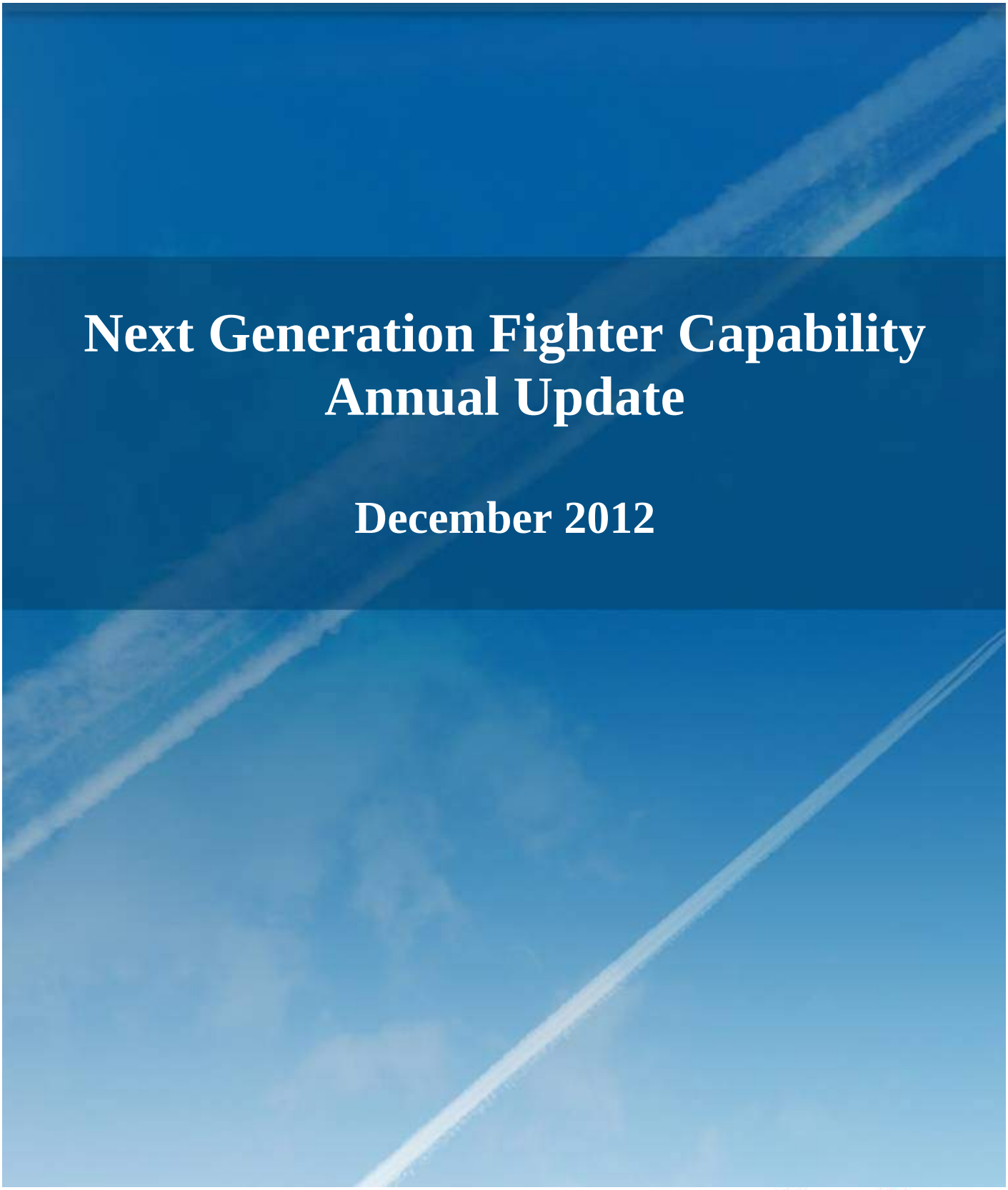
National Defence / Défense nationale



# Next Generation Fighter Capability Annual Update

## December 2012

Canada

**TABLE OF CONTENTS**

## Executive Summary

In the 2012 Spring Report, Replacing Canada's Fighter Jets, the Auditor General identified concerns with the way key information was being developed and presented to Canadians and recommended that the Department of National Defence refine its estimates for complete costs related to the full life cycle of the F-35A.

The Government of Canada agreed with the Auditor General's recommendation and launched a Seven-Point Plan to ensure that the Royal Canadian Air Force acquires the fighter aircraft it needs to complete the missions asked of it by the Government, and to do so through an open and transparent process.

The Seven-Point Plan calls on National Defence, through the National Fighter Procurement Secretariat, to provide annual updates to Parliament. This report is focused particularly on the cost of the F-35A. For this reporting period, the Secretariat recommended that this report be delayed until Fall to allow for an independent, third-party review of costs, including the development of a full life-cycle costing framework that draws on international best practices.

This Update provides revised cost estimates based on a Life-Cycle Cost Framework developed for National Defence by KPMG, an independent private sector consulting firm. These revised estimates, and the assumptions underlying them, were reviewed by KPMG. This report explains how and why the cost estimates differ from those previously reported. All future cost estimates for any CF-18 fighter replacement capability will be informed by this Framework.

For example, in 2010 the Department calculated that the cost of acquiring 65 F-35A aircraft was $9.0 billion. For decision-making purposes, the Department also calculated sustainment costs for 20 years at $6.6 billion ($5.7 billion for sustainment and $0.9 billion for contingency), and operating costs – which are funded from the Department's annually approved budget – at $9.6 billion. Altogether, including contingency, the estimated cost for acquiring, sustaining and operating the fleet based on those figures was $25.1 billion.

National Defence's application of the amended life-cycle cost methodology to the original 20-year period results in a revised estimate of approximately $25.8 billion. This is less than three per cent higher than the original National Defence cost estimate prepared in 2010. When $356 million in Memorandum of Understanding payments that National Defence identified in 2010 are included in the 2010 estimate the difference is less than one and a half percent. Table 9 in the comparative analysis on page 45 provides additional information.

Whereas National Defence's 2010 cost estimate covered acquisition and 20-years of sustainment and operations after first aircraft delivery, this program life-cycle cost estimate covers the period beginning in 2010 with the Government's announcement of its intention to acquire the F35 and ending 42 years later with the disposal of the last aircraft in 2052.

Once the longer period is applied, the new estimated cost for development, acquisition, sustainment and operating, and disposal of the fleet is $44.8 billion. The longer program life-cycle period of 42 years accounts for the vast majority of the cost increase over the originally reported estimate. The remaining changes result from more up-to-date costing information, refined planning assumptions, the addition of development and disposal costs, as well updated economic factors. Table 8 on page 44 and the accompanying text explain in more detail the changes in the estimates between 2010 and 2012.

| **COMPARATIVE ESTIMATE<br>$M BY ($ Million in Budget Years)** | | | |
|---|---|---|---|
| Cost Element (Note1) | 2010 Estimate (as presented in the Spring 2012 Auditor General Report, pg. 27) | 2012 LCC Estimate (using the same time period as the 2010 estimate) | 2012 LCC Estimate (42-year Program Life Cycle Estimate) |
| Time Period | Acquisition plus 20 years of sustainment and operating costs from delivery of first aircraft | Development, acquisition plus 20 years of sustainment and operating costs from delivery of first aircraft | Development, acquisition plus 30 years of sustainment and operating for each aircraft and includes disposal |
| Development | Not included (Note 2) | 446 | 565 |
| Acquisition | 8,980 | 8,990 | 8,990 |
| Sustainment | 6,570 | 7,303 | 15,240 |
| Operating | 9,570 | 9,092 | 19,960 |
| Disposal | n/a | n/a | 65 |
| **Total** | **25,120** | **25,831** | **44,820** |
| Attrition | | | 982 |
| **Total** | | | **45,802** |

Notes: 1. For further details please refer to Table 9.
2. DND had identified MOU payments of $356M in its 2010 cost estimates. Adding the MOU costs to the $25.120 billion estimate would bring the total to $25.476 billion and close the gap to the 2012 LCC estimate to $355 million or less than 1.5%.

KPMG's Life-Cycle Cost Framework is "principles-based," and is not fully prescriptive. As a result, some choices had to be made about whether and how to apply those guidelines to the National Defence cost estimate. For example, an additional cost that is not included in the full life-cycle cost of $44.8 billion is the cost for the replacement of aircraft lost due to peace-time accidents.

It is estimated that seven to eleven aircraft could be lost over the 42-year timeframe and the cost to replace these lost aircraft could be in the order of $1 billion. Rather than initially acquiring more aircraft than are required, the

Government has retained the option to purchase or not replacement aircraft in the future. Production of the F-35A is planned to continue until at least 2035.

The F-35A is still in development, and there is a high degree of uncertainty associated with variables such as exchange rates and inflation. Therefore the level of contingency set aside to manage the risk of unforecasted cost increases is important. The 42-year program life-cycle cost estimate in this report includes $602 million for acquisition contingency and $1.95 billion for sustainment contingency. While the total level of contingency falls within the recommended range in KPMG's Framework, the acquisition contingency amount could still be considered low for a project of this scope and size. As a result, any option moving forward will be informed by the Government's $9 billion acquisition cap to acquire next generation fighter aircraft to replace the existing fleet of CF-18s.

The report *Next Generation Fighter Capability: Independent Review of Life-Cycle Cost* prepared by KPMG for the Treasury Board Secretariat of Canada found that the cost methodologies and assumptions used to develop the life-cycle cost estimate contained in this Annual Update are appropriate. Furthermore, the life-cycle cost estimate complies with the key principles of the framework contained in the KPMG report *Next Generation Fighter Capability: Life-Cycle Cost Framework.*

The KPMG report concludes that their independent review "… did not identify significant quantifiable differences in the Estimate resulting from DND's application of the Framework." 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.

This report is divided into seven parts. Part I reviews briefly the observations and recommendations of the Auditor General, and sets out the reasons for the Annual Update. The next section, Part II, explains the three roles identified for the Canadian Armed Forces in the *Canada First* Defence Strategy: Canadian security and sovereignty, the defence of the North American continent, and international peace and security. This section also discusses the challenges facing the CF-18 fighter aircraft fleet and the importance of replacing it to ensure that the Canadian Armed Forces are able to continue to fulfill the roles identified in the Defence Strategy.

Part III provides insight into the methodology used for estimating the life-cycle costs of a new aircraft fleet. This section explains the uncertainties associated with life-cycle costing and the importance of understanding differences in terminology between Canada and the United States.

Part IV responds to the concerns of the Auditor General, the public and other stakeholders by reporting on the full life-cycle costs of a fleet of F-35A aircraft. This section demonstrates how Canada's participation in the various stages of

the United States-led Joint Strike Fighter Program, established to develop the F-35A, has benefited this country in military and economic terms. It also shows how the cost information received from the Program provides National Defence with the statistical basis for estimating the cost of the F-35A option.

This section also provides current cost estimates based on the KPMG Framework, and spells out in considerable detail National Defence's current planning assumptions with regard to development, acquisition, sustainment and operating costs for a fleet of 65 F-35A Joint Strike Fighters.

Part V covers the risks and uncertainties pertaining specifically to the life-cycle costs of the F-35A option and describes in detail a variety of risks—from foreign exchange fluctuations and inflation to possible increase in the cost of aircraft.

Part VI discusses program affordability, which decision-makers must take into account when evaluating options, and presents a table comparing estimated costs using a 20-year view and a 42-year program life cycle. Part VI also undertakes a comparative analysis and explains the changes from the cost estimate reflected in the Spring 2012 Auditor General Report to the current estimate.

Finally, Part VII contains concluding remarks, and commits National Defence to updating decision makers and Parliament on an annual basis. The KPMG Life-Cycle Cost Framework will help to provide the basis on which National Defence continuously refines and publishes its life-cycle estimates and to prepare these annual updates on the replacement of the CF-18 fleet.

While this Update provides a comprehensive assessment of costs related to the F-35A, National Defence nonetheless continues to evaluate other options to sustain Canada's fighter capability well into the 21st century. These alternatives will, of course, have their own costs that need to be compared to the F-35A option. Cost estimates for each option analyzed will be developed to the extent possible while respecting commercial sensitivities and informed by the independently developed Life-Cycle Cost Framework.

The Government will make a decision on a CF-18 replacement after the Seven-Point Plan has been completed and the National Fighter Procurement Secretariat Deputy Minister-Level Governance Committee has presented its conclusions to Ministers.

## 1. 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 National Fighter Procurement Secretariat Plan: National Defence, through the Secretariat, will provide annual updates to Parliament.

The decision-making process to acquire the F-35A as a possible replacement for the CF-18 fleet was examined by the Auditor General of Canada in the 2012 Spring Report—"Replacing Canada's Fighter Jets". The Auditor General recommended that the Department of National Defence should refine its cost estimates so that they cover the total cost to the government, including acquisition and ownership during the entire useful life of the F-35A.

> **Recommendation.** National Defence should refine its estimates for complete costs related to the full life-cycle of the F-35A capability, and provide complete estimated costs and the supporting assumptions as soon as possible. Furthermore, National Defence should regularly provide the actual complete costs incurred throughout the full life cycle of the F-35A capability.
>
> **The Department's response.** Agreed. National Defence will continue to refine its full life-cycle cost estimates for the F-35A capability and commits to making the estimates and actual costs of the F-35A available to the public.

The Department has accepted this recommendation. It has committed to continuously refining its full life-cycle cost estimates for replacement of the CF-18 and to providing the public with these estimates and, when available, with the actual costs.

The Department of National Defence presents herein its first Annual Update to Parliament on the costing for a replacement of the CF-18 fleet. 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.

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

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.

## II. Replacing Canada's Fighter Aircraft

### *1. The Canada First Defence Strategy*

The *Canada First* Defence Strategy, supported by a 20-year investment plan, includes provision 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.

> "Today, we live in an uncertain world, and the security challenges facing Canada are real."
>
> - *Canada First* Defence Strategy

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-lateral agreement 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, better known as NATO, 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. Most recently, CF-18s were deployed to southern Italy to participate in a multinational response to the crisis in Libya.

### *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. These initiatives have ensured the CF-18 aircraft has remained capable and relevant.

Nevertheless, because of the CF-18 fleet's life expectancy, 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 2012 Spring Auditor General Report and the Seven-Point Plan*

The Auditor General's Spring 2012 report made observations regarding the process to replace Canada's fleet of CF-18 aircraft. The Auditor General recommended that the Government refine its estimates to incorporate the full life-cycle costs of the F-35A and regularly make those estimates public.[2]

The Government agreed, and put in place a Seven-Point Plan that responds to and exceeds the Auditor General's recommendation. The Plan will 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 the 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 replacing the CF-18.

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[2] 2012 Spring Report of the Auditor General of Canada, http://www.oag-bvg.gc.ca/internet/docs/parl_oag_201204_02_e.pdf

In addition, the Plan directed the Treasury Board Secretariat of Canada to commission an independent, third-party review of the costs specifically associated with the F-35A and to make public the findings of that review.

This report, together with the results of the Treasury Board Secretariat-commissioned independent review that informs it, represents the first Annual Update to Parliament since the Plan was put in place. The report aims to address the Auditor General's recommendation to provide the full life-cycle costs of the F-35A to Canadians. It exceeds the recommendation by making available figures that have been independently reviewed and by using a costing framework and methodology proposed by an independent third party using leading international life-cycle cost-estimating practices.

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 the fighter replacement 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. This is called the “cradle to grave” approach.

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 a forecasting 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.

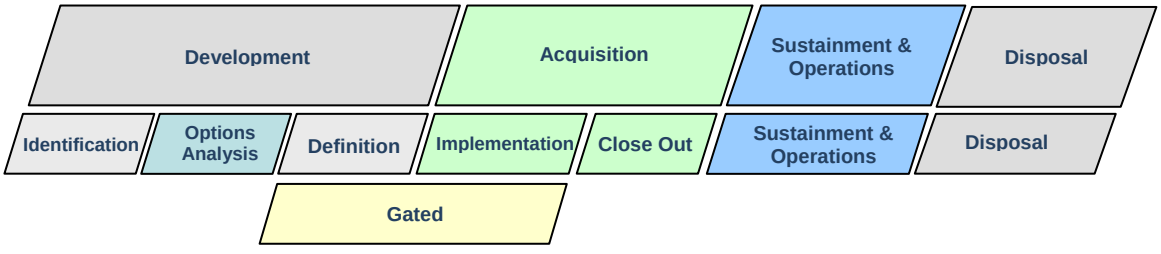
**Operating Costs**: Operating costs are expenses that the Department of National Defence incurs in the course of delivering its programs. For a fighter fleet, the operating cost estimate includes salaries, fuel and base-support costs.

**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*[3]. 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

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

governance may be achieved through a gated expenditure approval process for Project Definition and Implementation.
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.<br>- Discard invalid options.<br>- Assess benefits of remaining options.<br>- Examine risks.<br>- Decide which option should be pursued.<br>- Develop rough order of magnitude and indicative cost estimate. | - Confirm option choice.<br>- Prepare detailed review, risk assessment and costing of selected option.<br>- Undertake implementation planning.<br>- Develop substantive cost estimate. | - Proceed with implementation.<br>- Proceed with implementation management.<br>- Do implementation monitoring.<br>- Present reports on status of implementation.<br>- Do operational handover.<br>- 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*

Under the Government's Seven-Point Plan, the Department of National Defence continues to evaluate options to replace the CF-18 fleet, which provides Canada's current fighter capability. The Government will not make a decision on the replacement for the CF-18 until the Plan has been completed and the conclusions are presented to Ministers. The ongoing full evaluation of options will provide the best available information about the range of choices that could meet Canada's needs for a fighter capability.

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*[4], developed by KPMG. 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 3,100 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.

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.

[4] 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 $130.0 million ($126.1 million U.S.). A participating country's maximum contribution amount may only be increased through an amendment to the Memorandum of Understanding.

To date, Canada has invested a total of $284.6 million ($231.1 million U.S.) as its share of the Joint Strike Fighter Program, and $77.9 million ($50 million U.S.) to Canadian aerospace industries through SADI. As explained in the Industry Canada *Industrial Participation in the F-35A Joint Strike Fighter Report to Parliament*, Canadian companies have so far secured $438 million U.S. in contracts as a result of Canada's participation in the Joint Strike Fighter Program.

### *4. Cost Methodology and Estimates*

The acquisition cost estimate for a fleet of Canadian F-35A aircraft has two distinct data sources. The Joint Strike Fighter Program Office provides estimates for over 90 per cent of the acquisition cost data. The remainder of the estimates are based on data from Canadian sources. As a Joint Strike Fighter Program participant, Canada receives cost figures directly from the Joint Strike Fighter Program Office. The Department of National Defence builds on these figures to develop its own program cost estimates, and revises these estimates on an annual basis.

Cost estimates for the acquisition and sustainment of the Joint Strike Fighter are provided to Partners in the Joint Strike Fighter Memorandum of Understanding on an annual basis through bilateral communications. The information provided by the Joint Strike Fighter Program Office in these bilateral communications is based on the same source information as is used by the United States Department of Defense and presented annually to the United States Congress through Selected Acquistion Reports. The accuracy of these estimates will continue to improve as more aircraft are produced and more experience is gained with the F-35A.

In order to complete its cost estimates, National Defence further adds its own estimates for Canada-specific elements of the acquisition, and long-term operating costs. These elements include infrastructure requirements, aircrew and ground crew training, and forecasted aircraft fuel costs.

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.

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 Joint Strike Fighter 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 42-year program life cycle begins with the start of the Next Generation Fighter Capability Program in 2010 and ends in 2052, the expected disposal date of the last F-35.

The 42-year calculation is based on the following: development from 2010 to 2016; acquisition of the aircraft from 2017 to 2023; and 30 years of operations for each aircraft (2017 to 2052), recognizing there are overlap years when Canada would be both acquiring and operating the aircraft. Planned disposal would occur between 2047 and 2052.

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 cadré of pilots and support personnel.

Canadian Modifications: At this point, no unique Canadian modifications to the aircraft are planned, and there are no provisions in the estimate for costs for such 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 chose 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[5] seven to eleven aircraft could be lost over the fleet's lifetime. 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.

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

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.

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, such as program administrative support and, eventually, the follow-on development of modifications and upgrades to the aircraft. Forecast Memorandum of Understanding payments from July 2010 to the end of the program life cycle in 2051 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.

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. Such a loss of supply might also occur when a new health, safety, environmental or other legislation restricts the production of an item—for example a certain type of adhesive—needed for an aircraft or equipment.

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 F-35A program, the potential cost to Canada resulting from diminishing manufacturing sources is currently estimated at approximately $78 million. However, it is expected that investments in diminishing manufacturing sources will result in a credit later in the Program. As a result of this offsetting credit, costs for diminishing manufacturing sources have not been included in the acquisition cost 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:

> Simulators: 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 Joint Strike Fighter'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 Joint Strike Fighter, 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 participants. Depot Stand-up costs are included in the current estimate.

Air System Manpower: Manpower resources required to procure and deliver the F-35A sustainment solution are included in manpower 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 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 Joint Strike Fighter 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.

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 Joint Strike Fighter operators to meet their initial training requirements.

Canada's current planning assumption is that this capability will be used to train an initial cadré 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). Costs associated with initial training in the United States are included in the current acquisition cost estimates.

Program Management Office: To support the acquisition phase, National Defence 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 Joint Strike Fighter Program Office provided almost 100 per cent of the cost estimate data for this cost category. As actual costs for sustainment are not yet mature, these estimates are still largely based on parametric analyses and should therefore be considered as rough order of magnitude. As noted in Section V (Cost Risks and Uncertainty) as experience is gained with the global F-35A fleet, these sustainment cost estimates will continue to mature, and will be based on actual experience. In accordance with the Joint Strike Fighter Program Office assumptions and related data provided, aircraft will not undergo major repairs in their last year of life; hence, no sustainment costs are included in the estimate for the last year of aircraft operations.

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 per cent 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.

Unit Level Consumption: This cost element represents the ongoing cost of the maintenance and repair of the aircraft and associated systems. This includes replacement parts, consumable items and associated labour costs. In addition to the initial purchase of spare parts mentioned under acquisition, the cost of materiel consumed in the operation and maintenance of an aircraft is included in Sustainment costs. These include costs for aircraft systems, propulsion systems, and support equipment replacement parts. They also include consumable items that are procured on an ongoing basis to maintain an appropriate inventory to meet domestic and deployed operations. The anticipated annual requirements for all replacement assets are included in the sustainment cost estimates.

Depot: Throughout the life of a fleet, there will be requirements for major overhauls or maintenance of aircraft and engines, their components, and associated support equipment. These functions will be performed at central repair depots, contractor repair facilities, or on-site by depot teams. The anticipated annual costs of labour, materiel and overhead incurred in performing these activities are included in sustainment cost estimate.

Contractor Support: Contractors may be used to provide fleet support such as for management, engineering and training. This element of sustainment costs also includes the repair of training centres, training simulators and business equipment, and global supply-chain management and support. All costs associated with contractor support are included in the sustainment cost estimates.

Sustaining and Other Support: The following costs are included under this cost element:

> Sustaining Support: Sustaining support encompasses a wide array of in-service support cost elements, such as software maintenance for information management systems and simulator support. For the Joint Strike Fighter Program in particular, sustaining support accounts for the acquisition and installation of system modifications and betterments required to sustain the capability of the fleet over its extended life time. This ongoing follow-on development program provides for regular improvements and enhancements rather than midlife upgrades.

Reprogramming Lab Support: Reprogramming lab support includes 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.

**Operating Phase Assumptions**

Operating Costs: Operating costs include all costs associated with operating the aircraft. These include military personnel 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 Joint Strike Fighter 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. 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: The CF-18 fuel burn rate has been adjusted based on information provided by the Joint Strike Fighter Program Office on the expected fuel burn rate for the F-35A. For the purposes of the current cost estimate, specific F-35A fuel consumption rates, which are higher than for the CF-18, have been used.

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 8000 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 has been 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.*

## *6. Life-Cycle Cost Estimate*

This report is based on program-level cost estimates, as recommended by KPMG[6]. Accordingly, the estimates in this document include the acquisition of a replacement fighter capability 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 referred to as contingency operations and cannot be predicted 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.

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

Prior to that time, there was no formal decision to acquire the F-35A, 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 | 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 July 2012. It includes foreign exchange and inflation data that are current as of July 2012. The estimate is substantially based on the Canadian Bi-Lateral cost report prepared by the Joint Strike Fighter Program Office and delivered to Canada in May 2012.

The Canadian Bi-Lateral report was prepared using the same data that was used to prepare United States Selected Acquisition Report 2011 (SAR 11), which was published in March 2012. This estimate spans the period commencing in Fiscal Year 2010-2011 and ending in Fiscal Year 2051-2052, 30 years after the anticipated delivery of the last aircraft.

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.

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 2018. The long-run average exchange rate used in this cost estimate

is $1 Canadian = $0.94 United States based on the *Consensus Economics* July 2012 report. To varying degrees, partner 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 Joint Strike Fighter Program Office have inflation figures built in. In all other instances, inflation is based on the *National Defence Economic Model.*

**Sources of Cost Data**

The Joint Strike Fighter 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 Joint Strike Fighter Program Office, and Canadian data related to project management costs.

Acquisition Cost Data: The Joint Strike Fighter Program Office provides estimates for over 90 per cent of the acquisition cost data. As noted earlier, the data from the Joint Strike Fighter Program Office is based on the Selected Acquisition Report 2011 as expressed in the Canadian Bi-Lateral cost report. The Joint Strike Fighter Program Office continues to refine its estimates, and will continue to update them at least annually. At this point, this estimate classifies Joint Strike Fighter Program Office cost estimates as rough order of magnitude.

However, the estimates are beginning to be informed by actual production costs, and are therefore increasing in quality. The Joint Strike Fighter Program Office estimates have been converted from United States dollars to Canadian dollars and re-aligned with Canadian fiscal years.

Sustainment Cost Data: The Joint Strike Fighter Program Office provides almost 100 per cent 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.

Operating Cost Data: Operating costs are phased in according to the purchase profile. Project Definition will provide a detailed operating concept for the F-35A. 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, therefore, considered as rough order of magnitude.

Disposal Cost Data: The disposal cost estimate for the F-35A fleet has been 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*. 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 (2010-2052)

Table 2 summarizes the 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 in 2052.

| LCC Phase | Cost Element | | Estimate $Million CAD (BY) | |
|---|---|---|---|---|
| **Development** | Production, Sustainment, Follow-on Development MOU | | 465 | |
| | Project Management Office | | 26 | |
| | Contingency | | 74 | |
| **Development Total** | | | | **565** |
| **Acquisition** | Unit Recurring Flyaway cost | F-35A Airframe | 3,098 | |
| | | Vehicle Systems | 743 | |
| | | Mission Systems | 1,217 | |
| | | Propulsion System | 835 | |
| | | Engineering Change Orders | 99 | |
| | URF Total | | | 5,992 |
| | Ancillary Equipment | | | 246 |
| | Sustainment Set-Up | Training and Simulation | 346 | |
| | | Support Equipment | 379 | |
| | | Autonomic Logistics | 44 | |
| | | Manpower | 371 | |
| | | Depot Stand-Up | 14 | |
| | Sustainment Set-Up Total | | | 1,154 |
| | Initial Spares | | | 259 |
| | Reprogramming Lab | | | 216 |
| | Infrastructure | | | 244 |
| | Ammunition | | | 52 |
| | Training | | | 65 |
| | Project Management Office | | | 120 |
| | Other | | | 40 |
| | Contingency (Note) | | | 602 |
| **Acquisition Total** | | | | **8,990** |
| **Sustainment** | Unit Level Consumption | | | 5,357 |
| | Depot Maintenance | | | 791 |
| | Contractor Support | | | 1,979 |
| | Sustaining and Other Support | Sustaining Support | 4,530 | |
| | | Other Support | 633 | |
| | Total Sustaining Support | | | 5,163 |
| | Contingency | | | 1,950 |
| **Sustainment Total** | | | | **15,240** |
| **Operating** | Personnel | Direct Personnel | 5,643 | |
| | | Support Personnel | 4,614 | |
| | Total Personnel | | | 10,257 |
| | Operating | Aviation Fuel | 4,630 | |
| | | Unit Level Consumption | 1,625 | |
| | | Base Support Cost | 3,448 | |
| | Total Operating | | | 9,703 |
| **Total Operating** | | | | **19,960** |
| **Disposal** | Disposal | | 43 | |
| | Contingency | | 22 | |
| **Disposal Total** | | | | **65** |
| **Full Program Life-Cycle Cost Estimate (2010 – 2052)** | | | | **44,820** |
| **Attrition replacement** | | | | **982** |
| | | | | **45,802** |

Note: The full amount of contingency suggested by the Life-Cycle Cost Framework would be approximately $1,450 million (Table 4). If the full available acquisition contingency was required, the shortfall would be met by buying fewer aircraft.

**Table 2: Full Program Life-Cycle Cost Estimate (2010-2052)**

### *7. Independent Third-Party Review*

KPMG, the independent third party engaged by the Treasury Board Secretariat of Canada, prepared a Life-Cycle Cost Framework for National Defence based on a review of Canadian government policies, departmental guidance and international leading practices. The Framework is documented in the KPMG report *Next Generation Fighter Capability: Life-Cycle Cost Framework*, 27 November 2012. The updated cost estimate contained in this Annual Update is in accordance with this Framework.

KPMG subsequently completed an independent review of National Defence's project assumptions and the estimated costs totaling $44.8 billion presented in this Annual Update for program development, acquisition, sustainment, operations and disposal.

KPMG concluded in their 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 this Annual Update are appropriate and consider key principles of the costing approaches contained in the Framework. 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.

In response to the recommendations made by KPMG, National Defence is planning regular reviews and updating of this life-cycle cost estimate which will result in a natural evolution and improvement of the fidelity of such estimates over time. More specifically, National Defence will:

- Formalize and document its life-cycle costing plan;
- Continue to update key assumptions and the life-cycle cost estimate on a regular basis and will ensure that agreed changes are reflected in the life-cycle cost estimate in a timely manner;
- Continue to review and update the program cost breakdown structure to ensure that the life-cycle cost estimate includes all capability requirements;
- Refine and simplify the financial cost model used to prepare life-cycle cost estimates so that the model is more flexible and traceable and so that it will facilitate sensitivity analysis;
- Work with other government agencies to investigate mechanisms to more proactively manage foreign exchange risk for the program;
- Continue to further refine the estimate;
- Conduct further analysis and communicate key assumptions in regards to the effective use of aircraft life; and
- Continue to refine the calculation of contingency, including its allocation amongst the cost elements, while continuing to respect the Government's direction that total acquisition cost cannot exceed $9 billion.

## V. Cost Risks and Uncertainty

### *1. Explanation of Terms*

This section on cost risk and uncertainty begins with an explanation of a few 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 per cent 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 Joint Strike Fighter Program Office 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 fluctuations and inflation, that affect every phase of the life cycle, and these are generally described below.

Foreign Exchange Fluctuations: 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 per cent over the last 10 years, and has had swings of over 10 per cent 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 July 2012 rate where $1 Canadian = $0.94 U.S. Foreign exchange uncertainty applies to all phases of the program. The rate of $0.94 provides a confidence interval of approximately 75 per cent. The 26 November 2012 spot rate (approximately at par) provides a 50 per cent confidence interval while the rate of $0.78 provides a 95 per cent confidence interval.

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 Joint Strike Fighter 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. A change of one cent (1¢) in the Canadian/United States dollar exchange rate will impact the program development phase cost estimate by approximately
$3 million.

Shared costs paid on an annual basis by participants in the Production, Sustainment and Follow-up 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 in 2051.

There is a possibility that economic factors, higher-than-expected costs or a change in Memorandum of Understanding participation will result in a need for an increase in

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

the cost allocation that was originally forecast for Memorandum of Understanding partners in 2006. By the terms of the Memorandum of Understanding, the $551.6 million U.S. ceiling amount documented for Canada's participation in the Production, Sustainment, Follow-on Development Memorandum of Understanding can only be increased through a formal amendment.

### *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 bracket at the bottom left indicate reduced cost estimates. The red bars and the figures at bottom right indicate increased cost estimates.

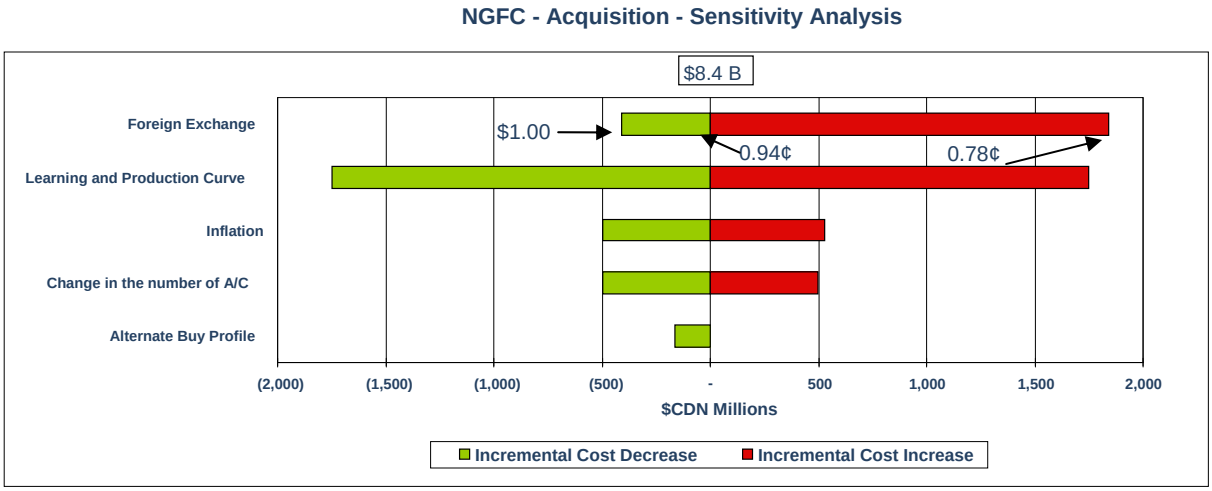



**Figure 1: Acquisition Costs**

Foreign Exchange: A change of one cent in the Canadian dollar/United States dollar exchange rate will impact the acquisition cost estimate by approximately $80 million. Figure 1 illustrates the possible impact of this volatility on the acquisition cost estimate. The rate of $0.94 provides a confidence interval of approximately 75 per cent and is the basis for the baseline cost estimate. The 26 November 2012 spot rate (approximately par) provides a 50 per cent confidence interval and would reduce the estimate by over $400 million while the rate of $0.78 provides a 95 per cent confidence interval and would increase the estimate by approximately $1.8 billion.

Learning and Production Curve: The unit recurring flyaway cost estimate provided by the Joint Strike Fighter Program Office is based on a detailed engineering bottom-up approach based on commercial confidential data provided to the Joint Strike Fighter Program Office by the contractor. Confidence intervals could be computed for low-level components and rolled up to obtain a confidence interval around the Joint Strike Fighter 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 Joint Strike Fighter 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 relationship between learning/production efficiencies and unit recurring flyaway costs.

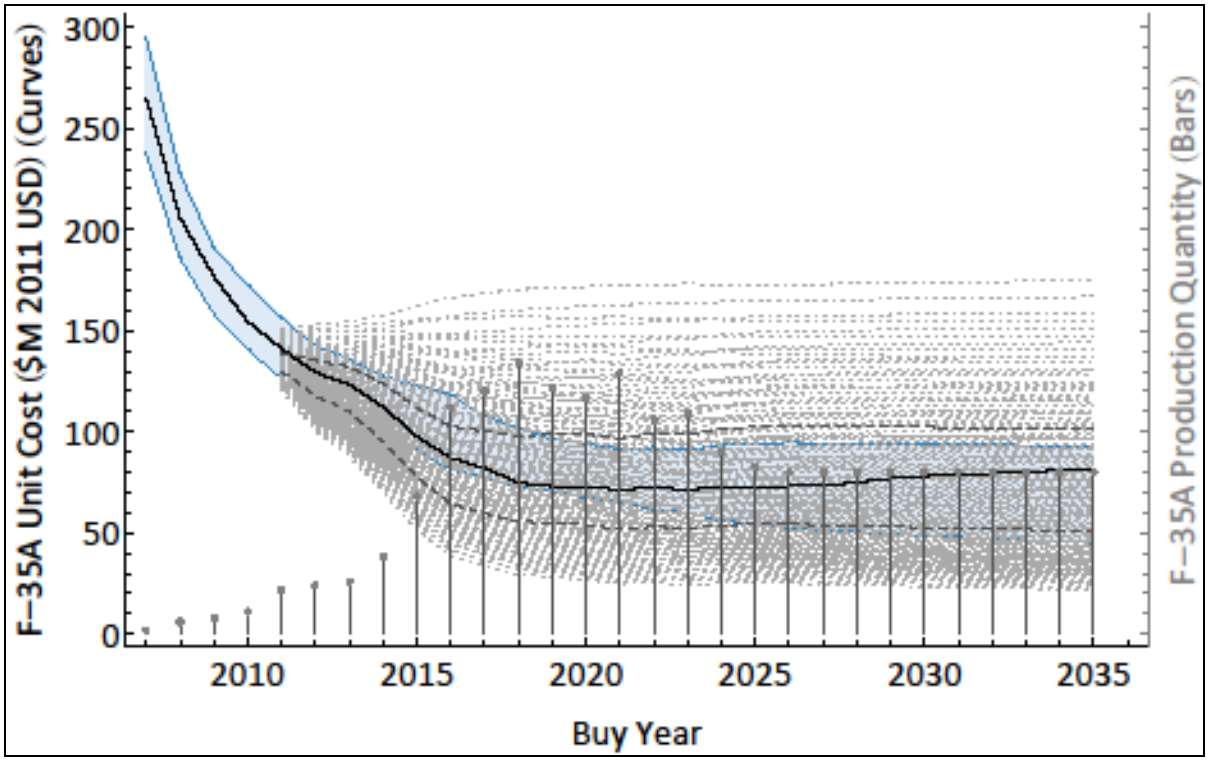



**Figure 2: F-35A Unit Recurring Flyaway Cost Estimating Curve**

The solid black line represents the Joint Strike Fighter Program Office's estimated cost curve. The blue region is the 95 per cent confidence band based on the latest Selected Acquisition Report data and the light grey dotted lines represent possible cost curves if the production rate and cost improvement rates stray from the anticipated current best-fit.

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

The combined effect of a three per cent variation (which lies in the blue region) in both the currently forecasted learning and production efficiency factors, occurring prior to Canada placing its orders, would change the unit recurring flyaway cost by approximately 28 per cent. This translates to approximately $1.7 billion variation in the acquisition cost.

Inflation: The life-cycle cost estimate incorporates both United States and Canadian inflation assumptions. While it is impossible to accurately predict inflation rates until completion of aircraft delivery, this cost estimate relies on Joint Strike Fighter 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 per cent for the acquisition phase of the project, which translates to a variance of approximately $500 million in the acquisition cost.

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.

For example, some nations may reduce the total number of jets they intend to purchase. As a result, the unit recurring flyaway cost of each fighter jet would increase. National Defence's study[9] of the potential impacts of this risk factor shows that a reduction of 400 aircraft would result in an increase in the acquisition cost for Canada of approximately $500 million.

Alternate Buy Profile: Joint Strike Fighter 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 Bi-lateral 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.

The current cost estimate was prepared using the buy profile formally on file with the Joint Strike Fighter Program Office in July 2012, 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. The actual purchase profile will be determined during Project Definition.

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

| Selected Acquisition Report 2011 – Unit Recurring Flyaway Cost Estimate | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| US Fiscal Year | Number of Aircraft | | | | | | | | Weighted Average ($M US) |
| | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Total | |
| # aircraft | 4 | 9 | 7 | 13 | 15 | 13 | 4 | 65 | 87.4 |

**Table 3: Notional Canadian Buy Profile (July 2012)**

National Defence has analysed the sensitivity of the current cost estimate to a change in its current notional aircraft acquisition plans. Delaying the first aircraft delivery by one year, and compressing the delivery schedule from six years to five years, would result in an acquisition cost savings of approximately $160 million. There would, however, also be an associated increase in sustainment costs, as described in the next section, “Sustainment Cost Risk and Uncertainty”.

Other Acquisition Cost Risks:The cost risks associated with other acquisition costs such as the Program 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. An average contingency of 13 per cent has been derived and the potential impact is estimated at $340 million.

### *5. Sustainment Cost Risk and Uncertainty*

The Joint Strike Fighter Program Office sustainment cost estimating model, while highly detailed and data-intensive, provides only point estimates, which, as noted above, lack the precision of confidence interval estimates. In order to construct confidence intervals around these point estimates, National Defence has to account for numerous variables, interdependencies and associated uncertainties. Currently, National Defence does not have sufficient information about these variables and their inter-relationships to construct bottom-up confidence intervals.

As an alternative, National Defence has used a top-down approach based on the assumption that given the same role and mission profiles, National Defence can use historical costs of the CF-18 fleet to model the ratio of sustainment requirement per flying hour to capital demand amortized over time for the F-35A fleet. [10]

This model shows that increases in F-35A sustainment (relative to that of the CF-18) will be proportional to the higher F-35A acquisition costs, reflecting the technological advancements inherent in a more advanced fighter. The predicted sustainment costs for the F-35A also include 95 per cent confidence intervals. The Joint Strike Fighter Program Office sustainment estimate for the life of the F-35A generally falls within the National Defence model’s 95 per cent confidence interval, as shown in Figure 3.

[10] Desmier, P (2012) Forecasting National Procurement Costs for the Joint Strike Fighter DRDC CORA TR 2012-093

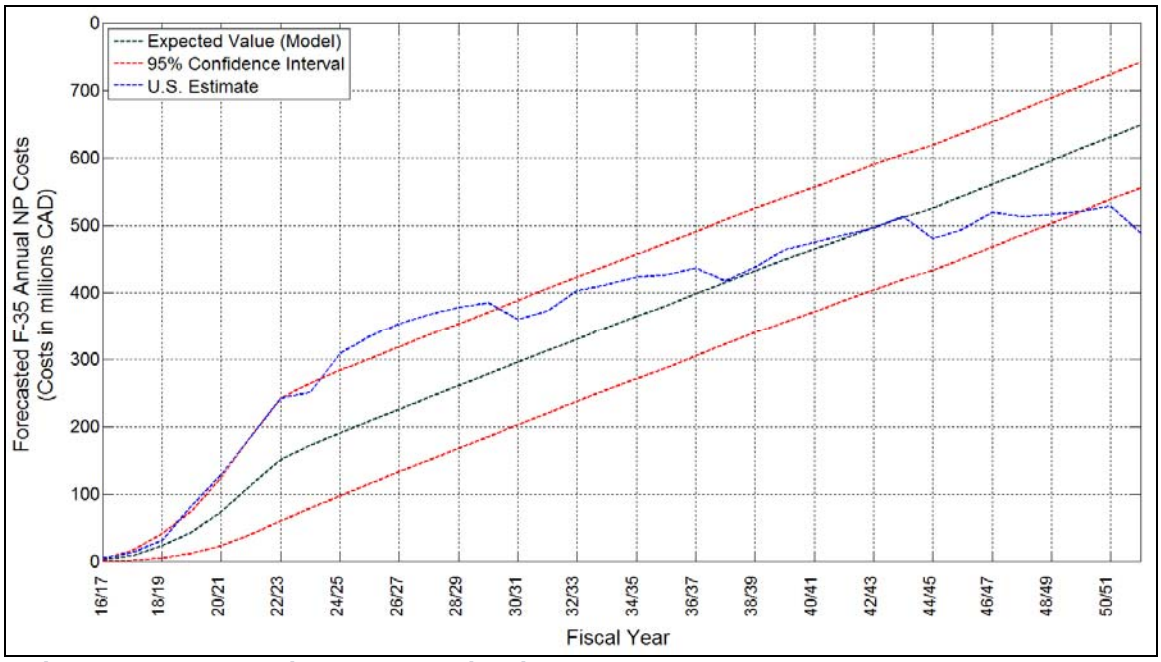



**Figure 3: Forecasted F-35A Annual Maintenance Costs**

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

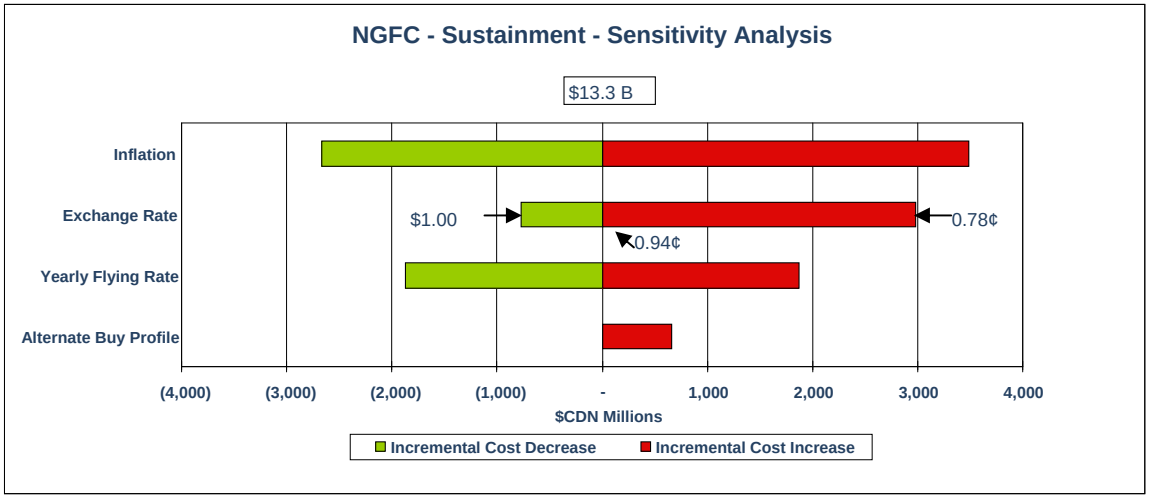



**Figure 4: Sustainment Costs**

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 Joint Strike Fighter Program Office. This analysis allows the planners to predict the increased or reduced impact if inflation is one per cent higher or lower than the level projected by the Joint Strike Fighter Program.

A one per cent cumulative increase in the inflation rate built into the estimate would increase the sustainment cost by almost $3.5 billion over the project life cycle. A one per cent decrease from that inflation rate would result in an approximate $2.7 billion

reduction in the estimate. The difference between the two figures is attributable to the compounding effect of the two per cent 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 $59 million. For the rates considered, the potential increase would be $3 billion, and the potential savings are approximately $900 million.

Yearly Flying Rate: Another element of the Next Generation Fighter Capability 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. Delaying the first aircraft delivery by one year, and compressing the delivery schedule from six years to five years, would result in a sustainment cost increase of over $650 million. This increase is due to a more rapid introduction of the full fixed cost of sustainment.

### *6. Operating Cost Risk and Uncertainty*

Figure 5 provides information on the sensitivity of the operating cost estimate to various assumptions about specific factors affecting it.

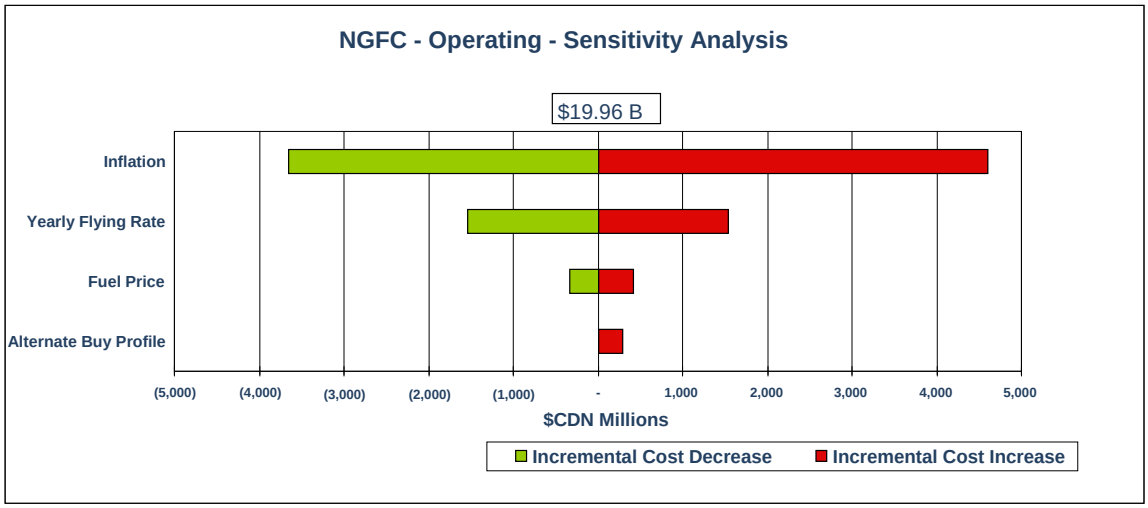



**Figure 5: Operating Costs**

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 per cent increase would increase operating costs by approximately $4.6 billion over the program life cycle, while a one per cent decrease

would result in a $3.6 billion decrease in the estimate. The difference between the two figures is attributable to the compounding effect of a two per cent 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 $1.5 billion variation in the cost estimate over the program 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 $0.885 per litre (excluding taxes), with a possible range of 10 per cent (i.e. from $0.797 to $0.974). Over the past 25 years, the average annual compounded fuel price inflation has been 4.7 per cent.

In this analysis, the fuel price increases were modeled on an assumed two per cent inflationary lower bound (consistent with the Bank of Canada's Consumer Price Index target), a four per cent average (consistent with the National Defence economic model) and a five per cent upper bound. At the 50 per cent confidence interval, the analysis shows a minimum cost savings of about $325 million while at the 95 per cent confidence interval the cost increase could be as much as $425 million.

Alternate Buy Profile: Changing the aircraft delivery schedule as described above would result in additional operating costs of approximately $300 million. This increase is mainly due to a more rapid introduction of the full fixed cost of operating would remain in place for the full life of the entire fleet

### *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 professional and expert judgment or the use of past experience.

Contingency on Development: Within the Development Phase, costs are mostly based on known Memorandum of Understanding payments stipulated by the agreement. As a result, there is a risk, other than foreign exchange. A 15 per cent contingency was calculated using the guidelines articulated in the *DND Costing Handbook Second Edition, 2006*.

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 determined by a group of subject-matter experts facilitated by an independent risk management consultant.

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 Joint Strike Fighter 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*.

The subject-matter experts developed an agreement around the likelihood of each risk occurring. The maximum value for the risk was calculated from the sensitivity analysis described in the previous sections of this report. The expected value of the risk exposure to the acquisition cost estimate was $1,450 million, calculated as shown in Table 4.

| Contingency Tables | Max Impact $Million | Mid-Point of Likelihood Ranges | Expected Value $Million |
|---|---|---|---|
| Foreign Exchange | 1,800 | 30% | 540 |
| Inflation | 500 | 30% | 150 |
| Learning/Production | 1,700 | 10% | 170 |
| Number of Aircraft | 500 | 50% | 250 |
| Other Acquisition Cost Risks | n/a | n/a | 340 |
| **Total** | **4,500** | | **1,450** |

**Table 4: Contingency on Acquisition**

Contingency on Sustainment: The expected value for contingency on sustainment is $1,950 million, as shown in Table 5.

| Contingency Tables | Max Impact $M | Mid-Point of Likelihood Ranges | Expected Value $M |
|---|---|---|---|
| Foreign Exchange | 3,000 | 30% | 900 |
| Inflation | 3,500 | 30% | 1,050 |
| **Total** | **6,500** | | **1,950** |

**Table 5: Contingency on Sustainment**

The calculation follows the same risk-based analysis as for acquisition, but the only cost risk factors considered were inflation and foreign exchange. While there are other risk factors related to the sustainment cost in general, these risks can be fully mitigated by reducing operations or through adjustments to the National Defence long-term budget.

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; 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*. It was set at the high range, as disposal will occur very far in the future and there is no specific disposal plan in place.

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.

| | | Recommended | Resulting Rate | Available | | |
|---|---|---|---|---|---|---|
| **Phase** | **LCC Estimate Without Contingency $M** | **Amount $M** | **Rate** | **Ceiling $M** | **Shortfall $M** | **Mitigation Strategy for Shortfall** |
| Development | 491 | 74 | 15% | 74 | 0 | n/a |
| Acquisition | 8,388 | 1,450 | 17% | 602 | (848) | Reduce number of jets purchased |
| Sustainment | 13,290 | 1,950 | 15% | 1,950 | (0) | n/a |
| Operating | 19,960 | 0 | 0% | 0 | 0 | n/a |
| Disposal | 43 | 22 | 50% | 22 | 0 | n/a |
| **Total** | **42,172** | **3,496** | **8%** | **2,648** | **(848)** | **n/a** |

**Table 6: Contingency**

The table also displays the contingency amount that is capped by Government policy. The difference between the recommended contingency and the established expenditure ceiling constitutes a contingency shortfall of approximately $848 million.

If the full available acquisition contingency was required, the remaining shortfall would be met by buying fewer aircraft.

## VI. Cost Analysis

The following sections discuss affordability of the program, and compare the 2012 estimate to previously reported estimates.

### *1. Affordability*

National Defence has a long-term (20-year) budget which is updated periodically. The next version of this long-term budget, scheduled for presentation to Treasury Board in 2013, will include 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.

Any option moving forward will be informed by the Government's $9 billion acquisition cap to acquire next generation fighter aircraft to replace the existing fleet of CF-18s. Should the Government decide to proceed with the purchase of 65 F-35A aircraft, it is forecast that the one-time acquisition cost is currently affordable within the $9 billion Canadian 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 an analog for the operating costs of the F-35. The current estimate, as independently reviewed by KPMG, 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*

In support of the 2010 policy decision to replace the CF-18, National Defence prepared a cost estimate based on a 20-year period of sustainment and operating costs from the purchase of the first jet. The use of the 20-year period was based on several factors:

- Twenty years has been a standard practice and norm for reporting to Treasury Board for all major Defence projects;
- The National Defence Investment Plan covers a 20-year period;
- The 20-year period aligned well with anticipated sustainment contracting authorities to be sought from Treasury Board; and
- The reliability of cost data after 20 years is suspect. Often the only additional cost information that varies in the longer-term forecasts is inflation and foreign exchange.

As is normal and expected for a project in the Options Analysis phase, assumptions and plans change over time. Table 7 compares the 2010 cost estimate to the current cost estimate based on the KPMG Life-Cycle Cost Framework and using the current Cost Breakdown Structure. The 2012 estimate uses a different and more detailed cost breakdown structure than the 2010 estimate. As a result, some of the 2010 estimate values are shown at the summary level to allow for ease of comparison.

| | | Acquisition plus 20 years of sustainment and operating costs from delivery of first aircraft | Development, acquisition plus 30 years of sustainment and operating for each aircraft and includes disposal |
|---|---|---|---|
| **Life Cycle Phase** (Note 1) | **Cost Element** | **Estimate Used for 2010 Decision Making** | **2012 Life Cycle Framework Program Costing** |
| **Development** | Development | n/a (Note 2) | 491 |
| | Contingency | 0 | 74 |
| **Development Total** | | **0** | **565** |
| **Acquisition** | URF | 6,000 | 5,992 (Note 3) |
| | Ancillary | | 246 |
| | Sustainment Set-up | 749 | 1,154 |
| | Initial Spares | 478 | 259 |
| | Reprogramming Lab | 22 | 216 |
| | Infrastructure | 400 | 244 |
| | Ammunition | 270 | 52 |
| | Training | 71 | 65 |
| | Project Management Office | 160 | 120 |
| | Other | n/a | 40 |
| | Contingency | 830 | 602 |
| **Acquisition Total** | | **8,980** | **8,990** |
| **Sustainment** | Unit Level Consumption | 5,710 | 5,357 |
| | Depot Maintenance | | 791 |
| | Contractor Support | | 1,979 |
| | Sustaining and Other Support | | 5,163 |
| | Contingency | 860 | 1,950 |
| **Sustainment Total** | | **6,570** | **15,240** |
| | Personnel | 4,740 | 10,257 |
| | Operating | 4,830 | 9,703 |
| **Operating Total** | | **9,570** | **19,960** |
| **Disposal** | Disposal | n/a | 43 |
| | Contingency | n/a | 22 |
| **Disposal Total** | | **n/a** | **65** |
| **Total Estimate** | | **25,120** | **44,820** (Note 4) |

**Table 7: 2010 versus 2012 Cost Estimate**

Notes: 1. The 2010 estimate was based on Selected Acquisition Report 2009. The 2012 estimate is based on Selected Acquisition Report 2011.
2. In 2010, DND included $356 million in MOU payments in the costing.
3. The average unit recurring flyaway price denominated in Canadian dollars is $92.2 million ($87.4 million U.S. dollars).
4. It is estimated that seven to eleven aircraft could be lost over the 42-year timeframe and the cost to replace these lost aircraft could be in the order of $1 billion. This cost is not included in this table.

As summarized in Table 8 and in the text below, differences result from a number of factors.

| Factor | | $M CAD |
|---|---|---|
| 1 | Cost Refinement | 2,566 |
| 2 | Refined Planning Assumptions | (2,304) |
| 3 | Additional Life-Cycle Cost Elements | 276 |
| 4 | MOU Payments | 356 |
| 5 | Additional Years | 18,806 |
| **Total** | | **19,700** |

Note: The amounts above include an impact of $1.4 billion due to updated foreign exchange and inflation rates.

**Table 8: Factors that Impact Life-Cycle Cost Estimate**

1. The cost estimates have been refined ($2,566 million):
   - Increases in unit recurring flyaway cost from $75 million U.S. dollars from Selected Acquisition Report 2009 (which was used to support the cost estimate developed in 2010) and the $87.4 million U.S. dollar used for this 2012 Life-Cycle Cost Estimate are largely a result of delays in aircraft production rates, increased labour costs, and costs resulting from design improvements identified during testing;
   - Estimates for unit recurring flyaway costs, Initial Logistics, Sustainment Set-up, Sustainment, and other cost elements such as the reprogramming lab reflect best available information and have been updated; and
   - A revised cost allocation split transferred some costs from the Sustainment category into Acquisition (Sustainment Set-up) category.

2. Some of the planning assumptions have been refined (-$2,304 million):
   - Yearly flying rate was reduced from 15,800 to 11,700 to reflect the increased use of simulation;
   - The number of full mission simulators has been adjusted from 12 to eight to reflect current plans;
   - The Reprogramming capability will be fielded through a collaborative effort with other Joint Strike Fighter partner nations;
   - Infrastructure requirements were adjusted based on site survey and cost containment measures;
   - Weapons requirements were adjusted based on the re-use of existing inventory; and
   - No Canadian modifications are planned.

3. The costing has been updated to include additional cost elements to respect the Life-Cycle Cost Framework ($276 million):
   - Program Development phase costs have been added; and
   - Disposal phase costs have been added.

4. The inclusion of Memorandum of Understanding contributions that were not reflected in Exhibit 2.6 of the Auditor General of Canada Spring 2012 Report ($356 million).

5. In accordance with Cost Framework principles, the estimate timeframe was extended from 2037 to 2052 ($18,806 million).

Also included in the base-cost estimate and in all of the above factors are updated economic factors for foreign exchange and inflation ($1,430 million).

In 2010, the methodology used by National Defence for calculating cost estimates identified a total cost estimate of $25.1 billion over 20 years. This approach was consistent with standard practice at the time, recognizing the inherent uncertainties in cost estimates beyond 20 years, which was the normal timeframe used for reporting to Treasury Board on all major Defence projects.

As this is the first cost estimate using the Next Generation Fighter Capability Life-Cycle Cost Framework, it is not possible to compare this current estimate against any previous estimate compliant with the Framework.

However, for ease of comparison to previous cost estimates, Table 9 compares the current life-cycle cost estimate to the one displayed in the April 2012 Office of the Auditor General Report.

| | Elements Related to Purchase of F-35A | National Defence's 2010 Estimate ($M) | National Defence's 2012 Estimate - 20 Years only ($M) (Note 2) |
|---|---|---|---|
| Development | **Development Total** (Note 1) | **n/a** | **446** |
| Capital acquisition costs – aircraft | Aircraft | 5,580 | 5,992 |
| | Canadian Modifications | 420 | 0 |
| | **Total Capital cost for 65 F-35A** | **6,000** | **5,992** (Note3) |
| Additional capital acquisition costs | Initial Logistics and training (including simulators) | 1,320 | 1,940 |
| | Project Management (initial) | 160 | 160 |
| | Weapons (initial buy) | 270 | 52 |
| | Infrastructure | 400 | 244 |
| | Contingency | 830 | 602 |
| | **Total additional capital acquisition costs** | **2,980** | **2,998** |
| | **Total capital acquisition costs** | **8,980** | **8,990** |
| Personnel, operating, and maintenance costs | Contracted sustainment | 5,710 | 6,350 |
| | Contingency | 860 | 953 |
| | Operating costs | 4,830 | 4,133 |
| | National Defence personnel | 4,740 | 4,959 |
| | **Total personnel/operating/maintenance costs** | **16,140** | **16,395** |
| | **Total 20-year costs** | **25,120** | **25,831** |

Note: 1. DND had identified MOU payments of $356M in its 2010 cost estimates. Adding the MOU costs to the $25.120 billion estimate would bring the total to $25.476 billion.
2. See Page 14 for updated planning assumptions behind the 2012 life-cycle cost estimate.
3. The average unit recurring flyaway price denominated in Canadian dollars is $92.2 million.

**Table 9: Comparison 20-Year Cost Estimate**

When limited to a 20-year period, the current life-cycle costing methodology results in a total estimate that is less than three per cent higher than the National Defence estimate used in 2010 to support decision-making.

## VII. Conclusion

In his 2012 Spring Report, *Replacing Canada's Fighter Jets*, the Auditor General made a number of observations about the process being pursued to acquire a replacement to the CF-18 aircraft fleet. He recommended that the Department of National Defence refine its estimates for complete costs related to the full life-cycle of the F-35A. The Government of Canada accepted the recommendation, and issued a Seven-Point Plan.

This document is the product of one of the commitments under the Plan—that National Defence, through the National Fighter Procurement Secretariat, will provide annual updates to Parliament. This first annual update is focused particularly on the cost of the F-35A, which remains one of the options for replacing the CF-18.

This update provides revised cost estimates based on the Life-Cycle Cost Framework developed using international best practices. The Life-Cycle Cost Framework will help to provide the means by which National Defence can evaluate options to replace the CF-18 fleet and to refine and publish these estimates in future public communications.

These revised estimates, and the assumptions underlying them, were reviewed by KPMG, contracted by the Treasury Board of Canada Secretariat as an independent third party in keeping with one of the points under the Seven-Point Plan.

This report explains how and why the cost estimates differ from those previously reported. The original National Defence cost estimate covered a 20-year period, starting after the first aircraft delivery, the current estimate covers the period beginning in 2010 and ending 42 years later with the disposal of the last aircraft in 2052. This longer life-cycle period accounts for almost all of the cost increase.

This estimate includes $602 million for acquisition contingency and $1.95 billion for sustainment contingency. While these provisions fall within the range recommended in the KPMG Framework, the provision for acquisition contingency could be considered low for a project of this scope and size. As a result, any option moving forward will be informed by the Government's $9 billion acquisition cap to acquire next generation fighter aircraft to replace the existing fleet of CF-18s.

National Defence remains committed to updating decision makers and Parliament on an annual basis. The new Life-Cycle Cost Framework will help to provide the basis on which National Defence continuously refines and publishes its estimate and to prepare these annual updates on the replacement of the CF-18 fleet.