused some dismay.

AVM Osley: *To make a valid assessment of F35 versus opposing aircraft you need access to the classified capabilities of the aeroplane itself. Also, the structure of the scenario needs to be a realistic one.*

Response: This is a logical fallacy that if a simulation does not include classified information, it is ipso-facto wrong. This point was addressed on 7 Feb 2012 by Mr Price's evidence to the Committee. REPSIM unclassified simulations do include capabilities of the JSF that may be classified – Directed Energy Weapons for example. His comment regarding realistic scenarios is agreed, but as in the case of the RAND simulations, did the scenarios include Chinese HF Skywave radar (like Australia's JORN) capable of detecting the JSF and directing fighters (like the Su-35S the Chinese are seeking from Russia) to an intercept?

AVM Osley: *If you wanted to assess the effectiveness of an F35 versus other air combat capabilities then you would need to have a scenario that enabled you to take into account* *all the support aircraft and other capabilities that would be in the area. You would need to take into account the transfer of information using data-links, the situational awareness that you would have and the tactics that you would use in flying those aeroplanes. The tactics for using a fifth generation fighter are significantly different from the tactics used for a fourth generation fighter. Also, you would need to take into account detailed analysis of weapons and other things, including electronic attack.*

Response: REPSIM's simulations include all these elements and many more, including all-aspect radar cross section and infrared signature modelling not mentioned by the AVM, but essential to a realistic representation of 'Low Observable' aircraft. Data on the H3MilSim capabilities and assumptions has been provided to the Committee in a Response to Senator Johnston's question on the subject.

AVM Osley: *Regrettably, I cannot go into the detail of exactly the types of threats we had—they were top-end, high-end threats—and exactly how we structured that. I will take on notice to see what we can share at the unclassified level.*

Response: There is no requirement to classify the type of threat aircraft – these are the types that are relevant to future air combat versus the JSF: Su-30MK series, Su-35S, PAK-FA / T-50, MiG-29K, J-10B, J-11B, J-20, Rafale, Gripen-E/F, Typhoon, F-16 and F-15E exports. Is the reason for the classification to hide that the threat aircraft is NOT one of these types, and so it 'easy meat' for the JSF? If not, what is the reason for the classification of aircraft types well known to air combat analysts.

Dr Jensen: *Have you done any simulations, using adversary HF over-the-horizon radar equipped naval surface vessels as a component of IADS? Have you done any simulations using current generation passive detection systems, incorporated as additional constructive elements of an adversary IADS against the F35 scenarios?*

AVM Osley: *I will take the detailed questions there on the sensors on notice.*

Response: The JSF 'Survivability' relies 'you can't detect me, so you can't kill me'. Sensors as mentioned by Dr Jensen have the capability to detect, track and guide an intercept to the JSF, where-after its inferior aerodynamic performance leads to its destruction in air combat.

AVM Osley: *For instance, the situational awareness is linked to the capacity of the software. It has roughly three times the software of the F22. That gives you an indication of its capability. It has a data-link capability that is exceptional for talking to not only other F35s but the rest of the system out there.*

Response: The claim that the size of the software determines the situational awareness capability is a logical fallacy. Sensor performance is the key and the F-22A has a more powerful radar than the JSF. The the F-22A employs only secure, highly directional Intra-Flight Data Link for F-22A to F-22A communications. The project to provide a secure data-link to an aircraft outside the battle zone so the JSF can be securely networked with off-board sensors has been cancelled, so it must reply on the detectable Link 16 data-link. Any aircraft that transmits on a data-link that is detectable is subject to detection and is a weakness of the JSF design where it has to be data-linked with (say) AEW&C aircraft to be fully effective. If the JSF communicates '*with the rest of the system out there*' using Link 16, it will be detected and attacked.

AVM Osley: *If you have the right weapons on board, and they will need to be upgraded, if you have good training, good tactics and good supporting capabilities, the F35 will prevail.*

Response: They will certainly need to be upgraded. Since the JSF's only Beyond Visual Range missile is the AIM-120 it becomes, to quote RAND's Dr Stillion, 'a single point of failure'. As noted by Dr Jensen, the AIM-120's combat record is a Probability-of-Kill of less than 50%, and enemy countermeasures have improved vastly since this record was compiled. The question is 'with what' as the US does not have a new missile type in development, while the Russians and Chinese, already fielding competent missiles with a variety of seekers, have active missile development programs.

Dr Jensen: *What about the passive systems for detecting stealthy aircraft?*

Air Vice Marshal Osley: *Again, I would probably have to take that on notice. The point I would like to make in general at the unclassified level is that there is a vast difference between detecting the presence of a very low-observable aircraft and being able to track it or to pass that information.*

Response: The JSFs F135 jet engine has the hottest exhaust in air combat history. The Su-35s OLS-35 Infrared Scan and Track (IRST) is tuned to an infrared window in the atmosphere that freely transmits the emissions from jet exhausts as well as the heat being radiated from the airframe. Russia has decades of experience in this technology and fields it on all their fighters. Such detectors will find the JSF at ranges beyond 40 nautical miles. These detections are shared and triangulated over data-links to pinpoint the source. This tracking technology has been fielded for years, e.g. by Sweden. The OLS-35 includes a laser rangefinder with a range of 20 Km for aircraft target-ranging in single aircraft operations. Within a decade they are likely to field two-colour Quantum-Well Infrared Photomultipliers (QWIPs) which will further increase the background clutter, increasing range. Germany has been producing QWIP FLIR equipment for about a decade.

Dr Jensen: *The doors close but the AMRAAM itself is not a designed stealth missile, in addition to which the rocket motor is putting out an awful lot of infrared. Particularly the Russian Su35s and so on have very good infrared detectors, so they would still know where you are. Aren't they likely to shoot a couple of missiles your way, probably a combination infrared-radar homing missile or two missiles, one infrared homing and one radar?*

Air Vice Marshal Osley: *They could fire that. The risk we have here is that, again, we are now firmly approaching classified territory with regard to the exact capabilities of the F35 in that scenario. You are talking about weapons. You are talking about ability, signature and all those things, which I cannot talk about.*

Response: There is nothing secret about the way missile finds and kill a target, especially the Russian and Chinese missiles that have a Beyond Visual Range Infrared seekers. Tactical doctrine is included in the Russian flight manuals, and incudes firing a missiles with and active radar seeker first, then an infrared seeker missile a few seconds later. REPSIM replicates this tactic in its simulations. The AVM may be making claims that Directed Energy Weapons will destroy the missiles inbound. This subject is covered later in this submission.

Air Vice Marshal Osley: *No. As I have indicated, I do not recognise the percentages you are talking about and I certainly cannot talk about actual PKs for missiles.*

Response: The Beyond-Visual Range AIM-120 kills were part of the 'Air Combat Past Present and Future' Pacific Vision 2008 presentation given to Senior Officers and the slide from the RAND presentation is included later in this submission. The Pk (Probability-of-Kill) from past operational experience is now 'open source' and RAND calculates it to be 46%. The AIM-120D is expected to deliver better results, but has not been fielded because of technical difficulties. In an Aviation Week article 'Testing Times' dated 23 February 2009 describes the difficulty of getting representative targets to test capabilities found in threat aircraft like the Su-35S. REPSIM's simulations recognise the improvements of the AIM-120D and can be considered 'reasonable and representative' at this time. Typically Pks of below 0.2 are demonstrated against the Su-35S employing its full set of countermeasures.

AVM Osley: *The second thing that came up was jitter. Because the seat moves when you are pulling a lot of G, the helmet display is not compensated for, so you get some jitter, and it makes it hard to read at high angles of attack when you are pulling G.*

Response: The JSF has yet to be flown in in areas of very high angle of attack and at high G, but the data that has been collected approaching this combat-common segment of the flight envelope indicates severe airframe buffet which may overstress such corrective feedback systems. Resolving 'buffet' issues is an extraordinarily difficult engineering task.

AVM Osley: *The design criteria of the F35 provided that it would have representative performance similar to the advanced legacy aeroplanes. When you get down to this level you need to make sure you are comparing apples with apples. For instance, with some of those figures, if you say that you want 50 per cent of remaining fuel in the aircraft, the F16 normally flies with tanks. With some of the acceleration numbers they have used a clean aeroplane with half fuel. If you had a clean F16 with half fuel, all it is going to do is accelerate, declare an emergency and land with minimum fuel, because it has almost no fuel. The F35 carries a lot of fuel internally and so 50 per cent fuel is actually more than the total internal fuel of an F16. I will not compare every part of the envelope, but the indications are that the F35 is of very comparable acceleration and performance to an F18 in a combat configuration. In a combat configuration, no F18 and no F16 goes into combat without some form of external tank.*

Response: AVM Osley completely misconstrues the operational use of 'drop-tanks' which in air combat are routinely dropped on contact with the enemy. The F-16 has substantially superior performance to the F/A-18 'Super' Hornet, which in turn is inferior in performance to the 'Classic' Hornets. As fuel from drop-tanks is used first, a legacy aircraft may enter an air combat engagement with a higher fuel fraction than the JSF, giving it more 'afterburner' time. The only reasonable '*apples with apples*' comparison is a 'clean' legacy aircraft with the JSF, which Lockheed Martin's own charts show is inferior in performance. The comments about the limited performance of 'clean' aircraft are wrong and the subject is covered later in this submission.

Dr Jensen: *Okay. Can you tell me why Super Hornets in the United States are not allowed to operate with radar on in close vicinity to the Joint Strike Fighter?*

Air Vice Marshall Osley: *I have not heard that, so I would have to take that on notice.*

Response: This is an important issue that goes to the heart of the detectability of the JSF by modern, powerful air-to-air radars as fielded in the Su-35S. As a '*caveat emptor*' measure Australia should insist on observing a production JSF with the excellent APG-79 radar of the F/A-18F – very similar in detection capability to the Su-35S IRBIS-E, to 'see what it can see'. If the APG-79 detects the JSF at tactically ranges, so will the IRBIS-E.

AVM Osley: *Actually, within visual range the issue is not how it performs against a Su-35, it is how it performs against a modern generation missile. Essentially, within visual range—and I do not want to go into too much detail—means that you are within a mile or two and you actually are able to see the other airplane. You basically have gone to a merge. If you go to the merge, and if you each have a helmet mounted sight and you have a highly-agile missile then chances are you are both within range of not escaping if they find the missile. So there is a very high likelihood that both of you will die.*

Response: The JSF will be very unlikely to surrender two AIM-120 missiles for two AIM-9X missiles which will be deployed in a close-in fight that the JSF cannot win against (say) the Su-35S. The more likely scenario is that it will be attempting to escape at Mach 1.6 against a Mach 2+ aircraft, and be engaged from the rear first with Beyond Visual Range and then Within Visual Range Missiles. Even if the JSF is carrying the AIM-9X, the Su-35S shooting a longer range R-73 or R-74 will have a 'first-lock, first-kill' advantage.

AVM Osley: *The F35 will play to its strengths using low observability and using better situational awareness. Its aim would be not to get within visual range. It does not need to be within visual range because of the sensors it has on board. I mentioned before that it has perhaps three times the software and therefore the discrimination of other modern aircraft. Its strength is its ability to recognise and identify an enemy aircraft at beyond visual range well ahead of the other aircraft … And so the strength of the joint strike fighter—and I use this as an example—is that it has the ability to have up to 650 parameters by which it will identify a potential threat out there.*

Response: And those strengths versus advanced air combat fighters are? The JSF may have to operate against non-transmitting aircraft receiving satellite communication of detections from HF Skywave Radar, employing telescopic IRST detectors that have much longer detection range than the JSF's staring EO-DAS sensors. Modern Sukhois have advanced electronic warfare systems, and if the JSF transmits to collect data, it will have a high probability of being detected and intercepted. Given its inferior aerodynamic performance, the JSF may not have the luxury of avoiding WVR engagements.

AVM Osley: *I am talking about a situation where we have man-sims where I have fighter combat instructors and people who fly the F18s, several of whom have flown in combat, and, admittedly air to ground in the Iraq war, but these people are experienced. We have USAF people who are manning it up on the other side and I think we have come up with scenarios that challenge the F35, and the F35 prevails. The nearest thing that we can get to combat is manned-sims versus man-sims with the level of detail that the—*

Response: The last RAAF air-to-air kill was in the Korean War. Unless independently accredited, validated and verified, air combat simulations can be (and have been) used negligently or wilfully to produce a biased result.

The complication for AVM Osley in adopting the stance that REPSIM's simulations are flawed is that Director Michael Price and Wing Commander Chris Mills worked for him during his tenure as AIRCDRE Osley, Director General of Capability Plans in the Capability Development Division of the ADO. The work we did at that time was nearly identical to the services we provide as the Principals of REPSIM Pty Ltd, and was highly commended by AIRCDRE Osley. Mr Price received a Commander's Commendation for this work from General Hurley, now Chief of the Defence Force.

The results of these simulations which included the JSF were used to justify hundreds of millions of dollars of expenditure on Explosive Ordnance. There was no suggestion at the time that the results were unusable because they were based on open-source data and they were cross-checked with highly classified simulations as part of the verification and validation process. In scientific terms, this is known as A-B replication. Since then, the Harpoon 3 Professional has been considerably improved, especially in the areas of modelling signatures and assessing the effects of battle damage. More advanced aircraft are represented such as the F/A-18E/F Super Hornet and the Su-35S, and there is more open source data on the JSF, improving the fidelity and veracity of the simulation results.

AVM Osley cannot 'have it both ways' and praise our past work, then denigrate our present work when it presents an 'inconvenient truth'.

EXECUTIVE SUMMARY

The testimony presented to the Committee by AVM Osley on 16 March 2012 contains many errors of fact; this submission seeks to correct some of these errors.

The JSF was designed to be equivalent to legacy aircraft in aerodynamic performance, relying on signature management or 'stealth' to provide effective air combat performance. Flight tests are demonstrating that the JSF is failing to meet the performance of the legacy aircraft it is replacing. AVM Osley presented the argument that the performance of legacy aircraft should be assessed with drop-tanks carried; in doing so, he demonstrated a lack of domain knowledge of air combat fighter operations. Drop-tanks are routinely 'dropped' when entering air combat. Thus, the only true comparison is a 'clean' legacy aircraft with the JSF, which cannot jettison the 'thick' structure, necessary to carry fuel internally.

Simulation of aircraft performance was discussed. AVM Osley advised that 'Pilot-in-the-Loop' simulation was being employed. Historically, such simulations have been misused to generate marketing material not representative of the 'real world'. The USAF and Lockheed Martin, in an Aviation Week article, 'Raptor's Edge', revealed that the JSF, designed to a year 2000 specification, which has not been updated and no longer represents the world of future air combat, was only able to generate a 3:1 Loss Exchange Rate (LER) against obsolete aircraft that will be decades out of date when the JSF begins operations.

REPSIM's simulation of future air combat, using the same, but updated simulation software as the Australian Defence Organisation (ADO) and the same analysts previously used by the ADO for this task shows a diminution of LERS as potential adversaries field more advanced aircraft like the Russian Sukhoi Su-30 series, the Su-35S. The low-observable PAK-FA / T-50 stealth fighter and the Chinese J-20 stealth fighter will accelerate this diminution.

REPSIM advises the Committee that simulations can only be relied on if they are accredited, and all scenarios verified and validated as per ADO policy. AVM Osley declined to comment on the nature of the simulations being employed to evaluate the air combat performance of the JSF, claiming they are 'classified'. REPSIM notes that security classification can be used to hide simulation biases, introduced either wilfully or negligently. Examples of bias are misrepresentation of weapons systems performance by overstating the capabilities of the JSF's system an understating those of potential adversaries, and matching the JSF against obsolete aircraft as was described in the Raptor's Edge' article. Without independent review, no 'classified' simulation can be trusted, especially when the results are presented by an enterprise or taxpayer-funded organisation with a vested interest in marketing the JSF.

The behaviour of the Australian Defence Organisation over many years appears to be more of a marketing Agency for the JSF than one conducting a diligent '*caveat emptor*' assessment of the air combat capabilities of the aircraft against the known competitors it will meet in future air combat. Defence's acquisition posture of accepting supplier's claims until disproven is risky, and it should be changed to the proper and safe acquisition posture that claims will be considered not-proven until proven by physical trial.

Simulation should be employed to assess risk of a program failure such as adverse Loss Exchange Rates so that in the long period between design and demonstrated operational capability, risk can be mitigated if the simulations demonstrate unacceptable performance.

INTRODUCTION

I watched the testimony presented by AVM Osley on 16 March 2010 via the Internet. The purpose of this submission is to correct matters-of-fact relating to future air combat, and the use of simulation technology to estimate the combat-effectiveness, not only of the Joint Strike Fighter, but of its principal adversaries.

In making this submission the Committee should know that AVM Osley is a highly respected and very competent Strike-Navigator with extensive experience on the F-111 flying bombing sorties. He is not a Fighter-Pilot and clearly lacks essential knowledge of the complexities of future air combat. His answers and statements prima-facie mislead Parliament, most probably inadvertently because of a lack of specific domain knowledge. This submission corrects some of those misleading statements.

COMPARING THE PERFORMANCE OF THE JOINT STRIKE FIGTHER WITH 'LEGACY' AIRCRAFT

The Joint Operation Requirement Document (JORD) specifies that the JSF must have 'F-16 Like' and 'F-18 Like' aerodynamic performance. This requirement is problematic. The F/A-18's predecessor, the YF-17, was the loser to the F-16 in the USAF's Lightweight Fighter Competition, and an F-18 is substantially inferior in performance to an F-16; thus the JSF legacy criterion can satisfy comparable performance with one type, but not both.

http://en.wikipedia.org/wiki/Lightweight_Fighter_program

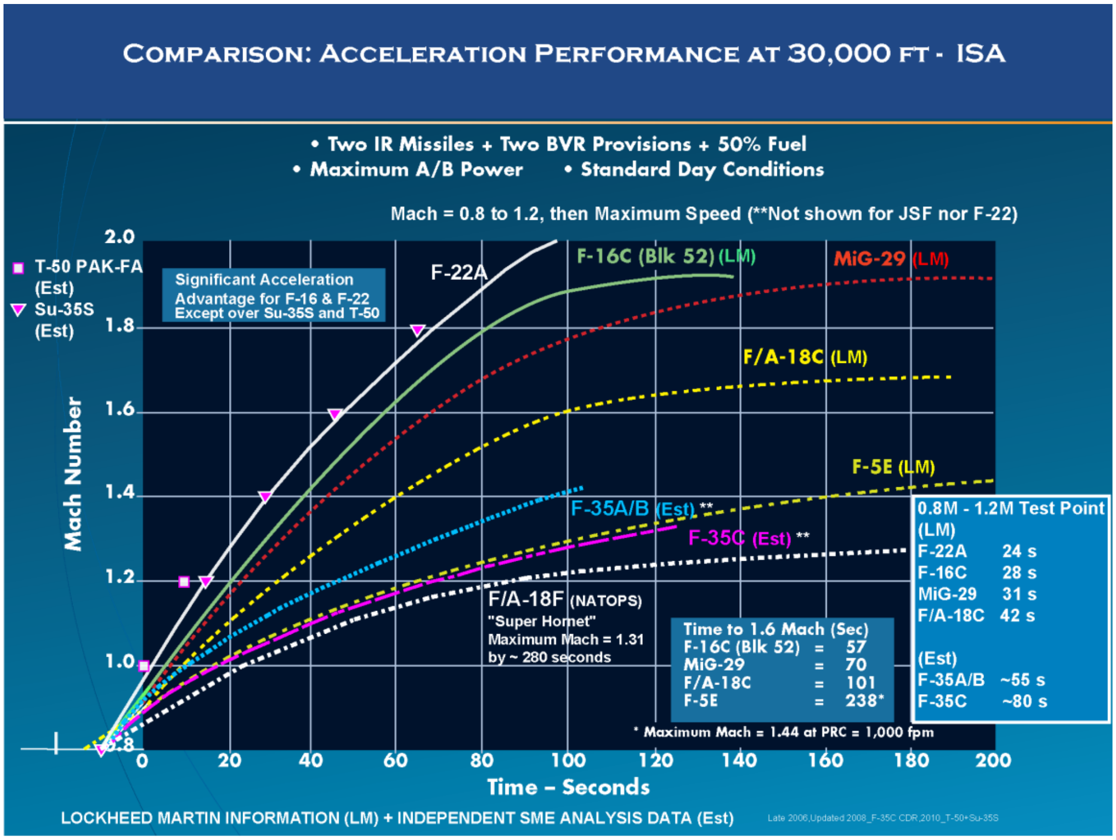
AVM Osley seems to have fundamentally misconstrued the operational use of external fuel tanks. Pilots generally call these 'drop-tanks' because they are attached to the main aircraft structure with an explosive bolt and can be jettisoned at the pilot's command by a press of a button.

Drop-tanks impose severe operational constraints as noted by AVM Osley. They limit maximum speed, add weight to the aircraft making it less agile, impose drag while ever they are attached to the aircraft and greatly increase the radar signature. In an emergency or when entering air combat against other comparable Fighters, a pilot can choose to jettison the drop-tanks with a press of a button; they instantly separate cleanly from the aircraft, whether full, empty or with an intermediate fuel load.

Air Combat is rarely entered close to home base, but when the threat is that close, the aircraft are configured without drop-tanks, so they can 'scramble' and intercept the enemy in the shortest time and provide the maximum air combat performance. Sorties times are short as noted by AVM Osley, mostly through extensive use of afterburner. More commonly, the drop tanks are empty before a Fighter enters distant air combat, as the aircraft feeds the fuel from the drop-tanks first so as to be instantly ready for air combat by jettisoning empty drop-tanks, but retaining a high percentage of internal fuel for combat use of the afterburner to increase thrust. However, as the fuel tanks are expensive, they are only jettisoned when it is necessary to give a Fighter aircraft a 'combat edge'.

After the drop-tanks are jettisoned, the Fighter regains a 'clean' airframe performance, substantially better than with external tanks attached. By contrast, the JSF has a 'thick', high-drag airframe and wing to accommodate its fuel load internally and maintain some semblance of low-observability (see below). The stark contrast is that the pilot of a legacy aircraft like the F-16 can (and will) jettison drop-tanks to improve air combat performance, while the JSF pilot cannot press a button and jettison its thick wing and fuselage.

The inexorable logic is that the only relevant air combat comparison between (say) an F-16 and a JSF is with both aircraft in 'combat configuration'. Typically, this is 50% internal fuel, the F-16 'clean' (no drop-tanks) and the JSF also 'clean' of eternal stores. AVM Osley claimed that the legacy aircraft should be compared with external drop-tanks fitted. Clearly, this is 'unreasonable and unrepresentative': they should not.



Graphs from Lockheed Martin, Estimates from Peter Goon, Air Power Australia

Lockheed Martin's own documents show that a 'clean' Lockheed-Martin F-16 has substantially superior aerodynamic performance to the estimated performance of the Lockheed Martin JSF. Thus, the F-35 is failing to meet one of its primary design specifications of performance equivalent to Legacy Fighters. AVM Osley's insistence on lumbering an F-16 with drop-tanks is a futile attempt to 'explain away' the substantial difference in acceleration performance shown in the graphs above. For the Fighter Pilot fraternity, it is a sad day when we see a new Fighter with performance substantially inferior to Fighter aircraft developed during the 1970s, and produced in the 1980s.

AVM Osley also suggested that legacy aircraft without external tanks are confined close to home-base. This is simply incorrect and this can be proven by reference to flight manuals which provide the detail on cruise performance or through operational experience.

As a junior Fighter Pilot in No 76 (Mirage) Squadron, I was appointed to be the Navigation Officer because of my knowledge of aircraft performance gained during a tour in 34 (VIP) Squadron. I developed a detailed database of specific range (air nautical miles per gallon of fuel) for the Mirage in all of its combat configurations.

We would deploy to Northern Bases like Townsville to practice our combat skills and to get there with adequate fuel reserves in bad weather, the Mirage would generally be configured with 2 * 286 gallon drop-tanks for a total of 572 gallons of external fuel. My recollection is that we would generally land with about 160 gallons of fuel remaining.

On one deployment, one of these drop-tanks self-detached from a Mirage, with the aircraft subsequently being safely recovered in an asymmetric configuration. The engineers planned to have a spare tank flow from Williamtown to Townsville – an expensive exercise. I offered to fly the Mirage from Townsville to Williamtown 'clean' (no drop-tanks) – a distance of 855 nautical miles.

My Pilot and Engineer colleagues did not believe this could be done, but applying my knowledge of Specific Range, and techniques such as 'optimum cruise-climb and descent', I flew a 'clean' Mirage from Townsville to Williamtown and landed with 110 gallons. The difference in this case of 'drop-tanks' and 'no-drop-tanks' was about 50 gallons. Thus we carried 572 gallons of fuel to produce an end-of-flight reserve of an additional 50 gallons. Put another way, 91% of the drop-tank fuel was burnt to offset drop-tank drag.

The JSF, already a 'thick' high-drag airframe, will not benefit significantly from carrying fuel in external tanks. This characteristic seems to have been recognised by the JSF Project Office, as the external fuel tanks have been removed from the SDD programme. What it also means is that the JSF's range cannot be substantially extended with external tanks, unless they are dropped immediately they become empty – an expensive option and a danger to habitation below.

PILOT-IN-THE-LOOP SIMULATIONS: EASILY PERVERTED TO MARKETING MATERIAL

AVM Osley advised the Committee that 'Pilot-in-the-Loop' simulations are being used to evaluate the combat performance of the JSF.

Great care should be taken with the credibility of claims arising from this type of simulation. I am reliably informed by a colleague, a retired Royal Air Force Air Marshal, Knight of the Realm and with decorations awarded for flying operations, that the UK Defence Evaluation and Research Agency (DERA) Pilot-in-the-Loop simulator JOUST was (mis)used to market the Eurofighter (EFA, now the Typhoon).

Here is how it was done. The EFA would be pitched against Su-27SK Flankers, already obsolete at this time because of the development of the improved Sukhoi Su-30M series. This is the first level of 'perversion': pitching our current or future Fighters against obsolete enemy Fighters. As the simulation proceeded, the EFAs would gain more initial kills than the Su-27s, but having fewer weapons and less fuel, would be forced to disengage and return to Base. The Su-27s would follow and close to missile range. At this time, but before the Su-27s were able to fire their missiles, the Simulation Director would call a halt to the simulation.

The result was that the EFA had a 'superior' Loss-Exchange-Rate than the Su-27s. However, had the simulator been flown for another few minutes and the Loss-Exchange-Rate number would be reversed and the Sukhois would have been correctly assessed as superior.

Dr Carlo Kopp of Air Power Australia, discusses the unrealistic evaluation of the EFA in this 2000 article:

http://www.ausairpower.net/Analysis-Typhoon.html

I have another Fighter Pilot colleague, recently retired from the Danish Air Force who corroborates this abuse of simulation technology. On an official evaluation, they were invited by Lockheed Martin to fly Pilot-in-the-Loop simulators of the JSF versus threat aircraft. When they asked to fly against modern Russian aircraft, they were refused. This refusal creates a serious credibility problem – if the JSF is as superior in future air combat as is being marketed (and advised to the Australian Parliament,) then a simulation of (say) JSF versus Su-35S showing the Su-35S being convincingly defeated would surely enhance the credibility of the JSF as 'fit for purpose'. The converse is also true.

If the Committee wishes to corroborate these reports, I can provide names and contact details in confidence.

'RAPTOR'S EDGE' – A REVEALING DISCLOSURE

Lockheed Martin and the USAF did use this 'obsolete aircraft' marketing ploy when attempting to stop the termination of the F-22A Raptor Program, with disclosures about simulation results revealed in a 9 February 2009 Aviation Week article 'Raptor's Edge' which states, inter-alia:

> The operational arguments focus on combat effectiveness against top foreign fighter aircraft such as the Russian Su-27 and MiG-29. Lockheed Martin and USAF analysts put the loss-exchange ratio at 30-1 for the F-22, 3-1 for the F-35 and 1-1 or less for the F-15, F/A-18 and F-16.

A copy of the 'Raptor's Edge' article is attached at the end of this document.

Where this revelation backfires on the JSF marketing program is its dismal performance of a Loss-Exchange-Rate of **ONLY** 3-1 for the F-35. Both the MiG-29 and the Su-27 are obsolete aircraft. Sukhoi next developed the Su-30MK series with greatly enhanced air combat performance. The following generation of Sukhoi air combat aircraft is the Su-35S, now attaining operational status with the Russian Air Force. China has requested the purchase of 48 Su-35S - see the attachments at the end of the submission.

Next comes the 'F-22A Raptor Killer' Sukhoi PAK-FA / T-50:

PAK-FA / T-50 Flying at the 2011 Moscow Air Show

The PAK-FA has been designed from the outset to be an F-22A 'killer'. Given the reported difference in air combat performance between the F-22A (30-1) and the F-35 (3-1) against obsolete aircraft like the Su-27, if the JSF cannot defeat the Su-35S then logically it will be annihilated by the PAK-FA.

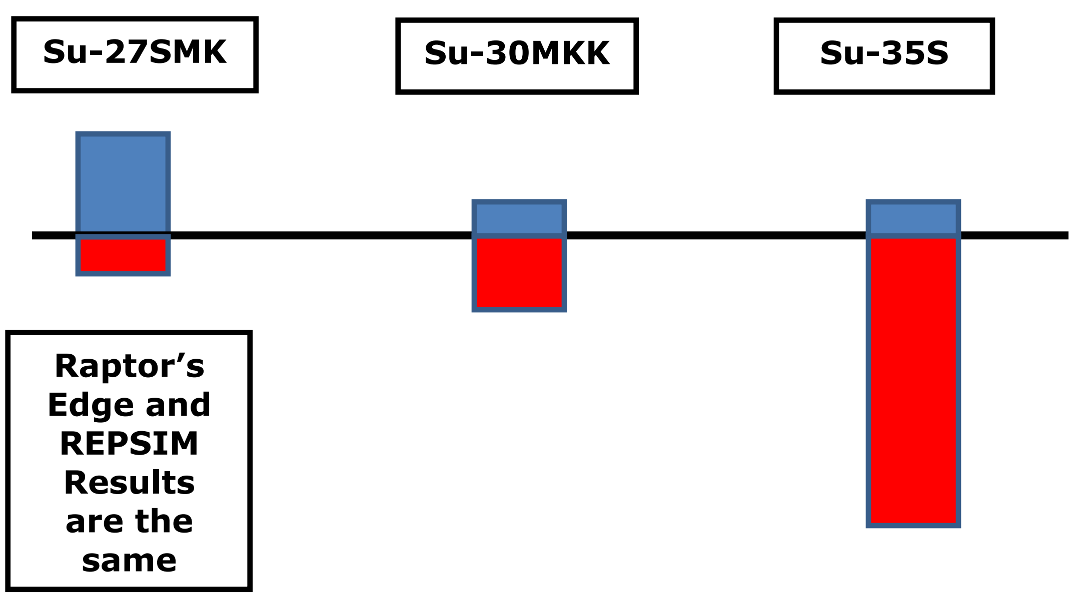
My REPSIM Colleagues and I set out to evaluate the performance of the F-35A using the simulation tool H3MilSim – a more advanced version of the simulation tool previously used by us as members of the Department of Defence for this purpose.

We initially created a simulation of the F-35A versus the Russian Su-27SK to replicate the 'Raptor's Edge' disclosures. The computed Loss-Exchange-Rates were 2.7 Su-27SKs killed for each F-35A killed. This result is remarkably close to the Lockheed-Martin / USAF quoted Loss-Exchange-Rate of 3-1 and 'calibrates' our open-source model against the results reported for the Lockheed Martin / USAF simulations.

Next, we evaluated the Loss-Exchange-Rates for the Su-35S versus the F-22A, the F-35A, and the F/A-18F. In response to a question from Senator David Johnston regarding the REPSIM simulations, my colleague Mr Michael Price has submitted additional material as a PowerPoint presentation. This work extends the evaluation of future air combat from the obsolete Su-27 as the threat to the Su-35S, now entering service with the Russian Air Force. As logically expected, the Su-35S, two generations of Sukhoi aircraft superior to the Su-27, greatly diminished the tactical advantage of the US aircraft. While the F-22A reduces from Air Dominance to Air Superiority, the F-35A declines from Air Superiority to Air Inferiority. This diminution of US air dominance in the reality of adversaries with evolving capabilities, in comparison with the static, 2000 fixed JORD capability of the JSF, should not come as a surprise to professional air combat analysts.

This exercise was repeated (and re-run completely on 28 March 2012, but with Chinese Sukhois and the latest version of H3MilSim) using the RAND Pacific Vision 2008 Activity Presentation Scenario to show the diminution of F-35 Loss-Exchange-Rate as the capability of potential adversaries increases and sensor suites such as HF Skywave Radars are active:

Time-Diminution of F-35A Loss-Exchange-Rates Versus:



F-35A Losses

The F-35A vs Su-35S runs on 28 March 2012 were with a more current and capable missile set than the Pacific Vision 2008 exercise and the result can only be described as 'grave'. The LER was 7.4 F-35A losses for each Su-35S killed. This LER masks the fact that the F-35As were annihilated. Of the 240 JSFs that were sent into battle, only two (2) returned.

The reason is remarkably simple. The missile countermeasures on the Su-35S are effective, and the AIM-120Ds become 'the single point of failure', achieving a Pk of 14.6% - a 'reasonable and representative' result given the operational Pk shown by RAND below to be 46% against obsolete, non-manoeuvring and un-alerted targets. Once the F-35As fire their four AIM-120Ds, they have no choice but to turn and run, but are trapped in engagement range of the Sukhois by their aerodynamic inferiority. The Sukhois run the JSFs down and kill them all in a 'cascading' effect where, as the ratio of killers to prey increases, the kill rate rises. Once the JSFs are killed, any surviving AWACs and AAR Tankers are destroyed.

The Pk of the Sukhoi's missiles is more difficult to establish, as several types are carried and different seeker heads employed and many of the kills were from cannon attack. As an approximation, the Pk was about 15%, so there were no 'super weapons' present. This places the Russian missiles as somewhat inferior to the AIM-120D, as the JSF lacks defensive measures like towed decoys, and does not have the agility of the Sukhoi that allows the aircraft to out-turn some missiles.

The loss rates for the different aircraft types represented in the RAND Pacific Vision 2008 Activity Presentation Scenario computer by the REPSIM simulation are:

Overall Loss Exchange Ratios (LER)

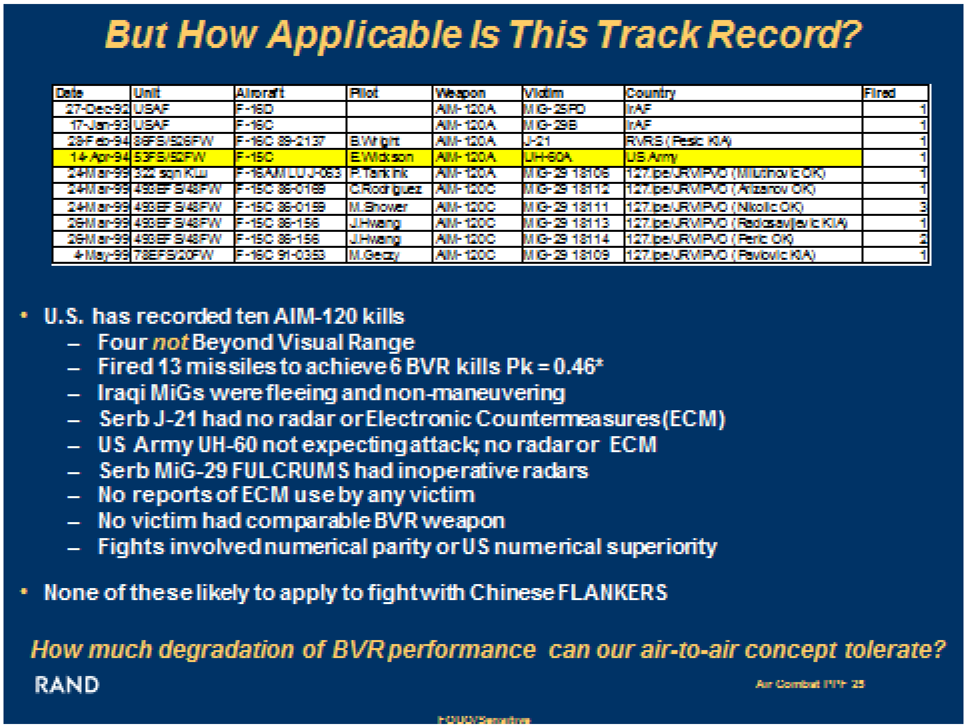
How many aircraft you lose compared to the enemy

F-22 v Su-35	F-35A v Su-35	F/A-18F v Su-35
1 to 2.1	2.4 to 1	8.0 to 1
Not bad at all	Depressing	Devastating
E3-F & KC-10A	E3-F & KC-10A	E3-F & KC-10A
Losses	Losses	Losses
2.0 & 3.6	2.0 & 4.2	2.0 & 6.0

H3MilSim results from the RAND Pacific Vision 2008 Scenarios
(Note: REPSIM Shows LERs as Aircraft Lost, Normalised on one side)

MISSILE KILL PROBABILITIES

Dr Jensen pursued the issue of the kill probability of the AIM-120, and he was entirely correct in doing so. This is one of the slides from the RAND Pacific Vision 2008 Activity presentation:



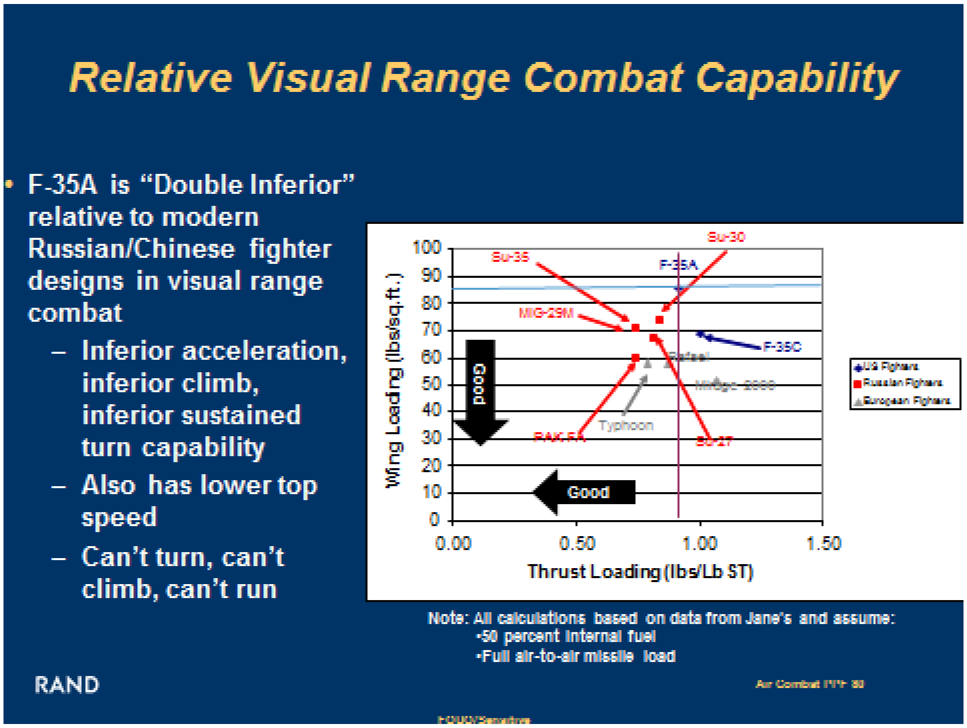
Note that the overall performance of the AIM-120 is a Probability of Kill of less than 50% as stated by Dr Jensen. Also note that the targets were fleeing, non-manoeuvring and lacked radar warning systems to alert them of the presence of opposing Fighters and incoming missiles. One 'kill' was a US Army Blackhawk helicopter.

In air combat, the Su-35S will fly about two miles higher than the F-35A and has the agility to outfly missiles in the end-game. The Sukhoi has an extensive suite of missile countermeasures which will substantially reduce the AIM-120D Probability of a Kill on a Su-35S. I will not detail these countermeasures, as a full analysis is available here:

http://www.ausairpower.net/APA-NOTAM-05072010-1.html

I did travel to Canberra in November 2011 discuss these matters with AVM Osley, and I specifically asked him, in the presence of a staff Fighter Combat Instructor, specifically 'how' the F-35A would defeat the Su-35S. They declined to answer. Drawing on my air combat experience and observation of many H3MilSim runs, I said: "The engagements will take place something like this. The F-35As will load four AIM-120Ds as they cannot win a WVR fight and must avoid it so they will not displace two AIM-120Ds with two AIM-9Xs. The F-35As and the Su-35Ss will exchange missiles BVR, but because of the excellent missile countermeasures of the Su-35S, most will miss – I estimate the AIM-120D Pk to be less than 0.2. As a result, the F-35As will have to turn to run for home when they are out of missiles. The surviving Su-35As, with more fuel, higher speed and more missiles, (either 10 or 12 depending on their countermeasures configuration,) will run the JSFs down and kill them with rear-end shots, both BVR and WVR, or shoot them down with the GsH-301 gun."

This point was also made in the RAND Pacific Vision 2008 Activity Presentation in this backup slide:



Dr Jensen made the point about the vulnerability of the JSF in such situations. AVM Osley advised that the JSF has some 650 ways to detect and avoid such threats. Put another way, if a JSF has to leave airspace because it detects the presence of a Su-35Ss that it cannot defeat, **then the Sukhois win airspace-dominance without firing a shot** – hardly the outcome Australia can tolerate in meeting its requirement to dominate Regional airspace.

However, to return to the Within-Visual-Range engagement, AVM Osley suggested that such situations would generally result in mutual destruction. While this is one of the possibilities, in a tail-chase where a JSF is fleeing from a Su-35S, most of the advantages go to the Sukhoi. If it has Beyond-Visual-Range missiles available, it will employ these first. The JSF's F135 jet-engine back-end of the JSF has been described as a 'flaming 44 gallon drum', radiating huge amounts of infra-red energy and being highly reflective to radar.

Air Power Australia's Dr Carlo Kopp has made an analysis of the radar-reflectivity of the axisymmetric nozzle of the JSF using the United States Navy Postgraduate School 'POFacets' program, and determined it's radar cross section to be in the range where it will be detected at considerable distance by the powerful Su-35S IRBIS-E 'phased array' radar. The Russian R-77M missiles have a choice of Active Radar, Scanning Infra-Red and Passive Anti-Radiation Homing seekers, and the rear end of a retreating JSF is a large and well-defined target. His analysis can be found here:

http://www.ausairpower.net/APA-2009-01-Annex.html#mozTocId685375

However, if the Sukhois fail to kill the JSFs with BVR missiles, they can still close to WVR ranges and hold the advantage. Flying higher and faster, the Su-35S is likely to reach the edge of the WVR R-73/74 missile envelope well before the JSF's AIM-9X reaches the edge of its envelope, giving the Sukhois a 'first-shot, first-kill' advantage. Janes 'Air Launched Weapons' has the range of the AIM-9X at 10Km and the R-73 at an estimated 40 Km – a clear advantage for the Sukhoi. The problem for a 'High-off-Boresight' (HOBs) AIM-9X shot is that the JSF pilot has to use his Helmet-Mounted-Cueing-Sight (HMCS) to look and fire 'over the shoulder'. This means the AIM-9X has to fire forward to a safe distance from the aircraft, at which time it will be at high Mach and have a large turn-radius; it must execute a 180 degree turn and head towards the Sukhoi. This is an energy-draining manoeuvre which substantially shrinks the AIM-9X's engagement range against rear-sector targets. So, the result could be an edge-of-the-envelope R-73/74 missile kill of the retreating JSF for the Sukhoi well before the JSF can even take a shot.

In closing this section, I should advise the Committee that BVR missiles can also enter a 'mutual destruction' mode as well – not mentioned by AVM Osley. BVR missiles can become autonomous at about 15 nautical miles from the target, using an Active Radar seeker in the case of the AIM-120 and some types of the R-77M to find the target, or Scanning-Infrared for other types of the R-77M. When the missiles are self-guiding, each of the target aircraft is under threat. The aircraft type that will prevail is the one with the most effective countermeasures. In this case, the honours go to the Sukhois.

A PAIR OF LOGICAL FALLACIES:
1: NO ACCESS TO CLASSIFIED DATA = SIMULATION WILL BE WRONG
2: ACCESS TO CLASSIFIED DATA = SIMULATION WILL BE RIGHT

In his Submission Number 8 dated 9 March 2012, AVM Osley made this statement:

> *"To comprehensively rebut many of APA's assertions in regard to F-35 performance would require release of highly sensitive U.S. data. As neither APA nor RepSim have access to the detailed classified F-35 data, their analysis is basically flawed through incorrect assumptions and lack of knowledge of classified F-35 performance information. Without this knowledge, APA and RepSim can only speculate on the F-35's capabilities and its ability to counter extant and evolving threats."*

This is a logical fallacy, the argument being that if you don't have access to classified data, simulation results will be ipso-facto incorrect. Mr Price addressed this issue directly in his presentation on 7 February 2012, advising the Committee that he has had access to classified material at the highest level on the JSF, and was asked to make an assessment of the aircraft, which he did in a highly classified document of which only two copies were produced.

In addition, he described the process whereby he compared the result of classified simulations with those produced by Harpoon 3 Professional, and found no significant differences.

What is important is to understand that much of the data that is fed into simulations both classified and unclassified are representations of the Laws of Physics. The Department of Defence cannot apply security classifications to the Laws of Physics, even if the 'reasonable and representative' results are inconvenient. As noted above, the physics of radar reflectivity strongly suggest that the JSF will not be 'invisible to radar', nor to infrared sensors, and will be vulnerable to attack as a result. This matter is discussed below.

The implication of AVM Osley's statement is that access to classified data ipso-facto produces true results. This is a second logical fallacy which is discussed next.

TRUSTED SIMULATIONS ARE INDEPENDENTLY VERIFIED, VALIDATED AND ACCREDITED

While AVM Osley advised that The Department was using 'Pilot-in-the-Loop' simulations, he did not provide advice on the name of the simulation suite and whether the Department of Defence had subjected the simulations in use to the Verification, Validation and Accreditation process prescribed by the Department's Simulation Office. When a Nation is purchasing a multi-billion dollar weapons system on which its future security will depend, it is essential that it Accredits, Validates and Verifies all simulations used for the evaluation of weapons system effectiveness.

The Australian Department of Defence, Simulation Office 'Simulation Verification, Validation and Accreditation Guide' provides these definitions:

> **Simulation VV&A Purpose**
>
> The purpose of VV&A is to assure development of correct and valid simulations and to provide simulation users with sufficient information to determine if the simulation can meet their needs.
>
> **Simulation Accreditation** is "the official certification that a simulation, or federation of simulations is acceptable for use for a specific purpose." H3MilSim (and its predecessor, Harpoon 3) was accredited by the Australian Defence organisation as part of the Explosive Ordnance Program.
>
> **Simulation Validation** is "the process of determining the degree to which a simulation, or federation of simulations, is an accurate representation of the real world from the perspective of the intended uses of the simulation".
>
> **Simulation Verification** is "the process of determining that a simulation, or federation of simulations, implementation accurately represents the developer's conceptual description and specifications."

There is an important point to make here. A simulation might be accredited, ***but each and every simulated scenario must be both validated and verified***. Accidental or intentional biases may be present in the simulation's particular scenario. Thus each simulation should be independently validated and verified, especially when the proponent has a vested interest in the results.

Examples of bias, also provided by my colleague Michael Price in answer to a question by Senator Johnston are:

a. **Matching modern air combat aircraft against obsolete opponents**. This structure will produce Loss-Exchange-Ratios that are favourable, but unrepresentative of future air combat. This type of matching-bias of the 2018 F-35 JSF with the 1985 Su-27 is described above with the 'Raptors' Edge' disclosure. Another example is found here:

   F-35 Air Combat Skills Analysed

b. **Failure to represent the 'real world' environment.** An example is the omission of low frequency radars when 'Stealth' aircraft are present. These radars, like Australia's JORN Skywave HF Radar, have the capability of detecting and tracking 'Stealth' aircraft, and cueing air combat fighter Interceptors so they fly close enough to targets for them to complete the attack using their on-board sensors. Would

Australia turn off JORN in the presence of future 'Stealth' aircraft like the PAK-FA and the J-20 in a future conflict? Of course not.

c. **Misrepresentation of the capabilities of opponents.** An example that came to REPSIM's notice that a test pilot of a large aerospace Company claimed that a Sukhoi could only fire a single missile at a time, and had to wait until the intercept was complete before firing the next missile. Meanwhile, the company's fighter aircraft could fire up to eight missiles in 'Track-While-Scan' mode. REPSIM has Russian flight manuals and can prove this claim to be false, and the capability of the missiles was checked via a third party with the Chief Designer of Vympel – the Russian Company which makes the missiles being misrepresented. Such distortions have a profound effect on the Loss-Exchange-Ratios, turning near annihilation into a victory. If Sukhois' capabilities are being misrepresented this way in the Company's large air combat simulation (of which incidentally, they won't permit independent scrutiny,) then the results will be biased and therefore invalid. Similar biases are created by setting the Kill Probability of all our missiles at (say) 0.9, and all of the opponents to (say) 0.1. Tac-Brawler is a simulation suite used by USAF and it allows for skill biases for pilots to be included, with the USAF pilots being defined as superior. Whether this is valid can be assessed by the observation that at the end of the Vietnam war, USAF had one fighter ace, North Vietnam had 15, yet USAF pilots are routinely represented as being much more competent than their foreign counterparts.

The H3MilSim simulation suite used by REPSIM is a successor to Harpoon 3 Professional, Accredited by the Department of Defence for use in Capability Development and Assessment applications. REPSIM Pty Ltd uses an 'Open Architecture' model for Verification and Validation as follows:

a. there is a large database of entities that can be simulated and this database, having taken several man-years of effort to build, is RESIM's Intellectual Property and is not released in its entirety; however individual entities used in a simulation may be examined in complete detail;

b. scenarios that control the actions of entities and are also open to scrutiny;

c. as the simulation runs, the visual displays provide information regarding the level of fidelity of the simulation; individual entities may be selected and their actions read in a data-window and observed on the display;

d. H3MilSim produced detailed outputs in the form of an 'After Action Log' in which the actions of every entity in an engagement are recorded for later analysis; another form of output is a data stream that may be fed into post-simulation tools such as the Satellite Tool Kit for detailed examination; H3MilSim is fully 'DIS' compliant and output from a running simulation may be fed into other running simulations in real-time; and

e. the Australian Defence Organisation has full access to the source code of Harpoon 3 Professional and H3MilSim which can be examined to determine how simulation entities are processed; this is unusual as source cost code is often regarded as 'Propriety' property of a company and is not released.

Simulation is an essential tool to estimating the future performance of weapons systems under development and with an Initial Operations Capability that may be many years in the future. The caveat is that such simulations must be Validated and Verified for each scenario, ideally by an independent expert in computer simulation. This independent scrutiny is especially important when the person quoting the simulation results has a vested interest in the outcome. AVM Osley was silent on the important issue of Accreditation, Validation and Verification of simulations used for the evaluation of JSF air combat performance and before the result of any simulation is accepted, the simulation should pass the Department of Defence prescribed required qualification tests.

SECURITY CLASSIFICATION OF SIMULATION RESULTS: A WAY OF HIDING AN 'INCONVENIENT TRUTH'?

AVM Osley advised that the simulations being accessed by the Department of Defence are 'Classified' and did not provide further detail. He could have, without divulging classified data or sources, advised of the type of simulation being used, and the coverage of the scenarios, especially the threat aircraft being assessed. At present there are just eleven types in the world relevant to the assessment of JSF future air combat. These are: Su-30MK series, Su-35S, PAK-FA / T-50, MiG-29K, J-10B, J-11B, J-20, Rafale, Gripen-E/F, Typhoon, F-16 and F-15E Exports.

Committee members would be aware that an enterprise like Lockheed Martin has an inbuilt conflict-of-interest when it comes to revealing results of the JSF – designed, not as an air dominance Fighter, but a Strike aircraft with some second-tier (below the purpose-designed F-22A) Fighter capabilities. Previously in this submission I have presented the results of H3MilSim simulation based on the RAND Pacific Vision 2008 Activity Presentation Scenario. These Scenarios, now made more apposite by China's request to Russia for the purchase of 48 Su-35S, suggest that the JSF will fail as an effective weapons system in future air combat engagements.

Suppose, hypothetically, that the REPSIM simulation have truly produced a 'reasonable and representative' result, and as advised by Michael Price during the 7 February 2012 Committee hearing showing that the F-35A will be convincing defeated by the Su-35S, a result which closely matches the simulation results produced by 'Classified' simulations.

Next, suppose (in an alternate Universe of course) that Lockheed Martin have done the same work in parallel and, having computed the same results, called a press conference to announce:

'JSF is Soundly Defeated in Simulated Air Combat with the Sukhoi Su-35S'?

What would the reaction of potential Lockheed Martin's JSF customers be? At the very least, a review of air-combat weapons systems alternatives to the JSF and a probable collapse of the JSF marketing program.

Is this an example of the Mandy Rice-Davies syndrome: 'Well he would (say that) wouldn't he'. If AVM Osley were to admit that REPSIMs' simulation results showing the Su-35S is superior to the JSF in air combat are 'reasonable and representative' it would be instant death for the JSF program.

The complication for AVM Osley in adopting the stance that REPSIM's simulations are flawed is that Mr Michael Price and Wing Commander Chris Mills worked for him during his tenure as AIRCDRE Osley, Director General of Capability Plans in the Capability Development Division of the ADO. The work we did at that time was nearly identical to the services we provide as the Principals of REPSIM Pty Ltd, and was highly commended by AIRCDRE Osley. Mr Price received a Commander's Commendation for this work from General Hurley, now Chief of the Defence Force.

The results of the simulation were used to justify hundreds of millions of dollars of expenditure on Explosive Ordnance. There was no suggestion at the time that the results were unusable because they were based on open-source data. As noted in our evidence, they were cross-checked with highly classified simulations as part of the verification and validation process. In scientific terms, this is known as A-B replication. Since then, the Harpoon 3 Professional has been considerably improved, especially in the areas of modelling signatures and assessing the effects of battle damage. More advanced aircraft are represented such as the F/A-18F Super Hornet and the Su-35S, and there is more open source data on the JSF increasing the fidelity and veracity of the simulation results.

At best, AVM Osley's behaviour can be described as incongruent.

Security Classification of simulation results in time of conflict is entirely reasonable. If the simulations show that the weapons system will be defeated in a conflict by superior enemy weapons systems, then the last thing a Nation would disclose is its military inferiority and vulnerability. However, armed with this knowledge, a militarily competent Nation would seek alternative options leading to a victory.

False Security Classifications are inexcusable in the assessment of the combat effectiveness during the weapons development process. As noted above, there is a high degree of activity by other Nations such as Russia, China and India in developing weapons systems designed to prevail in future air combat conflicts, and especially to defeat the USA's principal air dominance Fighters: the 187 F-22As and the 2,443 JSF bombers improperly designated as air superiority fighters. Meanwhile, the JSF is 'stuck' with a year-2000 JORD specification that bears no relationship with the world that currently exists, let alone one that will exist in ten to twenty years' time. If simulations show the JSF to be inferior at the vital air combat task, this must be accepted and alternative military options found.

DIRECTED ENERGY: WONDER-WEAPON OR MARKETING-HYPE?

Highly classified Directed Energy Weapon (DEW) capabilities are a piece of marketing genius. The marketing agency can claim that an aircraft with a DEW can be highly combat effective, overcoming many other limitations and shortcomings of the platform. However, a potential customer, lacking the necessary security clearances, is unable to conduct *caveat-emptor* research, and must blindly trust the enterprise purveying the goods (or 'bads' as the case may be). The risk is that the customer can find that the DEW is combat-ineffective after placing an order, leaving the purchaser with an overall combat-ineffective aircraft, or worse still, on the first day of a war an uncompetitive aircraft leading to adverse Loss-Exchange-Rates.

Any aircraft with a High Power Microwave (HPM) generator, high-power radar or high-power laser beam has the potential to use it as a DEW. For radar, the pilot selects high Pulse-Repetition-Frequency and a high duty-cycle and directs the energy of the radar at a single target. The objective to disable an adversary's sensors or for some of the radar energy to enter the target's structure and 'fry' or transiently disrupt some vital electronic component. The pervasive use of computers throughout aircraft subsystems presents multiple vulnerabilities to HPM attack.

While this seems to be, prima-facie, an attractive capability, the power of aircraft radars is puny in comparison with the forces of nature such as lightning. Airliners are routinely struck by lightning, and must not be disabled by such electro-magnetic surges – they are 'electronically hardened' to resist failure from such events. Similarly, nuclear weapons produce strong electromagnetic pulses, and it would be an 'own-goal' if the pulse was to disable the aircraft releasing the bomb. Companies building civil and military aircraft have years of experience in protecting them from Electro-Magnetic Interference (EMI).

The challenges of fielding a safe and effective DEW in an Air Combat Fighter should not be underestimated. The objective is to generate HPM pulses that 'fry' the enemy's electronics at distances of tens of kilometres, noting that the power at the target falls off in an inverse square law, while not 'frying' the Fighter's electronics which are only centimetres and metres away from the source of the High Power Microwave radiation. To make matters worse, the small antenna sizes in Fighter aircraft yield large antenna side-lobes. This energy leakage puts electronic systems at risk across the aircraft carrying the DEW. The risk of Electro-Magnetic Interference in a JSF is discussed further below. Does a JSF DEW present a significant risk of an 'own goal'?

REPSIM routinely researches open source information for clues to advances in military capabilities and DEW systems is one area of research. While new capabilities can be highly classified, at times the funding of research (for example) and the purchase of materials are not. Examples are solving a breakdown in the frequency-selective-surface of the APG-81 radome and picosecond avalanche transistors used to generate HPM pulses. (Frequency-selective-surfaces are essential to low-observability, as they allow radar pulses and returns to pass, but block other radars from detecting the reflective radar antenna face and bulkhead.) Thus, it is highly probable that the JSF will have some DEW capability, whether a focussed AESA radar beam, a HPM generator or a high power laser fitted to the F-35A and F-35C in the lift-fan cavity.

Lockheed Martin's engineers were reported in 2004 as developing a 100Kw Laser for the lift-fan cavity, powered by the engine driveshaft. Effective range was expected to be 10 Km. The main limitation was dumping 900Kw of waste energy into the already heat-stressed fuel.

REPSIM routinely includes a DEW function in its JSF simulation models, but limits the effectiveness to 'reasonable and representative' effective ranges based on the laws of physics and the results of DEW weapons in other applications. Effective range is of the order of 10 km or less. The DEW does destroy some incoming missiles in the simulations, but the rate of destruction does not materially affect the overall result. Claims for longer effective range need to be demonstrated in a 'real-world' physical trial under operational conditions such as cloud, turbulence, atmospheric heating and against 'hardened' aircraft and/or missiles that are manoeuvring to limit DEW dwell times.

H3MilSim F-35A vs Su-35S Engagement Showing JSF DEW Engagements

This is screen capture from an H3MilSim simulation of an engagement between 24 JSF F-35As and 24 Su-35Ss follows. In this particular battle, the JSFs and supporting AWACs and AAR Tankers were annihilated. Note that 17 JSF DEW engagements took place.

As mentioned above, 'hardening' to resist DEWs has been practiced for decades. A missile can be programmed to fly erratically while still guiding to defeat the 'dwell time' necessary to the DEW to become effective. Missiles with Infrared seekers are less susceptible to electro-magnetic DEWs. Paradoxically, a 'stealth' aircraft activating a DEW becomes a 'self-designating' target, and there are numerous missile seekers designed to home on such transmissions.

Here is an example of the Russian Agat dual-mode seeker, exported to China for use in the Chinese AMRAAM analogue, the Luoyang PL-12 or SD-10:

Agat Dual-Mode Missile Seeker

One of the limitations of a radar-directed DEW is coverage. A fixed AESA antenna can deflect a radar and DEW beam over a cone of about 120 degrees around the backplane. That inevitably leaves 240 degrees of the sphere around the aircraft uncovered, and in air combat, missiles and aircraft can attack from any direction. Rear sector kills can be demonstrated from the REPSIM H3MilSim After-Action Logs.

Simulations of DEWs can be subjected to biases – deliberate or accidental, as discussed above. For example, the targets can be confined to the 120 degree cone around the nose of the aircraft, and the simulated effective range of the DEW extended to tens of nautical miles further than the range of the enemy's missiles with a designated high probability-of-kill on the aircraft and missiles in-flight. Typically, this could bias the Loss-Exchange-Rates from (say) 2.4:1 loss to 6:1 win. REPSIM can demonstrate such 'unreasonable and unrepresentative' bias of simulations simply by adjusting the effectiveness of the JSF DEW to levels that do not comply with the laws of physics and that have not been demonstrated in physical trials.

Finally, there is the issue of radar power-aperture – the ability for an aircraft to project energy onto a target. The small size of the radar and limited power and marginal cooling capacity of the JSF put it at a disadvantage with the much larger, twin engine Sukhois with large radar dishes and substantial power and cooling reserves. If it becomes an aircraft-on-aircraft contest, over time the design of the Sukhoi and the Chendu J-20 give the larger aircraft the advantage in DEW contests.

RADAR ON JSF CHASE AIRCRAFT

Dr Jensen raised the issue of radar observations of JSF aircraft by chase aircraft such as the F/A-18E/F Super Hornet. This is a subject that is long overdue for discussion.

While the F/A-18E/F may be far from an effective air superiority fighter against modern adversaries like the Su-35S, it does have an excellent avionics suite, with the APG-79 being the jewel-in-the-crown. This radar has detection capabilities similar to the Su-35S's IRBIS-E, albeit compromised by a much smaller antenna. The logic here is that if an F/A-18E/F's APG-79 can detect the JSF at tactically useful distances, so will the Su-35S.

I have a colleague who is a Boeing F/A-18E/F test and training pilot. He assesses that the APG-79 will detect and track a JSF at tactically useful distances, especially from the side and rear sectors. Given the 'flaming 44 gallon drum' analogy mentioned earlier, this is an entirely reasonable proposition. Third party signature modelling of the JSF shape supports this proposition.

During my November 2011 meeting with AVM Osley, I suggested that as a '*caveat emptor*' measure, Australia should insist on having one of its F/A-18F aircraft present during some of the JSF test flights 'to see what they can see'.

The statements regarding the JSF radar signatures are generally of the form of '*meeting planned requirements*'. However, if the '*planned requirements*' are of the order of 0.01 square metres from the sides and 0.1 square metres from the rear (it could be much greater from some angles,) then it is a disaster for the combat-effectiveness and consequently the marketing of the JSF as it will be easily detected by the APG-79 and the Su-35S IRBIS-E (which can share its radar detections with other Sukhoi aircraft in the flight over a tactical data-link). The design premise if the JSF is that an aircraft with a mediocre aerodynamic performance can only be combat-effective on the basis of 'you cannot detect me, so you cannot kill me'. Once the aircraft is detected, it becomes prey to lethal attack, both BVR and WVR. As noted in the RAND slide, it is 'doubly inferior – Can't turn, can't climb, can't run.'

Australia can 'test the waters' with a request to make observations of the JSF with the F/A-18F using the APG-79. There will be one of four outcomes:

a. the request will be refused in the knowledge that the APG-79 will detect the JSF at tactically useful ranges, in which case we know that the JSF has something to hide, or perhaps more accurately, is a failure at hiding from modern Fighter radars and Australia should reconsider it air combat options; or

b. the request will be refused in the knowledge that the APG-79's high power (similar to the Su-35S IRBIS-E,) can upset the JSF's electronic systems through by Electro-Magnetic Interference, in which case we know that the JSF can be attacked electronically by high-power, high PRF, high duty cycle radars like the IRBIS-E or other High Power Microwave weapons; Australia would reassess the JSF on the basis of this vulnerability; or

c. the request is granted, and we find that the JSF is not detectable at tactically useful ranges, in which case our confidence in the aircraft rises; if so the test conditions must still be investigated to determine whether the test was representative, or

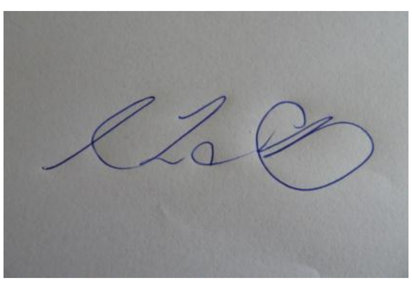
d. the request is granted and the APG-79 detects the JSF at tactically useful ranges, in which case Australia reconsider the viability of the JSF in future air combat environments.

CONCLUSIONS

Much of the evidence presented by AVM Osley needs to be scrutinised for accuracy and to make an assessment whether his observations are ‘reasonable and representative’ of a future world of lethal air combat. As the JSF displaces legacy aircraft world-wide, it becomes a ‘single point of failure’ for the security of the West relying on its air dominance. Potential adversaries are consequently determinedly producing weapons system to defeat weapons system such as the JSF that might be deployed against them in large (and exclusive) numbers.

Defence’s acquisition policy on the JSF seems to be to accept the claims of the manufacturer until they are disproven. This is a high-risk approach. The only safe and reliable acquisition posture (and the one used for previous decades) is to consider all claims to be not valid until proven by physical trial. The role of simulation is to cover the long gap between development of the aircraft and its entry into service, to ensure that if a high risk of program failure is apparent from the simulations, timely alternatives can be found.

Prima-facie, the statements AVM Osley made on 16 March 2012, and the examples he gave, fall factually and analytically short of the standard of advice required for presentation to Australia’s Parliament.



Chris Mills, AM, MSc (USAFIT), BSc
Director and Operations Analyst
REPSIM Pty Ltd

30 March 2012

China 'close to buying $4 bln worth' of Russian top interceptors

Get short URL
email story to a friend print version
Published: 06 March, 2012, 11:47

Sukhoi Su-35 fighter (image from http://nikultsev.livejournal.com/)
TAGS: Arms, Russia, Vehicles, China, Big deal

Russia and China are close to signing a US$4 billion arms contract, according to a media report. Beijing wants to purchase 48 Sukhoi Su-35 super-maneuverable multi-role interceptors, which are among most advanced Russian combat aircraft.

Most of the terms of the prospective contract, which may become the biggest arms deal between Russia and China in a decade, are already agreed upon, reports Kommersant daily citing sources close to the talks. The price for the jets will be around $85 million apiece, but may yet change.

China's interest in Su-35s was first hinted in 2008 during the Air Show China exhibition. Insider information that talks on such a deal may start surfaced in 2010, but only in February 2011 was it confirmed officially. Back then Aleksandr Fomin, deputy director for the Federal Service for Military-Technical Cooperation said the offer to buy the aircraft was put on table in 2011.

Kommersant says the biggest obstacle to sealing the deal now is Russia's insistence on a legal guarantee that China would not try to reverse-engineer the technology used in the aircraft. China already did this with Su-27, Su-30 and Mig-29, making them into domestic analogues called J-10, J-11 and FC-1 respectively. They also used a test version of Su-33 obtained through Ukraine to create their J-15 jet. The latest such incident is the copycatting of Su-30MK2 into the J-16 aircraft, the newspaper says.

The Sukhoi Su-35 is a 4++ generation long-range interceptor jet. It has maximum speed of 2,390 km/h and range of 3,400 kilometers. It is armed with 30mm cannon and has 12 wing and fuselage stations for up to 8,000 kg of ordinance, including air-to-air missiles, air-to-surface missiles, rockets, and bombs.

China's imports of Russian arms have been decreasing over the years, as the country developed its own defense industry. Moscow is concerned that Beijing could soon become a major competitor in the traditional markets like Middle East and Latin America.

Chinese copies of the Russian aircraft may be technically inferior, but are sold several times cheaper than the originals. For instance, in a 2009 tender from Myanmar, Russia offered Mig-29s for $35 million apiece, while China offered FC-1s at $10 million. The contract however went to Russia, but the trend cannot but worry Moscow.

Russia ready to sell Su-35 fighter jets to China

Topic: Airshow China 2010

Su-35 fighter aircraft

12:57 16/11/2010

Related News

- · Russia, China to address illegal arms production issue
- · Airshow China 2010 exhibition opens in Zhuhai
- · Russia delivers third Mi-26 helicopter to China
- · Russia may sign first Su-35 warplane export deal by yearend

Multimedia

- New Su-35 fighter can attack eight targets simultaneously

Russia's state-run arms exporter Rosoboronexport said on Tuesday it was ready to hold talks with China on the delivery of advanced Su-35 fighter aircraft to the Chinese air force.

"We are ready to work with our Chinese partners to this end [Su-35 deliveries]," Deputy General Director of Rosoboronexport Alexander Mikheyev said at the Airshow China 2010, which is being held on November 16-21 in Zhuhai.

The Su-35 Flanker-E, powered by two 117S engines with thrust vectoring, combines high maneuverability and the capability to effectively engage several air targets simultaneously using both guided and unguided missiles and weapon systems.

Russia's Sukhoi aircraft maker earlier said it planned to start deliveries of the new aircraft, billed as "4++ generation using fifth-generation technology," to foreign clients in 2011 and produce Su-35s over a period of 10 years up to 2020.

China International Aviation & Aerospace Exhibition (Airshow China) is the only international aerospace trade show in China that is endorsed by the Chinese central government. The biannual arms exhibition has been held in Zhuhai since 1996.
ZHUHAI (China), November 16 (RIA Novosti)

RAPTOR'S EDGE

Security and classification issues still bedevil efforts to sell F-22s

DAVID A. FULGHUM/MARIETTA, GA., and WASHINGTON

Hoping to win support for F-22 production beyond the current 183 aircraft, Lockheed Martin is revealing proprietary data that show performance in several areas is better than baseline requirements.

Moreover, the U.S. Air Force is taking the fighter to the Paris air show for the first time this summer, says Larry Lawson, executive vice president and general manager of the F-22 program. The promise of additional U.S. and, possibly, foreign sales has removed any obstacles.

The problem confronting the company is that Raptor backing is splintered. Senior Pentagon acquisition officials want to shut down production to cut defense spending. Congress wants more production to keep aerospace industry jobs going. Air Force leadership is setting on a new minimum requirement for 240-250 aircraft (about another 60 F-22s) but hasn't made the new number public, apparently waiting to introduce it as part of the Quadrennial Defense Review.

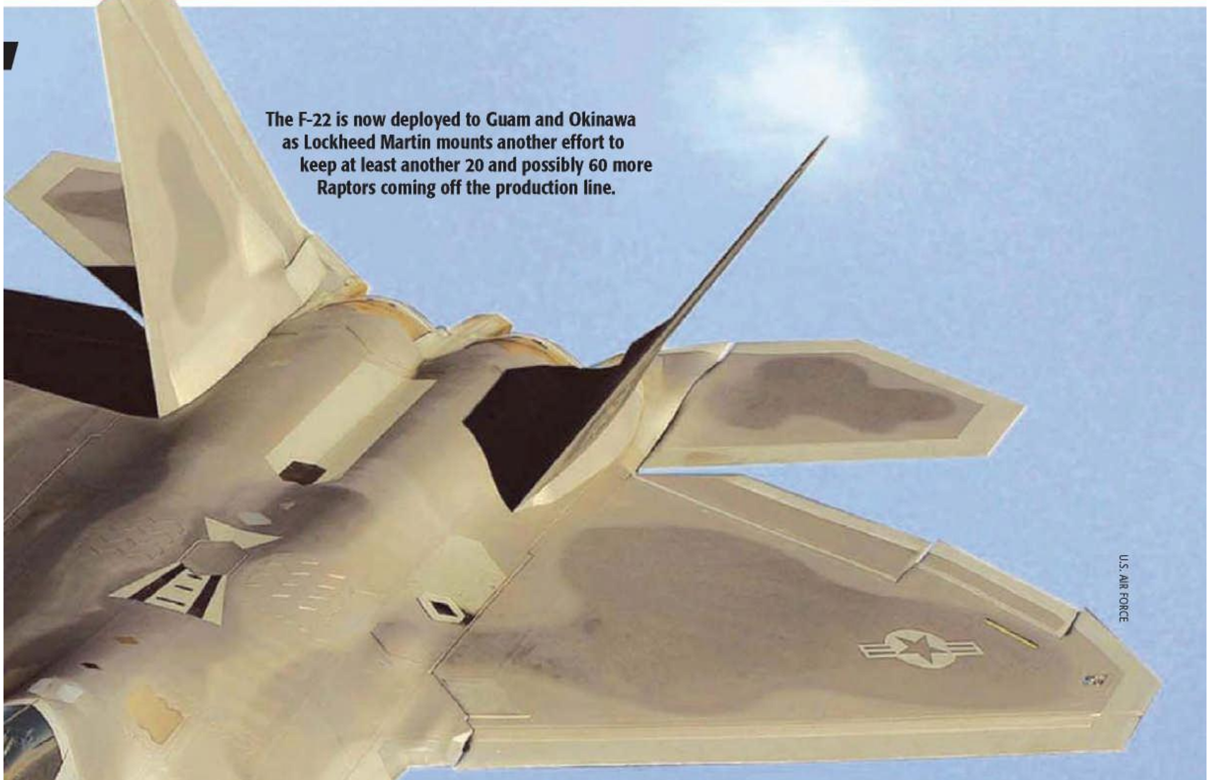
Another emerging issue is that some of the early, 550 low-rate-production F-35 Joint Strike Fighters will cost more (roughly $200 million each) than the $142 million it takes to buy a Raptor. That puts the Air Force in the position of spending its near-term fighter recapitalization money on aircraft they can't deploy until about 2014.

In addition, the secrecy-obscured question of just how good the F-22 is as an air-to-air combat design remains unanswered. It's a complex issue that involves the world of electronic surveillance and attack, information operations, network-centric roles and advanced radar. Right now, the F-22 is one of only two stealth fighters being flown. That may change in a decade as Russia and China introduce new designs. Advanced F-15 radars have a slightly greater range, but the F-22 can use its stealth to move closer to targets. U.S. aggressor pilots work daily to find ways to outmaneuver F-22s, but so far they've only accomplished a few kills, always by some fluke, says Lawson.

The F-22's newly revealed areas of overperformance include a radar cross section that officials will only characterize as "better" than what was asked for. Pentagon officials have said privately that the desired signature from certain critical angles was -40 dBsm., the equivalent radar reflection of a steel "marble." By comparison, the F-35 Joint Strike Fighter has a signature of -30 dBsm., about the size of a golfball.

Supercruise is at Mach 1.78 rather than Mach 1.5. Acceleration—although company officials would not say from what speed or at what altitude—is 3.05 sec. faster than the requirement of 54 sec. In nonafterburning, full military power, the Raptor can operate at slightly above 50,000 ft. However, it is known that the F-22 opened its aerial battles at about 65,000 ft. during its first joint exercise in Alaska, apparently using afterburner. There is also a mysterious admission that the range of the Raptor's Northrop Grumman/Raytheon active, electronically scanned array (AESA) radar has a range 5% greater than expected. That means a cushion of an additional 5-6 mi. of detection range against enemy aircraft and missiles.

Ranges of the new lines of AESA radars are classified. But they are estimated at about 90 mi. for the smallest (aimed at the F-16 radar-upgrade market). The F/A-18E/F and F-35 (with radar ranges of 100 mi.) are followed by the F-22 (110-115-mi.). The largest is carried by the upgraded F-15Cs and Es (125 mi.). By comparison, the range for a mechanically scanned, F-15C radar is 56 mi. according to Russian air force intelli-



The F-22 is now deployed to Guam and Okinawa as Lockheed Martin mounts another effort to keep at least another 20 and possibly 60 more Raptors coming off the production line.

gence. U.S. aerospace officials agree that an AESA radar "at least doubles" the range over standard military radars.

When coupled with the electronic techniques generator in an aircraft, the radar can project jamming, false targets and other false information into enemy sensors. Ranges for electronic attack equal the AESA radar plus that of the enemy radar. That could allow electronic attack at ranges of 150 mi. or more. The ability to pick out small targets at a long distance also lets AESA-equipped aircraft find and attack cruise missiles, stealth aircraft and small UAVs.

Lockheed Martin also makes an economic argument for continuing Raptor production. The F-22 unit cost in a USAF multiyear purchase is $142.6 million (average unit flyaway cost). Initial unit cost of the F-35 will be around $200 million and then start dropping as production continues. In Japan, the decision to indigenously build small numbers of F-15Js and F-2s (a larger F-16 design) drove their cost to roughly $100 million each. The Eurofighter Typhoon would likely cost even more in a small production run.

"If the [U.S.] wants to do a foreign military sale or sustain those [high-tech F-22 production] jobs longer or wanted to keep its [stealth fighter] insurance policy in place longer, it would have an option" if it continued production until 2014, says Lawson. "We're hoping for a positive decision to keep production going and allow the [U.S.] administration the time it needs to study the problem further to make a decision about what the ultimate quantity is. If you build more, they cost less."

The operational arguments focus on combat effectiveness against top foreign fighter aircraft such as the Russian Su-27 and MiG-29. Lockheed Martin and USAF analysts put the loss-exchange ratio at 30-1 for the F-22, 3-1 for the F-35 and 1-1 or less for the F-15, F/A-18 and F-16.

The speed of pilot training also has offered surprises. The first class of four first lieutenant F-22 pilots—with no experience in another operational fighters—has graduated from Raptor training, says David Scott, Lockheed Martin's director of F-22 business development. In addition, a second, full class of 13 pilots, just out of advanced jet training, has been selected for direct transition to the Raptor. Scott says the new pilots have far fewer habits to unlearn, and they adapted more quickly to improvising with the F-22's advanced network-centric capabilities.

Another element of the formula is that 183 Raptors—with production ending in 2011—provide the U.S. with only 126 combat-coded (capable) aircraft, says Lawson. Of those, only about 100 would be operationally available. A fleet of 183 F-22s would require the Air Force to continue using 177 F-15s through 2025 for air superiority roles, and the end of production would kill any chance for a foreign military sale, he says.

However, if production were extended by three years to 2014, when planners hope the U.S. economy will be stronger, company analysts say the number of operational F-22s would grow to 180, says Lawson. They would be supplemented by the first 68 F-35s, and foreign military sales of the F-22 would become feasible, he adds. While Australia has definitely dropped out of the chase for F-22s, Japanese and Israeli officials say even a single squadron would provide a large boost in deterrence to other military forces.

Russian opinions of the F-22's capabilities vary from awestruck to dismissive, according to a Jan. 26 article in *Pravda* (english.pravda.ru/world/americas/107010-raptor-0).

The stealthy fighter poses a "great danger to any modern missile defense system," says Konstantin Sivkov, vice president of the Academy for Geopolitical Sciences, with a "wide range of opportunities to defeat [air defenses]. Enormous speed . . . maneuverability and its airborne equipment . . . make it a very powerful and dangerous aircraft." However, the Raptor "should not be overestimated," says Alexander Khramchikhin, a specialist with the Institute of Military and Political Analysis. "It is radar-detectable and it is destructible." The *Pravda* article says the U.S. considers Russia and China as its "first and foremost threats [and] that the two countries may have "fifth-generation fighters during the upcoming 5-10 years."

Advanced air defense systems—called SA-20 and SA-21 by NATO and S-300 and S-400 by the Russians who export them—can only be penetrated by stealthy aircraft, say U.S. experts. The Russians note that their missiles are purely defensive (although that would be a tough argument to make in the Middle East) and that the S-300 is exported to a only few countries. In addition, the S-400 cannot be found outside Russia, and it equips only two divisions within the country, they assert. However, exports of such high-threat, "double-digit" surface-to-air missiles have been made to China, Vietnam and Syria, and are on order for Iran.

Lockheed Martin planners want to parlay the Raptor's operational enticements into support from the Obama administration, which would have to approve further fighter production by March. The pressure is on to find support for continued F-22 Raptor production of at least 20 more aircraft—for which Congress has approved long-lead funding—and as many as 60 total if the Air Force restates its requirement for the aircraft.

Some senior Air Force officials, while looking longingly at a larger fleet, think the odds are poor for funding beyond the next increment of 20 F-22s. They say internal Pentagon calculations are that Lockheed Martin has an adequate base with the C-130J and C-5B upgrades that will sustain their business while F-35 ramps up to a high-rate production of 110 aircraft per year.

GENERAL ELECTRIC

With the start of F136 ground tests in GE's Cell 43, assembly is beginning on the first of six flight-test engines for deliveries starting in 2010.

Spooling Up

Primary engine set for powered-lift flight in F-35 as alternative starts development runs

GUY NORRIS/LOS ANGELES and GRAHAM WARWICK/HARTFORD, CONN.

With competing engines for the F-35 Joint Strike Fighter achieving crucial milestones, their manufacturers are waiting to learn whether the U.S. Defense Dept. will make another bid this year to cancel the alternative powerplant.

The General Electric/Rolls-Royce Fighter Engine Team ran the first production-configuration F136 for the first time at idle on Jan. 30 and plans to push the engine to maximum military power by mid-February. Five engines will be under test by December for both conventional and short-takeoff-and-landing (CTOL and Stovl) versions of the F-35.

Primary engine supplier Pratt & Whitney, meanwhile, delivered the first redesigned F135 to Lockheed Martin on Jan. 29, for installation in the first Stovl F-35B, aircraft BF-1. Qualification for powered-lift testing was received a day later, ending a 4-6-month delay to Stovl trials caused by turbine blade failures.

Pratt is well ahead of GE/Rolls, and is close to delivering its 11th of 18 flight-test engines and beginning work on the first production batch of F135s; but the blade problem and congressional support for an alternative engine has kept the competition issue alive.

The F135 is a derivative of the F119 powering the F-22, with a larger fan for more thrust and a third turbine stage added to drive the lift fan in Stovl configuration. A blade in that third stage broke during powered-lift qualification testing in August 2007. In February 2008, a second Stovl engine suffered an identical failure during ground tests.

The failures were traced to high-cycle fatigue cracking due to vibration caused when the hollow unshrouded blades struck the wakes from third-stage stator vanes upstream. The Stovl engine was affected because the large pressure drop across the turbine when driving the lift fan intensifies the wakes, says Bill Gostic, vice president of the F135 program. The fix was to switch to asymmetric vane spacing, to disrupt the excitation causing the vibratory stress, and to redesign the blade to eliminate the stress concentration at an internal cooling hole.

Pratt conducted a series of ground tests to confirm that the asymmetric vanes eliminate the vibration and did not interfere with turbine cooling, and has completed a proof test on the redesigned FTE06 flight-test engine, says Gostic. This is the engine delivered to Lockheed Martin for installation in