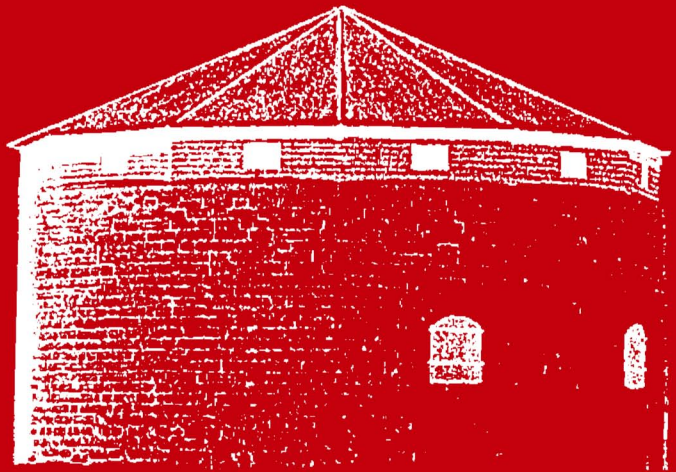


Jay “Hoss” Ballard

The F-35 and Canada: A Fighter Pilot’s View



17

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Centre for International and Defence Policy

*The F-35 and Canada:
A Fighter Pilot's View*

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Preface

Canada's program to replace the Royal Canadian Air Force's fleet of aging F-18 Hornet jet fighters sits in limbo. In December 2012, the Conservative government of Stephen Harper abruptly pulled the plug on its earlier attempts to acquire the Lockheed Martin F-35 Lightning Joint Strike Fighter (JSF). Following a series of seemingly damning investigations into the costs of the new fighters that revealed that the life cycle costs of the F-35 supposedly had ballooned from \$16 billion to \$45.8 billion, the government hit what it described as the "reset" button on the program. Two years later, in September 2014, Ottawa announced that the F-18 fleet, delivered in the early 1980s, would have their service life extended to 2025 while the government decides which of the fighters on the market to procure.

For many observers, the new fighter procurement represented an abject policy failure by the Harper government. For a cabinet that made a name for itself for control and micromanagement, the Harper cabinet badly misplayed the fighter replacement. Instead of treating the aging of Canada's jet fighter fleet as a major procurement problem to be cautiously managed, the Conservative cabinet drifted carelessly into embracing the F-35. Equally carelessly, Conservative ministers did not bother to look at how the Liberal government of Pierre Elliott Trudeau managed the acquisition of the F-18s in the late 1970s; after all, Liberals, particularly Trudeau Liberals, had nothing to teach the Conservatives. However, ignoring the lessons of history meant that the Harper government fell into the trap of allowing the Royal Canadian Air Force and the Department of National Defence to run the fighter procurement, prompting the political backlash that made it appear that the cost of the F-35 was ballooning.

Indeed, the issue of costs was indicative of the failure of management by the Conservative government, which allowed the opposition parties to play a completely disingenuous game of "Fun with Numbers" for their own partisan and parochial purposes. For of course the real costs of the F-35 never varied: that new fighter was always going to cost Canadians, on average,

\$1 billion per year. But one could—and some did—play with the so-called “total cost” by varying the number of years of the F-35’s life cycle. The Department of National Defence did this when it pitched an artificially low life-cycle number to the ministers, with a pleasantly palatable \$16 billion figure that came from a 20-year life cycle. But others who produced reports on the F-35 could readily make that number seemingly grow by the simply expedient of increasing the number of years in the life cycle, so that by the fall of 2012, the KPMG audit, by using a 42-year life cycle, could make the claim that the “real cost” of the F-35 was \$45.8 billion—a far cry from the \$16 billion figure used by the government just two years before. But by that time, the Harper government had lost the initiative, and simply stopped the F-35 acquisition, starting over at the beginning—and, ironically, using precisely the management model used by the Trudeau government in the 1970s.

For many observers, the delays caused by Conservative mismanagement represent a policy failure of major proportions. With the procurement in limbo for many years, the Royal Canadian Air Force will be forced to fly a progressively aging fleet of jet fighters well into the 2020s, with all the negative consequences for an effective and cost-effective Canadian defence policy.

But Jay “Hoss” Ballard would not be among those who mourn the political mis-steps that cast the F-35 into limbo. On the contrary: Ballard sees the “reset” of December 2012 as a timely opportunity to rethink the enthusiasm for the F-35. As an accomplished fighter pilot, Ballard argues that we need to be sceptical about the F-35’s stealth capabilities—the very facet of the Joint Strike Fighter that started life as a relatively cheap fighter to end up as a fighter that is not only highly expensive but far behind schedule. Ballard’s analysis leads him to the conclusion that if Canada wants a cost-effective fighter fleet, it should consider the F-18 Super Hornet, which is available immediately. Ballard’s analysis will also add considerable weight to those who are arguing that Canada should follow the Australian lead, and acquire a mixed fleet: F-18 Super Hornets for the short/medium term, and F-35s for the longer term.

* * *

The Claxton Papers series was initiated by Professor Douglas Bland, the Chair of Defence Management Studies in the School of Policy Studies, and supported by the Security and Defence Forum of the Canadian Department of National Defence (DND). With the retirement of Professor Bland, the series was taken over by the Centre for International and Defence Policy at Queen’s University.

This series is named for Brooke Claxton, Minister of National Defence from 1946 to 1954. Brooke Claxton was the first post–Second World War defence minister, and was largely responsible for founding the structure, procedures, and strategies that built Canada’s modern armed forces. As defence minister, Claxton unified the separate service ministries into the Department of National Defence; revamped the National Defence Act; established the office of Chairman, Chiefs of Staff Committee, the first step toward a single Chief of Defence Staff; organized the Defence Research Board; and led defence policy through the great defence rebuilding program of the 1950s, the Korean War, the formation of NATO, and the deployment of forces overseas in peacetime. Claxton was a master of Canadian defence politics: active, inventive, and wise.

Kim Richard Nossal
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“Why don’t we just buy one airplane and let the pilots take turns flying it?”¹

U.S. President Calvin Coolidge balking at the 1922
War Department request to buy more aircraft.

INTRODUCTION

Canada has made a timely decision to re-evaluate its planned purchase of 65 F-35 Joint Strike Fighter (JSF) jets. The rapid advances being made in defensive technologies are in stark contrast to the glacial speed of new fighter aircraft development programs. This development gap is even more problematic as the low observable (LO) technologies, also known as stealth, being built into new fighters become less effective with each passing cycle of Moore’s Law.² Advances in processing speed, the use of multiple radar frequency bands and the addition of passive receivers in adversary air defence systems have eroded the value of LO technology. As importantly, stealth design greatly increases the cost of each aircraft³ but its technology only has value during combat operations in contested airspace. To decide on its purchase, the Royal Canadian Air Force (RCAF) and the government have to grapple with two key questions:

1. Is a stealth capability critical to carrying out the Canada First Defence Strategy (CFDS)?
2. If so, how much stealth/LO do you need and, if it’s becoming less effective, how much are you willing to pay for it?

THE CURRENT ENVIRONMENT

The first imperative in the current RCAF defence environment is that Canada must replace its long serving CF-18⁴ fleet. These jets have kept Canada's contributions to alliance operations at a world-class level, but they are now past their prime and will soon be unable to deliver credible contributions to international operations or ensure the defence of North America. The costs to keep these 30+ years old jets operational is providing diminishing returns and the older technology onboard the Hornet makes it increasingly vulnerable to modern air defence systems and advanced adversary jets.

PAYLOAD-CENTRIC VERSUS PLATFORM-CENTRIC

A primary challenge for aircraft designers is that it takes more than 15 years to develop a new U.S. aircraft.⁵ Meanwhile, computing capacity in defensive systems doubles almost eight times over that same period. Lockheed-Martin, the prime contractor of the F-35 Joint Strike Fighter, is attempting to avoid stale technology in their jet by concurrently producing early design variant aircraft, while continuing with developmental work and testing with maturing technology.⁶ The downside to this approach is that early adopters of the F-35 will have to purchase expensive retrofits to correct any discrepancies that are identified in continuing integration, flight and durability testing.⁷ The concurrent developmental process has proven to be messy and unreliable and is suffering significant delays for a variety of reasons including expanded testing requirements, helmet integration, software development and sensor fusion to name a few.⁸

An alternative to concurrent development is to design and build less technology into a modular platform (aircraft or ship) and focus on the payload. In a 2012 *Proceedings* magazine article, the U.S. Navy Chief of Naval Operations (CNO) outlined the goal of moving the navy away from multi-mission, fully integrated (and expensive) platforms to a more modular and customizable bomb "truck."⁹ Historically, most countries developing a new ship or aircraft want to incorporate leading edge technology into a complex, multi-mission war-fighting platform. In other words, the new platform would have the capability of performing almost all of the potential missions envisioned for that aircraft or ship for the entire life of that platform. This makes sense if the new platform will continuously use all of those capabilities while operating, but it is a waste if it is carrying unused technology. For instance, every F-35 being built will leave the factory with stealth designed into the platform. Pilots, however, will only use those LO properties if they fly into contested airspace, which will likely be a very

small amount of time over the life of that fighter aircraft. Yet, taxpayers will carry the full cost of the integrated LO platform for the life of the jet regardless of its use. Alternatively, a jet that can be modified with an LO kit to lower its radar cross section (RCS) for contested combat operations would significantly reduce the overall fleet cost if you purchased only the number of kits needed to meet international commitments. For broader capabilities, a modular platform that is designed for varying payloads depending on the mission – payloads that could be developed sometimes in a matter of months – would in fact, be state of the art capable. This would provide the benefit of a much faster design timeline for the modular “truck,” and a cheaper technology refresh as the payloads, weapons and sensors increase in capability.

STEALTH AND WHY IT COUNTS

As mentioned in the introduction, all major strike fighter development programs incorporate varying levels of stealth. Modern LO technology made its public debut as a “silver bullet” during the First Gulf War in 1991. The LO technology designed into the F-117 Stealth Fighter specifically masked the jet against adversary radar frequencies that were associated with target engagement and tracking. Because it could not be attacked by radar missiles, the F-117 was used to devastating effect in the early stages of the coalition air campaign to “roll back” the most heavily defended Iraqi targets.

Stealth technology seeks to make an aircraft difficult for opposing radars on the ground or in the air to detect, track and engage with missiles. This is currently accomplished by reducing the amount of radar energy reflected off the stealth aircraft back to the adversary radar antennas. This is done in two ways:

Aircraft Shaping

Aircraft shaping scatters a specific frequency of radar waves in a direction other than back towards the radar transmitter leaving little to no return to indicate that an aircraft is there. In order to achieve the lowest radar cross-section (RCS) possible, aircraft designers incorporate shaping considerations in the earliest design stages.¹⁰ Aircraft shaping accounts for approximately 80-percent of the total RCS reduction for a jet, and requires an expansive use of computer design. The “Skunk Works” design team at Lockheed were the first team to realize the importance of aircraft shaping and initially designed the precursor to the F-117A Stealth Fighter for a minimal RCS, then they tried to figure out how to make it fly.¹¹

Radar Absorbent Material (RAM)

RAM reduces most of the remaining radar energy that hasn't been reflected away by shaping. RAM treatment is used to minimize the remaining 20-percent of radar reflection that aircraft shaping doesn't remove. RAM can include a coating that is painted on, a structural capping put in place over very reflective straight edges, or a combination of the two. Of note, the extraordinarily onerous, post-maintenance RAM treatment process associated with the F-117A was a primary reason for its low availability rate and early retirement. So most aircraft designers seek to minimize its use.

Stealth is important because it provides the Low Observable aircraft with a tactical advantage by interrupting the adversary's engagement "kill chain."¹² The closer you can get to a target unseen, especially if undetected to the point of friendly weapons impact, the better the chance for a kill against it. Many countries are spending billions of dollars to create overlapping umbrellas of surface to air missile (SAM) and surface-to-surface missile (SSM) coverage to prevent other nations or coalitions from operating near their coasts or borders. This is known as contested airspace or as an anti-access/area denial (A2/AD) environment. The strategic goal of this approach is to make it very difficult for a coalition (or assertive neighbour), to operate inside this denied environment without suffering unacceptable losses of their forces. Stealth makes it possible to operate further inside an A2/AD environment than conventional aircraft and target those defensive systems with a higher probability of success.

A major impetus for incorporating stealth into your air force is the reduction in the requirement for supporting aircraft. Unless the attacking forces have LO aircraft to penetrate the A2/AD environment, the only option is stand off missile strikes (both air and ship borne) against missile systems in conjunction with unmanned air system (UAS) strikes to crack open seams in the defensive coverage. This would be combined with massive amounts of electronic attack (from both manned and unmanned platforms) and coordinated cyber strikes to "soft kill"¹³ adversary command and control capabilities. A modern, non-LO attack requires a large number of dedicated support aircraft to degrade sectors of the A2/AD coverage and provide a sanctuary for friendly operations.

RADAR LOVE

Radars use different frequencies depending on the expected function of the system. For instance, long-range, early warning radars use a lower

frequency, 1-2 metre wavelength (VHF). This type of frequency is largely unaffected by moisture in the air, which allows for extended range operations. Current long-range radars can detect a fighter sized target out to 310 miles.¹⁴ This lower radar frequency has historically not posed a threat to stealth aircraft as the target location data, specifically angle accuracy and resolution, was too poor to cue and guide missiles.

In contrast, higher frequency (shorter wavelength) radar waves in the centimetric (S) and (X) bands, have historically been much better at providing quality tracking information to enable SAM systems to engage targets. The X-band is widely used in legacy target tracking systems that were produced in the Soviet Union and exported widely throughout the world. It follows that since this was the primary means of acquiring an aircraft and guiding a SAM onto a target, it would be the frequency band that LO aircraft designers would concentrate on. Countering the X-band is a solid game plan only as long as the folks making adversarial SAM systems continue to play by the same rules...

COUNTER STEALTH CAPABILITIES

Radar and SAM designers in the former Warsaw Pact countries embarked on a crash program to degrade the effectiveness of LO following the game changing combat debut of the F-117A Stealth Fighter in the first Gulf War.¹⁵ Their goal was to improve detection and engagement ranges out to tactically significant distances against LO aircraft. The earliest success in countering stealth occurred during the Kosovo Air War in 1999. The commander of a Serbian SAM battery reportedly embarked on a “home made” modification of radar frequencies for his SA-3 system. This modification resulted in a successful shoot down of one F-117A and significant damage to a second.¹⁶

The basic physics and engineering challenges in LO aircraft design are now widely understood amongst major aircraft firms. Therefore, the stealth “secret” is an open one (especially given the cyber raids at most major defence contractors in the U.S. in the 1990s and 2000s by Chinese and Russian hackers). Having a solid understanding of what shaping techniques would likely go into future western aircraft designs, engineers in the Russian defence industry have been focusing their efforts on thwarting any tactical advantage that could come from it. Recent advances at the air defence manufacturer level in Russia and China have yielded impressive results as can be seen in the photo below.



This Nizhny-Novogorod Research Institute (NNIIRT) 55Zh6ME radar system was on display at the August 2013 MAKS airshow at Zhukovsky, just outside of Moscow. It features VHF, L-band and S-band *modules* that are all part of an integrated radar system. Each *module* contains an active, electronically scanned array (AESA) radar. (AW&ST / Bill Sweetman Photo)

Current Russian counter stealth radar technology rests on three pillars. The first is a heavy reliance on the VHF band for detection and cueing; the second is the adoption of state of the art technology, which includes the integration of commercial, off the shelf (COTS) hardware and software to improve cueing and fuse inputs from multiple sources;¹⁷ and third is the addition of passive receivers¹⁸ onto new systems as well as retrofitted onto older SAM systems.

WHY VHF?

As mentioned earlier in aircraft shaping, LO aircraft were designed to minimize X-band reflected energy and ignored the VHF radar frequency because it wasn't being used as part of the *kill chain*. Well, interestingly, the VHF wavelength of 1-2 metres tends to be at the same length as major features of most tactical sized aircraft (such as wingtips and control surfaces). The Australia Air Power website describes it this way:

A fighter sized aircraft such as the JSF will see most of its carefully designed shaping features fall into the resonance or Raleigh scattering regions [of VHF waves], where shaping is of little or no import, and skin depth penetration of the induced electrical surface currents defeats most absorbent coatings or laminates.¹⁹

In other words, the radar energy will reflect back off of the target aircraft without regard to shaping techniques or RAM.²⁰ For illustration of how significant this is, Bill Sweetman from *Aviation Week & Space Technology* spoke with a Russian engineer at the MAKS air show in August 2013, regarding the difference in aircraft RCS from X-band to VHF. The engineer noted that, "the Chinese DF-15 short-range ballistic missile has a 0.002 m2 RCS in X-band, but is a very non-stealthy 0.6 m2 in VHF."²¹ That equates to an RCS that is 300 times larger in VHF than in X-band.

Russian VHF radar technology improvements start with the addition of multiple AESA radars covering different frequency bands. AESA radar allows for beam steering as well as greatly improved data processing and enhanced target angular track data over conventional radar transmitters. Also important are the jamming resistance capabilities inherent in the AESA radar due to nulling techniques²² as well as the COTS technology that has improved the hardware as well as software of newer SAM systems. All of these improvements have resulted in the ability for newer SAM systems to operate in a heavy jamming environment and still display one target if it receives returns on that same contact from two or more sensors operating in different bands. This means that LO targets can be acquired in VHF and then handed off to the L and S-band radars for improved targeting quality and engagement.

PASSIVE AGGRESSIVE

Perhaps the most worrisome technical development in Russian SAM systems is the incorporation of passive receivers. These multi-antennae systems are capable of receiving and triangulating active electromagnetic emissions from adversary aircraft radars, data link and radios. Even more troublesome is that transmissions from any source (multi-band radars, cell phone signals, AM and FM radio, television broadcasts, etc.) that reflect off of an aircraft can be collected and used for acquiring targets and cueing missiles. Since these receivers do not emit any transmissions, they are very difficult to locate and target and anti-radiation missiles will not see them. Aircraft that rely on using their own onboard AESA radars for jamming active SAM site transmissions will highlight themselves to passive receivers. Passive receivers can be hidden virtually anywhere and if located in an urban environment, will present significant collateral damage concerns if

they can actually be found. These receivers can be incorporated into legacy SAM systems as well as integrated into cutting edge Integrated Air Defence Systems (IADS) for added redundancy and counter LO capability.

The biggest takeaway from advances in counter-stealth is that highly integrated aircraft are taking so long to achieve initial operational capability that relatively cheap defensive systems can be fielded faster and with fresher technology. An opponent can be forced to spend huge amounts of money to counter the low cost defensive systems that are proliferating. Each *counter* has to be integrated into all aircraft, which makes them heavier, slower and less manoeuvrable. Aircraft then become so expensive to buy and operate that you can't purchase as many as needed, nor can you buy sufficient quantities of weapons and payloads to make them a true force multiplier.²³ Hmm – making your adversary spend themselves into bankruptcy to try and keep up with you militarily – does anything there sound familiar *comrade*?²⁴

IS STEALTH REQUIRED TO CARRY OUT THE CANADA FIRST DEFENCE STRATEGY?

Any new aircraft has to be capable of successfully carrying out its portion of the six core missions laid out in the Canada First Defence Strategy (CFDS). The primary of those six missions is, “Conduct daily domestic and continental operations, including in the Arctic and through NORAD.”²⁵ This mission requires aircraft capable of operating in the full range of Canadian climates, including the Arctic extremes. Fighters must be able to intercept and escort encroaching aircraft as well as engage hostile targets with air-to-air missiles – missions that can be performed by modern air superiority jets or multi-role fighters. The F-35 was designed as a multi-role platform and is not considered “a high-end air-to-air” fighter²⁶ by either the commander of the US Air Force Air Combat Command²⁷ or some international buyers, but it should be capable of handling domestic air-to-air missions. Interoperability with NORAD command and control is an absolute requirement as is the ability to maintain a combat air patrol presence over Canadian cities and vital areas. Since the RCAF fighters will be operating over friendly territory and not denied airspace, LO is not a requirement for this core mission. In fact, stealth might degrade the impact of a robust, forward deployed deterrence posture if Canadian aircraft are not detected at range by the forces they are trying to deter.

The other CFDS core mission area that a new fighter aircraft will contribute to is, “Lead and/or conduct a major international operation for an extended period.”²⁸ This type of mission can range from disaster relief

to combat and requires an aircraft capable of multi-spectrum operations. Capabilities required include, but are not limited to: non-traditional intelligence, surveillance and reconnaissance, offensive and defensive counter air operations, battlefield interdiction, strike, close air support and the suppression of enemy air defences (SEAD). Most recent international operations have occurred in largely permissive environments (Iraq, Libya and Afghanistan) with Kosovo being the exception. In permissive environments, stealth is a wildly expensive capital cost to carry around on every, unopposed combat sortie. In a contested environment, LO will make the F-35 less visible to X-band radars than other legacy aircraft. Unfortunately, the proliferation of VHF active, electronically scanned array (AESA) radars will force almost all U.S. and NATO airborne strike packages to include a strong compliment of SEAD aircraft and anti-radiation missiles within that flight. For Canada, this means that even if the decision is made to buy the F-35, it will not go in alone against a VHF AESA / passive radar equipped opponent.

HOW MUCH STEALTH DOES CANADA WANT TO PAY FOR?

The government of Canada announced in December 2012, that they were pulling back from a *non-binding commitment* to buy the F-35 Joint Strike Fighter (JSF). While this decision was taken, in part, due to the Auditor General report that took issue with the sole-source contract award to Lockheed-Martin, it had to be influenced by the numerous uncertainties that are still plaguing the development program. Primary of which are the purchase price and operating costs, which have slowly ballooned over the last decade. The JSF was pitched as an affordable replacement aircraft that was going to cost less and be available sooner than the alternatives, with more capability and be cheaper to operate than current, legacy aircraft (F-16 & FA-18). Sadly, it doesn't appear that any of these promises will come true. Without realistic costing data being supplied by Lockheed-Martin, the government of Canada and DND officials, government critics and the media have been left to estimate the purchase and operating costs per jet. The predicted costs have swung from highly optimistic to deeply pessimistic given the agenda of the “estimators” and none have been entirely accurate.

In the year and a half that has passed since Ottawa's decision to reset the next generation fighter purchase, the costing data and availability timeline have become a little clearer, with risk still to the upside due to the continued unknowns. The F-35's purchase price, which was expected to be around \$70-million USD²⁹ per jet in 2009, has swollen to \$100-million per jet today. Of note, the \$100-million figure doesn't include the engine,

which currently runs around \$14-million per motor, nor the retrofit cost of \$7-10-million dollars³⁰ per jet. The F-35's projected operating cost per flight hour, an expense that accounts for 80-percent of the life cost of a fighter jet, doesn't offer any good news either. The USAF, who will be the largest operator of the F-35, are using operating cost estimates of \$32,000 per flight hour for the F-35 compared to slightly less than \$25,000 per F-16 flight hour.³¹ Availability is also a risk factor since there have been continuing delays in software development, helmet integration, engine reliability and flight testing. The best estimate is that "international partners will not be operational, with the capabilities that they have signed up for, until 2020."³² Finally, due to aircraft weight gain and engineering limitations, the F-35 performance is no better than the 1970s designed aircraft (known as fourth generation³³) it is supposed to replace. If an F-35 pilot finds him or herself in a dogfight, they will have to rely on helmet / sensor integration and high off-boresight weapons to survive and will be unable to disengage (run away) from a persistent, fifth generation opponent. If engaged by an enemy SAM system, the JSF, unlike the F-22, will be unable to quickly accelerate out of, or climb above the threat weapons engagement zone and will remain vulnerable for A VERY LONG TIME.

All of the cost increases and delays in the F-35 program have opened the door for competitors, with Boeing making a strong case for its FA-18E/F/G Super Hornet. This jet is still in production at the Boeing factories in St. Louis, Missouri and costs \$56-million each. The U.S. Navy has been flying these jets for more than a decade and uses a cost-per-flight-hour model of \$16,000.³⁴ The U.S. Navy will be flying this jet well into the late 2030s to mid 2040s, so it will remain a fully interoperable, front line strike fighter aircraft for decades to come. Transition costs will be much lower than those associated with the F-35 since the Super Hornet's flight characteristics are very similar to the RCAF's current jets and the maintenance procedures follow the same general design philosophy of the older Hornet. The most recent modifications to the Super Hornet include a 50-percent frontal RCS reduction, more efficient engines, improved sensor fusion and an infrared search-and-tracking sensor for counter LO and passive targeting. Certainly, the Super Hornet has a larger X-band RCS than the JSF, and against legacy Soviet SAM systems, will be more visible than the F-35. However, when compared against a VHF AESA and passive radar system, that difference becomes less consequential if not downright moot.

A final cost that has to be factored into the new fighter purchase is that the current RCAF fleet of aerial tankers will not be able to refuel the JSF variant that Canada wants to buy. All RCAF tankers are configured with a

“probe and drogue” system, which has a long hose that is unreeled behind the aircraft, with a refuelling basket at the end that the pilot plugs into with an extendable probe in order to receive fuel. The F-35A, the jet Canada had initially signed up to buy, is the USAF model that uses that service’s aerial refuelling standard of “boom and receiver.” In this system, the receiving jet is flown into position behind the refuelling tanker and a rigid boom is guided by a crewman onboard the tanker, into the F-35’s receiver port behind the cockpit in order to transfer fuel. These two systems are incompatible. The RCAF will be forced to replace all of its CC-130 tankers with a new complement of “boom and receiver” tankers and its two existing CC-150 Polaris tankers will either require an expensive modification or replacement as well.

HOSS’ RECOMMENDATIONS

I was the Operations Officer and a Topgun certified Strike Fighter Tactics Instructor (SFTI) at the U.S. east coast FA-18 weapons school in the late 1990s and recall being amazed during a briefing at the JSF and its capabilities. At the time, that jet was envisioned as a cheap and technologically overwhelming answer to current and projected adversary capabilities. Unfortunately, the deeply flawed developmental process of the F-35 took away the “cheap” part and the weapons builders of the world didn’t follow our script on stealth. Their relatively cheap and elegant solutions in VHF AESA radars and passive receivers are widely negating the effectiveness of current, X-band LO technology. As well, many sacrifices of performance were made in favour of stealth rendering the F-35’s performance no better than the jets it was originally designed to replace.

Canada’s next fighter purchase decision should be most impacted by ensuring that the new aircraft can carry out the missions outlined in the CFDS as cost effectively as possible. The F-35 will almost certainly be able to fulfill the six core CFDS missions, but at what cost – and when? The JSF is still a work in progress, with the potential for more delays and cost increases in the years ahead. The LO technology in the JSF does not protect it against the newest, proliferating threat systems, and it will have to be protected in contested airspace or use stand off weapons. A 65-plane, F-35 buy will drain the RCAF’s budget so they will be unable to fly them as needed or afford many of the most current payloads available for stand off attack. The RCAF’s legacy CF-18s are aging and combat capable F-35s are not a reality until 2020 at the soonest.

In my opinion, it comes down to a fiscal argument. If Canada’s new fighter is not affordable and drains resources from other programs, then

the RCAF may feel like U.S. President Coolidge, and will only want to buy and operate “one” jet. But there is a compelling argument in favour of the FA-18E Super Hornet. Canada can buy two advanced Super Hornet fighters today for the same price as one F-35, which won’t be available until some point in the next decade. Then, when you compare the JSF’s and the Super Hornet’s operating cost per flight hour, an expense that represents a majority of the life cost of a fighter, the decision becomes a no-brainer. The Super Hornet would cost half as much to operate as the F-35 while providing Canada with all the capabilities required to carry out the fighter portion of the CFDS. The cost efficiencies could then be directed to more operational flying, periodic interoperability modifications to the jets and buying more capable payloads in greater numbers.

Notes

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2. Intel Corporation, "Talk the Talk," accessed 23 October 13, <http://www.intel.com/content/www/us/en/history/museum-terminology.html>. [Moore's Law is named after Intel co-founder Gordon Moore who predicted that the number of transistors incorporated in a chip will double approximately every 24 months.]
3. Cynthia R. Cook, *et al.*, *Final Assembly and Checkout Alternatives for the Joint Strike Fighter*, (Santa Monica, CA: RAND Corporation, 2002), 108-109.
4. The official RCAF designation for the Hornet is the CF-188, but the author is using the popular designation of CF-18 to refer to the jet.
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11. Ben Rich and Leo Janos, *Skunk Works* (New York: Back Bay Books, 1994), 28-36.
12. United States Air Force, *Irregular Warfare Doctrine Document 2-3*, (USAF: Air Force Doctrine Development and Education Center, August 2007), 16. ["Kill Chain" as in the find-fix-track-target-engage, assess (F2T2EA) process associated with prosecuting dynamic (emergent) target sets.]

13. A “soft kill” refers to a non-lethal or temporary impact against a system. It could include jamming, cyber attack or an anti radiation missile hit that knocks the radar off line, but leaves the launcher and missiles intact. The system would be unable to function long enough to allow for friendly operations inside its weapons engagement zone. A “hard kill” includes the destruction of that equipment, and if lucky, the deaths of the trained SAM operators and command and control decision makers.
14. Bill Sweetman, “Cloak and Dagger” *Aviation Week & Space Technology*, September 2nd, 2013: 29.
15. Dr. Carlo Kopp, “Evolving Technological Strategy in Advanced Air Defense Systems,” *Joint Forces Quarterly* issue 57 (2nd Quarter 2010): 87, <http://www.ndu.edu/press/jfq-57.html>.
16. USA Today, “Serb Discusses 1999 Downing of Stealth,” accessed 2 October 2013, http://usatoday30.usatoday.com/news/world/2005-10-26-serb-stealth_x.htm.
17. Arend G. Westra, “Radar versus Stealth: Passive Radar and the future of U.S. Military Power,” *Joint Forces Quarterly* issue 55 (4th Quarter 2009): 140, <http://www.ndu.edu/press/jfq-55.html>. Also see: Kopp, “Evolving Technological Strategy in Advanced Air Defense Systems”..., 90.
18. Westra, “Radar versus Stealth:...”, 139-141.
19. Australian Air Power, “Russian / PLA Low Band Surveillance Radars,” accessed 3 October 2013, <http://www.ausairpower.net/APA-Rus-Low-Band-Radars.html>.
20. Bill Sweetman, “Counter-Stealth: Russian radars shrink the U.S. lead,” *Aviation Week & Space Technology*, September 16, 2013: 16. Also see: Australian Air Power, “Russian / PLA Low Band Surveillance...” “Background” discussion.
21. Sweetman, “Counter-Stealth...”, 16.
22. Kopp, “Evolving Technological Strategy in Advanced Air Defense Systems”..., 90.
23. Author is using the DOD definition of the phrase “force multiplier,” which is: “A capability that, when added to and employed by a combat force, significantly increases the combat potential of that force and thus enhances the probability of successful mission accomplishment.” Source: JP 3-05.1
24. This question refers to the Reagan Administration’s successful strategy that forced the Soviet Union to spend itself into a financial collapse to counter new U.S. military technological and qualitative force advantages in the 1980s.
25. Department of National Defence, *Canada First Defence Strategy*..., 3, 7.
26. Bill Sweetman, “Cash Crunch,” *Aviation Week & Space Technology*, November 25, 2013: 42. [This is the opinion of the commander of the Italian Air Force’s 36th Fighter Wing when he recently discussed why they will fly the Typhoon as well as the JSF.]

27. Aaron Mehta, “Air Combat Command’s Challenge: Buy New or Modernize Older Aircraft,” *Airforce Times*, February 2, 2014, <http://www.airforcetimes.com/article/20140202/NEWS04/302020005/Air-Combat-Command-s-challenge-Buy-new-modernize-older-aircraft>. General Hostage, Commander of the ACC, stated that, “The F-35 is not built as an air superiority platform. It needs the F-22.”
28. Department of National Defence, *Canada First Defence Strategy*..., 9-10.
29. All dollar amounts stated are in U.S. dollars. Of note, at the time of writing, the Bank of Canada was expecting one Canadian dollar to be worth .90 cents U.S. in the near future and stay at that level for some time. Therefore, add 10-percent to the dollar amounts shown to arrive at expected costs in Loonies.
30. Amy Butler, “Cost Target,” *Aviation Week & Space Technology*, October 7, 2013: 31-32. [This is part of the *concurrency cost* to correct discrepancies that are still being identified in flight and integration testing.]
31. Amy Butler, “‘Normalized’ Apples,” *Aviation Week & Space Technology*, June 3, 2013: 27.
32. Bill Sweetman, “Unruly Partners,” *Aviation Week & Space Technology*, April 29, 2013: 17.
33. For a brief, but informed discussion on aircraft “generations” I recommend you read Dr. Paul Mitchell’s article at the following website: Canadian Military History, “Moore’s Law and Fifth Generation Fighters,” accessed 9 September 2013, <http://www.canadianmilitaryhistory.ca/moores-law-and-fifth-generation-fighters-implications-for-canada-by-paul-t-mitchell/>.
34. Canadian Broadcasting Corporation, “Boeing touts fighter jet to rival F-35,” accessed 19 November 2013, <http://www.cbc.ca/news/politics/boeing-touts-fighter-jet-to-rival-f-35-at-half-the-price-1.1320636>.

About the Author

Jay Ballard is a 28-year veteran of the Aerospace & Defence sector. He is a full time international military consultant, speaker and professional military educator with clients in Canada, the US and central and eastern Europe. He retired from the US Navy in 2008 after flying 3,800 hours in strike fighter aircraft, which included the FA-18 Hornet (2,000 hours), the F-5E, F-16A and TA-4J. He deployed five times around the world and participated in numerous operations while accumulating more than 500 arrested landings on aircraft carriers. He held qualifications that included: Topgun Strike Fighter Tactics Instructor, Carrier Air Wing – THREE Combat Strike Leader and USS ABRAHAM LINCOLN (CVN-72) Air Boss, among others.



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