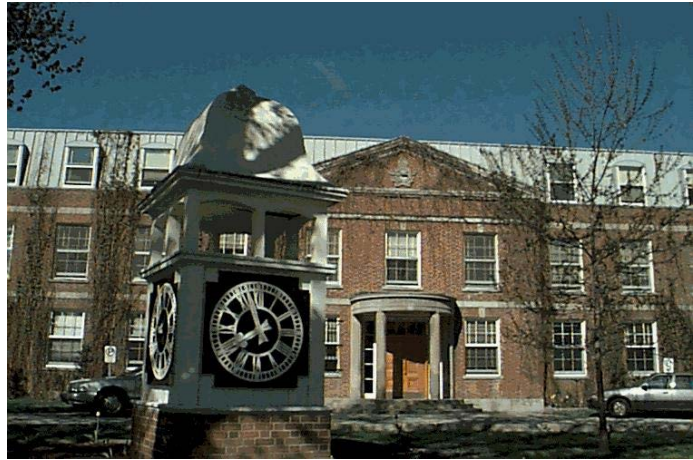


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**DOMINATING THE THIRD DIMENSION –
FIFTH GENERATION FIGHTER AIRCRAFT IN THE RCAF**

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JCSP 40

Exercise Solo Flight

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CANADIAN FORCES COLLEGE – COLLÈGE DES FORCES CANADIENNES

JCSP 40 – PCEMI 40
2013 – 2014

SOLO FLIGHT ESSAY

DOMINATING THE THIRD DIMENSION – FIFTH GENERATION**FIGHTER AIRCRAFT IN THE RCAF**

By OTL (DEU GAF) Marc Grüne

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Word Count: 5285

Compte de mots : 5285

DOMINATING THE THIRD DIMENSION – FIFTH GENERATION FIGHTER

AIRCRAFT IN THE RCAF

The power of an air force is terrific when there is nothing to oppose it.

Winston Churchill, Prime Minister during World War II

INTRODUCTION

The quietness at night in downtown Baghdad could not hide the fact that the ultimatum, on the 15th of January 1991 towards Saddam Hussein to withdraw from Kuwait, ran out. Thousands of Iraqi soldiers with high developed surface-to-air-missiles (SAM) and anti-aircraft-guns (AAA) were ready to defend Iraq's capital. The world focused with anxious attention on the reaction of the coalition forces when on the 17th of January at 03:00 o'clock at night, undetected from Iraqi air defense, the F-117 stealth bomber dropped the first precision bomb on Baghdad's *CNN Tower* commencing Desert Storm. This powerful demonstration of stealth technology enabled the coalition to destroy a vital communication tower in order to disrupt the command and control network of Saddam Hussein. The massive air campaign lasted 39 days and the coalition flew over 100.000 sorties, dropping 88.500 tons of bombs.¹ Subsequently the ground campaign started and hundred hours afterwards, on the 28th of February, President Bush declared a ceasefire and stated that Kuwait had been liberated.

¹ Edwin E. Moise, "Limited War: The Stereotypes", last accessed 13 May 2014, <http://www.clemson.edu/caah/history/FacultyPages/EdMoise/limit1.html>

While Operation Desert Storm serves as a paragon for the success of modern airpower and the importance to retain technological advantages, this essay will focus on a much closer issue concerning modern airpower. This paper will confirm that the best possible replacement for the McDonnell Douglas CF-18 in the Royal Canadian Air Force is the fifth generation fighter aircraft, the Lockheed Martin F-35 Lightning II joint strike fighter (JSF).

The Royal Canadian Air Force (RCAF) is seeking a replacement for its aging fleet of 77 CF-18 Hornet fighter aircraft in the next decade. Despite the modernisation of the fleet completed in 2010, the airframe will limit its utilization to about 2020 requiring Canada's next generation fighter aircraft. This dissertation will analyse predominantly three major areas: Canada's approach to security, the future fighter capability requirements and different procurement options. This methodology provides a clear and logical framework to examine and review a variety of causes in order to determine why a fifth generation fighter aircraft is the best choice for Canada. The overall analysis will be summarized in the conclusion.

In the first Chapter the strategic direction that guides the Canadian Forces, and more specifically the Canadian Air Force, as well as international and domestic challenges are examined in order to understand Canada's approach to security.

CANADA'S APPROACH TO SECURITY

A nation's ability to arm and protect itself is a strategic issue, both militarily but primarily politically. The Canadian Armed Forces receive their strategic guidance from

the Government of Canada (GC) constituted in Canada's First Defence Strategy (CFDS).² The purpose of Canada First Defence Strategy gives Canada clearly defined missions and capabilities which can be assured by a modern military. It consists of three key defence roles: defend Canada by delivering quality protection at home, defend North America by being a strong, reliable defence partner and contributing to international peace and security by projecting leadership abroad.³ The level of ambition focuses on six core missions, among others the daily domestic and continental operations, including the Arctic and through the North American Aerospace Defense Command (NORAD), lead and/or conduct a major international operation for an extended period and deploy forces in response to crises anywhere in the world for shorter periods.⁴

Consequently the Government of Canada's approach to security covers domestic as well as international duties. Aerospace assets have traditionally been required to support all of these roles and the mission of the Royal Canadian Air Force (RCAF) elucidates the level of commitment. The mission of the RCAF provides the Canadian Armed Forces with relevant, responsive and effective air power capabilities to meet the defence challenges of today and into the future. Indeed the Air Force of tomorrow requires advanced technology in combination with robust capabilities that contribute directly to its relevance and combat effectiveness.⁵

By all means the spectrum of demands for the CF is defying with a relatively small military compared to the size of Canada and its international commitments. For that reason the RCAF has to be equipped with modern weapon platforms to meet future

² Government Of Canada, "Canada First Defence Strategy - Summary", last accessed 13 May 2014, <http://www.forces.gc.ca/en/about/canada-first-defence-strategy-summary.page>

³ *Ibid.*

⁴ *Ibid.*

⁵ Department of National Defence, B-GA-400-000/FP-000, *Aerospace doctrine*, (Ottawa: Canada, 2010), 25

challenges. Indeed if the CF-18 will be replaced around 2020, Canada must assure that the new fighter aircraft is capable to cope with different scenarios in the next decades. The 1994 White Paper on Defence stated to purchase only equipment that would be *the best of the best*.⁶

In order to understand Canada's approach to security in the international environment with regards to fighter aircraft, preceding commitments can provide prominent examples. In the past, the RCAF demonstrated commitments abroad with the NATO in Kosovo in 1999; the CF-18 participated in UN-sanctioned NATO operations to protect ethnic-Albanian Kosovars as part of Operation Allied Force.⁷

Furthermore over Libya six CF-18 aircraft have been deployed as part of NATO's Operation Mobile.

However one could argue that CF-18 is presently not the best fighter aircraft on the planet but in all the above mentioned commitments, the RCAF accomplished successfully their mission. Therefore instead of acquiring the best fighter aircraft (fifth generation fighter aircraft), the second best aircraft is sufficient enough (fourth generation), which will be explained in the next chapter, to perform and fulfill the needs.

The second argument against substantial investments in modern fighter aircraft corresponds to the end of the Cold War where the world security structure changed from a bipolar world to a multi-polar one. Since the two great power nations, the U.S. and the former Soviet Union, no longer require to build-up military forces to specifically counter what they believe to be the ideological expansion of the other nation's interests.⁸ 9

⁶ Department of National Defence, UA600 A112 1994, *Defence White Paper*, (Ottawa: Canada, 1994), 11

⁷ Tim Dunne, "A Case for the F-35 Lightning," *Canadian Military Journal* 11, no. 4 (Autumn 2011): 59.

⁸ Ken Booth, *Statecraft and Security: The Cold War and Beyond*, (Cambridge: Cambridge University Press, 1998), 63.

While those arguments seem initially convincing, one must understand past and present security challenges in order to predict future security issues. The world of the 21st Century has already proven to be unpredictable and the unquestionable example illustrates the annexation of Crimea by the Russian Federation and the imminent threat from Russian force posture along the Ukrainian border. Canada acted as one of the first nations and deployed six CF-18 fighter jets from Canadian Forces Base Bagotville in Quebec for Romania, as part of Canada's contribution to a NATO operation to promote security in eastern and central Europe (X).⁹ If the crisis would further increase, suddenly the CF-18 would have to face equipollent Russian fighter aircraft and high threat SAM's in higher quantities. If we project this example into future challenges, the second best aircraft might lack the required technological advantages to master prospective air combat or equally important intelligence, surveillance and reconnaissance (ISR) missions.

Additionally while western nations have enjoyed technological superiority since World War II, this advantage has not remained constant since potential adversaries are also increasing their military capabilities. For instance, China and Russia continue to develop and export increasingly sophisticated fighter aircraft and SAM systems. We cannot know what threats and dangers the future will bring but we can learn from past and present situations, thus we must anticipate that coming operations can be expected to happen in a similar manner, with little or no notice able to face advanced weapon systems.¹⁰

⁹ CTV News, "*Mission-at-a-glance: What are Canada's CF-18s doing in eastern Europe?*", last accessed 13 May 2014, <http://www.ctvnews.ca/canada/mission-at-a-glance-what-are-canada-s-cf-18s-doing-in-eastern-europe-1.1797213>

¹⁰ Tim Dunne, "A Case for the F-35 Lightning," *Canadian Military Journal* 11, no. 4 (Autumn 2011): 59.

As a consequence, the fifth generation fighter aircraft (FGFA) requires the highest technological standards in various areas of capabilities (will be explained in greater detail in Chapter 2), as stated in the introduction of this paper through the Operation Desert Storm example, enabling the GC and the CAF to achieve the desired result.

Once we have analyzed Canada's approach to security abroad, we will devote the last part of this chapter to domestic security responsibilities.

Canada's most important defence and security partner is the United States of America. From a defence perspective, Canada – United States (CANUS) ties are longstanding and persistent, with some agreements spanning more than five decades of evolving security challenges.¹¹ One prominent example presents the NORAD commitment between both nations. Founded over 55 years ago, NORAD mission provides aerospace surveillance, identification, control and warning for the defence of Canada and North America.¹²

(<http://www.norad.mil/AboutNORAD/CanadianNORADRegion.aspx>)

Canada's contribution to the aerospace control aspect of this agreement has been in the form of CF-18s on Air Sovereignty Alert (ASA) working in close coordination with USAF assets such as F-15s and F-16s. A FGFA with a fully integrated air capability would increase the RCAF and USAF interoperability as well as the ability to respond to threats towards North America resulting in higher security.

Opponent views, with regards to the FGFA, state that unmanned combat air vehicles (UCAV) will be a more cost effective way to accomplish the roles of fighter

¹¹ Department of National Defence, A-GA-007-000/AF-002 *The Aerospace Capabilities Framework* (Ottawa: DND Canada, 2003), 30.

¹² NORAD, "Canadian NORAD Region", last accessed 13 May 2014, <http://www.norad.mil/AboutNORAD/CanadianNORADRegion.aspx>

aircraft in the future without jeopardizing human life. While there is a certain potential in UCAV, this argument does not apply especially in terms of aerospace control with regards to intercepting aircraft.

Take as an example the scenario where terrorists would hijack an airliner from Air Canada in order to use it as a weapon against the Parliament of Canada in Ottawa. Canadian authorities would decide to shoot down the airliner in order to avoid a tragedy similar to that of 9/11. Nations in Europe argue that in this situation, visual identification with pilot eyes on the target are required prior to shoot down.¹³

Additionally, there is no doubt that piloted aircraft will be dedicated to missions where on-scene judgement is a priority--such as close air support (CAS) or strike missions near civilian populated areas.¹⁴²³

In any situation where the ASA aircraft is scrambled to intercept or shoot down another aircraft, time is critical and modern fighter aircraft, such as the FGFA could decrease that time period due to its superior detection system and enhanced pilot awareness provided by onboard systems. (see Chapter 2) Likewise the above mentioned example can be used to understand how Canada might deal with security challenges in the north. Canada is one of seven nations which share the Arctic whereas four nations are competing with Canada for increased ownership. Furthermore several nations contest Canada's claim for the Northwest Passage that lies within the Canadian Arctic

¹³ Bundeswehr, "QRA presentation Fighter Wing 74", last accessed 13 May 2014, file:///C:/Users/Marc/Downloads/Pressemappe_Neuburg_en.pdf

¹⁴ William B. Scott, "Unmanned Aerial Vehicles," last accessed 13 May 2014, http://www.gyrodynhelicopters.com/uavs_today.htm

archipelago.¹⁵ If the Passage becomes internationalized then the airspace above it also becomes internationalized. Russian president Dmitry Medvedev announced in March 2010 his intention to ensure Russian access to mineral resources in the Arctic and acknowledged that competition over these resources could spark future conflicts between Arctic states.¹⁶

This creates another strategic challenge for Canada with Russian ISR assets approaching Canadian airspace.¹⁷ Hence the CAF need a highly capable platform to deal with those challenges and defence planners must prepare for the potential future adversaries i.e. Russia.

The first chapter has illustrated the strategic direction that guides the CF, it also demonstrated through different examples that Canada's approach to security is challenged by a variety of security issues abroad as well as domestically. The world will likely remain insecure and with these potential threats in mind Canada together with its strongest partner the US have to continue to pursue high technology aerospace capabilities like the F-35.¹⁸ This enables CG maximum flexibility in countering security challenges in the future and provides the CF the technological advantages and capabilities needed to ensure mission success worldwide.

The following chapter will analyse the future capability requirements.

¹⁵ Government Of Canada, "Canada's Arctic Foreign Policy", last accessed 13 May 2014, http://www.international.gc.ca/arctic-arctique/arctic_policy-canada-politique_arctique.aspx?lang=eng

¹⁶ Tim Dunne, "A Case for the F-35 Lightning," Canadian Military Journal 11, no. 4 (Autumn 2011): 59.

¹⁷ *Ibid.*

¹⁸ Samuel Walker, "Interoperability at the Speed of Sound: Canada-United States Aerospace Cooperation...Modernizing the CF-18 Hornet," (Queen's University Kingston (Ontario) Centre for International Relations, 8 Feb 2013),

5, <http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA393987>.

FUTURE CAPABILITY REQUIREMENTS

As the Government of Canada announced in the CFDS in 2008¹⁹ that it would be buying a next generation fighter, the field of potential replacement fighters could be considerably narrowed.²⁰ For the purpose of the following examination it is helpful to understand the general difference between a fourth generation plus (4+), a fourth generation plus plus (4++) and a fifth generation fighter aircraft.

The definition of fighter generations has long been subject to debate. However, most agree that the generations break down along the mentioned broad lines: The 4+ generation features high agility, sensor fusion and reduced signatures like the Eurofighter Typhoon, the Su-30, the advanced versions of F-16 and F/A-18 as well as the Rafale.

The further advanced 4++ generation involves active electronically scanned arrays (advanced radar), continued reduced signatures or some active (waveform canceling) stealth, some supercruise (the ability to fly continuously at supersonic speed without use of afterburner) like the Su-35 and the F-15SE.

Finally the most advanced fighter aircraft to date the fifth generation includes all-aspect stealth with internal weapons, extreme agility, full-sensor fusion, integrated avionics and some supercruise like the F-22 and the F-35. The only fifth generation aircraft currently in operation is the F-22 Raptor, unavailable for export.²¹

¹⁹ Government Of Canada, "Canada First Defence Strategy - Summary", last accessed 13 May 2014, <http://www.forces.gc.ca/en/about/canada-first-defence-strategy-summary.page>

²⁰ John Siebert, "What's driving the F-35 Procurement?" *The Ploughshares Monitor* Vol 32, no. 1, (Spring 2011): 22. <http://ehis.ebscohost.com/ehost/detail?vid=5&sid=9a695e2a-3d63-4776-862e-2dd650a0e56d%40sessionmgr13&hid=2&bdata=JnNpdGU9ZWwhvc3QtbGl2ZQ%3d%3d#db=poh&AN=65290279>.

²¹ Martin van Creveld, *The Age of Airpower*. (New York: Public Affairs, 2011), 204

The listing of the different generations helps differentiate roughly between the technological standards. Nevertheless we will focus predominantly on the 4+ generation and FGFA.

The current CF-18A Hornet fighter aircraft, purchased in the 1980s, will be nearly 40 years old when they are ultimately decommissioned and replaced.²²

However, the fighter airplanes of the future have to endure probably the same timeframe especially due to substantial costs. Hence the CF-18 should be replaced around 2020 and the next fighter airplane will remain in service until 2060.

This understanding is vital in order to analyse how the choice of the desired aircraft impacts the GC. Therefore the RCAF gathered specific requirements for the future fighter aircraft to make sure it is suitable and can cope with future operations. The Department of National Defence (DND) commenced an evaluation process, considering western 4+ generation and FGFA with the demands that the future fighter aircraft should be interoperable with key allies, have specific performance parameters, be deployable, be survivable as well as contribute to integrated intelligence, surveillance and reconnaissance capability (JX).²³ At the end of the evaluation, Canada concluded that only three airplanes, namely the Eurofighter, the F-18 E/F and the F-35 can be considered. However the F-35 was the only airplane that met all the specification requirements. While further details of these specific requirements must remain classified, we will evaluate three major capabilities of the FGFA in the following order: all-aspect stealth, engine redundancy and full-sensor fusion.

²² Tim Dunne, "A Case for the F-35 Lightning," *Canadian Military Journal* 11, no. 4 (Autumn 2011): 55.

²³ Ken Pennie, "Strategy and the F-35," *Front Line Defense* 11, no. 3 (Autumn 2011): 36.

ALL ASPECT STEALTH

A FGFA classification reveals the most advanced generation of fighter aircraft available today. This generation is the first to fully benefit from computer assisted design techniques like novel materials, special shaped airframes resulting in high maneuverability and all aspect stealth capabilities. The increasing accuracy and reliability of guided weapons demands that airframes become less detectable to electronic systems.²⁴ Stealth technology changed the nature of the battlefield in the past years. The most distinct demonstration was the crucial role of the USAF F-117 Nighthawk bomber in Operation Desert Storm as stated in the introduction.

Stealth itself should not be considered as the cure-all capability of Canada's next fighter aircraft. Stealth critics allege that stealth technology will be detected in the future. Indeed U.S. military sources acknowledge that current stealth technology will likely be defeated in the next few years by advances in radar and infrared technologies.²⁵ 32

However without diving into the roots of stealth and radar technology, one must understand that opposing radars (air or ground assets) might be able to detect stealth airplanes in the future but missiles are able to shoot down other aircraft.²⁶ Those missile heads work with Pulse Doppler Radar (advanced missiles) and are unable to detect stealth airplanes. Therefore they will miss their target in the final phase of the flight.²⁷

²⁴ Paul Stavatti, "Cold Plasma Cavity Active Stealth Technology", last accessed 13 May 2014, <http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA432633>

²⁵ Pat Cooper, "U.S. Stealth Enhancements are Key to 'Air Occupation,'" in *Defence News* (16-22 September 1996, 1. in Elinor C. Sloan, *The Revolution in Military Affairs* (Kingston: McGill – Queen's University Press, 2002), 5.

²⁶ Paul Umrysh, interview by Marc Grüne, April 30, 2014, Canadian Forces College

²⁷ *Ibid.*

One example of missile engagements is the NATO bombing campaign in Kosovo in 1999 where an estimated 700 SAM's were fired at coalition aircraft.²⁸ In addition, stealth technologies require continual advances to make up for improved detection capabilities. Besides 4+ generation aircraft prioritize low observability with a reduced radar cross section instead of stealth because they were developed at an earlier stage than FGFA aircraft. Reduced radar cross sections have the effect that opponent radars can detect them later but they can't match all-aspect stealth technology.

As a matter of fact, in a medium to high threat environment like in the early stages of Operation Desert Storm, where surface-to-air threats have not been entirely suppressed, the ability to operate undetected in enemy territory is indispensable. Finally other competing nations are working to develop their own stealth technologies. As for China, its aircraft industry has made an apparent quantum leap²⁹ and in early 2011, China took the world by surprise as they unveiled the prototype of a fifth-generation fighter, the J-20.³⁰ It is thus probable that the Chinese will have their own operational fifth generation aircraft within a decade.³¹ In early 2010 Russia introduced the prototype Sukhoi T-50 or PAK. Although its precise capabilities remain classified, it appears to have the attributes of a fifth generation fighter.³²

Canada would jeopardize mission success for the RCAF by acquiring a less capable aircraft as the F-35 which would not possess the same stealth qualities. Stealth aircraft raise the ability to carry out a mission successfully and return safely.

²⁸ Rebecca Grant, "Airpower Made it Work," *Airforce Magazine*, (November 1999):

³⁴ http://www.airforcemagazine.com/MagazineArchive/Documents/1999/November%201999/1199airpower_r.pdf.

²⁹ Marco Wyss and Alex Willner, "The next generation fighter club: How shifting markets will shape Canada's F-35 debate", *Canadian Military Journal* 12, no. 2 (Spring 2012): 24.

³⁰ *Ibid.*

³¹ *Ibid.*, 23.

³² *Ibid.*

In the next part of this chapter, we will focus on engine redundancy and supercruise.

ENGINE REDUNDANCY

Redundancy is another key factor of any modern combat aircraft. Almost all essential systems, such as flight controls computers, hydraulic, electrical and fuels systems have some form of redundancy.³³ One critical component in any aircraft is the engine. They deliver thrust, drive generators, hydraulic pumps and are the main source to keep onboard system alive. In terms of security any single engine fighter, like the F-35 suffers from a significant lack of redundancy. The most critical phase in flight are the take-off and landing phase when in combat enemy fire can be fatal. A compressor stall, an engine failure/fire or simply due to a bird strike the single engine aircraft essentially becomes a potential loss of a valuable asset.³⁴

However engines are far more dependable than in recent years due to better material (reduced fatigue), different automatic engine emergency procedures and advanced testing opportunities. The danger that the engine might fail at some point remains a fact, based on experience. Single engine fighter aircraft like the American F-16 or the French Mirage2000 lost few airplanes in their lifespan due to engine failures.³⁵ The Eurofighter, F-18 E/F, Rafale as well as the FGFA F-22 all have two engines in order to

³³ Paul Umrysh, interview by Marc Grüne, April 30, 2014, Canadian Forces College

³⁴ *Ibid.*

³⁵ Dailymail, "Second safe-to-fly Mirage combat aircraft crashes after jet engine failure near Jaipur", last accessed 13 May 2014, <http://www.dailymail.co.uk/indiahome/indianews/article-2110606/Second-safe-fly-Mirage-combat-aircraft-crashes-jet-engine-failure.html>

mitigate the risk. Therefore the probability of losing a single JSF out of a fleet of 65 (desired amount of aircraft for the RCAF) must be considered.

Ultimately the overall question related to risk management in any fighter aircraft lies in the weighing between the advantages and disadvantages. In other words what advantages does the CAF gain from a FGFA versus a 4+ generation fighter in order to accept the above mentioned risk? While stealth technology outlines one of the advantages, the full sensor fusion capability presents a further improvement. This will be analysed in the next part of this chapter.

FULL SENSOR FUSION

The FGFA real strength, alongside stealth, is its integrated defensive and offensive sensor systems that provide the aircraft with the ability to see, identify, and counter everything around it, day or night.³⁶ Due to modern sensor technologies which are fused together in a seamless network, the pilot's cockpit workload is reduced in order to focus on accomplishing the mission. Indeed that enables the pilot to make accurate and timely decisions in demanding situations. This point must be stressed since, especially in air combat, the speed of decision making is vital. When a pilot is capable to make better decisions in shorter amount of time than his opponent, success is more likely.

Furthermore, air combat is clearly governed by who can detect the opponent first therefore sensor information is critical in winning this contest. Additionally those superior

³⁶ Marco Wyss and Alex Willner, "The next generation fighter club: How shifting markets will shape Canada's F-35 debate", *Canadian Military Journal* 12, no. 2 (Spring 2012): 20.

sensor capabilities allow FGFA to detect older generation aircraft (i.e. 4+ generation fighter aircraft) at great distances and remain undetected thanks to stealth.³⁷

The ability both to see and remain hidden was demonstrated during the 2012 Red Flag Exercise (military flying exercise) in the United States Alaska.³⁸ The first German Eurofighter participation tested its capabilities together with the FGFA, the F-22, against highly developed eastern generation fighter aircraft. Despite the enormous success from both weapon systems the F-22 dominated the battlefield due to its full sensor fusion and stealth.³⁹ The Raptor (NATO call sign of the F-22) could operate between hundreds of fighter aircraft without being detected and contributed substantially to the overall success.⁴⁰

Critics, however, mention in today's conflict environment, 4+ generation aircraft remain highly competitive. During the Libyan Air Campaign, for instance, the French Rafale, the Swedish Gripen and the British-flown Eurofighter have all performed well.

Although this argument is relevant, it is a short term evaluation based on present threats. As stated before, Canada's next generation fighter aircraft has to face the challenges in the decades to come. A Super Hornet or a Eurofighter might be good enough for today's strategic demands, but they are less prepared, because of their older technology, to meet challenges in the coming decades.

The F-35 will have a qualitative edge over older, fourth generation models like the Eurofighter, and upgraded models, like the F-18 Super Hornet. In terms of the CF,

³⁷ John A. Tirpak, "The six generation fighter", Air Force Magazine 10, no. 92 (October 2009): 9.

³⁸ Dave Majumdar, "In focus : German Eurofighters impress during Red Flag debut", last accessed 13 May 2014, <http://www.flightglobal.com/news/articles/in-focus-german-eurofighters-impress-during-red-flag-373312/>

³⁹ *Ibid.*

⁴⁰ *Ibid.*

various scenarios with the full spectrum of a FGFA is needed, in order to face threats like Russia and China who have active development programs on their own fifth generation fighters.⁴¹ 15

Finally the above mentioned advantages enable a FGFA to contribute directly to the functions of the Canadian Forces aerospace doctrine. The document emphasizes that all effective air forces, either large or small, are capable of performing a number of specific functions. Achieving control of the air environment prevents the enemy from using air power effectively against friendly forces while allowing friendly use of air power against the enemy. Delaying, disrupting, or destroying the enemy air forces achieve control of the air resulting in air superiority or air supremacy.⁴² FGFA can contribute substantially to those requirements due to its multitude of capabilities. The combination of stealth and full sensor fusion capability results in effective air power projection even against an opponent whose air defence systems and aircraft are modern.

Consequently the JSF program is the best possible replacement for the McDonnell Douglas CF-18 in the Royal Canadian Air Force.

Overall the second chapter has examined three predominant future capability requirements. Whereas the F-35 clearly dominates the future with stealth technology and full sensor fusion, the CF must consider the missing engine redundancy. All things considered, the capability advantages of a FGFA stand out and prepare the CF for the coming decades to deal with the highest degree possible future challenges. The F-35

⁴¹ Marco Wyss and Alex Willner, "The next generation fighter club: How shifting markets will shape Canada's F-35 debate", *Canadian Military Journal* 12, no. 2 (Spring 2012): 24.

⁴² Department of National Defence, A-GA-007-000/AF-002 *The Aerospace Capabilities Framework* (Ottawa: DND Canada, 2003), 26.

program is today the world's most advanced weapons development program in which Canada takes part as one of the partner nations.

The following chapter will study the procurement issues.

PROCUREMENTS

The DND announced in July 2010 that it would acquire 65 F-35 JSF to replace the CF-18 at a cost of 9 billion CAD.⁴³ That decision led to a fierce national debate about Canada's military procurement. While each country has several options in the procurement of advanced weapon systems with complex procedures and a number of procurement possibilities, this chapter will examine three procurement options: develop weapons domestically, purchase from abroad and enter collaboration agreements with other nations to develop and/or produce systems together.⁴⁴

Although the JSF program is an international collaboration between Canada and eight other countries with the US as the lead partner nation⁴⁵, we will briefly focus on domestic development and the purchase from abroad followed in greater detail by cooperative arrangements.

⁴³ National Defence, "Backgrounder: Canada's Next Generation Fighter Capability – The Joint Strike Fighter F-35 Lightning II," last accessed 13 May 2014, <http://www.forces.gc.ca/site/news-nouvelles/news-nouvelles-eng.asp?id=3471>.

⁴⁴ Stefan Markowski and Peter Hall, "Defense Offsets in Australia and New Zealand" in *Arms Trade and Economic Development*. Ed. Jurgen Brauer and J. Paul Dunne, (Milton Park: Routledge, 2004), 276.

⁴⁵ United States, *Memorandum of Understanding Among the Department of Defence of Australia and the Minister of National Defence of Canada and the Ministry of Defence of Denmark and the Ministry of Defence of the Republic of Italy and the State Secretary of Defence of the Kingdom of the Netherlands and the Ministry of Defence of the Kingdom of Norway and the Undersecretariat for Defense Industries on Behalf of the Ministry of National Defense of the Republic of Turkey and the Secretary of State for Defence of the United Kingdom of Great Britain and Northern Ireland and the Secretary of Defense on behalf of the Department of Defense of the United States of America Concerning the Production, Sustainment, and Follow-On Development of the Joint Strike Fighter (Short Title – JSF PSFD MOU)*, 12/2009, 4.

DOMESTIC DEVELOPMENT AND PURCHASE FROM ABROAD

The domestic development and production of high technology fighter aircraft binds enormous industrial, financial, technological and political resources. Thus only few countries possess the means to engage in domestic fighter aircraft development programs.

In the heated debate about the costs of the JSF project, as above mentioned, some claimed that the RCAF should replace the CF-18 with an aircraft domestically developed, rather than procuring one internationally.⁴⁶

However without a current Canadian fighter development program in service, the level of financial commitment and the risk for Canada as well as the narrow time frame to replace the CF-18 around 2020, can be arguably excluded. Therefore countries like Canada are forced to look beyond their borders to ensure their fighter aircraft requirements.

The second procurement alternative available to governments is to purchase from abroad. A prime example of a foreign purchase program is Canada's current fighter, the CF-18, which was purchased from the US. Indeed, foreign purchase acquisitions are generally the simplest and most cost-effective way.

However if Canada would acquire the Super Hornet for instance in the same manner as the CF-18, the national defense industry would suffer due to its present involvement in the JSF program since 1997 and substantial development costs of 168

⁴⁶ Canadian Broadcasting Corporation, "Ottawa Accused of Axing Avro Arrow Revival Too Soon," last accessed 27 April 2013, <http://www.cbc.ca/news/politics/story/2012/09/10/avro-arrow-revival-plan.html>.

million CAD from the GC would be wasted.⁴⁷ Also from a political perspective, import from abroad is the least desired option since there are no return investments.⁴⁸

Additionally there is currently no other FGFA available on the international market. Consequently the international collaboration option is the only means that Canada can acquire a FGFA.

COLLABORATION

The JSF is the largest single fighter aircraft program in history, with expenditures expected to exceed US\$383 billion in producing up to 5000 aircraft.⁴⁹

Moreover, it is known to be the greatest weapons procurement program in Canadian history.⁵⁰ While any weapons procurement decisions generally aim at reaching a compromise between military capability and cost, each nation strives to spread the financial risk. By sharing cost and risks, countries often turn to international collaborative agreements for the purpose of political, operational and financial benefits such as economies of scale, shared access to new technologies and increased interoperability.

The financial benefits in form of offsets are agreements between purchaser and vendor in which the vendor agrees to invest a percentage (perhaps even 100%) of the total

⁴⁷ The Star, "F-35 a poor fit for Canada" last accessed 13 May 2014, http://www.thestar.com/opinion/editorialopinion/2011/04/13/f35_a_poor_fit_for_canada.html

⁴⁸ Ethan Kapstein, "International Collaboration in Armaments Production: A Second-Best Solution," *Political Science Quarterly* 106 no. 4, (1991-92):659 <http://search.proquest.com/docview/208290804/13DD32C733A40024A36/10?accountid=9867>.

⁴⁹ Tim Dunne, "A Case for the F-35 Lightning," *Canadian Military Journal* 11, no. 4 (Autumn 2011): 56.

⁵⁰ John Siebert, "What's Driving the F-35 Procurement?," *The Ploughshares Monitor* 32 no. 1, (Spring 2011): 22. <http://ehis.ebscohost.com/ehost/detail?vid=5&sid=9a695e2a-3d63-4776-862e-2dd650a0e56d%40sessionmgr13&hid=2&bdata=JnNpdGU9ZWwhvc3QtbGl2ZQ%3d%3d#db=poh&AN=65290279>.

procurement cost back in the economy of the purchaser.⁵¹ 58 The advantages of those offset agreements could support Canada's own defence industry while they are setting up domestic production lines in order to produce either components or complete aircraft.

Furthermore the potential gain from whatever technology transfer is required in order to establish the necessary production capability. One example of such collaboration is the UK, Germany, Italy and Spain who have formed a multinational consortium to produce the Eurofighter.⁵² Depending on the quantity ordered, the four nations produce percentage-wise certain components and each country owns his own assembly line.

One of the basic principles behind collaboration is based on longer production runs, thus enabling lower unit costs resulting from economies of scale. Hence Canada would gain from participating in collaborative programs.

There are, however, risks to collaboration which affect military, political and financial perspectives. Any nation is bound to sign a Memorandum of Understanding (MOU) which deals with the procedures in case a nation requires a change in the aircraft design. It is obvious that both production timelines and cost could be affected, should this process be applied.⁵³ 54

This situation occurred in the above mentioned Eurofighter consortium whereby several changes to aircraft orders from the participant nations resulted in increased program costs. Consequently all partner nations must negotiate program details, identify common requirements and share tactical as much as operational development early on, to reduce the risk of runaway costs.

⁵¹ Jurgen Brauer and John Paul Dunne, "Arms trade offsets: what do we know?" in *The Handbook on the Political Economy of War*, Ed. Christopher J. Coyne and Rachel L. Mathers, (Northampton: Edward Elgar, 2011), 244.

⁵² Wyss and Wilner, *The Next Generation Fighter Club ...*, 22

⁵³ JSF PSFD MOU, 28.

Ultimately from an economic point of view, Canada is able to share the development and unit costs with the JSF program partners and support the national defense industry, for instance in July 2012 Canadian companies had secured \$438 million USD in industrial contracts related to the JSF program, with an estimated \$9.7 billion USD in potential opportunities until 2051.⁵⁴

Indeed, collaboration promotes trade relationships, industrial integration as well as technological transfer. On the political site it strengthens the cohesion to partner nations, especially between Canada and the US. Although the associated costs and risks are not insignificant, the JSF program is the only realistic way for the Government of Canada to acquire a FGFA.

This chapter evaluated the three procurement options: develop weapons domestically, purchase from abroad and enter collaboration agreements with other nations to develop and/or produce systems together. Out of those three, collaboration offers the greatest benefits in political, operational, financial and economic terms.

CONCLUSION

The Royal Canadian Air Force is seeking a replacement for its aging fleet of 77 CF-18 Hornet fighter aircraft around 2020, requiring Canada's next generation fighter aircraft. When the DND announced in July 2010 that it would acquire 65 F-35 to replace the CF-18 at a cost of 9 billion CAD, a fierce national debate followed.

⁵⁴ Industry Canada, "Canadian Industrial Participation in the F-35 Joint Strike Fighter Program," Last accessed 13 May 2014, <http://www.ic.gc.ca/eic/site/ad-ad.nsf/eng/ad03962.html>.

This dissertation examined Canada's approach to security, the future fighter capability requirements and different procurement options in order to verify the best choice for Canada's future fighter aircraft.

The Canadian Forces are guided by Canada's First Defence Strategy which underlines Canada's approach to security abroad as well as domestically. International commitments like Kosovo, Iraq, and Afghanistan as much as national responsibilities like the NORAD and the Arctic illustrate the need for a modern fifth generation fighter aircraft. The Ukraine crisis serves as a paragon that the world will likely remain insecure and with these potential threats in mind, Canada together with its strongest partner the US have to continue to pursue high technology aerospace capabilities like the F-35. This enables the Canadian Government maximum flexibility to deal with security challenges in the future and provides the CF with the technological advantages and capabilities needed to ensure mission success worldwide.

Let's summarize those advantages. While the F-35 clearly dominates the future with stealth technology and full sensor fusion, the CF must consider the missing engine redundancy. Stealth technology raises the ability to carry out a mission successfully and return safely, besides the ability to operate undetected in enemy territory is indispensable.

Additionally, full sensor fusion enables the pilot to make accurate and timely decisions in demanding situations because its integrated defensive and offensive sensor systems provide the aircraft with the ability to see, identify, and counter everything around it, day or night.

However the F-35 is a single engine aircraft and therefore the probability of losing a JSF out of a fleet of 65 due to engine failure must be considered.

Overall the capability advantages of a FGFA stand out and prepare the CF in coming decades to cope with the highest degree possible future challenges. The F-35 program is today the world's most advanced weapons development program in the world in which Canada takes part as one of the partner nations.

The last chapter of this essay focused on three procurement options. Canada has currently no fighter development program in service and the level of financial commitment and risk exclude this option.

While the second alternative available to governments is to purchase from abroad, the national defense industry would suffer from it due to its present involvement in the JSF program. Consequently collaboration agreements offer the greatest benefits in political, operational, financial and economic terms. Canada is able to share the development and unit costs with the JSF program partners and support the national defense industry.

Furthermore collaboration promotes trade relationships, industrial integration as well as technological transfer. On the political side, it strengthens the cohesion with partner nations, especially between Canada and the US. Although the associated costs and risks are not insignificant, the JSF program is the only realistic way for the Government of Canada to acquire a FGFA.

As a result the RCAF's focus on technological advantages is vital for air power effectiveness and flexibility in the 21st century. The future rests with fifth, not fourth generation fighters. Indeed a fleet of fifth generation fighter aircraft would considerably increase the sum of tactical, operational and strategic capabilities for Canada. Likewise it provides the Royal Canadian Air Force with a multi-purpose asset, which is versatile but

cost-intensive. Ultimately it contributes to the government's vision articulated in the Canada First Defence Strategy.

All things considered, the best possible replacement for the McDonnell Douglas CF-18 in the Royal Canadian Air Force is the fifth generation fighter aircraft, the Lockheed Martin F-35 Lightning II joint strike fighter (JSF).

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