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FIFTH GENERATION CANADA, WHY SHOULD CANADA BUY THE F-35 JOINT STRIKE FIGHTER?

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JCSP 40

Exercise *Solo Flight*

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If you always do what you always did, you will always get what you always got.

-Albert Einstein

INTRODUCTION

Like many upgraded fourth generation fighters in different Western Air Forces, the Royal Canadian Air Force (RCAF) CF-18 Hornet multirole fighter is approaching end of life in the coming ten years. Upgrading the aircraft to remain in service any longer would require economically challenging solutions considering its service life of over 40 years and consequential obsolescence problems. In other words, keeping the aircraft serviceable would cost more in a relative sense than buying new fighters that will possibly last for the next 40 years. This brings great challenges to the Canadian government of the day, as it approaches not only a decision on whether to replace the CF-18 by a new fighter aircraft, but also on the type of aircraft itself. Several options are available, like the European made Eurofighter Typhoon, the French Rafale, the Swedish Gripen Next Generation (NG) or Boeing's Advanced Super Hornet.[1] The latter seems to be a viable and obvious option for the RCAF based on its prior experience with the Boeing CF-18. Another option for the RCAF is the American built F-35 or Joint Strike Fighter (JSF), the only Western true fifth generation platform available on the market.[2]

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[1] Only Western types of aircraft are considered viable CF-18 successor options as it is highly unlikely that Canada, given the interoperability requirements of its NATO and US allies, would decide differently.

[2] The F-22 Raptor is also a fifth generation platform, but the US decided that it is unavailable for purchase.

The aim of this paper is not to compare detailed capabilities and numbers of the different types of future fighter options for the RCAF. It will rather study them in a broader context of RCAF requirements to prove that the F-35 JSF with its specific characteristics is the most viable successor to the CF-18. After briefly answering the question why Canada needs a manned fighter aircraft, several RCAF requirements will be studied versus future fighter options to conclude that the JSF is the best match. This will prove that true fifth generation is really the way ahead for Canada and the RCAF.

DOES CANADA NEED A MANNED FIGHTER AIRCRAFT TO REPLACE ITS CF-18?

The first questions that need to be answered are to know if Canada needs a fighter aircraft to replace the CF-18 and whether this should be a manned platform.

Canada, a vast country with huge airspace ranging from the US-Canada border in the south to the outskirts of the Arctic in the north, has a firm requirement to defend its sovereignty, because of the possibility of violation of airspace by countries like Russia. It is also part of NORAD,[3] which creates a responsibility towards its US ally in the defence of North America, and there is the will to be recognized as a reliable partner in international operations. All of these realities are translated in the 2008 Canada First Defence Strategy (CFDS). The CFDS clearly mentions the priorities for the Canadian Armed Forces (CAF): defend Canada, defend North America and contribute to

[3] North American Aerospace Defense Command.

international peace and security.[4] Within this framework, it is hence necessary for Canada to have an operational fighter fleet as mentioned further on in the CFDS:

> Starting in 2017, 65 next-generation fighter aircraft to replace the existing fleet of CF-18s. These new fighters will help the military defend the sovereignty of Canadian airspace, remain a strong and reliable partner in the defence of North America through NORAD, and provide Canada with an effective and modern air capability for international operations.[5]

Based on its experience with the CF-18, it is also important for a small air force like the RCAF, to envision a long employment horizon for its future fighter, with an eventual possibility for midlife upgrades and updates.

The question whether a manned fighter aircraft is the best solution for Canada is interesting and could be the subject of a study by itself. Even though unmanned aircraft technology has progressed rapidly during the last decade, as proven in recent conflicts like Afghanistan, its limitations are obvious. Apart from long loiter times, slow speed surveillance and limited Air-Ground intervention capabilities, the technology still does not match the survivability and wide range of employment options of manned fighter aircraft.[6] After all, manned fighters can also be used in an air superiority role, which is definitely a Canadian requirement based on the CFDS. It is highly probable for the future that the possibilities of unmanned technology will grow to allow other employment options including a role in gaining or maintaining air superiority. At this stage however, the technology is not at the level of confidence required for the CAF to see unmanned

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[4] Department of National Defence, *Canada First Defence Strategy* (Ottawa: Department of National Defence, 2008), 7-9.

[5] Department of National Defence, *Canada First Defence Strategy* (Ottawa: Department of National Defence, 2008), 17.

[6] Frontline Defence Articles, "The Debate: Manned vs Unmanned," last accessed 01 May 2014, http://www frontline-defence.com/index_archives.php?page=1655.

technology as a viable option to replace its manned fighter fleet. Another interesting aspect is the integration of manned and unmanned technology in future warfare. Immature at this stage, it might be a factor to consider when comparing manned platforms and their future growth possibilities.[7]

RCAF REQUIREMENTS

Evolving threat environment, the environment of the future

As mentioned above, the RCAF will need a fighter that has a considerable employment horizon. Therefore, that fighter needs to be able to operate not only in today's environment, but also in the uncertain threat environment of the future.

Where the MiG-21 once used to be the baseline enemy aircraft in Western air warfare training, it have now become the very capable MiG-29 SMT[8] or Su-27 Flanker with AA-10C air-air missiles, or even better export versions like the Indian Su-30 MKI. The same trend is happening in the Electronic Warfare and Surface to Air threat domains. Facing this new baseline opposition, the currently available fleet of Western fighters[9] using Western tactics would have a hard time winning the imaginary air war of today. All CF-18 successor options mentioned in the introduction are likely to be more successful in this already evolved threat environment.

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[7] The Diplomat, "UAVs and the F-35: Partners in Air Power?" last modified 03 January 2014, http://thediplomat.com/2014/01/uavs-and-the-f-35-partners-in-air-power/.

[8] This type of aircraft is operated by for example the Syrian Air Force.

[9] Like the F-16, F-18 and F-15.

Besides these changes in baseline threats, other fighters and systems are being developed and fielded, like the Russian Su-35 Super Flanker and T-50 PAK FA,[10] and different types of Chinese next generation stealth fighters, like the J-20.[11] Even though it is highly unlikely that Canada will ever directly face opponents like Russia or China in full scale conflict, it is highly likely that, due to weapons proliferation, it might face Russian or Chinese manufactured systems in lower intensity conflicts. This proliferation of fifth generation platforms in a future threat environment might require a new way of aerial warfare and capabilities that can only be delivered by fifth generation aircraft. Typical fifth generation capabilities are:

Full sensor integration

Analysis of information provided by on- and off-board sources and sensors is done by the airplane and presented to the pilot in a single battlefield picture to enhance his situational awareness and allow rapid decision making.

Information sharing

Fifth generation will allow information management and sharing with different platforms in the battle space. These could be other aircraft, command and control platforms and nodes, ships or any other platform that possesses the right protocols to

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[10] Military Factory, "Sukhoi T-50 (PAK FA) 5th Generation Multi-Role Stealth Aircraft (2017)," last modified 01 May 2014, http://www militaryfactory.com/aircraft/detail.asp?aircraft_id=782.

[11] US Naval Institute, USNI News, "China Unveils More Capable Stealth Fighter Prototype," last modified 19 March 2014, http://news.usni.org/2014/03/19/china-unveils-capable-stealth-fighter-prototype.

access the information. In order to have access to the available information, it will be of utmost important to link in with the network on which this information is passed.

Battlefield Management

The fifth generation fighter will become a battlefield management platform, rather than the pure fighter aircraft we currently know. The pilot becomes a decision maker and modularity will allow full integration with other platforms in a shared information network as mentioned previously. As such, every aircraft will become a node in the command and control network.

Stealth

Stealth will allow penetration in heavily defended airspace with limited risk of detection by air or surface threats. It will require an alteration of currently used tactics and procedures, which are still heavily dependent on the use of voice communications, despite the availability of data sharing networks like Link 16.[12]

While it is clear that platforms like the Eurofighter, Rafale and Gripen NG,[13] will never have formal stealth, it is hard to predict at this stage if they will ever be upgradeable to the other capabilities required in the fifth generation environment. It is certain however, that the new US platforms are built for this environment, because the

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[12] The US is currently investigating ways to integrate fourth generation aircraft in the environment created by fifth generation aircraft due to the different way of operating. This will become particularly important during the transition period where both generation platforms will have to operate together (2015-2035).

[13] All these aircraft have been designed to directly eliminate existing weaknesses of fourth generation aircraft, like lack of engine power, lack of on-board firepower and limited radar performance.

US has always been prone to keep a technological edge over all its opponents. This could even mean that the US might refuse fighters designed outside its borders to fully integrate and upgrade to the specific requirements of fifth generation air warfare.

If Canada consequently wants to be ready for the current as well as the future threat environment, the options are really limited to the two US successor platforms, namely the JSF and the Advanced Super Hornet. Opponents of the JSF often use the argument that countries like Canada do not require stealth by design as a capability and should not buy the JSF. They promote the Advanced Super Hornet,[14] which has all fifth generation capabilities but formal stealth, despite Boeing's claims around the Advanced Super Hornet's stealthy characteristics.[15]

Besides the huge advantage of the JSF's built in stealth, which enables operations in a future threat environment where non-stealth fighters are denied, it is true that stealth will probably require extra maintenance attention and hence increase costs.[16] It is also true that the JSF will only be able to carry payload internally to avoid breaking its stealth. This is a limitation compared to the actual fighter fleet, even though the JSF's firepower with external payload is comparable to any other aircraft, especially with its smaller, more effective baseline munitions.[17] Some also state that the JSF is not as manoeuvrable as actual fighters, which is hard to verify this early in the operational flight testing.

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[14] Boeing, "Feature Story: Advanced Super Hornet makes its Debut," last accessed 04 May 2014, http://www.boeing.com/boeing/Features/2013/08/bds_adv_super_hornet_08_28_13.page.

[15] Stealth has never formally been part of the Advanced Super Hornet design, because it is built on the concept of the already fielded Super Hornet.

[16] These costs are currently hard to quantify.

[17] Like the Small Diameter Bomb (SDB) II, a multi sensor 250 pound standoff weapon.

While the payload and lack of manoeuvrability arguments against the JSF might hold true in the air warfare environment of today, where fighters carry their own weapons and sometimes have to fight their way through in ferocious dogfights, they will become irrelevant in the air combat arena dominated by fifth generation fighters, where each aircraft is a battlefield management platform that is fully networked and integrated in the environment. It will use weapons carried by other platforms, like ships or unmanned vehicles, and its own payload will merely be for self defence. It will have battlefield awareness created by fully integrated on- and off-board sensors that prevents it from ever ending up in a visual fight where manoeuvrability is important.

Based on the evolving threat environment and future of air warfare, both the JSF and Advanced Super Hornet seem viable options for Canada. Stealth by design discriminates between them. While it has huge operational advantages in an environment where the threat denies access to non-stealth fighters, it will probably require extra maintenance attention and force the JSF to internal payload only. This does not have to be a problem, because of the JSF's smaller, more lethal baseline munitions and the fifth generation air combat arena, where networking and integration allow use of on-board and off-board weapon systems.

US-Canadian Interoperability

As mentioned in the CFDS, participation with the US in NORAD is part of the core missions for the CAF.[18] It is thus of utmost importance that the RCAF continues to operate a fighter platform that is interoperable with that of its US ally. Considering the fact that all US services will eventually migrate to the JSF and the fact that fifth generation will bring game changing capabilities to air warfare, a US built platform seems to be a requirement,[19] and the JSF consequently becomes the obvious option for Canada.

Operations over the Arctic

Canada's next generation fighter needs to be able to operate in the airspace over the Arctic, a desolate region with limited support facilities and airbases where survivability is very important. This requirement seems to make a two engine aircraft more appropriate, because of the redundancy in case of single engine failure, which favours the Eurofighter, Rafale and Advanced Super Hornet, all two engine aircraft. The fact that the JSF, like the Gripen NG, has one engine, cannot be argued, but the engine is reliable and powerful enough for the airframe. It is important to realize as well that aircraft do not have multiple engines for redundancy, but rather to produce the power required to operate. Besides this, newer engines consume less and have become even more powerful and reliable, which is also reflected in the civilian aviation world.[20, 21] The

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[18] Department of National Defence, *Canada First Defence Strategy* (Ottawa: Department of National Defence, 2008), 10.

[19] It is highly unlikely that the US will allow integration of this type of sensitive technology in non-US built aircraft, like for example the French built Rafale.

[20] More and more civilian aircraft are migrating from 4 to 2 engines.

F-16 actually is the most successful fighter aircraft in the world with only one engine, and all US services, ready to operate all around the globe, will migrate to the JSF eventually, so one would expect its engine to be highly reliable. Reliability statistics however, are still in the making. It remains thus a matter of risk assessment, because one can never eliminate the chance of incidents like a bird strike in the engine that causes catastrophic loss of an aircraft.[22]

Non-operational requirements

For smaller air forces, like the RCAF, that envision buying a small fleet of aircraft, the non-operational arguments, like acquisition and lifecycle cost, long term employability, upgradeability, sustainment and economic benefits, are probably more important than the operational arguments in the light of maximizing their "bang for the buck", which tends to happen when joining the biggest partnership.

Rafale and Gripen NG are single country initiatives that remain to be sold to other partners and thus provide very limited options. The Eurofighter is built by a European consortium of four countries[23] and has been sold to other customers, like Austria and Saudi Arabia.[24] This could provide potential for Canada, but the partnership has shown weaknesses in co-development and sustainment of the aircraft, which has led to much

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[21] F-35 Lightning II, "A Pilot's Perspective: F-35's Single Engine," last accessed 02 May 2014, https://www.f35.com/global/videos/canada/detail/a-pilots-perspective-f-35s-single-engine//

[22] The last F-16 crash in the Belgian Air Force was caused by a bird strike in the engine. The pilot ejected safely, but the jet was lost.

[23] Eurofighter Typhoon, "About Us," last accessed 07 May 2014, http://www.eurofighter.com/about-us.

[24] Eurofighter Typhoon, "Customers," last accessed 07 May 2014, http://www.eurofighter.com/customers.

differing baselines among the different partners. The amount of aircraft sold, currently only 390, also limits profit from economy of scale. Boeing is still looking for customers for the Advanced Super Hornet of which initial flight tests only started in 2013. The latter could mean that if Canada would decide to pursue the Advanced Super Hornet, it could end up being the sole customer, required to carry the remainder of the development and sustainment costs. This would be a lot more expensive in the long run, so unless Boeing starts selling its new Super Hornet, it should not be considered a viable option.

The JSF currently shows the most advantages in the domain of non-operational requirements, even though issues in the program and the training and maintenance cost will be discussed as well:

Acquisition and lifecycle cost

There are many estimates of what the unit price of a JSF will be. They range from as wide as 65 million dollars per plane without the engine[25] to as high as 182 million to 299 million dollars all included, depending on the version.[26, 27] The reason why these numbers are so far apart is that not all numbers use the same baseline model and there is confusion about the difference in the unit cost of a low rate production model versus a full rate production model. Based on these numbers however, many claim that the JSF will be too expensive to buy and maintain. Although it is too early to judge the final full

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[25] DefenseNews, "What's The Price Tag For a Production F-35?" last accessed 01 May 2014, http://www.defensenews.com/article/20110912/DEFSECT01/109120306/What-s-Price-Tag-Production-F-35-

[26] The F-35 will be produced in three different versions: the F-35A, the vertical-landing Marine F-35B and the carrier-compatible F-35C.

[27] Outside the Beltway, "F-35 Costs $182 Million to $299 Million Per Plane," last accessed 01 May 2014, http://www.outsidethebeltway.com/f-35-costs-182-million-to-299-million-per-plane/.

rate unit cost, because the more aircraft are produced, the lower the unit cost (see big partnership below), a good estimate will be somewhere between 80 and 100 million dollars all in, which makes the aircraft comparable to all other competitor aircraft.

The second important consideration is the lifecycle cost of a platform. This notion combines the costs necessary to buy and sustain the aircraft over its entire service life. The longer that service life, the lower the overall cost, even if the purchase price would be higher. Based on previous experiences with airplanes like the F-16 and the F-18, and the fact that all US services will employ the jet, the JSF's predicted service life will be somewhere between 40 and 50 years, which is expected to be higher than its competitor platforms. This means that even if the initial purchase price would be higher, its overall cost would be lower.

Big partnership

With a production goal of 3000 aircraft, the JSF consortium is currently the biggest partnership to manage a next generation fighter aircraft project, which will limit the full rate production unit cost. Based on the successful model of the F-16 Multinational Fighter Program (MNFP),[28] the consortium will also allow cost sharing options to set conditions for further development and sustainment throughout the JSF's service life, which enables a long employment horizon.

[28] The MNFP was originally stood up to support F-16s of the US, Belgium, Denmark, the Netherlands and Norway. Portugal joined the programme in 2000. The programme has been highly successful for well over 40 years in making sure that the F-16s of the countries involved remain operationally relevant for an affordable price.

Long employment horizon

The current projected employment horizon for the JSF is foreseen to be around 50 years, which is comparable to that of the F-16 at its end of life. This will probably imply several upgrades and a midlife update, but it is longer than any competitor aircraft currently available on the market. This will limit the lifecycle cost, which eventually is more important than the acquisition cost as mentioned earlier.

Room for growth

While it is unlikely that Rafale, Eurofighter and Gripen NG will ever be upgraded to become fifth generation fighters for the reasons explained earlier, it is probable that not all fifth generation capabilities will be fully developed at the moment of fielding of the JSF. It might even take several years before the JSF will be at the level of capabilities of the fighter it will replace. This should not be seen as a weakness, because the JSF technology will allow room for quantum leaps forward in development to answer the challenges of new ways of warfare.[29] The biggest mistake one can make is to solely judge the capabilities of the JSF versus the requirements of today's air warfare, because the JSF is designed to optimally function in the aerial warfare environment of the future, where stealth is a game changer and manned and unmanned platforms function fully integrated.

[29] The F-16 is a perfect example of a platform that has known constant growth and adaptation to the new challenges posed by its operating environment. At the end of its life, it will have had a 50 year service life in frontline operations.

Economic compensation

Many governments require return on investment when they pursue projects of the nature of fighter acquisition. They want maximum involvement of the national industry in the project to mitigate government expenses by securing jobs, building know-how and returning part of the investment to enhance the overall welfare of the country and its citizens. While it is hard to quantify and compare to the other future fighter alternatives, there are great possibilities for Canada in the JSF program "with $450M contracted and $10B in opportunities over the life of the partnership."[30, 31]

Issues in the program

It is true that the JSF program has known some delays, as mentioned many times in different media,[32] but it would be naïve to believe that such an ambitious, complex program remains on schedule. The JSF is such a big technology leap forward and there are so many factors to be taken into account and so many interdependencies, that delays are simply normal.[33]

For the first time in history, all US services know they will end up with the same product, so it is in their interest that that product becomes as good as it can get. It is therefore not unthinkable that those services use the media to pressure the company in

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[30] F-35 Lightning II, "Canadians talk about Building the F-35," last modified 13 May 2013, https://www.f35.com/global/videos/canada/detail/canadians-talk-about-building-the-f-35//.

[31] F-35 Lightning II, "Canada: Canadian Industry Partners," last accessed 04 May 2014, https://www.f35.com/global/participation/canada-industry-partners.

[32] Fox News, "F-35 fighters plagued with delays, cost overruns, federal report says," last accessed 01 May 2014, http://www foxnews.com/tech/2014/04/03/f-35-fighters-plagued-with-delays-cost-overruns-federal-report-says/.

[33] In the F-16 program, that has run over 40 years, there are still delays in development of new hardware or software.

delivering what they expect. The downside to this is that the negative press attention influences decision makers and public opinion in countries with smaller air forces, like Canada, which causes them to reconsider.[34]

Another important factor when comparing the JSF development program to competitor programs, like the Eurofighter or the Rafale, is that those aircraft were developed in the nineties. All those programs ran into similar or worse issues and delays, and they were evenly controversial to the public. The Gripen NG and Advanced Super Hornet are too early in development to judge how well their programs will go, but based on previous experiences, similar issues and delays can be expected.

Training and maintenance cost

It is true that the estimated cost per flying hour of a JSF will be higher than the hourly cost to operate current fighter aircraft,[35] but a JSF airframe will eventually be able to produce more hours per year[36] due to reduced maintenance requirements.[37] This will allow production of the same amount of flying hours per year with less aircraft, allowing air forces to do the same with a smaller fleet.[38]

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[34] This was also the case in the Netherlands, where the government reconsidered the program after they had bought their first aircraft and already invested some hundreds millions of euros. The Dutch government eventually decided to buy 37 aircraft, which is a lot less than the 85 initially considered.

[35] Flightglobal, News Military, "USAF estimates F-35 will cost $32,000 per hour to operate," last accessed 08 May 2014, http://www.flightglobal.com/news/articles/usaf-estimates-f-35-will-cost-32000-per-hour-to-operate-386430/.

[36] The Belgian Air Force F-16 MLU produces between 200 and 250 hours per year; the JSF is expected to produce up to 300 hours per year.

[37] Similar to modern cars compared to older cars: recurring maintenance requirements are lower.

[38] The Dutch Air Force is planning to buy only 37 JSF, compared to their current fleet of 64 F-16, and there is no indication that they will reduce their ambition level.

Another important factor to be taken into account is that the training concept will need to fundamentally change: there will be less actual flying and a bigger role for simulation and integrated simulation with actual flying. One of the reasons for this is the fact that creation of the challenges required for fifth generation platforms is simply too difficult and expensive. It would require a huge airspace, which is not necessarily a problem in Canada, but more so in Europe, and a significant amount of threat simulators and emulators on a daily basis. Those are only available in large scale exercises, like Red Flag or Maple Flag.[39] Another aspect of the change in training is that pilots will probably fly a number of their annual flying hours on lower end training aircraft that allow simulation of cockpit displays, controls and sensor functionality of high end fighters, like the JSF.[40] These aircraft are much cheaper to operate and will allow an overall reduction in the yearly training costs. These alterations in training concept will probably allow having an operating budget comparable to that of the current CF-18 fleet, but it is true that extra efforts and investments are needed to purchase the simulation equipment and infrastructure, as well as to adopt a fleet of low end training aircraft, to enable this new training concept.

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[39] Red Flag in the US and Maple Flag in Canada are large scale exercises where Combined Air Operations are trained in a full scale war scenario.

[40] The Swiss made PC-21 allows this already.

CONCLUSION: CANADA SHOULD BUY THE F-35 JSF

The aim of this paper was not to compare detailed capabilities and numbers of the different types of future fighter options for the RCAF. It has rather studied them in a broader context of RCAF requirements to eventually prove that the F-35 JSF is the most viable successor to the CF-18. After having briefly answered the question why Canada needs a manned fighter aircraft, several operational and non-operational RCAF requirements were studied versus future fighter options.

The operational requirement of the evolving threat environment and the future of air warfare have demonstrated that the JSF and Advanced Super Hornet, both US designed fighters, are viable options for Canada. It is stealth by design that discriminates between them. While stealth brings huge operational advantages in an environment where the threat denies access to non-stealth fighters, it also has some disadvantages, which are not necessarily problematic in the fifth generation air combat arena.

The requirement for interoperability with the US has demonstrated again that a US designed plane would be the best option for Canada. Taking into account the added value of stealth and the fact that all US services will eventually fly the JSF, it seems logic that Canada decides in favour of the JSF.

The requirement for operations over the Arctic provides less obvious outcomes. While at first sight, a two engine airplane seems to be more suitable in order to have redundancy in case of engine failure, it is clear that aircraft do not have multiple engines

for redundancy, but rather to produce the power required to operate. In any case, employing a single engine aircraft, like the JSF, remains a risk management decision, despite a probably very reliable engine.

While the operational requirements are not all fully in favour of the JSF, there are a number of non-operational requirements, like acquisition and lifecycle cost, long term employability, upgradeability, sustainment and economic benefits that could be more conclusive for Canada than any of the operational arguments. Here the JSF clearly comes out strongest, despite the program issues and the impact on the training and maintenance concept. The JSF's unit full rate production and lifecycle cost, its big international partnership currently envisioned to build up to 3000 fighters, and its long employment horizon give it huge advantages over any other competitor at this time. On top of this, the JSF will allow the modularity and room for growth required to answer to the challenges and uncertainties of the future battlefield. Last but not least, there is room for Canadian industrial participation.

Canada's RCAF is a small air force looking for a small fleet of next generation manned fighters, yet it is required to fulfill a wide array of missions in an environment at home and abroad that is uncertain and hard to predict. After analyzing the RCAF's main requirements, operational and non-operational, it has become clear that the JSF as the only full fifth generation platform will allow the RCAF, and the CAF at large, to continue to answer to its commitments as laid out in the CFDS and to leap forward in the uncertain future that lies beyond the CF-18's service life.

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