CF-18 Hornet Estimated Life Expectancy

Background

The Estimated Life Expectancy (ELE) of a weapon system is a management decision which must consider all projected requirements (including airworthiness, sustainability, operational capability and relevance) versus the costs and benefits along with operational risk. The concept of ELE is analogous to the business concept of 'useful life', which is the period of time an asset is expected to be usable for the purpose it was acquired and may not necessarily correspond to the asset's physical or economic life.[1] An approved ELE also provides the related Weapon System Manager (WSM) with the authority to appropriately manage financial resources to assure sustainability of the fleet until ELE. Additionally, ELE may also take into account the fact that not all aircraft reach their structural safe life limit at the same time; it may also consider transition requirements with a replacement aircraft fleet (such as aircraft delivery schedules, and achievable aircrew and technician training schedules), as applicable. Accordingly, ELE may be defined with a planned 'ramp-down' or transition window as a fleet's aircraft are progressively retired. A final ELE date identifies the latest date for the cessation of flying operations for the fleet in question, and unless otherwise specified, is usually assumed to be calendar-year based. Thus, an ELE of 2020 assumes that flying operations will cease no later than 31 December 2020.

The ELE for CF aircraft fleets is established at the time of their entry into service. The CF-18 Hornet entered service in 1982 as a multirole fighter/interceptor replacement for the CF-5 Freedom Fighter, the CF-101 Voodoo and the CF-104 Starfighter. The Hornet fleet's ELE was initially set to 2003, which represented a service life of 20 years after the declaration of Initial Operational Capability (IOC)[2]. This value was based upon projected initial usage when calculated against the original equipment manufacturer's certified design life.[3]

It must be emphasized that ELE is, first and foremost, an estimate. Numerous assumptions must be made for the various competing factors involved, which must all be balanced to determine the optimum withdrawal date. This means that an aircraft fleet's ELE target may or may not be proven correct as the future unfolds, and may actually be advanced or extended during its service life. An ELE change can be triggered by a number of factors

[1] The physical life of an aircraft is its potential service life before it physically becomes unusable. An aircraft is often physically able to continue operating but at a cost or rate that renders it economically obsolete. The economic life, as opposed to the physical life, is important in determining its value. The economic life is therefore usually less than the aircraft's physical life, and is the period over which depreciation is calculated.
[2] IOC is defined as the first attainment of the capability to employ effectively a weapon, item of equipment, or system of approved specific characteristics that is manned or operated by an adequately trained, equipped, and supported military unit or force.
[3] The Hornet aircraft was originally designed and manufactured by McDonnell Douglas (now Boeing), to a US Navy specification, with a structural fatigue safe life of 6000 airframe hours of US Navy usage. In relation to structural fatigue, an aircraft's remaining safe life is measured by its Fatigue Life Expended Index (FLEI). The FLEI is a measure of the proportion of the certified safe life of a structure that has been consumed. A FLEI of 1.0 therefore represents the attainment of the structure's safe life limit.

such as a capability deficiency, or an engineering/maintenance advance enhancing fleet life expectancy.

In the case of the CF-18 fleet, early structural lifing concerns led to the implementation of a structural fatigue life management program (FLMP) in 1988, and a collaborative full-scale structural fatigue test program with the Royal Australian Air Force (RAAF) to re-certify the CF-18's design life based on Canadian and Australian usage. This collaborative effort was known as the International Follow-on Structural Test Program (IFOSTP) and was completed in 2006. Results from this test program formed the basis from which the CF-18 Hornet's structural Life Extension Program (LEP)[4] was developed. As the aircraft's structural life is an airworthiness limitation, it is an important factor in calculating a realistic ELE. The implementation of the FLMP, a LEP tailored to Royal Canadian Air Force (RCAF) usage requirements, changes to how the CF-18 was flown[5], and reductions in the planned yearly flying rate (YFR) over the years have all combined to extend the CF-18's projected physical life.[6] The CF-18 ELE was extended to 2020 with an assumed three-year overlapping transition window to a new fighter (i.e. 2017-2020) following an extensive study first started in 2004. This study was based on known facts at the time along with a number of key assumptions, including projected YFR, fatigue rates, structural modification requirements, continued US Navy support, the cost benefit of proceeding with an extensive avionics modification effort, and assumptions regarding the timelines associated with the introduction of a replacement fleet.

Under the auspices of this study, CF-18 ELE has once again been examined to determine if it can be viably extended beyond 2020. The analysis for this report assessed the option of extending the CF-18 ELE to 2025 and 2030, using a new five year overlapping transition window to a new fighter. This longer ELE transition window is based on an assessment of the achievable timelines associated with standing up a new fleet by the fighter force given its current size and structure. Specific numbers of CF-18 aircraft required during the five year transition window are identified as operational assumptions below. The ELE targets in this study were logically chosen, based upon expected cost versus benefit as well as overall risk:

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[4] The current CF-18 structural Life Extension Program (LEP) was developed from data generated in partnership with the RAAF during the various IFOSTP full-scale fatigue tests. The RCAF LEP approach was to induct aircraft through a three-pass structural refurbishment effort known as Control Points 1, 2 and 3 (i.e. CP1 to 3). CP1 extended CF-18 fatigue life from a FLEI of 0.56 to 0.68; CP2 extended CF-18 fatigue life to 0.80 FLEI and CP3 will extend CF-18 fatigue life to a FLEI of 1.0 (i.e. the full safe life limit based on IFOSTP data). As part of the CP1 package, thirteen (13) CF-18 aircraft went through a Centre Barrel Replacement (CBR) program. This effort replaced a key section of the centre fuselage of the aircraft where the wing attachment points are located since this area is prone to cracking in its original configuration. The RCAF eventually opted for discrete modifications to the centre fuselage area vice continuing with the CBR program due to implementation costs. Any extension beyond a FLEI of 1.0 will require additional testing, tear-downs and detailed analysis to certify and risk assess the aircraft structure beyond its originally certified design life.

[5] Once the CF-18 was certified to use precision guided munitions in 1997, low level flight training effectively ceased. Low level flying was a significant driver of structural fatigue life consumption because that type of flying demanded intense manoeuvring by aircraft loaded with weapons.

[6] As an analogy, one might purchase a car with the idea of owning it for 10 years but depending on how demanding the driving conditions were, even with proper maintenance, it might only last 7 years, or conversely, could last up to 15 or 20 years.

a. An ELE of 2020-2025 represents a target beyond which significant structural investments will be required to maintain the fleet's airworthiness. As such, it represents an ELE extension for modest cost while still resulting in reasonably low to moderate technical and operational risk respectively. Once the US Navy drawdown begins in earnest, and prior to final fleet retirement, sustainment will become more difficult and costly with less access to either Repair and Overhaul (R&O) facilities or the availability of spare parts for purchase.[7]

b. An ELE of 2025-2030 represents a technically feasible albeit risky stretch target. It would require the entire fleet to undergo the Control Point 3 (CP3) Life Extension Program (LEP) along with other significant structural refurbishment investments. This option is a high risk solution, from both a technical and operational perspective. Also, reduced R&O and spares sources increase sustainment challenges. From a cost perspective, there is increased uncertainty in projecting non-recurring engineering (NRE) as well as sustainment costs out that far since even small changes to current assumptions could cause significant impacts to cost projections. From an operational perspective, the fleet will be exposed to a more lethal threat environment. In addition, there will be decreased interoperability with newer aircraft flown by Canada's allies.

Since ELE is both a management tool and a management decision, any life extension decision must be based upon three important variables: technical feasibility, operational relevance and cost effectiveness. This ELE study has examined all upgrades required to extend the CF-18 Hornet from an airworthiness, regulatory and sustainment perspective. However it does not examine the technical feasibility and costs associated with major operational relevance upgrades to improve existing capabilities, other than those critical to maintain a basic level of interoperability with the US, and, by extension, NATO allies.

ELE Considerations

<u>Continuing Airworthiness – CF-18 Structure</u>. As previously noted, structural life is a key assessment factor. A preliminary analysis of the assumptions upon which the current CF-18 ELE is based on has revealed several downward trends in terms of YFR and FLEI consumption since 2004.

<u>Regulatory Requirements</u>. The current CF-18 transponder[8] will need to be upgraded if the fleet is to continue flying after 2020. This means that the implementation effort will need to begin up to three years prior, with investment decisions even sooner. Both civil and military Identification Friend-or-Foe (IFF) regulations will require, respectively, Mode S – already a

[7] The US Navy plans to retire their F/A-18A/D Hornets incrementally as their service lives expire, and cannibalize retired aircraft for spare parts to decrease their sustainment costs. This will result in fewer required large scale spare parts purchases and decreased R&O capacity, which will negatively impact the ability of countries with much smaller F/A-18 fleets to purchase and repair spares, while also increasing their sustainment costs.

[8] A transponder emits an identifying signal in response to an interrogating received signal. It is used in Identification Friend or Foe (IFF) and air traffic control management systems to identify aircraft and/or provide secondary location information such as altitude to help air traffic controllers to identify the aircraft and determine its location more precisely.

requirement in Europe – and Mode 5. Incorporation of this capability will require both hardware and Operational Flight Program (OFP)[9] changes. More importantly however, the US Federal Aviation Administration (FAA) will be mandating the use of ADS-B (Automatic Dependent Surveillance – Broadcast) surveillance technology in US airspace by 2020, with the roll-out commencing over the next few years in accordance with their NEXTGEN Air Traffic Management plan. It is also expected that most other ICAO signatories will also adopt the ADS-B standard. For example, Europe is implementing ADS-B standards by 2017. An earlier decision would allow greater flexibility for planning and implementation and result in a better return on the investment by putting the improved equipment into service for a longer period of time.

Sustainment. From a weapon system life cycle perspective, sustainment refers to the in-service support required to maintain a weapon system as operational. As such it considers supportability issues (reliability, maintainability, access to required spares and repair facilities) and obsolescence management requirements (forecasted last or life-time buys of required spares, or the re-certification of the affected system to use newer parts to replace those parts no longer available). From a parts availability perspective, recent announcements from other F/A-18 users, particularly the US Navy, that they will be extending their fleets well into the 2020's provides a level of assurance that there will be sufficient demand for spares to financially incentivize manufacturers to continue to support production of parts and keep critical R&O lines open. Obsolescence for some components will undoubtedly become an issue, but with a greater number of users, the associated NRE to resolve obsolescence issues can likely be shared cost-effectively between F/A-18 Hornet user nations with only limited risk until approximately 2025. Avionics in particular includes a multitude of systems and components regularly plagued with obsolescence and reliability issues, including the Automated Test Equipment used to repair avionics components; there will need to be flexibility to procure additional spare parts as opportunity buys present themselves if the fleet is to be sustained beyond 2020.

Interoperability – Baseline Mandatory Requirements. The operational relevance of the CF-18 Hornet is assured until 2020. Based on the analysis conducted during the Operational Analysis phase of the Next Generation Fighter Capability (NGFC) project, the modernized CF-18 avionics suite remains compliant with the current interoperability requirements of other Canadian services and allies until 2020. However, beyond 2020, some core CF-18 avionics systems will need to be upgraded. These requirements are driven by the US National Security Agency (NSA) modernization of their cryptographic architecture which enables secure (encrypted) communications. These hardware upgrades will also require OFP upgrades, which will also drive hardware and firmware upgrades to the CF-18 mission computers which run them. As a final point, these essential upgrades also demand that CF-18 flight simulators be upgraded to ensure they remain adequate as training platforms.

Operational Relevance. The technical upgrades discussed above mainly relate to technical requirements associated with aircraft interoperability. Interoperability has multiple meanings and is only one component of operational relevance. Operational relevance can be summarized by three items: survivability, effectiveness and interoperability. The

[9] OFPs are the software programs of avionics embedded computer systems.

emergence of ever-increasing technological challenges in the future operating environment will affect each of the relevance components. The pivotal technological growth trends are in the Low-Observable (LO) realm, not only in aerospace systems but also in maritime and ground-based systems. They range from new designs, retrofit upgrades and overall electromagnetic spectrum reductions or exploitation capabilities. The challenges associated with these new capabilities stem from increasing threat offensive and defensive capabilities, improved target of interest denial and concealment, increasing global proliferation, cyber attacks against airborne systems and information management in complex geopolitical areas of concern.

Operational relevance is a continually sliding scale of measure. When an aircraft weapon system is new, it is usually near the 'front edge' of operational relevance. Over time, it slides away from the front until an upgrade program is completed to keep up with advancing technologies which drive new capabilities. The CF-18 was a leading edge state-of-the-art fighter when it was introduced in the 1980s and it gradually fell behind over time until during the Kosovo conflict it had reached the 'back edge' of coalition capability. The capability upgrades over the last 10 years have resulted in the CF-18 again being near the 'front edge' during the 2011 Libya operations. This capability will now once again erode over the remainder of the Hornet's service life as technology continues to evolve.

The three relevance items are somewhat interdependent and can be looked at holistically. This interdependence and their shifting importance will depend on the operating realm; however, they are all required to some extent within any domestic or expeditionary scenario. The best way to illustrate their varied importance at the strategic level is to highlight their importance within both roles.

a. Survivability. As previously mentioned, LO encompasses many aspects including emissions control. In the domestic realm, an aircraft's survivability may not be directly impacted in the traditional sense by the absence of adequate LO characteristics; rather, it would be more tied to the ability of the aircraft weapon system to effectively continue executing the required mission. These new stand-off weapons are also applicable to maritime operations. It must also be emphasized that NORAD has evolved to include a meaningful maritime component within its scope. This would leave the CF-18 deficient in both domestic and expeditionary operations in order to improve its survivability against advanced threat capabilities.

b. Effectiveness. The level of information required during both domestic and expeditionary operations is forecast to increase. In the NORAD context, the emergence of more satellite, UAV and other information gathering systems paired with increased air and maritime traffic will exponentially increase operational data levels. In the expeditionary role, the addition of more coalition systems and operations within more congested theatres will result in similar increases. In an emerging complex information-heavy future operating environment, the CF-18 is limited by physical cockpit display set-up and non-sensor-fused data. Accordingly, in both domestic and expeditionary scenarios, the operational effectiveness of the CF-18 will decrease.

<u>Interoperability in the operational context</u>. Besides the technical interoperability aspects previously discussed, the operational interoperability must also be examined. During coalition operations, aircraft of the same capability levels usually operate together. Operational interoperability is most easily exemplified by the F-117 stealth fighter operations during the Kosovo conflict. This aircraft type operated independently from other types to preclude non-stealth aircraft from giving away F-117 locations during combat missions. As a greater number of aircraft become LO, non-LO aircraft will be segregated so as to not be a liability. This has implications for both domestic and expeditionary operations. In the domestic context, as the US upgrades its own fighter forces, NORAD operations of the future could require the same interoperability considerations as coalition operations.

<u>Operational Relevance – Bottom Line</u>. The CF-18's *current* capabilities are assessed as sufficient to meet most operational requirements until the mid-2020s. However, as technology and the battlespace evolve, the *relative* capability of the CF-18 will erode through the 2020s. Maintaining the CF-18's relative capability levels into the future would potentially require additional capability investments in new technologies through key system upgrades. However, pursuing such upgrades in the current context was assessed as infeasible, which will result in increasing mission risk the further the CF-18's ELE is extended, especially if expeditionary missions were to be considered.

<u>Air Weapons.</u> New air weapon procurement costs were not included in this study. Air weapons which introduce new capabilities are normally procured under discrete capital programs. Any such air weapons considered for procurement and integration while the CF-18 is Canada's primary fighter aircraft will be forward compatible with any replacement fighter being procured in accordance with the RCAF air weapons procurement roadmap; accordingly, they are not considered as a unique expenditure requirement to specifically maintain CF-18 operational relevance.

<u>Fleet Operational Capacity</u>. Assessing the capabilities of a weapon system in the context of the environment in which it operates determines its operational relevance. However, the overall or collective operational capability of the fleet (i.e. operational capacity) must also be assessed when determining if the ELE can be extended. CF-18 fleet size has decreased 44% since the aircraft were purchased due to attrition (operational losses due to accidents) and the management decision to retire older configuration aircraft which would have required significant NRE costs to modernize to the current ECP-583R2 configuration. Current fleet size is sufficient to meet CFDS commitments; however the flexibility to withdraw significant numbers of aircraft for required upgrades has decreased significantly.[10] Any decision to pursue lengthy and complex upgrades would result in a commitment-capability gap. Furthermore, the CF-18 attrition rate of one aircraft loss (i.e. crashed or damaged beyond economical repair) per 28,000 flying hours has held fairly constant over its operational life and the longer the fleet continues to operate, the smaller the projected fleet size will be. Although the impact of attrition can be mitigated over time

[10] As an example, an extra 14-25 older configuration CF-18 Hornets were available for operations while the ECP-583 modernization and CP2 structural lines were active. These non-modernized aircraft were still operationally available to offset those aircraft being modified at that time. All have since been disposed of.

by decreasing the fleet's YFR, such a decision must be balanced against required training and operational commitments.

Analysis Summary

An ELE extension past 2020 is currently assessed as technically feasible with respect to the structural life, wiring integrity, reliability and maintainability of aging aircraft systems and associated obsolescence management. As expected, the results show that the further ELE is extended, the more costly it will be to continue supporting the CF-18 fleet, above and beyond the current annual recurring In-Service Support (ISS) costs. Also, based upon current assessments, operational relevance of the CF-18 is assured until 2020. Beyond this point, a number of weapon system modifications would be required to ensure continued interoperability with the US and other potential coalition partners, and compliance with International Civil Aviation Organization rules to operate in domestic and international airspace.

In developing the requisite cost estimates, the following technical assumptions were made:

a. FLEI consumption (i.e. fatigue usage) rates will mirror current ten-year fleet averages for CF-18A and CF-18B aircraft. In other words, the current concepts of operations and training for the CF-18 fleet will remain essentially unchanged;

b. The historical attrition rate will continue;

c. All CF-18 aircraft reaching their fatigue (structural life) thresholds prior to the final cessation of CF-18 operations will be retained and stripped for spare parts;

d. The US Navy and some F/A-18 fleet partners will continue to operate legacy Hornet aircraft until at least 2025 thereby ensuring the availability of spare parts and key components to enable continued maintenance, repair and overhaul activities; and

e. A new structural life extension program, known as Control Point 4 (CP4), will be required if there is a need to extend the CF-18 aircraft structural life beyond a FLEI of 1.0 for some of the fleet's aircraft.

The following operational assumptions were also made:

a. The number of CF-18 aircraft required during ELE drawdown is based on the Next Generation Fighter Capability (NGFC) Project ground rules and assumptions for transition to a new fighter aircraft, CFDS requirements predicated on NORAD and NATO commitments, and RCAF pilot training capacity;

b. A minimum fleet size of 65 aircraft is required.

c. A ramp-down of forty-two CF-18 aircraft to twelve CF-18 aircraft will be required; and

d. Yearly Flying Rate (YFR) maximum represents the practical upper limit of normal aircraft usage.

Sensitivity Analysis. While the above assumptions are sound based on currently available information, it is possible that one or more of the assumptions will vary significantly between now and the chosen ELE target. A sensitivity analysis was therefore conducted to determine the effect of varying CF-18 usage parameters (YFR, fatigue consumption and attrition) on structural upgrade, sustainment and operating costs.

a. YFR was varied;

b. CF-18A/B FLEI Rates were varied;

c. Attrition Rate was varied.

On a percentage change basis, the analysis showed that the fleet fatigue life curves were most sensitive to variances in YFR and least sensitive to changes in attrition rates. The analysis results for all ELE options identify the number of months lost or gained to the target ELE date for a constant investment of funds.[11] Viewed holistically, the analysis shows that some potential flexibility exists to manage the fleet to mitigate unforeseen or unforecasted circumstances.[12]

The results of this analysis were used to determine the number of required LEP repairs and upgrades to fleet aircraft in order to achieve the required ELE targets from which projected structural repair and other sustainment costs were then derived.

Aging Fleet Issues. Aging fleets become increasingly expensive to maintain over time. As aircraft age, their maintenance burden increases. More specifically, preventive maintenance requirements (scheduled inspections and component replacements) grow. Additionally, corrective maintenance requirements (the probability of unscheduled maintenance actions after a flight) also increase with aircraft age. Thus, sustainment costs continue to escalate the longer a fleet is kept in service due to increasing spares purchases and repair costs.[13] However, when a fleet is incrementally retired, sustainment costs tend to decrease during the planned ramp-down because non-procured spare parts become available from decommissioned aircraft. Consistent with the methodology used in US aging aircraft

[11] A constant investment requires the total cost for the structural upgrade program to be held constant, meaning the number of structural inductions and required component buys is held constant. The output of the sensitivity analysis is an assessment of the time variable (i.e. how long the fleet could fly). Conversely, the ELE date (i.e. time) could be held constant, and the number of LEP inductions and component buys could be increased or decreased to meet the required ELE. The variable in this case becomes the required investment (cost) to meet the ELE target.

[12] Note that the sensitivity of the fleet life expectancy to changes in YFR or FLEI continues to decrease as the fleet nears retirement

[13] A number of US aging aircraft studies identify cost escalation factor of 1.7% per annum, which is the aging aircraft inflation factor accepted by DND/Chief of Review Services. See Matthew Dixon, “The Costs of Aging Aircraft – Insights from Commercial Aviation”, (Santa Monica: Rand Corporation, 2005) and Raymond A. Pyles, “Aging Aircraft – USAF Workload and Material Consumption Life Cycle Patterns”, (Santa Monica: Rand Corporation, 2003).

studies, the aging factor were derived by applying a cost growth above inflation of approximately 1.7% compounded annually.

Operational Availability. An additional factor associated with aging aircraft is an expected decrease in operational availability. When aircraft fleets are operating early in their life cycle, availability[14] is generally high, with a limited number of aircraft down for extended maintenance requirements (e.g. upgrades or complex repairs). Furthermore, their serviceability rates are also relatively high, assuming adequate sparing and competent maintenance personnel.[15] As the maintenance burden for an aging aircraft fleet increases, serviceability rates generally decline if maintenance personnel resources remain constant. Furthermore, as the fleet retires, the removal of spare parts from decommissioned aircraft induces an additional maintenance burden, further decreasing serviceability. As experience has shown with other aging fleets, at a certain point, regardless of available funding, CF-18 readiness rates will continue to decrease because of declining serviceability and fleet size such that the fighter force will be challenged to meet all force generation (training) and CFDS commitments.

Rampdown Requirements. The new required ELE targets for the CF-18 fleet were defined by the RCAF for a planned five-year rampdown with specific numbers of aircraft at specific points in time. The defined rampdown drives the number of structural upgrades required and the induction schedule for the affected aircraft. In accordance with the latest rampdown plan, a reasonable fleet size is maintained for approximately two years with either ELE extension option. The last three years results in a significant decline in numbers as aircraft are retired and cannibalized, at which point only a handful of aircraft would actually be operational at the fleet retirement date. For the two ELE extension options examined, this decline in legacy CF-18 numbers corresponds with the anticipated entry into operational service of a replacement fighter. This rampdown could be somewhat altered by increasing or decreasing the number of structural inductions and fleet usage as identified in the sensitivity analysis. However, any changes to structural inductions will result in changes to the incremental costs associated with these ELE extensions. In an ideal situation, declining CF-18 fleet numbers would be built into the transition plan to a new fleet, with the decreased CF-18 fleet capacity offset to a level and at a rate determined by the planned build-up of a replacement fleet of fighter aircraft.

ECP-583. The current ELE baseline is funded from a structural betterments perspective. The remaining required funding (all costs are presented in budget year (BY) dollars unless otherwise stated) for ECP-583 is approved and allocated in the CF-18 betterment budget. As this funding has already been approved, it is not included in the life cycle cost estimate for the ELE 2020 Baseline. No additional avionics upgrades beyond the ECP-583 retrofit program were originally forecast to meet the ELE 2020 Baseline requirement. However since 2008, the new Air Traffic Control management framework has been developed and scheduled for implementation, and a cryptographic modernization program has been initiated by the US government. This program also includes the updated cryptographic Key

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[14] Availability is defined as fleet size, less those aircraft in depot-level maintenance (i.e. those in the possession of a support contractor).

[15] Serviceability is the percentage of aircraft at flying units, which are ready to fly (i.e. not requiring any maintenance actions prior to flight).

Management initiative for NATO interoperability, and the USN is planning a series of F/A-18 hardware and software upgrade efforts between 2013 and 2019. These programs have generated acquisition requirements in addition to those for ECP-583.

ELE 2020 Baseline. Required structural upgrades and additional avionics update requirements to meet the current ELE are forecasted. While the required structural upgrade costs are known and funded, the avionics upgrades needed to meet the ELE 2020 target are a recent requirement, not identified during the previous CF-18 ELE extension study. These costs are not yet funded.

ELE 2025. A CF-18 ELE extension to 2025 is assessed as a low risk option in terms of cost, schedule and technical factors. This ELE target would generate some robust requirements in order to manage continuing airworthiness and obsolescence issues.

ELE 2030. A CF-18 ELE extension to 2030 would be a very technically challenging, lengthy and costly endeavour. A majority of the fleet (50 aircraft) would need to be flown beyond the currently certified safe life of 1.0 FLEI based on current projections, and also requires all CF-18s to undergo CP3. This would necessitate development of a new structural life extension program, with some significant NRE costs to develop and certify the requisite modifications, repairs and inspections. A large and costly procurement of new wings and flight controls would also be required to support this effort, as the structural lives of these components would expire for many of the fleet's aircraft.

The projections are based on program-level costing, as defined in KMPG's Life-Cycle Costing Framework[16] and are based on known CF-18 upgrade and support requirements at the time the report was finalized. Costs have been inflated to BY dollars using the DND Economic Model. The calculated contingency values mitigate the potential cost risks associated with variations in operational usage, which would negatively impact fatigue life and spares consumption, as well as potential changes to inflation rates for goods and services, and foreign exchange rate fluctuations.

The current ongoing baseline spending for sustainment and operating would continue regardless of the option chosen and disposal will occur at some point under both new ELE extension options. Costs that are common between all options, (including the status quo) are excluded to derive incremental costs. (Incremental costs are those costs which relate to new spending that is a direct result of the decision to extend the life of the CF-18, excluding the ongoing baseline). Therefore, the *increased* cost specifically associated with extending the CF-18 fleet past the current ELE is due to development, project management and acquisition costs associated with required structural and avionics upgrades along with some cost escalations within the sustainment budget due to aging aircraft effects.

The costs to extend the CF-18 aircraft beyond 2020 result from additional development efforts, structural upgrades, avionics upgrades, software and simulator upgrades, new project management, structural component purchases, an increase in fleet sustainment

[16] KPMG Next Generation Fighter Capability: Life-Cycle Cost Framework, 27 November 2012.

expenses due to aging aircraft effects, and contingency funds to mitigate risk. These incremental costs are further detailed below.

Development Costs (Vote 5 Capital Funded). This includes the costs for all activities necessary to achieve expenditure approval for avionics upgrade activities and verify the technical feasibility of the chosen ELE.[17]

Acquisition Costs (Vote 5 Capital Funded). Acquisition costs associated with extending the CF-18's ELE are one-time costs associated with improving its service potential through upgrades or other improvements (known as "Betterments"), which either increase capabilities, or extend the useful life of the aircraft. These betterment costs are categorized as follows:

a. Structural Upgrades. These incremental costs are for the development and embodiment of required structural upgrades and the purchase of new structural components such as centre barrels, wings and flight controls to enable the CF-18 fleet to fly past 2020. These costs must be expended to extend the fleet in order to maintain an adequate fleet size. However, these costs could be reduced by decreasing YFR.

b. Avionics Upgrades. These incremental costs are a combination of: 1) regulatory upgrades required to comply with upgraded Air Traffic Control architecture and regulations being implemented worldwide commencing in 2017 in Europe and 2020 in North America; 2) Interoperability upgrades to provide secure (encrypted) communications capability between the CF-18 and allied units once NATO encryption architecture is upgraded; and 3) associated Program Management Office costs.

Sustainment Costs (Vote 1 National Procurement Funded). Sustainment costs increase the longer a fleet is kept in service, due to decreasing system reliability. The incremental cost associated with aircraft aging represents the escalation of sustainment costs between 2020 and the target ELE in addition to inflation. These yearly increases will continue for as long as the CF-18 is operated. However, these costs are only a portion of the total CF-18 annual sustainment budget, which is part of the ongoing sustainment baseline. These costs cannot be eliminated as they will continue to accrue as long as the CF-18 fleet is operated beyond the currently declared ELE.

Incremental Cost Summary. To fly the CF-18 past the current ELE of 2020 will incur additional costs to the Department. These expenditures are necessary to expand the current structural life program to more aircraft in order to allow the CF-18 fleet to fly beyond its current ELE of 2020, and to address avionics upgrade requirements as well as increased sustainment costs due to aircraft ageing effects. Incremental costs for an ELE of 2030 are primarily due to the requirement for a new structural life extension program needed to enable the CF-18 to be flown beyond its current safe life. These costs include non-recurring engineering, the acquisition of new centre-barrels, new wings and flight controls, avionics

[17] This includes the set-up of a Project Management Office (PMO), which manages all Development and Acquisition activities.

upgrade costs and increased sustainment costs due to aircraft ageing affects for a longer period of time. If the ELE of the CF-18 is extended beyond 2020, the incremental costs will be amortized over the remaining useful life of the upgraded aircraft.

Implementation Timelines

The Estimated Life Expectancy (ELE) of the CF-18 fleet is currently set at 2020. An early ELE extension approval would minimize programmatic risk and cost.

ELE 2025

Structural Upgrades: DND approval of an ELE extension to 2025 by Fall 2015 would provide sufficient time to continue with the CP3 structural program without workflow disruption.

Avionics Upgrades: An upgraded Identification Friend-or-Foe (IFF) - specifically Mode S, Mode 5 and Automatic Dependant Surveillance Broadcast - frequency agile radios and secure data-link are required by the 2020 timeframe to meet regulatory and interoperability requirements as identified above. A 2025 ELE extension approval by Summer 2014 would provide sufficient time to obtain the necessary approvals and execute the required work.

ELE 2030

Structural Upgrades: Given the major development, procurement and installation efforts associated with a CP4 structural upgrade program, an ELE extension approval to 2030 by Summer 2014 would allow sufficient time to obtain the necessary approvals and to execute the work. Delays could result in schedule and cost risks. For example, as suppliers terminate production of required aircraft components through this decade, acquisition time and costs will increase.

Avionics Upgrades: An upgraded Identification Friend-or-Foe (IFF) - specifically Mode S, Mode 5 and Automatic Dependant Surveillance Broadcast - frequency agile radios and secure data-link are required by the 2020 timeframe to meet regulatory and interoperability requirements. An ELE extension to 2030 would require that these systems be acquired and embodied in order to ensure fleet operational relevance. A 2030 ELE extension approval by Summer 2014 would provide sufficient time to obtain the necessary approvals and execute the required work.

Conclusion

To summarize, flying the CF-18 past the current ELE of 2020 will incur additional costs to the Department. All expenditures associated with extending the CF-18 operating life represent investments in an ever-declining capability in an aging fleet. Nevertheless, an ELE extension to 2025 is currently assessed as a low risk option in terms of cost, schedule and technical factors. An ELE extension to 2030 is assessed as a high risk option in terms of cost, schedule and technical factors.

A decision by Summer 2014 for an ELE of 2025 is required to minimize the programmatic, schedule and cost risks for the required structural and avionics upgrades.

While this report does not provide any specific recommendations related to any assessment of cost effectiveness, relevant factors such as availability, serviceability and fleet operational capacity have been analysed and presented herein to provide context to the assessed options.