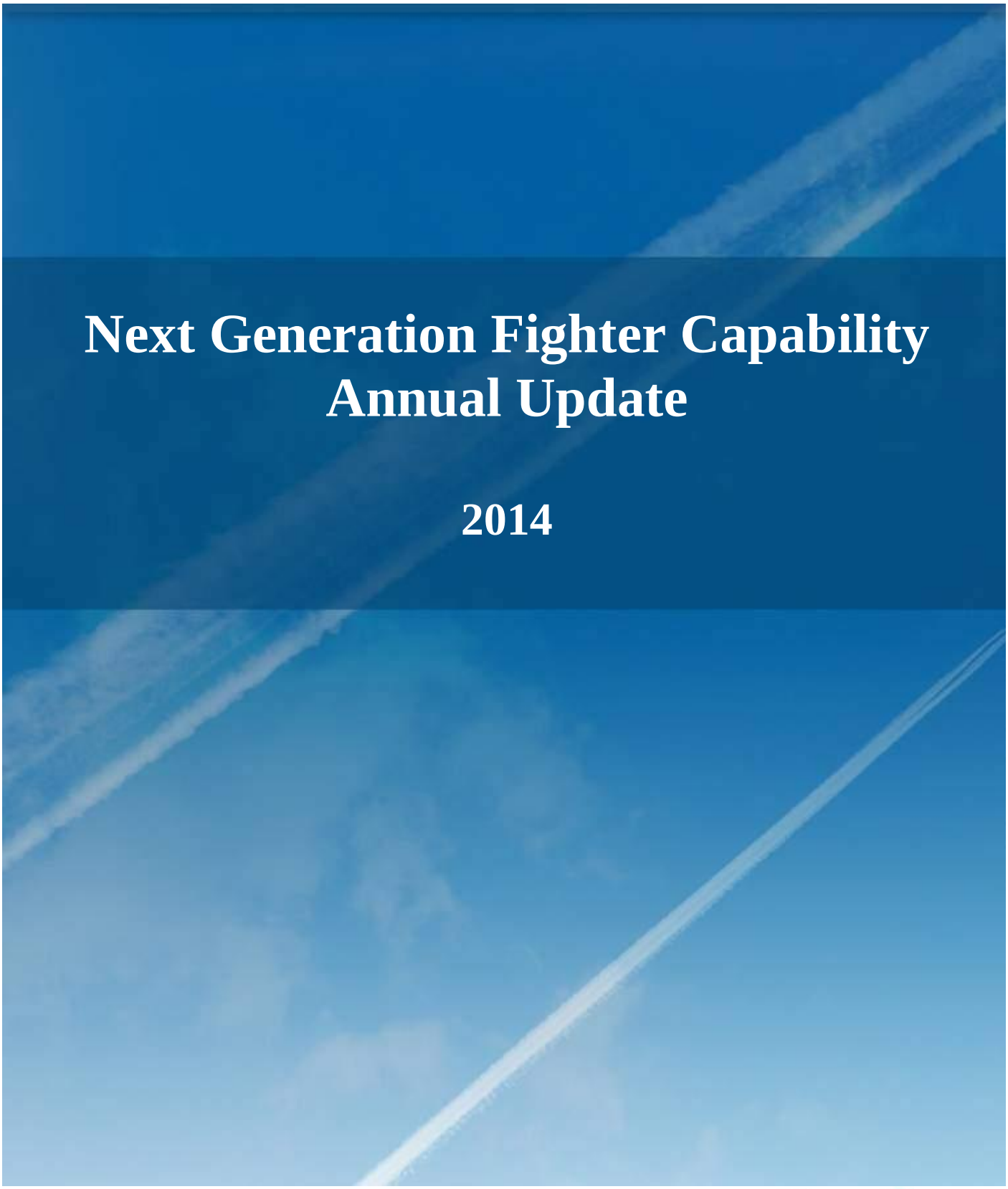
National Defence / Défense nationale



Next Generation Fighter Capability Annual Update

2014

Canada

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Executive Summary

Introduction

In response to the Auditor General's Spring 2012 Report on *Replacing Canada's Fighter Jets,* the Government of Canada implemented a Seven-Point Plan to assist the government in making the best possible decision on sustaining a Canadian Armed Forces fighter capability well into the 21st century. Since the launch of the Seven-Point Plan, funding for the acquisition of a replacement fighter has been frozen.

One element of the Seven-Point Plan requires National Defence, through the National Fighter Procurement Secretariat, to provide annual updates to Parliament on the cost estimates of the F-35, and to continuously refine its full life-cycle costs estimates and make these estimates available to the public. On 12 December 2012, the Department of National Defence released its first Next Generation Fighter Capability Annual Update to Parliament, and on 9 August 2013 the second Next Generation Fighter Capability Annual Update was released.

The Department of National Defence presents herein its third Annual Update on the cost to potentially replace the CF-18 fleet with a fleet of F-35A Joint Strike Fighter aircraft. These costs cover program development through delivery and operations, to withdrawal from service. The scope of activity used to prepare this update is unchanged from what was contained in the 2013 Annual Update. For this update, the delivery of the first aircraft is assumed to be in 2020 taking into account the life extension of the CF-18 fleet to 2025.

Raymond Chabot Grant Thornton completed an independent review of National Defence's estimated life-cycle costs presented in this Annual Update. This updated cost estimate has been prepared in accordance with the framework documented in the KPMG report *Next Generation Fighter Capability: Life-Cycle Cost Framework*, 27 November 2012.

Cost Methodology and Estimates

For the annual updates to Parliament the Department uses two distinct data sources to derive the acquisition cost estimate for a fleet of Canadian F-35A aircraft and the associated life-cycle costs estimates. The F-35 Joint Program Office provides estimates for over 90 percent of the acquisition and sustainment cost data. The remainder of the life-cycle cost data is dependent on how Canada would operate its fleet, and the cost estimate is based on data from Canadian sources. National Defence also takes into account actual and projected differences between the Canadian and United States currencies, and other such economic factors that affect cost estimates.

Canada received a bilateral cost estimate from the F-35 Joint Program Office on 28 August 2014. The table below presents a side-by-side comparison of the 2013 and 2014 life-cycle cost estimates, including development, acquisition, 30-years of sustainment and operations for each aircraft, and disposal. The life-cycle cost estimate presented is a risk-adjusted "point estimate" of the full life-cycle cost of a Canadian fighter acquisition program. It is important to consider the accompanying sensitivity, risk and uncertainty analysis contained in Section V. That analysis provides a sense of the possible variations in the cost estimate.

Comparative Estimate ($ CAD Million in Budget Years, including contingency)

Cost Element	2012 LCC Estimate	2013 LCC Estimate	2014 LCC Estimate	2013/2014 Variance
Development	565	606	633	27
Acquisition	8,990	8,990	8,990	0
Sustainment	15,240	15,055	14,258	-797
Operating	19,960	19,857	20,736	879
Disposal	65	168	179	11
Total LCC	44,820	44,676	44,796	120
Attrition (note 1)	982	1,015	1,036	21
Total	**45,802**	**45,691**	**45,832**	**141**

Note 1: It is estimated that seven to eleven aircraft could be lost over the useful life of the fleet and the cost to replace these lost aircraft could be in the order of $1 billion. However, this cost is not part of the Life-Cycle Cost estimate.

Compared to the 2013 Annual Update, deliveries are now assumed to start in 2020 and end in 2025, extending the Life Cycle Cost Estimate by two years and lengthening the development phase of the project. As such, the general cost differences impacting each major cost element are attributable to the extended timeframes and the associated inflationary indexes and uncertainty around foreign exchange rates.

In the 2013 Annual Update, contingency for the Sustainment cost element was augmented through a prudence factor due to increased uncertainty around the estimate. At the time of the 2013 Annual Update, the Operating and Sustainment estimate provided by F-35 Joint Program Office had decreased by approximately 17% from the previous year. The U.S. Department of Defense Office of Cost Analysis and Program Evaluation (CAPE) had not confirmed the decrease through an independent cost estimate, therefore increasing uncertainty around the sustainment estimate. CAPE has now produced an independent Operating and Sustainment cost estimate that, according to the 2013 Selected Acquisition Report, is within 2% of the F-35 Joint Program Office estimate once adjusted for the same technical baseline. The confirmation of the F-35 Joint Program Office sustainment estimate in the 2013 Selected Acquisition Report has eliminated the requirement for the prudence factor. The contingency included for sustainment is now approximately 16%.

Details on changes to the cost estimate since the 2013 Annual Update can be found within Part VI, Section 2 of this report.

Risks and Uncertainty

Programmatic: Software continues to be the most challenging technical risk to the F-35 program. Software build delays and limitations in delivered software capabilities have caused delays in mission system testing, putting at risk the schedule for achieving initial operating capability. To address the risk, significant changes have been made in software processes, showing positive effects. The F-35 Joint Program Office remains confident that the current schedule for achieving an initial operating capability can be met.

The affordability of the F-35 program remains a challenge for participants. Maturing manufacturing and supply process are helping to lower unit costs, though a significant amount of acquisition cost reduction has to be realized if targets are to be achieved.[1] The F-35 Joint Program Office has focused on improving reliability as a means to lowering sustainment costs.

Some of the Program's past instability was related to the concurrency of development, test, and production. Concurrency results from design and tooling changes and altered manufacturing processes concurrent with developmental testing. Concurrency remains a concern, though concurrency cost estimates have stabilized over the past year. As testing progresses the risks and costs of concurrency should progressively decline as the program approaches full rate production.[2]

Overall, the F-35 program is making steady progress while moving forward in a disciplined manner. Royal Canadian Air Force personnel within the F-35 Joint Program Office continue to track and monitor developments closely.

Contingency: The current estimate includes $76 million for acquisition contingency, a reduction of $266 million since the 2013 Annual Update. The full amount of acquisition contingency suggested by the Life-Cycle Cost Framework would be $1,080 million. The $1,920 million for sustainment contingency reflects a decrease of $1,576 million since the 2013 Annual Update. While the overall contingency provisions fall within the range recommended in the KPMG

[1] United States Government Accountability Office Report to Congressional Committees, F-35 Joint Strike Fighter, Problems Completing Software Testing May Hinder Delivery of Expected Warfighting Capabilities, March 2014.

[2] United States Department of Defense, written Testimony for the House Armed Services Committee, 26 March 2014.

Framework, the provision for acquisition contingency is considered low for a project of this scope and size. If the full acquisition contingency was required, the remaining shortfall could be met by buying fewer aircraft. Moving forward, the Government will consider the frozen acquisition envelope in relation to the capability needed to meet the *Canada First* Defence Strategy to replace Canada's CF-18 fleet. Taking into account the above adjustments to contingency and the fact that the overall cost estimate has not changed materially from the previous estimate, the provision for contingency remains consistent with known risks.

Conclusion

As part of the Seven-Point Plan for replacing Canada's fighter aircraft, the Department of National Defence has completed an analysis of the estimated life-cycle cost for a notional F-35A fleet, based on updated cost data received from the F-35 Joint Program Office in August 2014. This analysis compares current life cycle cost estimates with those reported in the 2013 Annual Update. While cost estimates continue to be refined based on the evolution of the Joint Strike Fighter Program, the comparative analysis generally indicates marginal changes in various sub-elements and an overall increase of 0.27% between the life-cycle cost estimates calculated in 2013 and 2014.

Planning assumptions and the associated estimates will continue to be refined in future annual updates. Raymond Chabot Grant Thornton completed an independent review of National Defence's estimated life-cycle costs presented in this Annual Update. Their report concluded that the 2014 Annual Update appears complete and offers proper support to decision-makers, provides a reasonable and comprehensive presentation of key issues related to the Life Cycle Cost estimate, and that there were no deviations from the Framework that would result in any material changes to the overall life-cycle cost estimate.

Next Generation Fighter Capability

Annual Update

2014 Report

I. What This Report Is About

In June 2012, the National Fighter Procurement Secretariat embarked on its mandate to ensure that due diligence, oversight, and transparency are applied to the process of acquiring fighter aircraft for the Royal Canadian Air Force. The Secretariat is achieving this goal through the implementation of a Seven-Point Plan. This report meets one element of the Seven-Point Plan: National Defence, through the National Fighter Procurement Secretariat, will provide annual updates to Parliament.

The Department of National Defence presents herein its third Annual Update to Parliament on the cost estimates for the F-35. This Update is based on program-level costing, as defined in KMPG's *Life-Cycle Costing Framework*[1]. It covers the cost of a replacement fighter aircraft capability for Canada, from program development through delivery and operations to withdrawal from service.

Based on updated cost estimates and current planning assumptions, this report by the Department communicates clearly and frankly with the Canadian people and Parliament, and contributes valuable information with which to facilitate and enhance Canadians' ongoing understanding of the future replacement of the CF-18 aircraft.

The next section, Part II, discusses the importance of replacing Canada's aging CF-18 fighter aircraft fleet if the Canadian Armed Forces are to continue to fulfill the roles identified in the *Canada First* Defence Strategy.

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

II. Replacing Canada's Fighter Aircraft

1. The Canada First Defence Strategy

The *Canada First* Defence Strategy provides for the replacement of the CF-18 fighter. According to the Strategy, announced in May 2008, "First and foremost, the Canadian Forces must ensure the security of our citizens and help exercise Canada's sovereignty." In addition to this role of defending Canada, the Strategy outlines two other roles of the Canadian Armed Forces: defending North America and contributing to international peace and security. The Strategy was developed, in part, to ensure that the Canadian Armed Forces have the right equipment and other resources needed to fulfill these three roles.

Two key and related responsibilities of any national government are exercising the country's sovereignty and securing the population from harm. Defending Canada, in the widest sense, extends to preventing and confronting possible terrorist attacks, human and drug trafficking, and foreign encroachments on Canada's natural resources.

Ensuring excellence in the domestic role paves the way for Canada's role as a reliable military partner at the continental level. North America's common defence and security requirements find expression in the continued validity, viability and success of the North American Aerospace Defence Command, commonly known as NORAD, a bi-national command structure with the United States.

Internationally, Canada remains a robust contributor to the maintenance of peace and security, which, in turn, is crucial to Canada's interest as a global trading nation. Canada plays an active military role in the United Nations, the North Atlantic Treaty Organization, and the Organization for Security and Co-operation in Europe. Canada also participates actively in special coalition arrangements, as deemed appropriate by the Canadian government, in response to an ever-changing global security environment.

The Canadian Armed Forces must therefore be a flexible military, capable of playing a variety of roles and responding to a broad range of threats to our security and prosperity. To deliver on this wide range of missions, the Canadian Armed Forces use various resources at sea, on land and in the air.

For the past 25 years, the CF-18 has been the cornerstone of Canada's ability to fight in the air. At home and in North America, Canadian fighters operate through NORAD to ensure both sovereignty and air defence of Canada and the United States. NORAD aircraft are prepared to respond to any potential threat to North America, every hour of every day. They conduct approximately 200 such missions each year. Fighters also provide an important contribution to joint operations with the Royal Canadian Navy and the Canadian Army.

Canada is also committed to providing fighter aircraft in support of NATO if required. In the past, Canada's fighters have deployed as part of multinational operations, as they did during the First Gulf War and the Kosovo campaign, both in the 1990s. In 2011 CF-18s were deployed to southern Italy to participate in a multinational response to the crisis in Libya. Most recently in 2014 CF-18s were deployed to Romania to support NATO assurance measures in Central and Eastern Europe, and to the Middle East joining allies and partners to halt the terrorist spread in that region.

2. Replacing Canada's CF-18 Fighter Aircraft

When the CF-18 aircraft fleet entered into service in 1982, it was expected to be in service until 2003. Proactive aircraft management, including structural airframe repair programs, has since extended the life of this aircraft. The CF-18 has also undergone a comprehensive modernization of its systems. Combined with current plans to extend the life of the CF-18 fleet to 2025, these initiatives will ensure that Canada has a multi-role, fighter-jet capability throughout the next decade.

Nevertheless, spare parts will become increasingly scarce and expensive as its aircraft systems and airframe continue to age, and aircraft availability will become increasingly limited. Furthermore, as more sophisticated equipment comes into service internationally, CF-18s will be less compatible with other fleets, and will lose their ability to support coalition operations.

3. The Seven-Point Plan

The objective of the Seven-Point Plan that the Government put in place in April 2012 is to ensure that Canada has the fighter aircraft needed to complete the core missions of the Canadian Armed Forces. The Plan will also help to ensure public confidence in, and the transparency of, the process to replace Canada's fleet of CF-18s.

One element of the Seven-Point Plan requires National Defence, through the National Fighter Procurement Secretariat, to provide annual updates to Parliament on the cost of an F-35 option to replace the CF-18.

This report, together with the results of the independent review is the third Annual Update to Parliament since the Plan was put in place.

Issues related to life-cycle cost estimates are dealt with further in the next two parts of this update. Part III addresses life-cycle costs generally; Part IV does so with specific regard to the life-cycle costs of the F-35A as a possible replacement for the CF-18.

III. Estimating Life-Cycle Costs

This third part of the Annual Update focuses on the life-cycle costing methodology used to prepare this report. Part III also examines the uncertainty associated with life-cycle cost estimating, and outlines some of the steps to refine these estimates as a project progresses. It also provides an overview of the project management process in the Department of National Defence.

1. Life-Cycle Costs

A life-cycle cost estimate calculates all costs associated with a product, project or program from initial concept through operations to retirement and disposal.

The focus of life-cycle costing is to develop cost estimates that are driven by the purposes of the decision maker. Life-cycle costing is used in part to enhance decision making about acquisition and affordability. It can also support budgetary decisions, key decision points, milestone reviews and investment decisions.

Life-cycle costing is fundamentally an estimating activity, and is therefore imprecise, uncertain and highly sensitive to many factors that may be difficult to quantify at the time the life-cycle costing is being developed. As a program matures, costing estimates become better informed and more reliable.

As shown in the following table from the KPMG report, *Next Generation Fighter Capability: Life-Cycle Framework*, the total cost to the government of acquisition and ownership of a system over its useful life includes costs related to the phases of a program. These are: development, acquisition, sustainment and operations, and disposal.

Typical Phase	Phase Description
Development	All activities necessary to achieve expenditure approval
Acquisition	All activities necessary to introduce assets into operational service
Sustainment & Operations	Ongoing operations and maintenance of the assets
Disposal	Removal of assets from service and retirement, with any potential financial liabilities

Development Costs: All activities necessary to achieve expenditure approval. This includes the establishment of a Project Management Office and, for the F-35A, payments under the various Joint Strike Fighter Memoranda of Understanding.

Acquisition Costs: Acquisition costs are one-time costs associated with bringing a new or replacement equipment into service. For the replacement of the CF-18 fleet, the acquisition cost estimate includes: the cost of aircraft and engines, ancillary equipment, initial spares and set-up of maintenance support, set-up of

mission software reprogramming capability, project management, directly related infrastructure modifications, and initial training.

Sustainment Costs: Sustainment estimates include the costs of contracted in-service support activities for the life of an operational fleet. For the replacement of the CF-18 fleet, sustainment cost estimates include contracted labour and materials costs related to the major repair, overhaul, and upgrade of the aircraft and equipment, the management of the supply chain, and training-support management.

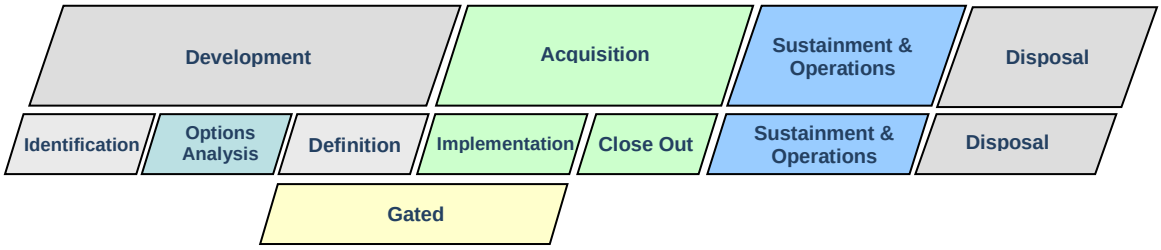
Operating Costs: Operating costs are expenses that the Department of National Defence incurs in the course of delivering its programs. For a fighter fleet, the operating cost estimate includes salaries, fuel, first-line maintenance, and base-support costs.

Disposal Costs: Disposal costs include the costs of demilitarizing the aircraft, removing hazardous materials, storage and final disposition of the airframe.

2. Project Management Cycle

As will be seen later in this document, there is a strong link between life-cycle costing as practised by National Defence and the Department's project management cycle. A brief look at the latter will therefore be helpful.

The Department of National Defence project management cycle aligns with the life-cycle costing Framework program phases, and reflects standard practices derived from the *Project Management Body of Knowledge*[2]. There are four project-approval phases: Project Identification, Options Analysis, Project Definition, and Project Implementation, which includes project closeout.



The diagram above depicts the relationship between program life-cycle phases used for cost estimating and the project-management cycle. By necessity, these cycles often overlap. Depending on the complexity of the project, additional governance may be achieved through a gated expenditure approval process for Project Definition and Implementation.

[2] A Guide to the Project Management Body of Knowledge (PMBOK Guide) - Fourth Edition. Project Management Institute

Gated approval simply means that expenditure and contract authority may be granted in phases as definition work progresses and substantive cost estimates are produced.

The implementation of the CF-18 replacement aircraft is expected to be phased over a period of years. As a result, a number of new aircraft will be operational while other aircraft are still being acquired.

National Defence's project cycle has four phases as depicted in the table below.

IDENTIFICATION	OPTIONS ANALYSIS	DEFINITION	IMPLEMENTATION
Identify capability deficiency.	Formulate options. Discard invalid options. Assess benefits of remaining options. Examine risks. Decide which option should be pursued. Develop rough order of magnitude and indicative cost estimate.	Confirm option choice. Prepare detailed review, risk assessment and costing of selected option. Undertake implementation planning. Develop substantive cost estimate.	Proceed with implementation. Proceed with implementation management. Do implementation monitoring. Present reports on status of implementation. Do operational handover. Proceed with close out.

Project Identification takes place when one of the operational branches of the Canadian Armed Forces – the Canadian Army, the Royal Canadian Navy, or the Royal Canadian Air Force – identifies a need based on a capability deficiency.

The Options Analysis phase enables senior management to make an informed decision on the best way to implement the project to meet the identified need. This phase includes work on a project charter, a statement of operational requirements, project risk assessments, and a project management plan for the next phase of the project, the Definition phase.

Life-cycle cost estimates for development, acquisition, sustainment and operating are prepared during the Project Identification and Options Analysis phases of a project. These estimates arise from a large number of planning assumptions based on prior and/or ongoing experience with the same or similar products or technology and the use of parameters and variables to develop cost-estimating relationships. Cost estimates during these early phases of a project are generally characterised as rough order of magnitude.

The Project Definition phase marks the transition from determining what should be done to determining how the preferred option will be implemented. The objective of the Definition phase is to complete studies to refine the way forward for the selected option. This work leads to a more refined cost estimate of the proposal using a 'bottom-up' approach (direct estimation of a particular cost element by examining products component by component). This includes the investigation of project management and risk-management strategies, and the development of a project management team. At each phase, departmental

costing experts must validate all project costs. During Project Definition, cost estimates become increasingly substantive.

A project moves into the Implementation phase after receiving the authorities required to enter into contracts and to make commitments of approved project resources. At this point, the goal is to achieve an operational capability within the scope, schedule and approved cost limits. During the implementation phase, full life-cycle estimates continue to be refined as actual costs are realized.

Project Closeout is triggered when a project achieves what is called full operational capability – that is, when it fully achieves its objectives. Project closeout also allows departmental authorities to close the books and the accounts for the project, releasing any unused resources for reassignment. Following project closeout, sustainment and operations for the asset are managed through standard equipment management and operational capability business processes.

3. The Importance of Understanding Differences in Terminology

A clear understanding of terminology is essential when reporting on costs, particularly when more than one country is involved in the acquisition. This understanding is also crucial in the public discourse on the future of the CF-18. The following information on terminology is presented to meet both needs.

Different governments sometimes use different terms to mean the same thing. For example, Canada uses the term “buy profile” to refer to the schedule on which it might want to receive and pay for the F-35A, a schedule that could change the overall cost by millions of dollars. The United States program office uses the term “bed down plan” to mean the same thing. Meanwhile, a company which is understandably focused on the manufacturing aspect of a plan may refer to this as a “production profile.”

On the other hand, governments–and, of course, industry–sometimes use the same term to refer to entirely different or even opposite concepts. When Canada says an aircraft will cost $X million (Canadian) in “BY” it is referring to Budget Year, which in the United States would be referred to as Then Year (TY). Canada is therefore communicating that those are dollars complete with calculations for inflation. On the other hand, when the United States says “BY,” it means Base Year, what Canadians would call “Constant Year” (CY). In this report, unless otherwise noted, all figures are presented in Canadian Budget Year dollars.

Another term often used by different jurisdictions, organizations or individuals to mean different things is unit cost. When Canadian authorities use the term “unit cost”, they usually mean “Unit-Recurring Flyaway” Cost, known as URF or URFC. As the name suggests, unit recurring flyaway cost includes costs for an aircraft to be flyable, including the costs of the engine and the mission systems.

When the United States speaks of unit cost, however, it is more likely to be referring to average production unit cost (APUC) or program acquisition unit cost (PAUC). Average production unit cost involves all the items covered by unit recurring flyaway costs plus such expenditures as those for ancillary mission equipment, and initial spares as well as technical data, publications and support and test equipment. Program acquisition unit cost includes all the costs included in average production unit cost, plus the costs for facility construction, and for research, development, test and evaluation.

The program acquisition unit cost of a single aircraft could be almost twice as much as—and therefore millions of dollars more than—the unit recurring flyaway cost for the same aircraft. Any reference to the “unit cost” of an aircraft, or any comparison between the stated unit cost for one aircraft and the stated unit cost for another—must, therefore, be clear about what is included in the estimate.

IV. Life-Cycle Cost Estimates for the F-35A

1. Reporting Back on the Cost of the F-35A Program

One element of the Seven-Point Plan requires National Defence, through the National Fighter Procurement Secretariat, to provide annual updates to Parliament on the cost estimates of the F-35, and to continuously refine its full life-cycle costs estimates and make these estimates available to the public.

This part of the report provides a comprehensive description of the planning assumptions that underpin the cost estimate for the F-35A, which remains one of the options being evaluated. These planning assumptions reflect the program Cost Breakdown Structure identified within the *Next Generation Fighter Capability: Life-Cycle Cost Framework*[3], developed by KPMG, including the addition of new cost elements for Concurrency Modifications and Diminishing Manufacturing Sources. To put these cost estimates in context, Part IV also provides information on Canada's participation in the United States-led Joint Strike Fighter Program, under which the F-35A is being developed.

2. Canada and the Joint Strike Fighter Program

As in the case of Canada, a number of like-minded countries are in the process of replacing their fighter fleets. Nine of them, including Canada, have signed the Joint Strike Fighter Production, Sustainment and Follow-on Development Memorandum of Understanding.

The Joint Strike Fighter Program is a United States-led multinational cooperative effort to build an advanced combat aircraft equipped to fulfill multiple roles. Planners intend the Joint Strike Fighter Program to run until at least fiscal year 2051/2052 and to produce approximately 3,055 F-35 Lightning II aircraft for purchase by Joint Strike Fighter partners by 2035. The actual number of aircraft produced may increase as additional aircraft are purchased through United States Foreign Military Sales legislation by countries not part of the Program, such as Israel and Japan, which have already committed to acquire aircraft. In 2014, South Korea also selected the F-35 as its new fighter.

Canada's participation in the Joint Strike Fighter Program is managed through the Next Generation Fighter Capability Project Management Office, which is part of the Department of National Defence. Royal Canadian Air Force personnel are also embedded, alongside personnel from the eight other Partner Nations, in the F-35 Joint Strike Fighter Program Office, in Washington D.C.

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

3. Phases in the Joint Strike Fighter Program

Canada has been an active participant in the Joint Strike Fighter Program since 1997. This country joined the Concept Demonstration Phase with a contribution of $15.2 million ($10.6 million U.S).

Canada also joined the second phase, System Development and Demonstration, in 2002 by contributing an additional $139.4 million ($94.4 million U.S.). Additionally, this country invested $77.9 million ($50 million U.S.) in Canadian aerospace industries through Industry Canada's Strategic Aerospace and Defence Initiative (SADI), formerly Technology Partnership Canada. Contributions made under the SADI program are repayable to Canada by Industry.

Canada's participation in these early phases of the Joint Strike Fighter Program provided Canada with access to technologies and data, new management and engineering approaches, and increased opportunities for Canadian industry to bid for Joint Strike Fighter contracts.

In December 2006, Canada became a partner in the third phase of the Joint Strike Fighter Program by signing the Production Sustainment and Follow-on Development Memorandum of Understanding. This Joint Strike Fighter Memorandum of Understanding provides a framework that allows participants to cooperate effectively in the production, sustainment and follow-on development of the F-35. Signing the Memorandum of Understanding in 2006 did not commit Canada to buy the F-35A.

Should Canada decide to acquire the F-35A, the primary benefits of participation in this phase of the Joint Strike Fighter Program are continuing opportunities for Canadian industry, a projected reduction in acquisition costs and potential savings in sustainment costs as a result of the collective purchase and management of available spares within a global sustainment system. Additional benefits include continuing access to, and use of, Joint Strike Fighter Program information; the opportunity to influence the Joint Strike Fighter Program and to share future development costs; and closer interoperability between Canada and the eight other partner nations.

Contributions made to the Production Sustainment and Follow-on Development Memorandum of Understanding pay for costs shared by Joint Strike Fighter Program participants, such as for program administration and the development of future modifications and upgrades to the aircraft. The current ceiling for Canada's participation in this phase is $551.6 million U.S of which Canada has so far contributed $189.8 million ($183.7 million U.S.). This includes a payment of $22.9 million ($21.0 million U.S.) made by the Department of National Defence in May 2014 for continuing participation in the Joint Strike Fighter Program through U.S. fiscal year 2014. A participating country's maximum contribution amount

may only be increased through an amendment to the Memorandum of Understanding.

To date, Canada has invested $344.4 million ($288.7 million U.S.) as its share of the Joint Strike Fighter Program, and committed $77.9 million ($50 million U.S.) to Canadian aerospace companies through Industry Canada programs under the System Development and Demonstration Phase of the Program. As explained in the Summer 2014 update to Industry Canada's report on *Canadian Industrial Participation in the F-35 Joint Strike Fighter Program*, Canadian companies have so far secured $587 million U.S. in contracts as a result of Canada's participation in the Joint Strike Fighter Program. This is an increase of $83 million U.S. over the results reported in the Fall 2013 report.

4. Cost Methodology and Estimates

For the annual updates to Parliament the Department uses two distinct data sources to derive life-cycle costs estimates. The F-35 Joint Program Office provides estimates for over 90 percent of the acquisition and sustainment cost data. The remainder of the life-cycle cost data is dependent on how Canada would operate its fleet, and the cost estimate is based on data from Canadian sources. National Defence also takes into account actual and projected differences between the Canadian and United States currencies, and other such factors that affect cost estimates. Part V provides details on these factors and the assumptions underlying them. For planning purposes, the costs are then expressed in Budget Year Canadian dollars, that is, future dollars adjusted for inflation.

Canada received a bilateral cost estimate from the F-35 Joint Program Office on 28 August 2014. At this phase of the project to replace the CF-18, these costs should be considered as rough order of magnitude approximations based on initial planning assumptions and maturing Joint Strike Fighter Program costs. As the project progresses and as plans are defined and assumptions confirmed, the methods used to cost the individual elements will also progress to reflect actual and more detailed costs.

5. National Defence Planning Assumptions

The project to replace the CF-18 is currently in the Options Analysis phase. The cost estimates done during this phase are meant to lead to approval to begin more refined planning during the Definition phase. These estimates are underpinned by a number of preliminary planning assumptions. In this document, estimates are presented on the basis of the acquisition of a fleet of 65 F-35A aircraft, the Conventional Take-off and Landing (CTOL) variant. However, many of these same cost elements would apply to the development, acquisition, sustainment and operations, and disposal of any fleet of replacement fighter

aircraft.

Program Assumptions

The following assumptions are used to support program cost estimates. These assumptions and the associated estimates will continue to be refined in future Annual Updates on costing for replacement of the CF-18.

Project Approval: Even though Project Approval has not yet been sought from Treasury Board, this program life-cycle cost estimate captures cost elements since Fiscal Year 2010-2011. Current cost estimates will be amended to reflect the final decision on a CF-18 replacement as they pertain to planning for aircraft deliveries, project management requirements, and on cost considerations such as unit recurring flyaway costs and inflation.

Aircraft Life Cycle: The F-35A has been designed for 30-years or 8,000 flying hours. For planning purposes, the F-35 Joint Program Office and a number of other F-35 partners have elected to base their cost estimates on a 30-year aircraft life cycle.

Program Life-Cycle: National Defence has implemented the framework for calculating program life-cycle cost outlined in the KPMG Life-Cycle Cost Framework. National Defence's program life cycle begins with the start of the Next Generation Fighter Capability Program in 2010 and ends following the expected disposal date of the last F-35.

The life-cycle cost calculation is based on the following: development from 2010 to 2019; acquisition of the aircraft from 2020 to 2025; and 30 years of operations for each aircraft, recognizing there are overlap years when Canada would be both acquiring and operating the aircraft. Planned disposal would occur following 30 years of operation of each aircraft.

Transition between CF-18 and F-35A: The retirement of the existing CF-18 fleet will be coordinated with the delivery of the replacement fleet in order to maintain required operational capability during the transition. Details of the transition between fleets will be refined through the Definition phase as training plans are developed for the initial cadre of pilots and support personnel.

Canadian Modifications: At this point, no unique Canadian major modifications to the aircraft are planned, and there are no provisions in the estimate for costs for major modifications as the F-35A meets all operational requirements.

Attrition Aircraft: It is anticipated that the Canadian Armed Forces will lose fighter aircraft to accidents throughout the lifetime of the aircraft fleet. It is recognized that the loss of aircraft over the life of the fleet would result in a diminished capacity to undertake and sustain discretionary operations. Therefore,

operational risk will need to be managed, partly through the assignment of additional flying hours to the remaining aircraft, if lost aircraft are not replaced.

Rather than planning for the acquisition of more aircraft than are required to fill current needs, planners have recognized that the Government will retain the option to acquire replacement aircraft in the future if they choose to do so. In the case of the F-35A, production is planned to continue until at least 2035. Assuming the loss of two to three aircraft for every 100,000 hours of flying, seven to eleven aircraft could be lost over the fleet's lifetime[4]. Should a decision be taken by the Government to replace lost aircraft, the cost would depend on the budget year(s) in which the replacement aircraft were purchased. While the cost impact of replacing attrition aircraft has not been included in the life-cycle cost estimate, it is currently estimated to be approximately $1 billion.

Force Structure: Canada conducts day-to-day fighter operations out of two Main Operating Bases located at 3 Wing Bagotville, Quebec and, 4 Wing Cold Lake, Alberta with each of these bases supporting one tactical fighter squadron. In addition, 4 Wing Cold Lake supports an operational training unit for CF-18 pilot training. Five forward operating locations and four deployed operating bases are also in place with dedicated infrastructure and services to support domestic fighter operations. At this point, it has been assumed that this force structure will not change. When a decision has been made on a replacement for the CF-18, concepts of operations, training and support will be defined to reflect the unique aspects of the associated technology, and cost estimates will be updated accordingly.

Development Phase Assumptions

Costs related specifically to the Development phase include those for activities necessary to bring a project to the Implementation phase and, consistent with the KPMG Framework, are included in the life-cycle cost estimate.

Project Management: To support the planning and delivery of a major capability such as a new fleet of fighter aircraft, the Department of National Defence must establish a Project Management Office. This office interacts with various Government departments, such as Public Works and Government Services Canada and Industry Canada, to ensure that procurement activities meet the various objectives, policies and principles of the Government.

Development costs incurred prior to project approval are funded from the Department's existing baseline budget. These costs include salaries and travel for National Defence, Public Works and Government Services Canada and National Fighter Procurement Secretariat staff.

[4] Hunter, D.G. (2011) Preliminary Estimate of Likely Bounds of Peacetime Attrition for Future Fighter Aircraft DRDC

Joint Strike Fighter Memorandum of Understanding: Contributions under the Joint Strike Fighter Production, Sustainment, and Follow-on Development Memorandum of Understanding pay for agreed-upon common elements of the Joint Strike Fighter Program covering the following categories:

> Production Non-Recurring: Costs attributed to the development of the production lines producing the F-35 covering project overhead and administration, production test and tooling, and the eventual shut down of the production line.
>
> Sustainment Non-Recurring: Costs attributed to sustainment development including contracted or government manpower associated with the design and development of the sustainment solution.
>
> Follow-on Development Non-Recurring Engineering: Costs attributed to the design of upgrades or improvements for the F-35 beyond its initial capability at the completion of the System Development and Demonstration phase.

Forecast Memorandum of Understanding payments from July 2010 to the end of the program life cycle are included in the Development cost estimate.

Acquisition Phase Assumptions

Acquisition costs include the price Canada will pay to acquire CF-18 replacement aircraft. Included in acquisition costs are the one-time costs associated with acquiring aircraft, ancillary equipment, infrastructure, information systems, mission software reprogramming capability, initial aircrew and ground crew training, weapons, support equipment, initial spares and project management. Current assumptions related to acquisition costs are elaborated on below.

Unit Recurring Flyaway: Based on the capability of modern aircraft and simulator technology, it is expected that a fleet of up to 65 aircraft will provide sufficient capacity and flexibility to meet and sustain Canada's defence commitments at home and abroad. The current estimate for the acquisition of a replacement for the CF-18 is based on the forecast acquisition cost of 65 F-35A Conventional Take-off and Landing aircraft. The unit-recurring flyaway cost includes the costs for aircraft to be flyable, including the costs for the engine, mission systems such as the radar, radios, and other electronic equipment, and the vehicle systems such as the landing gear, flaps, and ailerons.

Concurrency: Concurrency is defined as the overlap in the development and production phases of an aircraft acquisition program. It introduces the risk that the aircraft built in the early production lots will require modification due to discoveries made during qualification, flight and ground tests or as a result of

engineering analysis. Incorporation of concurrency changes adds cost due to recurring engineering efforts, break-in of the change into the ongoing production line, and retrofit of existing aircraft. This year's annual update captures the costs associated with concurrency in the Unit Recurring Flyaway cost.

Country Unique Modifications: This term is used to capture country specific requirements such as individual country aircraft markings and country specific certification requirements.

Diminishing Manufacturing Sources: The term diminishing manufacturing sources is used to describe the loss of the source of supply for parts or raw materials needed in the development, production or post-production support of an aircraft or equipment. Such a loss of supply occurs when a manufacturer stops producing a part or raw material for business reasons. An example would be when a certain computer chip is no longer needed in the wider market and the manufacturer considers its production exclusively for military purposes to be unprofitable.

Timely solutions to diminishing manufacturing sources are usually difficult and expensive. Investments in diminishing manufacturing sources help to ensure that a country can acquire and sustain its aircraft as needed.

In the case of the Joint Strike Fighter Program, the potential cost to Canada resulting from diminishing manufacturing sources has two separate elements: the cost of redesigning a replacement part and the cost to purchase a sufficient quantity of the old part to support production until the replacement part is available ("Bridge Buys"). The cost of redesign is captured within development contribution payments. "Bridge Buys" are reflected in the acquisition estimate.

Ancillary Equipment: Ancillary equipment includes items such as the aircrew's specialized life-support equipment, the helmet-mounted display, external fuel tanks, and pylons for carrying weapons internally and externally. This equipment is included in the acquisition costs.

Sustainment Set-Up: This cost element includes the purchase of the equipment and services required to support the F-35A aircraft:

> Training Devices: To meet long-term training needs, planners currently assume that existing CF-18 operating locations will be upgraded with the addition of various F-35A training simulators (flight simulators, aircraft maintenance training aids, etc). The procurement of eight flight simulators, various aircraft maintenance training aids, and the related infrastructure are included in the current estimate.
>
> Support Equipment: Aircraft support equipment and tooling currently in the Canadian Armed Forces inventory that are compatible with the new fleet

will be retained. The Project will procure only the necessary equipment and tools, such as aircraft ground power units, hydraulic test stands, aircraft cooling units, and specialized aircraft maintenance tools, to meet the support requirements associated with operations while in Canada and while deployed. The requirement for support equipment is included in the current estimate.

Autonomic Logistics Information System: The F-35's integrated information management system is the Autonomic Logistics Information System. This system consists of computers, network infrastructure and software programs required to provide globally integrated support to the F-35A aircraft.

The Autonomic Logistics Information System impacts all support aspects of the F-35, including maintenance, logistics, training management, and operations support. The implementation of an F-35A fleet would require the acquisition of a suite of the Autonomic Logistics Information System hardware, as well as integration within the National Defence Information Management architecture. These elements have been included in the cost estimate.

Depot Stand-up: Aircraft and equipment repair beyond the capability of operational bases is performed at Government or commercial depot facilities. The cost associated with developing unique depot repair procedures and tools necessary for F-35A sustainment are accounted for in Depot Stand-up costs, and shared amongst all Joint Strike Fighter Program participants. Depot Stand-up costs are included in the current estimate.

Air System Labour: Labour resources required to procure and deliver the F-35A sustainment solution are included in the calculations for Sustainment Set-Up. This encompasses contractor resources necessary to plan and coordinate the introduction of the new fleet into service, including the supply chain, sustaining engineering, Autonomic Logistics Information System support, or software maintenance. The labour costs associated with these activities are included in the estimate.

Initial Spares: To support the operation of a new fleet, an initial acquisition of spare parts is required. These spares include aircraft replacement parts (for example gear box assemblies, heat exchangers), as well as consumable items such as tires and lubricants. The specific quantity of parts is determined by currently anticipated reliability and maintenance information, as well as operational parameters, such as the number of aircraft and operating locations, and the operating environment such as cold-weather operations.

A cost estimate for the establishment of this initial base-level inventory is included in acquisition cost estimates. However, requirements will continue to be refined as Canadian operating and support concepts for a replacement fleet become clearer, and cost estimates will be refined accordingly.

Reprogramming Lab: Like all modern fighter aircraft, including the CF-18, the F-35A is equipped with sensors (e.g. radar, electro-optical, infra-red, communication, etc.) that detect threats in the air or on the surface. These sensors must be reprogrammed so that they continue to recognize and properly categorize what they are detecting. In the case of advanced aircraft such as the F-35A, programming also ensures that the output of the full suite of sensors is reconciled, or 'fused' into a single source of information for the pilot.

This software reprogramming effort and the equipment required to support an advanced system exceed the Canadian Armed Forces' current capabilities. In order to reduce costs while meeting Canada's operational requirements, a collaborative effort has been considered with other Joint Strike Fighter Program partner nations to deliver this capability. The current cost estimate for this shared software reprogramming capability is included in the cost estimate for the potential acquisition of a Canadian F-35A fleet.

Infrastructure: New construction as well as upgrades to existing infrastructure is required for two Main Operating Bases, in Bagotville, Quebec and Cold Lake, Alberta and for the five Forward Operating Locations in Inuvik and Yellowknife in the North West Territories; Iqaluit and Rankin Inlet in Nunavut; and Goose Bay in Newfoundland and Labrador. A preliminary cost estimate to potentially accommodate an F-35A fleet has been developed based on a number of planning assumptions related to operational concepts in Canada and the current understanding of facility requirements published by the F-35 Joint Program Office.

This estimate encompasses construction and upgrades that would be essential to the introduction of the F-35A in order to achieve a full operational capability. Also it includes requirements such as the modification of hangars to enable the use of new equipment, the building of required secure facilities and modifications to existing information technology infrastructure. The current estimate for infrastructure requirements has been included in the total cost estimate for the potential acquisition of a Canadian F-35A fleet. The current estimate does not include costs related to routine infrastructure recapitalization.

Weapons/Ammunition: Weapons currently in the Canadian Armed Forces inventory that can be employed on the F-35A fleet will be retained. In the case of the F-35A, the project acquisition cost estimate provides for the acquisition of an initial stock of gun ammunition and countermeasures (e.g., flares), as the existing stock of CF-18 gun ammunition and flares are incompatible with the F-35A. Over

the life cycle of the replacement fleet, the acquisition of newer weapons will be considered and funded as separate projects.

Initial Training: The introduction of any new fleet of aircraft requires the establishment of initial training for the transition of aircrew and support personnel, as well as continuation training to ensure the safe and efficient operation and support of the fleet for its entire life cycle. Within the Joint Strike Fighter Program, training centres located in the United States will provide an initial capability for all F-35 operators to meet their initial training requirements.

Canada's current planning assumption is that this capability will be used to train an initial cadre of pilots, and aircraft maintenance and support personnel, to build the necessary 'critical mass' before transferring the training to Canada.

To meet long-term training needs, planners currently assume that existing CF-18 operating locations will be upgraded with the addition of various F-35A training simulators (flight simulators, aircraft maintenance training aids, etc). Training costs associated with initial training in the United States are included in the current acquisition cost estimates.

Project Management Office: To support the acquisition phase, the Department must continue to provide resources for a Project Management Office. Project management costs include elements such as: salaries and benefits for National Defence personnel, both military and civilian; professional services for the conduct of definition studies; Public Works and Government Services Canada fees and service charges; and office costs such as travel, information technology, office equipment, accommodation, and translation etc. Once a project is approved, these expenses are funded from the acquisition budget until the replacement fleet achieves full operational capability and the Project Management Office is closed. These costs have been included in the acquisition cost estimates.

Other: This final acquisition cost element category includes Government-supplied material; developing an interface between the Autonomic Logistics Information System and the National Defence material management system; aircraft familiarization and test flights; the construction of a secure facility to store classified F-35A data; and other miscellaneous items. These costs have been included in the acquisition cost estimates.

Sustainment Phase Assumptions

Sustainment costs are those associated with sustaining fighter aircraft over the course of their life cycle. These include materials consumed, major overhauls and repairs, contractor support, sustaining support, and software reprogramming. Current assumptions related to sustainment costs are elaborated on below.

Sustainment Costs: The F-35 Joint Program Office provided almost 100 percent of the cost estimate data for this cost category. To note, the current F-35 Joint Program Office estimate has now been confirmed by an independent CAPE assessment. Actual costs for sustainment are maturing, but these estimates are still largely based on parametric analyses and should therefore be considered as rough order of magnitude. As experience is gained with the global F-35A fleet, these sustainment cost estimates will continue to mature, and will be based increasingly on actual experience.

Yearly Flying Rate: A significant cost driver for sustainment costs is the yearly flying rate. The yearly flying rate is described as a number of flying hours. This estimate uses a planned yearly flying rate of 11,700 hours – approximately 20 percent less than the currently planned CF-18 yearly flying rate – or 15 hours per month per aircraft. In new aircraft fleets, the use of increasingly advanced simulation is maximized in an effort to reduce the costs associated with sustainment and operations, and in order to maximize the service life of the aircraft. As concepts for operations and training are further refined during the Definition phase of the project, the extent to which yearly flying rates can be reduced will be better understood. Cost estimates will be refined accordingly.

The F-35 Joint Program Office cost breakdown reporting structure changed from the Cost Analysis Improvement Group (CAIG) in 2013 to the U.S. Department of Defense Office of Cost Analysis and Program Evaluation (CAPE) in 2014. Sustainment estimates are structured based on the following breakdown:

> Maintenance: This element represents the cost of materials consumed in the operation, maintenance, and support of the aircraft system and associated support equipment at the unit through depot levels. Replacement parts, consumable items and associated labour costs are also included.
>
> Sustaining Support: Sustaining support encompasses a wide array of in-service support activities such as support equipment replacement, technical publication maintenance, information system support and maintenance, and system specific training. Sustaining support also accounts for the Canada's portion of Autonomic Logistics Global Sustainment Operations including Configuration Management, Performance Management, and Supply Chain Management.
>
> Continuing System Improvements: Improvements costs cover the continuous modernization or modification of hardware and software for the entire system as a whole including the air vehicle, propulsion system, and information management systems. Costs include the procurement and installation of the modification kits necessary for system improvement and the associated support and training equipment.

Other: Reprogramming lab support including support of the mission software reprogramming laboratory throughout the in-service life of the replacement fleet. This lab support accounts for contracted personnel involved with operating the laboratory, as well as the procurement of replacement laboratory equipment. The current sustainment cost estimate assumes the equal sharing of these costs among participants in the laboratory.

Whereas the entire scope for sustainment remains the same, the individual sustainment sub elements cannot be compared between the respective CAIG and CAPE breakdown reporting structures.

Operating Phase Assumptions

Operating Costs: Operating costs include all costs associated with operating the aircraft. These include salaries, base operating costs, materiel costs, and ammunition for training. As some of these costs are very specific to conditions in which a fighter fleet will be operated in Canada, they are not estimated for partner countries by the F-35 Joint Program Office. Canadian Armed Forces' experience with the CF-18 has been used to develop an analogy-based estimation for the new fleet's operating life-cycle cost estimate. Operating costs in the estimate have been phased in, based on a notional aircraft delivery schedule.

Personnel: This element includes costs associated with all personnel that directly or indirectly support a fleet at base level, from pilots and aircraft maintenance personnel, to the medical or administrative staff to military personnel involved in mission software reprogramming. The current personnel cost estimate is based on the structure of the CF-18 fleet.

Operations: Operations costs relate to operating and supporting a fleet including such costs as aviation fuel, training weapons and ammunition usage, and the provision of base-level support infrastructure, materiel (administration, medical, firefighting, etc.) and maintenance. With the exception of fuel consumption, usage rates are based on current CF-18 data, and adjusted based on anticipated project planning parameters, such as the anticipated yearly flying rate.

Aviation Fuel: For the purposes of this cost estimate, the F-35A fuel consumption rates are based on litres per flight hour data provided by the F-35 Joint Program Office.

Unit-Level Operating Costs: This cost element includes operating budgets for squadrons, temporary duty costs and training ammunition.

Base-Support Costs: This cost element includes an apportionment of all fighter base support costs. The apportionment encompasses infrastructure (hangar and runway maintenance), materiel and personal support.

Given the current phase of the project, it is anticipated that some of the operating assumptions that underpin current operating cost estimates could change. For example:

- a smaller fleet of aircraft (up to 65 instead of the current 77 CF-18 aircraft) may allow for the reassignment of personnel;
- definition of maintenance and support concepts for a new F-35A fleet may provide opportunities to realize savings; and
- definition of a training concept may reveal an opportunity to further reduce fuel usage or training ammunition costs.

Further definition work is required to achieve greater confidence in the operating cost estimates.

Disposal Phase Assumptions

Canada does not yet have a disposal plan for the F-35A. Some potential disposal options could include selling airframes as surplus, either whole or for spare parts; storing them for later use; dismantling or otherwise destroying the aircraft; or providing them as artefacts for museums or display purposes. The F-35A has been designed for up to 8,000 flying hours. Based on the currently forecast fleet flying rate and Canadian usage profile, a portion of this design life could remain at the time of disposal. The disposal cost estimate for the F-35A fleet was originally prepared using the principles outlined in the United States Government Accountability Office report *GAO/AIMD-98-9 - DOD's Liability for Aircraft Disposal Can Be Estimated.* However, as more information is being obtained on CF-18 disposal costs, the methodology for calculating the disposal cost estimate has been changed to rely on the current preliminary disposal plan for the CF-18 as a basis for the estimate.

6. Life-Cycle Cost Estimate

This report is based on program-level cost estimates, as recommended by KPMG[5]. Accordingly, the estimates in this document include the acquisition of a replacement fighter and the cost of making and keeping the replacement fighter capability ready and available for operational use. Costs related to deployed operations, for example with the United Nations or NATO, which are normally

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

referred to as contingency operations and cannot be forecast at this time, are not included.

Unless otherwise noted, all figures in this cost estimate are stated in millions of Canadian dollars adjusted for inflation. As explained earlier, the standard terminology in the Government of Canada for an inflation-adjusted figure is Budget Year dollars ($BY). All costs are net of taxes.

This cost estimate uses the Government's 2010 announcement of its intention to acquire F-35As as the date on which to commence the accumulation of costs. Prior to that time, there was no formal decision to replace the CF-18, and any funds spent before then are considered to be outside the scope of the Program, as detailed in Table 1:

Item	$Million Budget Year	Fiscal Year Start	Fiscal Year End
Concept Demonstration Phase MOU	15.2	1997-1998	2000-2001
System Design and Development MOU	139.4	2001-2002	2006-2007
Production, Sustainment, Follow-on Development MOU	68.2	2006-2007	2009-2010
Defence Operating Budget (MOU related)	7.1	1997-1998	2009-2010
Total	**229.9**		

Table 1: Pre-Program Costs

Basis for Estimate

This estimate is based on the project plan as of September 2014. It includes foreign exchange and inflation data that are current as of August 2014. The acquisition and sustainment estimates are substantially based on the Canadian bilateral cost report prepared by the F-35 Joint Program Office and delivered to Canada on 28 August 2014. The Development, Operating and Disposal portions of the estimate are based on Canadian developed source data and cost estimating methodologies.

Cost Estimate Maturity: The Next Generation Fighter Capability project is in the Options Analysis phase. National Defence has limited authority at this phase of a project to conduct studies and produce detailed costing information. Although there is a relatively high degree of fidelity around some cost elements such as for the aircraft unit recurring flyaway cost and other acquisition costs, overall this estimate must be considered a rough order of magnitude until the project completes a funded Definition phase. Rough order of magnitude is a type of

estimate usually prepared early in the development of a project on the basis of preliminary information, and can be valuable in helping decision makers to determine whether to proceed with the project. In the context of the F-35, KPMG assessed the cost estimates to be better than rough order of magnitude.

A specific activity, should Treasury Board grant expenditure authority and the project move into the funded Definition Phase, would be to improve the life-cycle costing to a substantive estimate through detailed studies and analysis of such factors as initial and long-term training requirements.

Foreign Exchange: United States dollars have been converted to Canadian dollars using the forecast provided by the independent forecasting firm *Consensus Economics*. The forecast provides annual forecast rates, with a stable long-run rate commencing in 2020. The long-run average exchange rate used in this cost estimate is $1 Canadian = $0.916 United States based on the *Consensus Economics* August 2014 rate. To varying degrees, partner nation procurement projects have strategies available to protect them from the effects of foreign exchange fluctuations. These strategies vary from a “no gain, no loss” regime with their national treasury, to a more limited in-year currency hedging strategy, to full exposure to foreign exchange fluctuations.

Inflation: Cost data provided by the F-35 Joint Program Office include inflation. In all other instances, inflation is based on the *National Defence Economic Model.*

Sources of Cost Data

The F-35 Joint Program Office is the source of much of the data for Canada’s F-35A cost estimates. However, there are some differences among the different phases of the life cycle. The following summary indicates these differences, and comments on the level of reliability of the various estimates.

Development Cost Data: The development cost estimate includes two distinct data sources. These are Memorandum of Understanding payments data received from the F-35 Joint Program Office, and Canadian data related to project management costs.

Acquisition Cost Data: The F-35 Joint Program Office provides estimates for over 90 percent of the acquisition cost data. Bilateral cost estimates provided to Canada are derived from the same source information as is used to prepare the Department of Defense Selected Acquisition Report. The F-35 Joint Program Office continues to refine its estimates, and will continue to update them at least annually. At this point, this estimate classifies the F-35 Joint Program Office cost estimates as rough order of magnitude.

However, the estimates are now being informed by actual production costs, and are therefore increasing in quality. The F-35 Joint Program Office estimates have

been converted from United States dollars to Canadian dollars and re-aligned with Canadian fiscal years.

Sustainment Cost Data: The F-35 Joint Program Office provides almost 100 percent of the cost estimate data for this cost category. These estimates are still largely based on parametric analyses, and should be considered as rough order of magnitude. Sustainment costs are phased in commencing with the delivery of the first aircraft. The base estimate is then converted from United States dollars to Canadian dollars and inflation factors are included.

Operating Cost Data: Operating costs are phased in according to the purchase profile. Project Definition will provide a detailed operating concept for the CF-18 replacement. Without the benefit of Project Definition studies and empirical data on F-35A aircraft operations, these estimates use existing CF-18 operating costs as a substitute. The operating cost estimate is considered a rough order of magnitude.

Disposal Cost Data: The disposal cost estimate for the F-35A fleet has been prepared based on the CF-18 Fleet Long Term Disposal Cost Estimates. The disposal cost estimate is considered a rough order of magnitude. At this time, there is no disposal plan for the F-35A, as disposal is not expected to occur until well into the future.

Full Life-Cycle Cost Estimate (2010-2055)

Table 2 summarizes the 2014 full program life-cycle cost estimate for a Canadian F-35A capability from the start of program development in 2010, through disposal of the last aircraft, following 30 years of operation of each aircraft.

Cost Elements	Estimate $Million CAD (BY)
Development	
Production, Sustainment, Follow-on Development MOU	514
Project Management Office	36
Contingency	83
Development Total	**633**
Acquisition	
Unit Recurring Flyaway Cost	
F-35A Airframe	3,328
Vehicle Systems	762
Mission Systems	1,171
Propulsion System	927
Engineering Change Orders	124
URF Sub Total	6,312
Concurrency Modifications	0
Country Unique Modifications	15
Diminishing Manufacturing Sources	56
Ancillary Equipment	263
Sustainment Set-Up	
Training Devices	395
Support Equipment	507
Autonomic Logistics	83
Labour	110
Depot Stand-Up	0
Sustainment Set-Up Sub Total	1,095
Initial Spares	331
Reprogramming Lab	221
Infrastructure	254
Ammunition	64
Initial Training	83
Project Management Office	178
Other	42
Contingency (Note 1)	76
Acquisition Total	**8,990**
Sustainment	
Maintenance	6,147
Sustaining Support	3,634
Continuing System Improvements	2,134
Other	423
Contingency	**1,920**
Sustainment Total	14,258
Operating	
Personnel	
Direct Personnel	6,342
Support Personnel	5,137
Sub Total Personnel	11,479
Operating	
Aviation Fuel	3,900
Unit Level Consumption	1,845
Base Support Cost	3,512
Sub Total Operating	9,257
Total Operating	**20,736**
Disposal	
Disposal	137
Contingency	42
Disposal Total	**179**
Full Program Life-Cycle Cost Estimate	**44,796**
Attrition Replacement (Note 2)	**1,036**
	45,832

Note 1: The full amount of acquisition contingency suggested by the Life-Cycle Cost Framework would be approximately $1 billion.
Note 2: It is estimated that seven to eleven aircraft could be lost over the program life-cycle and the cost to replace these lost aircraft could be in the order of $1 billion. This cost is not included in the Life-Cycle Cost estimate. Sustainment and Operating estimates assume a constant number of 65 aircraft.

Table 2: 2014 Full Program Life-Cycle Cost Estimate

7. Independent Third-Party Review

KPMG concluded in their November 2012 report *Next Generation Fighter Capability: Independent Review of Life-Cycle Cost* that the methodology and cost model used to develop the life-cycle cost estimate contained in the 2012 Annual Update were appropriate. In addition to the overall conclusions, other findings and recommendations were noted; however, no significant quantifiable differences were noted as a result of these findings.

The Independent Review of the 2013 Annual Update was conducted by Raymond Chabot Grant Thornton. Their report concluded that DND has made good progress to improve and refine its cost estimating processes and methods. While the report identified other findings and recommendations, no significant differences from the KPMG Framework were noted as a result of these findings that would result in any material changes to the overall life cycle cost estimate.

In response to the recommendations made by KPMG and Raymond Chabot Grant Thornton, since tabling its first two Annual Updates, National Defence has conducted regular reviews and updates of the LCC estimate which continue to result in refinement and improvement of the fidelity of the estimates over time.

More specifically, DND has:

- Formalized and documented its LCC Cost Report through the production of a formal Cost Report and Summary of Findings report;
- Continued to update key assumptions and the LCC estimate on a regular basis and has ensured that agreed changes are reflected in the LCC estimate in a timely manner;
- Continued to review and update the program cost breakdown structure and costing methodologies to ensure that the LCC estimate includes all capability requirements;
- Refined and simplified the financial cost model used to prepare the LCC estimate so that the model is more flexible and traceable and so that it facilitates sensitivity analysis;
- DND continues to investigate mechanisms to more proactively manage foreign exchange risk for the program. Consideration of this issue is ongoing;
- Conducted further analysis and communicated key assumptions in regards to the effective use of aircraft life;
- Continued to refine the calculation of contingency, including its allocation amongst the cost elements, while continuing to respect the Government's direction that the total acquisition cost cannot exceed $9 billion;
- Instituted a standard practice of having program assumptions endorsed and held on record for each LCC estimate; and

- Developed and tested a Standard Operating Procedure that will formalize quality assurance of the cost model.

The Independent Review of the 2014 Annual Update was conducted by Raymond Chabot Grant Thornton. Their report[6] concludes that DND has made significant progress to address recommendations resulting from previous Independent Reviews, which have led to improvements to the Model and documentation processes. While the report identifies other findings and recommendations, no significant differences from the KPMG Framework were noted as a result of these findings that would result in any material changes to the overall life cycle cost estimate.

[6] Raymond Chabot Grant Thornton, Independent Review: 2014 Department of National Defence Annual Update on Next Generation Fighter Capability Life Cycle Costs

V. Cost Risks and Uncertainty

1. Explanation of Terms

This section on cost risk and uncertainty begins with an explanation of terms that will appear in Part V.

Point Estimate: A point estimate is a single figure that represents the best estimate of the cost element. A point estimate does not indicate its degree of precision or its level of uncertainty.

Cost Sensitivity and Sensitivity Analysis: The analysis of the cost sensitivity of the F-35A examines what would be the impact, negative or positive, on cost if there were changes, for example, in inflation or foreign exchange rates.

Confidence Interval: At this phase of the program and of the cost estimation process, there are considerable uncertainty and risk associated with the underlying assumptions and estimates. To provide a sense of the possible variation of costs around the point estimate, this cost report includes a sensitivity analysis around key cost elements. The reliability of a point estimate is often presented as a range of values known as a confidence interval which are normally stated as a percentage. A 90 percent confidence means that 90 out of 100 times the true cost will fall within the confidence interval.

Buy Profile: As noted earlier, the buy profile is a country's plan for the purchase of the aircraft. The buy profile includes how many aircraft will be purchased, and how many the country wants delivered at what time or times. Because the acquisition cost of the aircraft varies from one delivery date to another, a country's buy profile is a crucial factor in the costing of the aircraft or the fleet.

Tornado Graph: A Tornado graph is a special type of bar chart, with the bars running from left to right instead of from top to bottom. It is called a Tornado graph because it is shaped like a tornado with the more numerous values at the top and the less numerous ones at the bottom. The horizontal bar graphs in this part of the document illustrate this point.

2. Introduction

The National Defence costing model is informed by acquisition and sustainment cost estimates provided by the F-35 Joint Program Office, the Selected Acquisition Report 2013 (SAR 13) and by the National Defence estimate of the cost of development, operating and sustainment, and disposal. The model yields a risk-adjusted "point estimate" of the full life-cycle cost of an F-35A program.

The following sections of this Part of the report describe the risks and uncertainties associated with each sequential phase of the program's life cycle.

There are, however, two risk factors, namely foreign exchange and inflation, that affect every phase of the life cycle, and these are generally described below.

Foreign Exchange: Foreign exchange is a major, uncontrollable risk to the program cost estimate. The Canadian/United States exchange rate is quite volatile, having fluctuated by over 40 percent over the last 10 years, and has had swings of over 10 percent in a single year. For the purposes of the cost estimate, United States dollars have been converted to Canadian dollars using a rate provided by an independent forecasting firm, *Consensus Economics*.

The long-run exchange rate used in this cost estimate is the firm's August 2014 rate where $1 Canadian = $0.916 U.S. or $1 U.S. =$1.092 Canadian. Foreign exchange uncertainty applies to all phases of the program. The rate of $1.092 provides a confidence interval of approximately 60 percent.

Inflation: The project faces both domestic and international price variations. In addition, National Defence's specific goods and services, many of which are not generally purchased by the general population, respond to inflationary pressures not captured by broad national price indices[7]. These inflationary pressures are captured, however, by the F-35 Joint Program Office estimates and National Defence's Economic Model. For the purpose of this cost estimate, dollar amounts are expressed in Budget Year dollars, adjusted for inflation.

3. Development Cost Risk and Uncertainty

The Joint Strike Fighter Memorandum of Understanding payments are denominated in United States dollars. Shared costs paid on an annual basis by participants in the Memorandum of Understanding are used for non-recurring Joint Strike Fighter Program expenses related to production set-up (for example tooling), for non-recurring engineering activities related to follow-on development and for program administration until the expiration of the Memorandum of Understanding.

Subsequent to the final date for data inputs for this cost estimate (28 August 2014), Canada received notice through the JSF Joint Executive Steering Board meeting on 25 September 2014, that there is an intent to increase partner contribution ceilings under the Production Sustainment and Follow-on Development MOU.

Amendments to the MOU must be approved by all partner nations. The changes contemplated will be considered at the JSF Joint Executive Steering Board meeting currently expected to be held 26 March 2015. Should amendments be

[7] Solomon, Binyam (2003) Defence Specific Inflation: A Canadian Perspective Defence and Peace Economics, Volume 14(1) 19-36

approved at that time, the cost model will be updated appropriately. Canada's current ceiling under the MOU is $551 million U.S.

4. Acquisition Cost Risk and Uncertainty

The Tornado Graph below graphically depicts the major risk factors, and their impacts on the acquisition cost estimate. Note that the second bar from the top shows the greatest impact and the one at the bottom the least impact, on the acquisition cost estimates. The green bars and the figures in brackets at the top left indicate reduced cost estimates. The red bars and the figures at top right indicate increased cost estimates.

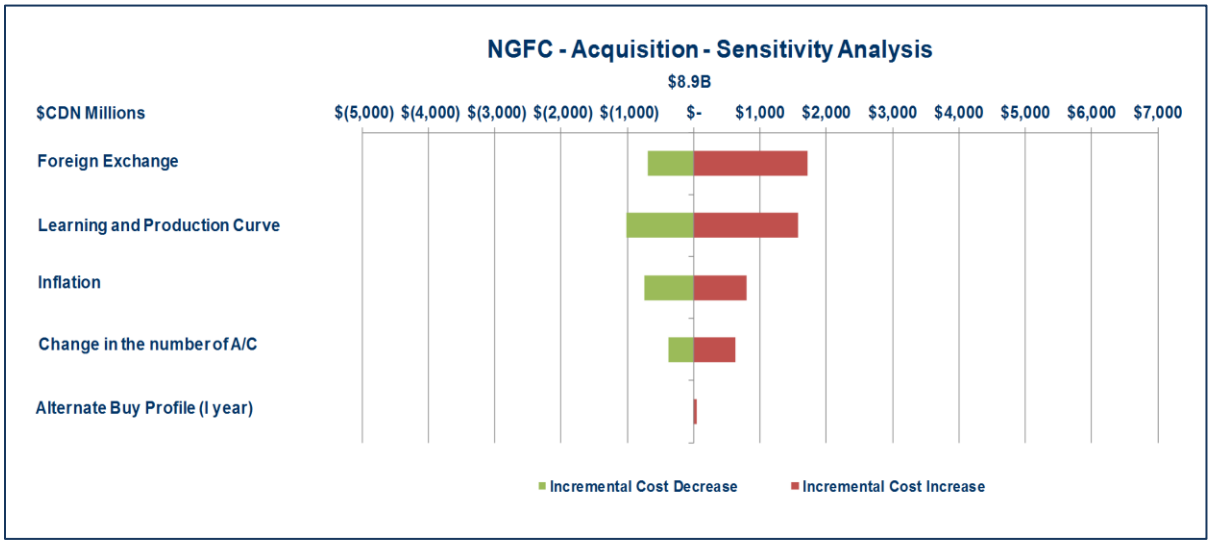

Figure 1: 2014 Acquisition Costs

Foreign Exchange: Figure 1 illustrates the possible impact of this volatility on the acquisition cost estimate. The rate of $0.916 provides a confidence interval of approximately 60 percent and is the basis for the baseline cost estimate. An exchange rate at par would reduce the estimate by over $690 million while the rate of $0.755 provides a 95 percent confidence interval and would increase the estimate by approximately $1.7 billion.

Learning and Production Curve: The unit recurring flyaway cost estimate provided by the F-35 Joint Program Office is based on a detailed engineering bottom-up approach based on commercial confidential data provided to the F-35 Joint Program Office by the contractor. Confidence intervals could be computed for low-level components and rolled up to obtain a confidence interval around the F-35 Joint Program Office unit recurring flyaway estimate. However this would require intricate knowledge of individual manufacturing processes and practices.

Alternatively, National Defence uses an independent top-down F-35A unit recurring flyaway cost estimating model to validate the F-35 Joint Program

Office's unit recurring flyaway cost estimate and to conduct high-level sensitivity analysis.[8]

The learning effect assumes that a large quantity ordered over time will lead to accumulated experience in producing the same system year after year, thus reducing the unit cost. The notion behind a production effect is that the quantity of aircraft produced in a given time period will likely reduce the unit cost through greater operating efficiency and spread fixed costs over more units.

Figure 2 depicts the updated relationship between learning/production efficiencies and unit recurring flyaway costs.

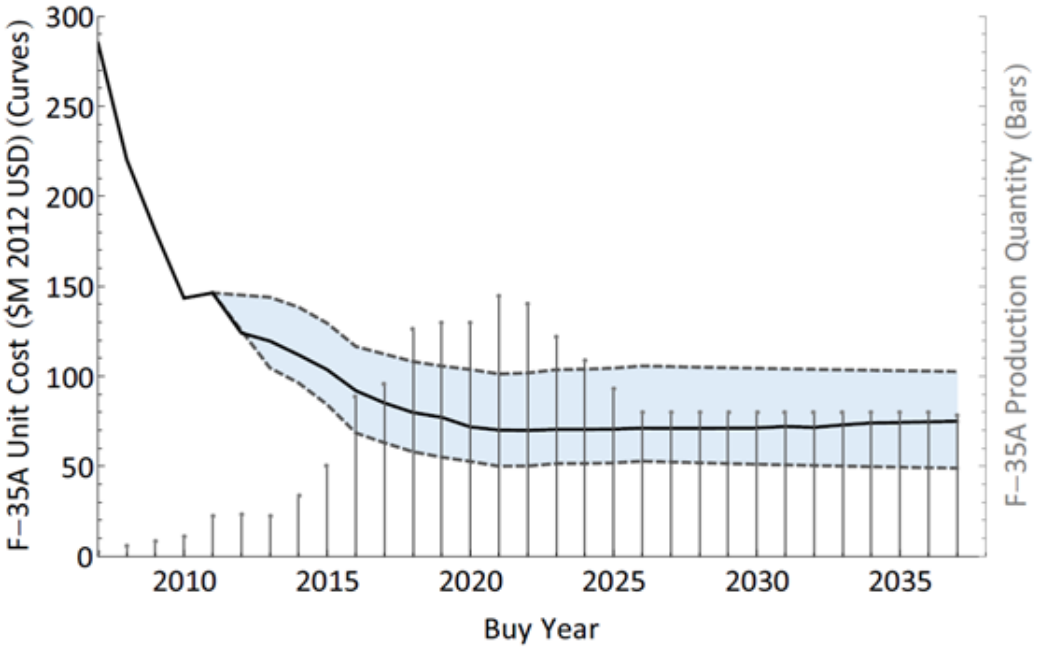

Figure 2: 2014 F-35A Unit Recurring Flyaway Cost Estimating Curve

The solid black line represents the F-35 Joint Program Office's estimated cost curve. The combined effect of a three percent increase (which lies in the blue region) in both the currently forecasted learning and production efficiency factors, occurring prior to Canada placing its orders, would increase the unit recurring flyaway cost by approximately 25 percent. This translates to approximately $1.6 billion variation in the acquisition cost. Conversely, a three percent decrease in both factors would reduce costs by approximately $1 billion.

[8] Kaluzny B.L. (2011) The Unit Recurring Flyaway Cost of a Canadian Joint Strike Fighter DRDC CORA TM 2011-200

Inflation: The life-cycle cost estimate incorporates both United States and Canadian inflation assumptions. While it is impossible to accurately forecast inflation rates until completion of aircraft delivery, this cost estimate relies on F-35 Joint Program Office inflation forecasts and the *National Defence Economic Model*. This factor assesses what would be the impact if the forecast rates of inflation built into the estimate vary by one percent for the acquisition phase of the project. A one percent cumulative increase in the inflation rate built into the estimate would increase the acquisition cost by more than $800 million over the project life cycle. A one percent decrease from that inflation rate would result in an approximate $740 million reduction in the estimate.

Change in the Number of Aircraft Produced: A key tenet of the Joint Strike Fighter Program is affordability achieved through high aircraft production rates. This is a multinational project, and the cost the partners pay for aircraft varies depending on the actual number of aircraft produced and sold. While baseline acquisition cost estimates are based on the buy profiles of the nine partner nations, these buy profiles, and actual purchasing patterns, may change over time.

Specifically, if partner nations delay the timing of their purchases and/or reduce the number of aircraft they purchase up to and during, the period Canada would be purchasing its aircraft, the unit price for Canadian orders may be higher. Some of the risk is reduced as more aircraft are produced as the notional Canadian buy period approaches. In addition, the availability of more information due to the maturity of the project has allowed a more precise and refined analysis that looks at the likely aircraft reductions before and during Canada's potential buy period. Finally, foreign military sales numbers and interested nations have increased since the last update. As a result, the assessed maximum impact based on the updated analyses is estimated at 220 aircraft, and would result in an increase in the acquisition cost for Canada of approximately $600 million. An increase in the number of aircraft by the same amount would result in an acquisition cost decrease of approximately $400 million.

Alternate Buy Profile: Joint Strike Fighter Program partner nations retain the flexibility to adjust the timing and number of aircraft they intend to buy. These adjustments feed into the Selected Acquisition Report and bilateral cost update preparation cycle.

The Canadian project intends to continue adjusting Canada's buy profile so that it continues to respect Government approval cycles and, at the same time, maximizes overall value for the Crown while respecting the notional timing for the phase-out of the CF-18 and phase-in of the F-35A.

DND has analyzed the sensitivity of the current cost estimate to a change in its current notional aircraft acquisition plans. Delaying the buy profile by one year

would result in an acquisition cost increase (Unit Recurring Flyaway only) of approximately $48 million. There would, however, also be an associated increase in sustainment and operating costs, as described in the subsequent sections.

The current cost estimate was prepared using the assumed buy profile as shown in Table 3. Each aircraft is expected to achieve its estimated economic useful life on a straight line, first-in, first-out basis over the useful life of the fleet.

U.S. Fiscal Year	2020	2021	2022	2023	2024	2025	Total # aircraft	Weighted Average ($M U.S.)
# aircraft	4	9	13	13	13	13	65	88. 9

Table 3: Notional Canadian Buy Profile

Other Acquisition Cost Risks: The cost risks associated with other acquisition costs such as the Project Management Office, infrastructure, sustainment set up, etc. are neither economic in nature nor related to airframe (unit recurring flyaway cost). The risks related to these other components can be estimated based on past projects with similar scope. In particular, the guidelines articulated in the DND Costing Handbook Second Edition, 2006 were used to develop the contingency amounts for these other acquisition cost risks. A 14% contingency was assigned and represents a slight increase from last year's assigned contingency (13%) due to increased risk associated with infrastructure set up.

5. Sustainment Cost Risk and Uncertainty

The F-35 Joint Program Office bottom up sustainment cost estimating model continues to mature with greater clarity and volume on input data. The results are assessed against an independent CAPE report. In both the 2012 and 2013 Annual Updates, the DND top down modeling and the F-35 Joint Program Office estimate for annual maintenance costs have remained within a 95% confidence level. Taking into consideration the greater level of refinement in the F-35 Joint Program Office estimate, the top down model is no longer reported.

Figure 3 provides information on the sensitivity of the sustainment cost estimate to various assumptions about specific factors affecting it.

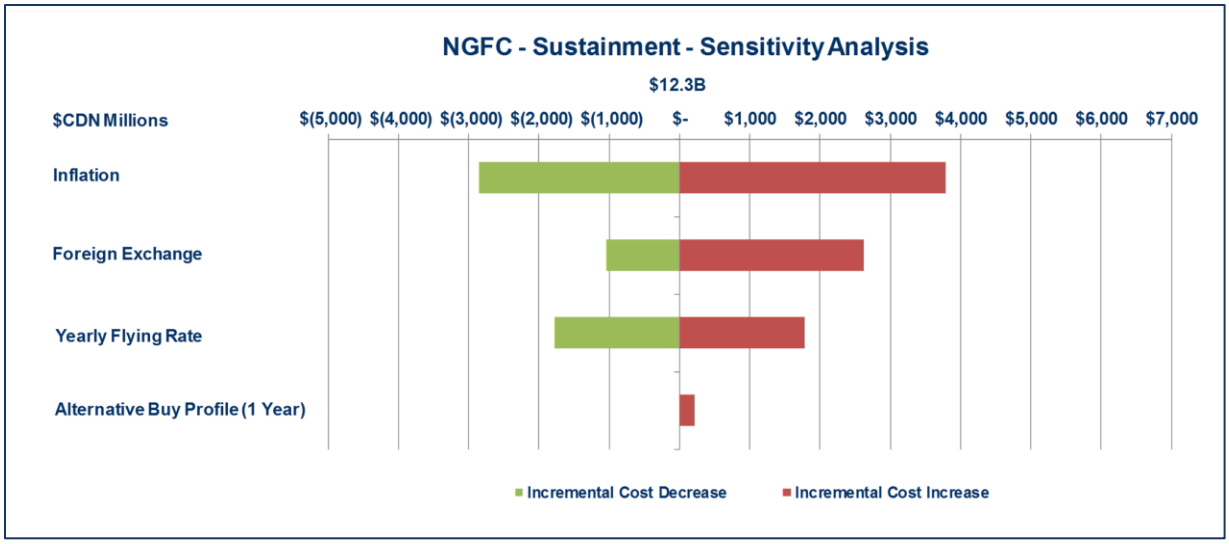

Figure 3: 2014 Sustainment Costs

Inflation: The sustainment cost estimate was subjected to a sensitivity analysis on a long-term annual average inflation rate adjusted by one percent from the rate used by the F-35 Joint Program Office. This analysis allows the planners to estimate the increased or reduced impact if inflation is one percent higher or lower than the level projected by the F-35 Joint Program Office.

A one percent cumulative increase in the inflation rate built into the estimate would increase the sustainment cost by almost $3.8 billion over the fleet life cycle. A one percent decrease from that inflation rate would result in an approximate $2.9 billion reduction in the estimate. The difference between the two figures is attributable to the compounding effect of the two percent spread.

Exchange Rate: A change in one cent (1¢) in the Canadian/United States dollar exchange rate will impact the sustainment cost estimate by approximately $113 million. For the rates considered, the potential increase would be $2.6 billion, and the potential savings are approximately $1 billion.

Yearly Flying Rate: Another element of the sustainment sensitivity analysis is change due to variation in yearly flying rates. The current planned yearly flying rate for the CF-18s is approximately 15,000 hours while for the F-35A it is estimated at approximately 11,700 hours. Conducting the sensitivity analysis around planned F-35 flying hours shows that changing the yearly flying rate by 4,000 hours results in an increase or decrease in sustainment costs of approximately $1.8 billion.

Alternate Buy Profile: National Defence has analysed the sensitivity of the current cost estimate to a change in its current notional aircraft acquisition plans. For example, delaying the 2020 assumed buy profile used in this update by one year would result in a sustainment cost increase of almost $219 million over the full

fleet life-cycle. This increase is due to economic factors such as inflation affecting sustainment costs in later years.

6. Operating Cost Risk and Uncertainty

Figure 4 provides information on the sensitivity of the operating cost estimate to various assumptions about specific factors affecting it.

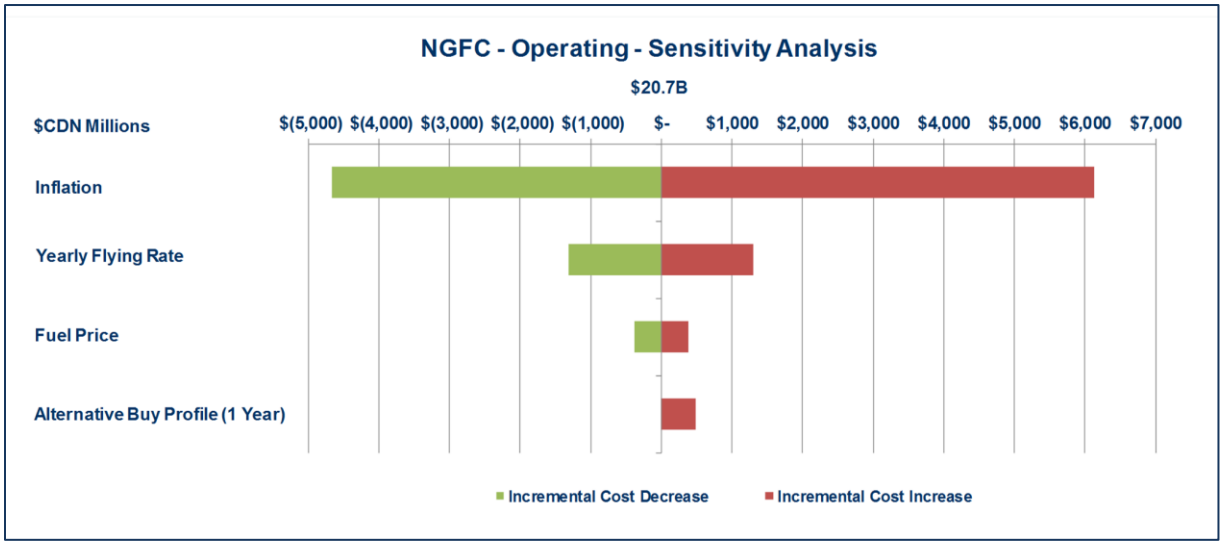

Figure 4: 2014 Operating Costs

Inflation: The cost estimate was subjected to a sensitivity analysis on a permanent one percent variance in the long-term forecast Canadian inflation for operating costs used in the estimate. A one percent increase would increase operating costs by approximately $6.1 billion over the fleet life cycle, while a one percent decrease would result in a $4.7 billion decrease in the estimate. The difference between the two figures is attributable to the compounding effect of a two percent spread.

Yearly Flying Rate: Changing the annual number of hours flown by the aircraft fleet would impact the level of variable fleet operating costs, while not affecting the fixed operating costs. In this analysis, the yearly flying rate changes affect the amount of fuel used, as well as unit-level operating costs. The sensitivity analysis indicates that a permanent 4,000-hour change in the annual flying rate would result in a +/- $1.3 billion variation in the cost estimate over the fleet life cycle.

Fuel Price: The volatility of aviation fuel prices relative to overall inflation required that a separate sensitivity analysis be conducted on this factor. For the purposes of this analysis, the average price of aviation fuel was assumed to be $0.8904 per litre (excluding taxes), with a possible range of 10 percent. The analysis shows a variation of about +/- $382 million due to a 10% change in price.

Alternate Buy Profile: Changing the aircraft delivery schedule as described above would result in additional operating costs of approximately $495 million over the fleet life-cycle. This increase is mainly due to economic factors such as inflation affecting operating cost in later years.

7. Cost Risks and Contingency

Contingency allowances are normally included in estimates to provide for a financial reserve to offset cost increases that may arise from unknown or uncertain future events or risks. Various techniques exist to estimate contingency allowances, ranging from statistical analysis to expert judgment or the use of past experience.

Contingency on Development: Within the Development Phase, costs are mostly based on estimated Memorandum of Understanding payments stipulated by the agreement. A 15 percent contingency was calculated using the guidelines articulated in the DND Costing Handbook Second Edition, 2006. The same percentage of contingency is maintained for this Annual Update.

Contingency on Acquisition: Acquisition contingency is primarily based on the statistical analysis technique of Expected Value. The Expected Value is the cost of a risk multiplied by the probability of the risk occurring. The maximum risk cost and probability of the occurrence of the risks considered in this analysis were updated from the 2013 Annual Update, as determined by a group of subject-matter experts.

The subject-matter experts, drawn from across National Defence, included representatives from the Royal Canadian Air Force, the Project Management Office, Chief Financial Officer staff, corporate risk management, operations research scientists, and defence economics specialists. For the acquisition estimate the subject matter experts analysed the following risk events:

- Foreign Exchange: that the value of the Canadian dollar would depreciate significantly more than the exchange rate already built into the cost estimate;
- Inflation: that the United States and Canadian inflation rates would exceed those already built into the cost estimate;
- Efficiency Gains: that the actual Production and Learning Efficiencies rates would be lower than those built into the F-35 Joint Program Office estimates;
- Aircraft Production: that the number of aircraft produced before or during the period of Canada's delivery profile would be lower, and this decrease would affect the unit recurring flyaway cost; and

- Other Cost Estimating Risks: Contingencies for other acquisition cost factors, such as ammunition, infrastructure, etc., were not calculated using the Expected Value method. Instead they were calculated using the guidelines articulated in the *DND Costing Handbook Second Edition, 2006*.

Subject matter experts developed an agreement around the likelihood of each risk occurring. Third party forecasts that have remained relatively optimistic on the exchange rate vis a vis the U.S. dollar and a low interest environment with an improving U.S. economy contributed to decreasing the likelihoods for foreign exchange and inflation from the range of 20% to 40% to the range of 1% to 20%. For the number for aircraft, the increase in foreign military sales and a higher number of interested nations also lead to a reduction in the likelihood from the range of 60%-80% to 40%-60%.

The likelihoods of each risk occurring combined with the maximum value for the risk calculated as part of the sensitivity analysis resulted in the expected value of the risk exposure to the acquisition cost estimate of $1,080 million. The details of the calculation are highlighted in Table 4 below.

Contingency Tables	Max Impact $M	Mid-Point of Likelihood Ranges	Expected Value $M
Foreign Exchange	1,700	10%	170
Inflation	800	10%	80
Learning/Production	1,600	10%	160
Number of Aircraft	600	50%	300
Other Acquisition Cost Risks*	n/a	n/a	370
Total	**4,100**		**1,080**

* Note that $370M is derived using the guidelines articulated in the DND Costing Handbook (Second Edition, 2006).

Table 4: Contingency on Acquisition

Contingency on Sustainment: The expected value for contingency on sustainment is $1,920 million, as shown in Table 5.

Contingency Tables	Max Impact $M	Mid-Point of Likelihood Ranges	Expected Value $M
Foreign Exchange	2,600	30%	780
Inflation	3,800	30%	1,140
Prudence factor	N/A	N/A	
Total	**5,400**		**1,920**

Table 5: 2014 Contingency on Sustainment

The DND Cost Risk Committee's sustainment risk assessment resulted in an unchanged likelihood range for foreign exchange and a decrease for inflation. For foreign exchange, the longer time frame implied by the sustainment phase contributed to the participants keeping the likelihood unchanged, while once again the stable economic and financial conditions implied by both short and long term interest rates were key factors in reducing the inflation likelihood ranges from 40%-60% to 20%-40%.

In the 2013 Annual Update, contingency for the Sustainment cost element included a Prudence Factor. At the time of the 2013 Annual Update, the F-35 Joint Program Office Operating and Sustainment estimate had decreased by approximately 17% from the previous year. CAPE had not independently verified that reduction. The Canadian Sustainment cost estimate is derived from the F-35 Joint Program Office Program Operating and Sustainment estimate. Given that it was not possible to rely on a CAPE independent assessment of the reduction in the Program Operating and Sustainment estimate, it increased uncertainty on the resulting Canadian Sustainment estimate. To off-set this uncertainty, a Prudence Factor was included to mitigate the increased risk.

CAPE has since produced an independent Operating and Sustainment cost estimate. The CAPE Operating and Sustainment estimate diverges from the F-35 Joint Program Office by approximately 10% over a period of 65 years. The SAR 2013 report discusses the difference between the F-35 Joint Program Office and CAPE Operating and Sustainment estimate. The SAR report concludes that CAPE uses a different technical baseline in four areas and, if the CAPE estimate incorporated the same technical baseline, the difference would be 2% vice the stated 10%. The major areas of difference in the technical baselines are as follows:

- Reliability: F-35 Joint Program Office reliability data is based on 12,000 test hours, CAPE uses data after 8,500 test hours;
- Manpower: F-35 Joint Program Office calculations are based on the current planned ratio of Government Employees to Contractors, CAPE used a standard 80/20 split for their estimate;
- Depot Overhaul: CAPE estimates are based on the sum of every piece of work whereas the F-35 Joint Program Office calculations account for user efficiencies; and
- Fuel Consumption (does not apply to the Canadian Sustainment estimate): The F-35 Joint Program Office and CAPE used burn rates validated at different points in time for their estimates. This issue will be rectified in future estimates.

As a result, with respect to the Sustainment estimate, the 2013 Selected Acquisition Report assertion that the CAPE and F-35 Joint Program Office are within 2% once adjusted for the same technical baseline provides confidence that the Canadian specific sustainment estimate produced by the F-35 Joint Program Office is reasonable. Based on this analysis, the Prudence Factor has been removed and contingency for the Sustainment estimate has been calculated according to the expected value method described above and represents a contingency of approximately 16%.

Contingency on Operating: Contingency was not calculated for operating costs. Operating costs have been calculated using current CF-18 expenditures as a substitute. CF-18 expenditures are funded from National Defence's

Parliamentary approved annual appropriation and are therefore included in the Department's reference levels. National Defence considers the operating cost estimate as a budget ceiling; future F-35A operations will be designed to respect the budget. As a result, a provision for contingency is not required.

Contingency on Disposal: Disposal contingency was calculated using the guidelines articulated in the *Costing Handbook Second Edition, 2006 DND*. The estimate has been updated from 2013 and is based on a study for the CF-18 fleet and within the standard 15%-30% contingency level for this type of estimate. Considering the timing of disposal and implied foreign exchange and inflation effect, the high end of the range (30%) has been applied.

Summary: Table 6 shows the total contingency amount for all phases in the life-cycle costing – from development to disposal. The data for Table 6 are derived from the application of the methods discussed above.

Phase	LCC Estimate Without Contingency $M	Recommended (Amount $M)	Resulting Rate (Rate)	Available Ceiling ($M)	Shortfall $M
Development	550	83	15%	83	0
Acquisition	8,914	1,080	12%	76	(1,004)
Sustainment	12,338	1,920	16%	1,920	0
Operating	20,736	0	0%	0	0
Disposal	137	42	30%	42	0
Total	**42,675**	**3,125**	**7%**	**2,121**	**(1,004)**

Table 6: Contingency Summary

The Government's $9B frozen acquisition envelope results in a $76 million acquisition contingency, which is considered low for a project of this scope and size. If the full acquisition contingency was required, the remaining shortfall could be met by buying fewer aircraft. Moving forward, the Government will consider the frozen acquisition envelope in relation to the capability needed to meet the *Canada First* Defence Strategy to replace Canada's CF-18 fleet.

VI. Cost Analysis

The following sections discuss affordability of the program, and compare the 2014 estimate to that reported in December 2013.

1. Affordability

National Defence has a long-term (20-year) budget which is updated periodically. The latest version of this long-term budget, was presented to Treasury Board in Spring 2014 and included the latest estimate for replacing the CF-18 fighter fleet. Replacement of the CF-18 fleet is one of the keystones of the *Canada First* Defence Strategy, and the F-35 remains one of the Government's options. Should the Government decide to proceed with the purchase of 65 F-35A aircraft, it is forecast that the one-time acquisition cost is affordable within the Department of National Defence's funding envelope.

The estimated sustainment cost for the F-35A is also affordable within the Department's long-term budget prorated over the entire life cycle of the fleet. To the extent that the sustainment costs could rise beyond the Department's long-term budget, despite the substantial contingency allowances built into the estimate, the Department will manage pressures through adjustments to the use of the aircraft and/or adjustments to the long-term budget.

The Department currently has an annual budget for operating the CF-18 aircraft which is funded from National Defence's Parliamentary approved annual appropriation. The operating cost estimate for the CF-18 has been used as a basis for estimating the operating costs of the F-35A. The current estimate, as independently reviewed by Raymond Chabot Grant Thornton is affordable within the Department's long-term budget. Should F-35 fleet operating costs be higher than expected, the Department has the ability to manage the costs through altering fleet operations or reallocating funds within its annual budget.

Cost estimates for a fighter capability will continue to be informed by the independently developed Life-Cycle Cost Framework that was commissioned by the Treasury Board Secretariat. To the extent possible, this same framework will be used to develop life-cycle cost estimates for other aircraft under consideration to replace the CF-18.

2. Cost Reports Comparisons

The 2013 and 2014 estimates are both based on the KPMG Life-Cycle Cost Framework and use a similar cost breakdown structure. The variance between the 2014 and 2013 Annual Updates are summarized in Table 7. An explanation of the main factors behind the variance can be found immediately following Table 7.

Cost Element	2013 (millions)	2014(millions)		Cost Variance
Development	527		550	23
Contingency	79		83	4
Development Total	**606**		**633**	**27**
URF	6,187		6,312	125
Concurrency Modifications	24		0	-24
Country Unique Modifications	0		15	15
DMS	70		56	-14
Ancillary	258		263	5
Sustainment Set-up	1,068		1,095	27
Initial Spares	236		331	95
Reprogramming Lab	219		221	2
Infrastructure	244		254	10
Ammunition	59		64	5
Initial Training	116		83	-33
Project Management Office	123		178	55
Other	44		42	-2
Contingency	342		76	-266
Acquisition Total	**8,990**		**8,990**	**0**
Unit Level Consumption	4,818	Maintenance	6,147	N/A*
Depot Maintenance	773	Sustaining Support	3,634	N/A*
Contractor Support	2,115	Continuing System Improvements	2,134	N/A*
Sustaining and Other Support	3,853	Other	423	N/A*
2013 Sustainment Sub Total Using CAIG Reporting Structure	11,559	2014 Sustainment Sub Total Using CAPE Reporting Structure	12,338	779
Contingency	3,496		1,920	-1,576
Sustainment Total	**15,055**		**14,258**	**-797**
Personnel	10,598		11,479	881
Operating	9,259		9,257	-2
Operating Total	**19,857**		**20,736**	**879**
Disposal	129		137	8
Contingency	39		42	3
Disposal Total	**168**		**179**	**11**
Full Program Life-Cycle Cost Estimate	**44,676**		**44,796**	**120**
Attrition Replacement	**1,015**		**1,036**	**21**
	45,691		**45,832**	**141**

***Note: The F-35 Joint Program Office cost break down structure modeling changed from the Cost Analysis Improvement Group (CAIG) in 2013 to CAPE in 2014. Whereas the entire scope for sustainment remains the same, the individual sub elements cannot be compared between 2013 and 2014.**

Table 7: 2014 versus 2013 Cost Estimate

General:

- The scope of the Life Cycle Cost estimate remains unchanged from the 2013 Annual Update. For this update, the delivery of the first aircraft is assumed to start in 2020 and extend to 2025. This has the impact of extending the period of the LCC estimate by two years including a lengthening of the development phase of the project. There are two common factors that affect the cost estimate in each category, increased costs due to the impact of inflation for the extended period and increased foreign exchange costs for all costs denominated in $U.S. due to an updated exchange rate forecast.

Development ($27M):

- Development increased due to the additional years added to the development phase in changing the assumed buy profile. Other changes include updates to source data, inflation rates and foreign exchange forecasts. The contingency rate remains the same as last year.

Acquisition ($0M):

- URF ($125M): This increase is the net effect of Canada's change in its assumed buy profile, as well as updates to source data, inflation rates and foreign exchange forecasts.

- Concurrency Modifications (-$24M): Removal of Concurrency Modifications resulted in a decrease of $24M. Concurrency Modifications are no longer reported separately. This item is now considered under the Unit Recurring Flyaway cost.

- Country Unique Modifications ($15M): The addition of a separate line to detail Country specific requirements resulted in an increase to acquisition. This line item includes such requirements as individual country aircraft markings and country specific certification requirements.

- Diminishing Manufacturing Sources (DMS) (-$14M): This is the result of a change in the cost estimating methodology used by the F-35 Joint Program Office.

- Initial Spares ($95M): The increase is due to updated source data from the F-35 Joint Program Office, as well as updated inflation and foreign exchange rates.

- Reprogramming Lab ($2M): This is the result of updated inflation rates and foreign exchange forecasts.

- Ammunition ($5M): This is the result of a change to the cost estimating methodology addressing a recommendation that came out of the independent review process in 2013, as well as the change in the assumed buy profile, and updates to inflation and foreign exchanges.

- Initial Training (- $33M): Reduction due to the delineation between Initial Training and Operating estimates and addresses the instance of double counting raised during the 2013 Annual Update review. Further refinement in this element is expected as the training concept continues to mature.

- PMO ($55M): Increased length of operation for the management office due to change in assumed buy profile resulting in increased PMO resource funding.

- Ancillary, Sustainment Set-up, Infrastructure and Other ($40M): These changes are the result of the continuous refinement of estimates and updated inflation and foreign exchange forecasts.

- Contingency (-$266M). Contingency has been adjusted to reflect the remaining available space within the Government's frozen acquisition envelope of $9B to acquire next generation fighter aircraft to replace the existing fleet of CF-18s.

Sustainment (-$797M):

- Analysis of the year-over-year variance in the sustainment cost estimate is limited to the total sustainment amount and contingency due to a change in the cost breakdown structure used by the F-35 Joint Program Office in the production of the estimates. This limitation will only pertain to this year, assuming the cost breakdown structure remains consistent in future estimates produced by the F-35 Joint Program Office. The scope of the sustainment estimate remains unchanged from the previous year.

- An increase in the overall estimate of $779M is due to updated source data from the F-35 Joint Program Office. The estimates received from the F-35 Joint Program Office are reflective of the updates performed during their normal costing cycle, including refined cost estimating relationships, updated F-35 Joint Program Office planning assumptions and data inputs, as well as changes in assumptions driven by Canada's change in purchase profile.

- Contingency was reduced by $1,576M. During last year's development of the Sustainment estimates, DND had provided for a Contingency amount of ~30%. This was the result of uncertainty around the F-35 Joint Program Office provided sustainment estimate as those estimates had not been independently confirmed by a CAPE estimate. Since the 2013 Annual Update to Parliament, the sustainment cost estimates have benefited from an additional year of data and updates. In addition, CAPE has provided their independent Operating and Support cost estimate as a part of the 2013 Selected Acquisition Report and confirmed a downward trend thereby reducing uncertainties around these costs and allowing DND to bring the current contingency amount back in line with the 2012 update.

Operating ($879M):

- The increase in the overall estimate of $879M is primarily related to the change in the start of aircraft delivery from 2017 to 2020. The later aircraft delivery shifted right the period of aircraft operation and resulted in a higher cumulative inflation effect. Other factors that impacted the cost estimate are updates in the source data, change in costing methodology based on last year's independent review recommendations and new inflation rates.

Disposal ($11M):

- Disposal increased by $11M, largely due to changes in the projected inflation rates and the shift in the disposal schedule.

Attrition ($21M)

- The attrition model is based on the weighted average URF calculation. The URF increase and the impact of inflation and foreign exchange account for the $21M increase.

VII. Conclusion

This third Annual Update provides the revised cost estimates of the F-35A, as called for in the Government's Seven-Point Plan, based on the application of the Life-Cycle Cost Framework developed by KPMG in November 2012 using international best practices, and reported in December 2012.

These revised estimates, and the assumptions underlying them, were reviewed by Raymond Chabot Grant Thornton, an independent third party in keeping with one of the points under the Seven-Point Plan.

The current program life-cycle has now been extended by two years and its cost estimate of $44,796 million (Canadian budget year dollars) represents an increase of $120 million (0. 27%) over the 2013 estimate. This report explains how and why current cost estimates differ from those reported in December 2013.

The current estimate includes $76 million for acquisition contingency, a reduction of $266 million since the 2013 Annual Update, and $1,920 million for sustainment contingency, a decrease of $1,576 million. While the overall contingency provisions fall within the range recommended in the November 2012 KPMG Framework, the provision for acquisition contingency is considered low for a project of this scope and size. If the full acquisition contingency was required, the remaining shortfall could be met by buying fewer aircraft. Moving forward, the Government will consider the frozen acquisition envelope in relation to the capability needed to meet the *Canada First* Defence Strategy to replace Canada's CF-18 fleet.

National Defence remains committed to updating Parliament on these estimates and to providing the Government of Canada with appropriate information to make an informed decision on sustaining Canada's fighter capability. Planning assumptions and the associated estimates will continue to be refined in future cost estimates.