October 27, 2022

The Life Cycle Cost of the Canadian Surface Combatants

A Fiscal Analysis

OFFICE OF THE PARLIAMENTARY BUDGET OFFICER
BUREAU DU DIRECTEUR PARLEMENTAIRE DU BUDGET

The Parliamentary Budget Officer (PBO) supports Parliament by providing economic and financial analysis for the purposes of raising the quality of parliamentary debate and promoting greater budget transparency and accountability.

In response to a request by the House of Commons Standing Committee on Government Operations and Estimates (OGGO), this report presents a cost analysis of the Canadian Surface Combatants (CSC) program, including estimates for the Development, Acquisition, Operations and Sustainment, and Disposal phases of the fleet's life cycle.

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Executive Summary

On June 3, 2022, the House of Commons Standing Committee on Government Operations and Estimates (OGGO) requested that the Office of the Parliamentary Budget Officer (PBO) undertake a costing analysis of the active life cycle costs for the Canadian Surface Combatants (CSC), including decommissioning and disposal, and that the report containing this analysis be presented to the Chair of the committee by Thursday, October 27, 2022.

In response to this request, this report presents PBO's full life cycle costs of the CSC program including updated estimates for the Development and Acquisition phases, as well as new estimates for the Operations and Sustainment phase, and the Disposal phase.

Summary Table 1 presents the cost estimates for each phase of the CSC life cycle. The total life cycle cost of the CSC program is estimated to be $306.0 billion, with an estimated $4.3 billion for the Development phase, $80.2 billion for the Acquisition phase, $219.8 billion for the Operations and Sustainment phase, and $1.7 billion for the Disposal phase.

Summary Table 1 CSC life cycle cost estimates, by phase ($ billions)

	Cost
Development	4.3
Acquisition	80.2
Operations and Sustainment	219.8
Disposal	1.7
Grand Total	**306.0**

Sources: Office of the Parliamentary Budget Officer.

Note: All figures are presented in nominal dollars unless otherwise specified.

1. Introduction

On June 3, 2022, the House of Commons Standing Committee on Government Operations and Estimates (OGGO) requested that the Office of the Parliamentary Budget Officer (PBO) undertake a costing analysis of the active life cycle costs for the Canadian Surface Combatants (CSC), including decommissioning and disposal, and that the report containing this analysis be presented to the Chair of the committee by Thursday, October 27, 2022.[1]

In response to this request, this report presents PBO's full life cycle costs of the CSC program including updated estimates for the Development and Acquisition phases, as well as new estimates for the Operations and Sustainment phase, and the Disposal phase.

Background

In 2008, the original budget for the CSC procurement was set at $26.2 billion (then-year, or nominal, dollars).[2] In 2017, the PBO estimated the cost of the Type 26 ships (the design chosen by the Government) to be almost $62.0 billion.[3] The Government of Canada subsequently revised their cost estimates of the procurement program to a total of $56-60 billion, with costs to be revisited at the completion of the Development phase.[4] In 2019, PBO updated its cost estimate of the Type 26 to $69.8 billion (then-year dollars).[5] These PBO cost estimates were inclusive of all activities associated with the Development and Acquisition phases and also accounted for taxes and an initial 2-year supply of spare parts for each vessel.

The most recent PBO update in 2021 estimated a cost of $77.3 billion for the Development and Acquisition phases.[6] This increased cost was reflective of changes to project assumptions and timelines, including an increase in the planned weight of the vessel and a later delivery schedule. Methodological changes were also effected to the PBO cost model and the federal portion of taxes on construction costs were removed.[7]

2. Understanding Life Cycle Costs

This report provides a fulsome estimate of the cost of not only procuring the fleet of surface combatants but also the costs of operating them throughout their useful life and their disposal.

Figure 2-1 shows a typical profile of annual expenditures over the course of a weapon system's life cycle. Costs can be divided into four distinct life cycle phases: Development, Acquisition, Operations and Sustainment, and Disposal.

Life cycle phases

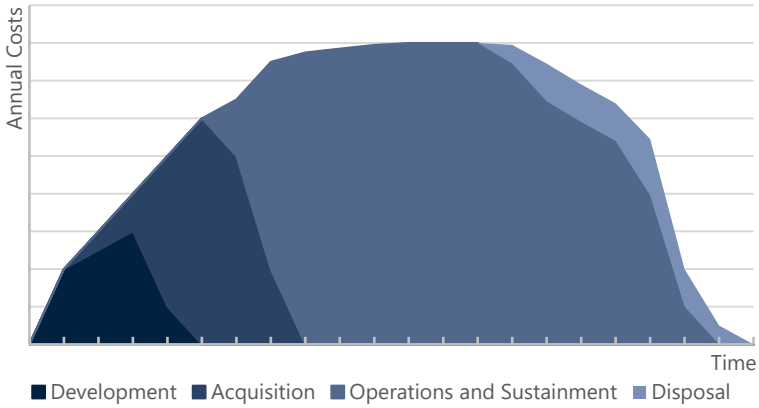
Development: all activities leading up to the purchase or construction of a given weapon system, such as options analysis, studies, and research and development.

Acquisition: all activities associated with the purchase or construction of the system and its integration into service and full operational capability.

Operations and Sustainment: all activities relating to the usage, support, and maintenance of the system, including mid-life upgrades and technology insertion.

Disposal: activities associated with the withdrawal of the system from service at the end of its useful life.

Figure 2-1 Illustration of annual costs over a system's life cycle, by phase



While the Development and Acquisition phases incur a significant portion of total life cycle costs, the Operations and Sustainment phase is usually the

costliest. Comparatively, the Disposal phase is the least costly phase of a given system's life cycle.

The CSC project is currently in the Development phase, with the Acquisition phase set to begin with the construction of the first ship starting in 2024-25. Development activities will continue in tandem with the early part of the construction phase as the design continues to be refined and finalized during this time, as is common in naval procurement.

2.1. Expected Life Cycle Phase Timelines

Table 2-1 displays a breakdown of expected timelines of the CSC project life cycle. Construction on the first vessel is slated to begin in 2024-25, with the first ship being delivered to the Royal Canadian Navy (RCN), thus officially beginning the Operations and Sustainment phase, in 2031-32. The 15th and final vessel is expected to enter service in 2048-49, marking the end of the Acquisition phase as all 15 vessels will have been delivered to the RCN. The disposal of the first vessel is projected to occur in 2061-62, with the last vessel being removed from service in 2080-81.[8]

Table 2-1 CSC Life Cycle Timelines

	Phase Start	Phase End
Development	2015-16	2026-27
Acquisition	2024-25	2048-49
Operations and Sustainment	2031-32	2078-79
Disposal	2061-62	2080-81

Sources: Office of the Parliamentary Budget Officer, Department of National Defence.

Note: All dates are estimates based on inputs provided by the Department of National Defence.

3. Estimates

The total estimated life cycle cost of the development, acquisition, operations and sustainment, and disposal of the CSC fleet is $306.0 billion. Table 3-1 displays a breakdown of the costs of each life cycle phase in nominal dollars.

Table 3-1 CSC life cycle cost estimates, by phase ($ billions)

	Cost
Development	4.3
Acquisition	80.2
Operations and Sustainment	219.8
Disposal	1.7
Grand Total	**306.0**

Sources: Office of the Parliamentary Budget Officer.

Note: All figures are presented in nominal dollars unless otherwise specified.

Sections 3.1, 3.2, and 3.3 provide additional details on the estimates associated with each life cycle phase. Importantly, Section 3.1 includes a comparison to previous PBO estimates, which covered only the Development and Acquisition phase costs.

3.1. Development phase and Acquisition phase

In this report, estimates for the Development phase and Acquisition phase are presented jointly to allow direct comparisons to previous PBO estimates and extant estimates from the Department of National Defence.

The current PBO estimate of the Development and Acquisition phases is $84.5 billion in nominal (then-year) dollars. The estimate is derived using data from the Department of National Defence (DND) and applying PBO's modelling approach. A complete description of the methodology may be found in the 2019 and 2021 PBO reports.

Comparison to 2021 PBO report

PBO's cost estimate of the Development and Acquisition phase of the CSC program has increased by 9 percent from $77.3 billion in the 2021 report to $84.5 billion as shown in Table 3-2. This estimate is driven by three developments since the 2021 report: updated production timelines; updated estimates of the consumer price index by PBO to reflect recent increased inflation; [9] and the removal of provincial taxes from the PBO estimate.

Table 3-2 Total Development and Acquisition cost, by phase (billions $)

	PBO 2022	PBO 2021	Difference
Development	4.3	4.4	(0.1)
Acquisition - Production	67.5	59.9	7.5
Acquisition - Ancillary	12.7	13.0	(0.3)
TOTAL	84.5	77.3	7.1

Sources: Office of the Parliamentary Budget Officer.

Note: Totals may not add due to rounding.
The cost of initial spares is now included with Acquisition – Production.
Acquisition – Ancillary costs include acquisition project management, engineering support, training and testing, facilities and infrastructure, and ammunition.

Since the publication of PBO's 2021 report, the acquisition phase has been delayed by one year and will now begin in 2024-25 with deliveries to commence in 2031-32. The delivery of the 15th ship has been reprofiled by four years, with the conclusion of development and acquisition now ending in 2048-49. Construction and ship delivery schedule delays directly affect the construction cost element, and consequently extend other cost elements such as project management, engineering support, training and testing, infrastructure and facilities, ammunition, and spare parts. Additionally, the design cost element was extended by one year.

The CPI projection is consistent with PBO's latest Economic and Fiscal Outlook, published October 2022.

Aside from the production timeline, the data provided by DND has not changed since the previous report, nor has the lightship weight of the CSC design.

3.2. Operations and Sustainment phase

The Operations and Sustainment phase is set to begin with the delivery of the first CSC to the RCN. While new naval vessels undergo sea trials and evaluations prior to reaching operational status, the costs associated with the Operations and Sustainment phase are assumed to begin immediately following delivery.

This analysis assumes that each vessel will have an Operations and Sustainment phase of 30 years, which includes several docking periods for maintenance and a mid-life refit. The mission profile is based on both inputs provided by the Department of National Defence and the historical experience of the Halifax-class frigate. [10]

As described in Section 2.1, the Operations and Sustainment phase is slated to begin in 2031-32 and will end in 2078-79, once the 15th ship has reached the end of its useful life.

What types of costs are included in the Operations and Sustainment phase estimate?

The Operations and Sustainment phase costs are grouped into three categories: Operations costs, Sustainment costs, and costs associated with a mid-life refit for each vessel.

Operations costs, as the name suggests, includes all cost categories associated with the operation of each vessel, such as personnel, fuel and lubricant, consumables, ammunition, and ancillary support costs.

Sustainment costs largely concern the corrective and preventive maintenance of the vessels and includes all costs for replacement materials and labour. All three levels of maintenance (shipboard maintenance, fleet-level maintenance, and contractor maintenance) are included in this category.

The **Mid-Life Refit** category refers to costs associated with an extensive period of modernization, upgrading, system refurbishment, and maintenance. Aside from increasing the vessels' capabilities through technology insertion, these activities help ensure that each vessel continues to operate at optimal capacity for the remainder of their service life.

What costs are excluded from this estimate?

The Operations and Sustainment phase cost estimate deliberately excludes cost categories associated with the DND's institutional surface combatant capability, such as the overhead cost for fleet maintenance facilities, costs for civilian personnel associated with the surface combatant capability at National Defence Headquarters, and so forth. These costs are not considered incremental to the CSC project.

Data and methodology

The PBO estimate of Operations and Sustainment costs is based on the combined estimates of three models that each draw upon separate data sources.

The first model uses a ratio-based approach, leveraging operations and sustainment data on the current Halifax-class fleet and adjusting for the difference between the cost of acquisition of the Halifax class and the estimated acquisition cost of the CSC. The second model consists of a

regression model based on United States Navy data adjusted for the Canadian naval context. The third model is an analogue-based approach that uses proprietary data and inputs provided by DND.

Further details on each of these three models is presented in Annex Appendix A:.

Estimated cost of the Operations and Sustainment phase

The total estimated cost of the Operations and Sustainment phase is $219.8 billion. This is inclusive of operations and sustainment costs of $203.5 billion and a mid-life refit estimate of $16.4 billion.

Table 3-3 Operations and Sustainment phase costs ($ billions)

	Cost
Operations and Sustainment†	203.5
Mid-Life Refit	16.4
Total	219.8

Source: Office of the Parliamentary Budget Officer.

Notes: Totals may not add due to rounding.
† Operations and Sustainment costs do not take into account recent Treasury Board revisions that increase the Employee Benefit Program (EBP) rate for Canadian Armed Forces members.[11]

3.3. Disposal phase

When a ship reaches the end of commission, they are 'paid off' for disposal.[12] This marks the final stage of a ship's life and makes up the last component of life cycle costs of naval vessels.

Historically, Canada has disposed of naval vessels in a variety of ways including reusing them for other purposes by the Canadian Government, the Navy and the commercial sector, sold as warships to other nations, sunk to create artificial reefs or for firing exercises, given to museums, turned into memorials, and scrapping them. The range of costs for each form of disposal would have varied, and in some cases generated revenue.

For the purpose of this report, and to align with the assumptions made by DND, PBO assumed all 15 CSC ships would be paid off for disposal after 30 years of service beginning in 2061-62. They would be stripped of their military parts and hazardous materials, then sold for scrap.

Data and methodology

As the starting point, PBO relied on DND's assumption for the planned form of disposal of the CSC ships, namely, that they would be sold for scrap.[13] From there, PBO used DND's cost estimates for the components of this form of disposal which include costs for disposal planning, demilitarization, dismantling or destruction of systems, disposal of hazardous materials, docking and transportation, sale of parts and management of these activities.

These component costs were inflated using PBO's projected CPI according to the PBO-adjusted timeline of the ship's disposal (adjusted to reflect delays in initial production as explained in previous sections of this report).

Finally, these costs were inflated again to correspond with PBO's methodology of the use of a cost-estimating relationship (CER). That is, PBO assumes the disposal costs reported to PBO by DND need to be increased to reflect the increase in lightship weight reported in recent years, consistent with PBO's methodology for estimating the cost of production.

Estimated Disposal phase costs

Using these assumptions, PBO estimates the disposal cost for all 15 CSC ships is $1.7 billion over 20 years. The first year of disposal costs are solely associated with disposal planning which begins before the first ship is paid off. In fact, the first three years reflect the cost for disposal planning as well as the cost of keeping the first ship docked before being disposed of in earnest in 2063-64. Subsequently, the rate of disposal reflects the rate of each ship reaching the end of their service life.

For comparison, the per ship disposal cost was estimated by the Congressional Budget Office for a variety of US naval vessels. While their estimates included other forms of disposal including resale, the average reported to Congress ranged from $0 (or an un-estimated amount of revenues) to $500,000.[14]

Appendix A: Methodology: Cost Estimate for Operations and Sustainment Phase

This Annex briefly describes the methodology employed for each of the three models used to produce estimates of the Operations and Sustainment Phase. These are, in turn, a Ratio-based Model, which is based on Canadian data; a regression model, based on US Navy data; and an analogue model based on proprietary data.

Ratio Model

The first model adopts an approach proposed in Desmier (2019)[15] that estimates operations and maintenance costs for next-generation fighter aircraft using the ratio of acquisition costs of a legacy platform to the estimated acquisition costs of a new platform. To tailor this approach to the context of the Royal Canadian Navy and the new generation of surface combatants, we rely on historical costs for both the acquisition and operations and sustainment phases of the Halifax-class frigate. These are converted to real dollars using, respectively, a CPI and defence-specific inflation index for the historical costs of acquisition and a CPI index for the operations and sustainment costs of the Halifax fleet. [16] The real acquisition costs of the 9th ship of the Halifax-class is then used as a basis for the ratio model, being compared to the estimated real dollar cost of the 9th ship of the CSC acquisition. This ratio is then applied to a historical average of operations and sustainment costs of the Halifax-class fleet, adjusted slightly downwards to account for fleet age. The result is an annual estimate of fleetwide operations and sustainment costs, evaluated in real dollars.

Regression Model

The second model uses a regression analysis based on operations and sustainment costs of US Navy surface combatants, notably the Arleigh Burke-class destroyers, the Ticonderoga-class cruisers, and the Independence and Freedom-class littoral combat ships. The data is adjusted to account for both a different definition of operations and sustainment costs in the Canadian context and for differences in exchange rates and local economic conditions. The resulting data is expressed in real terms and used as the basis of a regression model. The model is then used to produce an out-of-sample point estimate based on the CSC's own design specifications. This estimate represents annual operations and sustainment costs in real terms.

Analogue Model

The third model uses an analogue-based approach to estimate operations and sustainment costs. This approach uses proprietary data and inputs provided to the PBO by DND. This data consists of point estimates of each cost category comprising operations and sustainment phase costs. The base data is rendered into real terms and then augmented using PBO estimates of the relationship between cost and lightship weight. The individual cost categories are then summed to produce an estimate expressed in real dollars.

How are mid-life refit costs calculated?

The cost of the mid-life refit category is assumed to be proportional to the estimates of the operations and sustainment categories. This relationship is established using inputs and data provided DND. The above models first produce estimates for the operations and sustainment categories collectively and are then augmented using the relationship of mid-life refit costs to operations and sustainment costs.

How is the final estimate produced?

The three models each produce a point estimate of operations and sustainment costs expressed in real terms. These are then augmented to account for mid-life refit costs. Once this is done, the three cost categories (operations, sustainment, and mid-life refit) are plotted proportionally over each ship's expected operations and sustainment phase time horizon. Mid-life refits are spread over a five-year period at the midpoint of each ship's operations and sustainment phase to account for the uncertainty of the exact timing of the refit activities.

This process produces a set of three profiles of real costs for each category (operations, sustainment, and mid-life refit) over time. The three profiles are then averaged, combining the results from each of the three modelling approaches. The PBO CPI index[17] is then used to properly inflate the cost profile, producing a final nominal (then-year) cost estimate for the operations and sustainment phase.

Notes

1. Canada, Parliament, Standing Committee on Government Operations and Estimates (OGGO), *Minutes of Proceedings*, 44th Parliament, 1st Session, No 23 (June 3, 2022). URL: https://www.ourcommons.ca/DocumentViewer/en/44-1/OGGO/meeting-23/minutes. Accessed 2022-08-08.
2. Government of Canada, Media Response Lines on National Shipbuilding Strategy, Q3. URL: https://www.canada.ca/en/department-national-defence/corporate/reports-publications/proactive-disclosure/pacp-national-shipbuilding-strategy-25-may-2021/reference-materials/mrl-nss.html#tab38b. Accessed 2022-08-08.
3. Office of the Parliamentary Budget Officer. (2017). The Cost of Canada's Surface Combatants. URL: https://www.pbo-dpb.ca/en/publications/LIBARC-1718-346--cost-canada-surface-combatants--cout-navires-combat-canadiens.
4. Department of National Defence. Canadian surface combatant, from https://www.canada.ca/en/department-national-defence/services/procurement/canadian-surface-combatant.html. Accessed 2022-08-08.
5. Office of the Parliamentary Budget Officer. (June 2019). The Cost of Canada's Surface Combatants: 2019 Update. URL: https://www.pbo-dpb.ca/en/publications/RP-1920-021--cost-canada-surface-combatants-2019-update--cout-navires-combat-canadiens-mise-jour-2019.
6. Office of the Parliamentary Budget Officer. (February 2021). The Cost of Canada's Surface Combatants: 2021 Update and Options Analysis. URL: https://www.pbo-dpb.ca/en/publications/RP-2021-040-C--cost-canada-surface-combatants-2021-update-options-analysis--cout-navires-combat-canadiens-mise-jour-2021-analyse-options.
7. The current PBO cost estimate therefore does not include any taxes to ensure direct comparability with the Government's published estimates.
8. Each CSC is assumed to have a life span of 30 years, after which they begin their disposal phase. The first year where disposal costs are incurred, beginning in 2060-61 (29 years after the first ship enters service), is associated with disposal planning. The first ship is docked alongside beginning in 2061-62, with disposal activities beginning in 2063-64.
9. Office of the Parliamentary Budget Officer. (October 2022). Economic and Fiscal Outlook – October 2022. URL: https://www.pbo-dpb.ca/en/publications/RP-2223-018-S--economic-fiscal-outlook-october-2022--perspectives-economiques-financieres-octobre-2022
10. According to DND, the CSC mission profile will be diverse, the ships will be capable of supporting Canadian and allied armed forces ashore, conducting counter-piracy, counter-terrorism, interdiction and embargo operations for medium intensity operations; and delivering humanitarian aid, search and rescue, law and sovereignty enforcement for regional engagements. Source: Government of Canada, Canadian Surface Combatant, Project Summary, https://www.canada.ca/en/department-national-defence/services/procurement/canadian-surface-combatant.html. Accessed 2022-08-08.

11. National Defence does not consider the personnel required to staff the surface combatants to be incremental. If these positions were to be considered incremental, the new EBP rate of 85% would apply. This would increase Operations and Sustainment phase costs by $10.4 billion, for a total of $230.2 billion.
12. In Canada, naval ships can be paid off into one of three categories: major refit or conversion, reserve or disposal.
13. While there are other forms of disposal, the intended purpose of this report is to estimate the cost of the disposal of the 15 CSC ships as planned. Alternate scenarios were not considered.
14. Congressional Budget Office, Letter to Honorable Jeff Sessions, "Life-Cycle Costs of Selected Navy Ships". 2010. URL: https://www.cbo.gov/publication/21398. Accessed 2022-08-08.
15. Paul Desmier, 2019. "Chapter 6: Forecasting the Operations and Maintenance Costs of Aircraft". External Literature, Defence Research and Development Canada. https://cradpdf.drdc-rddc.gc.ca/PDFS/unc357/p812911_A1b.pdf. Accessed 2022-08-08.
16. Shipbuilding inflation is unchanged from our Joint Support Ship Report. See: Parliamentary Budget Officer. (November 2020). The Joint Support Ship program and the MV Asterix: a Fiscal Analysis. url: https://www.pbo-dpb.ca/en/publications/RP-2021-029-C--joint-support-ship-program-mv-asterix-fiscal-analysis--programme-navires-soutien-interarmees-nm-asterix-analyse-financiere.
17. Office of the Parliamentary Budget Officer. (October 2022). Economic and Fiscal Outlook – October 2022. URL: https://www.pbo-dpb.ca/en/publications/RP-2223-018-S--economic-fiscal-outlook-october-2022--perspectives-economiques-financieres-octobre-2022.